APPENDIX R: CITY OF EL PASO ALLEY INFORMATION

INFORMATION RECEIVED FROM THE CITY OF EL PASO

The Texas Commission on Environmental Quality (TCEQ) received a letter dated July 19, 2010, from the City of El Paso Environmental Services Department that included information pertaining to particulate matter reduction measures that have been implemented in the City of El Paso. The relevant alley information is included in this Appendix.

- Alley Paving Costs and Current/Future Plans
- El Paso City Ordinances and Standards
- Reclaimed Asphalt Pavement (RAP) Information

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SERVICE SOLUTIONS SUCCESS

July 19, 2010

Ms. Shelley Naik
El Paso SIP Project Manager
Texas Commission on Environmental Quality
MC-206, P. O. Box 13087
Austin, TX 78711-3087

RE: City of El Paso, PM-10 reduction measures

Dear Ms. Naik:

Please find the attached information pertaining to reduction measures which have been implemented in El Paso Texas. This information is in response to our meeting of June 3, 2010 and subsequent communications, in which you requested specific information outlining the measures that have been implemented to reduce the ambient air concentrations of PM-10. The attached table outlines your requests and refers to the applicable attachment for supporting information.

I hope you find the enclosed information to be sufficient, if you require additional information please contact Miguel Parra, P.E. at 915-599-6235.

Sincerely,

Ellen Smyth, P.E.
Director

Mayor
John F. Cook

City Council

District 1
Ann Morgan Lilly

District 2
Susie Byrd

District 3
Emma Acosta

District 4
Carl L. Robinson

District 5
Rachel Quintana

District 6
Eddie Holguin Jr.

District 7
Steve Ortega

District 8
Beto O'Rourke

City Manager
Joyce A. Wilson

El Paso
All-America City
2010

ENVIRONMENTAL SERVICES DEPARTMENT

7968 SAN PAULO, EL PASO, TEXAS 79907 · 915-621-6700 · FAX 915-621-6711 · WWW.ELPASOTEXAS.GOV

ALLEY PAVING COSTS AND CURRENT/FUTURE PLANS

Alley inventory and project budget information received by the TCEQ Quality from the City of El Paso Environmental Services Department in letter dated July 19, 2010.

Project	Square Yards	Miles	Project Budget	Average SY Cost
Phase I 2005-2007	120,069	9.37	$ 3,345,893.51	$ 27.87
Phase II 2008-2009	32,181	2.72	$ 911,020.52	$ 28.31
Phase III 2009-2010	14,919	1.26	$ 496,508.50	$ 33.28
Phase IV 2010	12,860	1.27	$ 552,805.00	$ 42.99

Alley Surface Type	Alley Count		Square Yards		Miles	
Double Penetration Paving	593	36%	604,045	37%	52	37%
Hot Mix Asphalt Paving	609	37%	542,967	33%	47	33%
Recycled Asphalt Surface	214	13%	225,082	14%	20	14%
Unpaved	252	15%	251,577	15%	23	16%
Totals	1,668		1,623,671		142	

EL PASO CITY ORDINANCES AND STANDARDS

El Paso, Texas, Code of Ordinances, Title 19 – Subdivisions, Article 2 – Subdivision Standards, Chapter 19.15 – Roadways, Sections 19.15.020 – Subdivider Responsibility and 19.15.160 – Alleys. Reprinted from the Municipal Code Library (http://www.municode.com/).

City of El Paso Design Standards for Construction for Alleys received by the Texas Commission on Environmental Quality from the City of El Paso Environmental Services Department in a letter dated July 19, 2010.

19.15.020 - Subdivider responsibility.

A. Safety, Convenience, Functionality. Proposed roads serving new development shall provide a safe, convenient and functional system for vehicular, bicycle and pedestrian circulation and shall conform to the applicable master thoroughfare plan and any amendments thereto, and shall be appropriate for the particular traffic characteristics of each proposed subdivision or development. New developments shall be supported by a thoroughfare network having adequate capacity, and safe and efficient traffic circulation as determined by staff and/or a traffic impact analysis.

B. Streets, Generally. All streets, including curb and gutter improvements, sidewalks, and required infrastructure shall be provided by and at the expense of the subdivider, subject to the rough proportionality provisions of this title. The subdivider shall dedicate all rights-of-way in accordance with subsection C of this section. The subdivider shall install streets at all locations and in accordance with all standards required by this title.

1. The subdivider shall pay the cost of all such improvements, except as follows:

   a. Arterial Streets and Collectors Within Subdivision Boundaries. If the right-of-way for any arterial or collector street lies entirely within the boundaries of any subdivision or portion thereof, the city shall have the option of designing the arterial or collector and/or of being responsible for awarding the contract for construction of required improvements, or allowing the subdivider to arrange for the construction of such arterial provided developer/city participation is in accordance with state bidding statutes. The subdivider shall deposit his share of construction costs with the city prior to award of the contract. The subdivider's share shall include the cost of pavement, curb and gutter, and sidewalks for a street thirty-six feet wide or the roughly proportional share as determined by a TIA.

   b. Arterial and Collector Streets Bordering Subdivision Boundaries. If the right-of-way of any arterial or collector street forms part of the subdivision boundary, the subdivider shall dedicate the right-of-way and either improve the street in conformance with this title and Section 19.10.050 or contribute to the city an amount of money equal to that necessary to improve the street in conformance with this title and Section 19.10.050. All money received from subdividers for improving boundary streets shall be deposited in an appropriate fund(s) of the city. When the city council resolves to design and improve a bounding arterial or collector street to standards appropriate to its use, then the assessment fund or similar funds shall be utilized in payment of necessary construction costs.

   c. Improving State or Federally Owned Right-of-Way. If the right-of-way for any thoroughfare owned by the state or federal government lies within or adjacent to the subdivision, the subdivider shall not be required to pave any portion of it. The subdivider shall, however, arrange to construct or contribute to the city an amount of money equal to that necessary to furnish curb and gutter and sidewalk improvements to any state- or federally-owned arterial lying within or adjacent to the subdivision, if adequate improvements do not already exist but are determined to be necessary within the next ten years and are not funded by others. The developer may also be required, based on the TIA, to contribute their rough proportional share of additional frontage road lanes, acceleration or deceleration lanes or bus turnouts. Funds shall be deposited and disposed of in a fashion similar to that described in the preceding paragraph (1)(b) of this subsection, concerning improvements to

arterial streets bordering subdivision boundaries.

2. Existing Boundary Streets for Small Subdivisions. If the right-of-way of an existing street forms part of the boundary for a subdivision meeting all of the following conditions, the subdivider shall have the option to make the contribution to the city for the cost of required street improvements, as determined by the City Manager or designee.

3. Alleys. Where provided, alleys shall be installed and improved in accordance with all standards required by this title and the DSC. Alleys shall be provided by and at the expense of the subdivider.

(Ord. 16882 § 2 (part), 2008)

(Ord. No. 17236, § 27, 11-10-2009; Ord. No. 17251, § 9, 12-15-2009)

19.15.160 - Alleys.

A. Required. The dedication of alleys shall be optional in all subdivisions, except where alleys must be dedicated as direct continuations or extensions of alleys existing in adjacent subdivisions. Such continuations shall be extended in the same alignment as evident from adjacent lots in the existing subdivision, except where an existing alley is less than sixteen feet wide. In that case, additional land shall be dedicated so as to form an alley at least sixteen feet wide.

B. Existing Subdivisions with Alleys. Where lots are subdivided or resubdivided adjacent to or within subdivisions already having alleys, the alley must be improved only to the same extent as may be evident from the existing alley. Where lots are subdivided as continuations of existing subdivisions already having alleys, alleys in the new subdivision shall be improved only to the same standards as those existing alleys, all the way to the first street intersection. Thereafter, if alleys are required or desired, they should conform to standards for alley dedication and improvement set forth in subsection C below.

C. Alley ROW and Paving Widths.

1. Alley ROW's in commercial, industrial, and multiple-family residential districts (including townhouses and patio homes where rear automobile access is intended) must be a minimum width of twenty-eight feet. Twenty-four feet of the minimum width must be surfaced in accordance with the DSC.

2. Alley ROW's in subdivisions, or portions thereof, proposed for single-family residential use must be a minimum width of sixteen feet. Sixteen feet of the minimum width must be surfaced in accordance with the DSC.

D. General Requirements.

1. Alleys shall be as nearly parallel to the street frontage as reasonably possible.

2. Alley intersections with streets shall be as close to right angles (ninety degrees) as practical.

3. Where two alleys intersect or turn at an angle, a corner clip of not less than ten feet from the normal intersection of the property line shall be provided along each property line.

4. If alleys are not straight within each block or do not connect on a straight course with alleys on adjoining blocks, an easement shall be provided for the placement of guy wires on lot division lines necessary to support overhead utility poles set on curving or deviating alley rights-of-way.

5. Alleys should not be platted to intersect any arterial streets.

6. Dead-end alleys shall not be permitted unless a permanent or temporary turnaround is provided. The following standards shall apply:

a. In subdivisions subject to subsection (B)(1) above, turnarounds shall be provided with a minimum radius of thirty-five feet;

b. In all other subdivisions, turnarounds shall be provided with a minimum radius of

thirty-two feet;

c. In instances where dead-end alleys will clearly be permanent, turnarounds shall be surfaced in accordance with subsection (B)(1) or (B)(2), as applicable;

d. In instances were dead-end alleys are of a temporary nature, turnarounds shall be improved with a minimum six-inch-base of crushed limestone.

7. Layout and arrangement of alleys shall be designed to avoid the creation of short cuts for traffic and to discourage use by traffic other than that generated by activity within property abutting the alley.

8. Cross intersections of alleys shall not be permitted.

9. Alleys forming the boundary of a subdivision, and adjacent to unplatted property, shall be dedicated and improved the same as if situated in the interior of a subdivision.

(Ord. 16882 § 2 (part), 2008)

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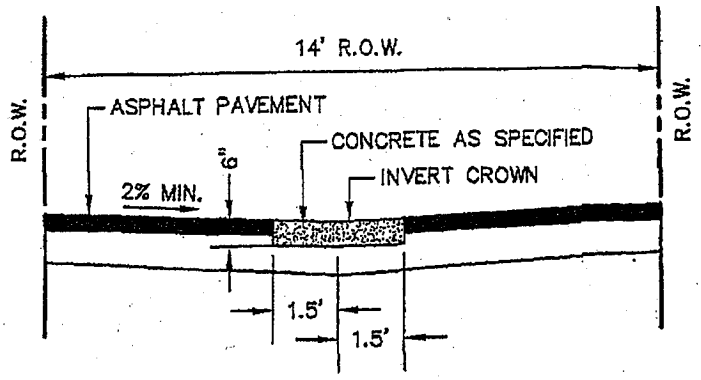
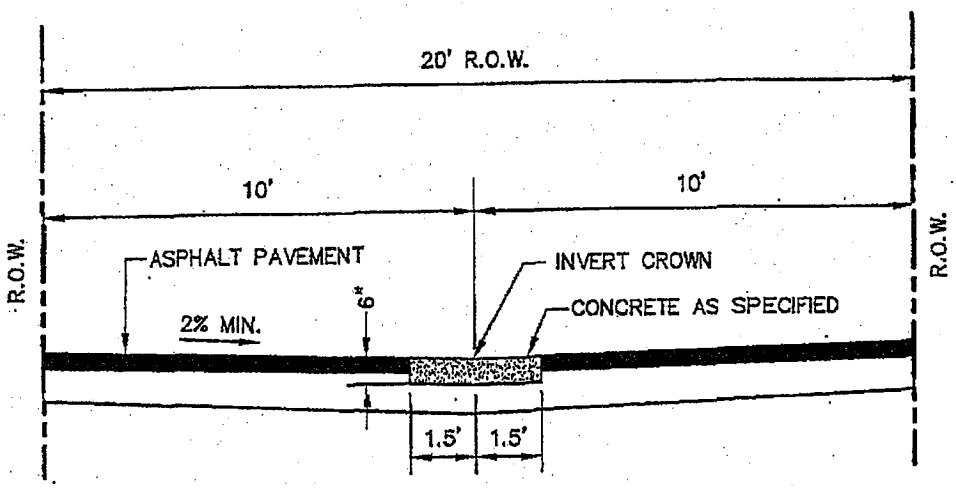


ALLEY
ONE (1) WAY LANE



ALLEY
TWO (2) LANES

NOTES:

1. ONE (1)–THREE FOOT CONCRETE VALLEY GUTTER LOCATED AT THE CENTERLINE OF THE RIGHT–OF–WAY WHEN THE LONGITUDINAL SLOPE OF THE ALLEY IS LESS THAN ONE (1) PERCENT, AND DRAINAGE IS TO BE CARRIED WITHIN THE ALLEY.
2. NO CONCRETE VALLEY GUTTER REQUIRED WHEN LONGITUDINAL SLOPE OF THE ALLEY IS EQUAL OR GREATER THAN ONE (1) PERCENT.

TITLE 19 - SUBDIVISION ORDINANCE

ENGINEERING DEPARTMENT

DESIGN STANDARDS FOR CONSTRUCTION

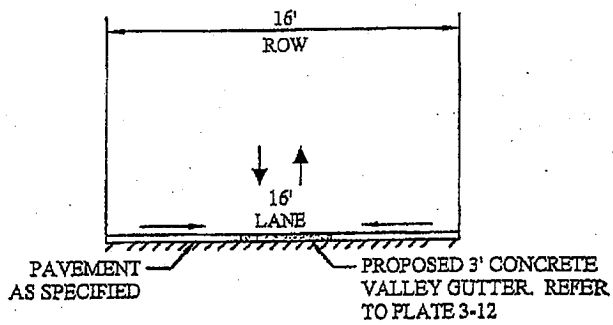
ALLEY CROSS-SECTIONS AND DETAILS

3-11

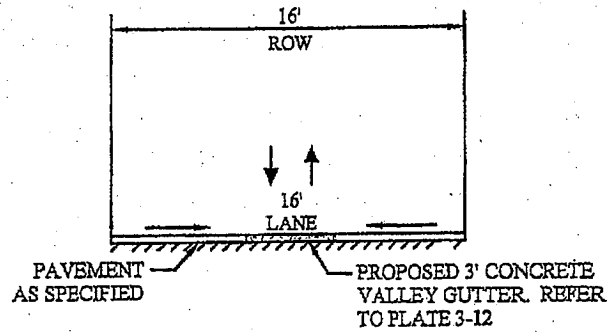
Approved By R. A. SHUBERT
Date JUNE 03, 2008

Checked By H. M. E.
Drawn By OEC / J. R.

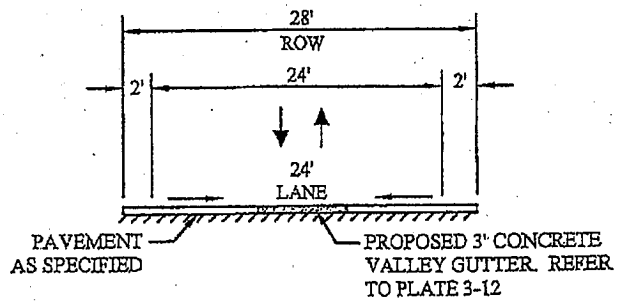
BACK TO TITLE INDEX PAGE



16' ALLEY NO PARKING



16' ALLEY
SINGLE FAMILY RESIDENTIAL



28' ALLEY
COMMERCIAL/INDUSTRIAL/MULTI-FAMILY

TITLE 19 - SUBDIVISION ORDINANCE

ENGINEERING DEPARTMENT

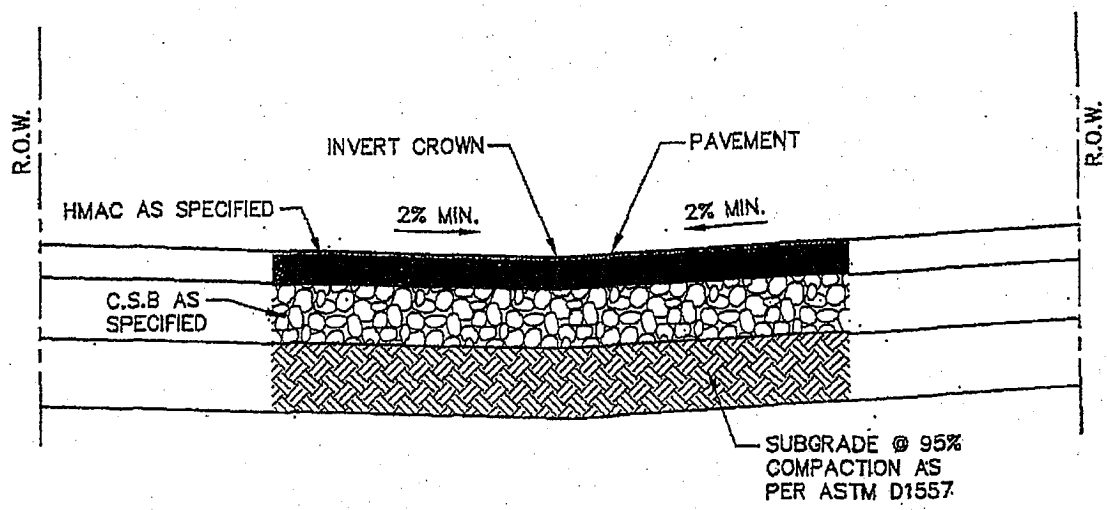
DESIGN STANDARDS
FOR CONSTRUCTION

ALLEY CROSS-SECTIONS

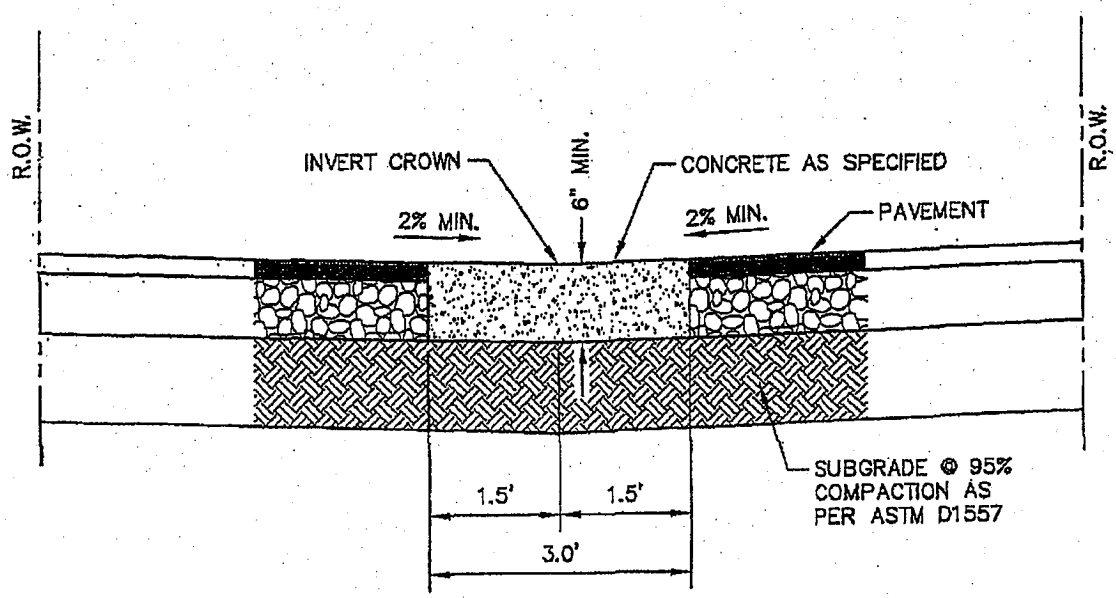
3-11A

Approved By R. A. SHUBERT	Checked By H.M.E.
Date JUNE 03, 2008	Drawn By QEC / J.R.

BACK TO TITLE INDEX PAGE



ALLEY PAVEMENT



VALLEY GUTTER

NOTES:

COMPRESSIVE STRENGTH OF CONCRETE SHALL BE F_C= 3000 P.S.I. MINIMUM

TITLE 19 - SUBDIVISION ORDINANCE

ENGINEERING DEPARTMENT

DESIGN STANDARDS FOR CONSTRUCTION

ALLEY DETAILS

3-12

Approved By R. A. SHUBERT	Checked By H. M. E.
Date JUNE 03, 2008	Drawn By QEC / J. R.

RECYCLED ASPHALT PAVEMENT (RAP) INFORMATION

Documentation on City of El Paso RAP usage received by the TCEQ from the City of El Paso Environmental Services Department in a letter dated July 19, 2010.

Reclaimed Asphalt Pavement Material Description and User Guideline from the United States Department of Transportation Federal Highway Administration Publication Number: FHWA-RD-97-148, "User Guidelines for Waste and Byproduct Materials in Pavement Construction." Reprinted from the United States Department of Transportation Federal Highway Administration Web site.
(http://www.fhwa.dot.gov/publications/research/infrastructure/structures/97148/index.cfm)

Excerpts from the November 2000 United States Department of Transportation Federal Highway publication, "Gravel Roads Maintenance and Design Manual" for the South Dakota Local Transportation Assistance Program received by the TCEQ from the City of El Paso Environmental Services Department in a letter dated July 19, 2010. Reprinted from the United States Environmental Protection Agency Web site.
(http://water.epa.gov/polwaste/nps/gravelroads_index.cfm)

ALLEY MAINTENANCE TOTAL MILLINGS APPLIED

9/1/2003	8/31/2004	108	CY
9/1/2004	8/31/2005	2658	CY
9/1/2005	8/31/2006	7646	CY
9/1/2006	8/31/2007	3656	CY
9/1/2007	8/31/2008	11929	CY
9/1/2008	8/31/2009	4233	CY
9/1/2009	6/30/2010	818	CY

REPORT

This report is an archived publication and may contain dated technical, contact, and link information

Publication Number: FHWA-RD-97-148

User Guidelines for Waste and Byproduct Materials in Pavement Construction

[**Asphalt Concrete (Hot Recycling)**] [**Asphalt Concrete (Cold Recycling)**] [**Granular Base**] [**Embankment or Fill**]

RECLAIMED ASPHALT PAVEMENT — Material Description

ORIGIN

Reclaimed asphalt pavement (RAP) is the term given to removed and/or reprocessed pavement materials containing asphalt and aggregates. These materials are generated when asphalt pavements are removed for reconstruction, resurfacing, or to obtain access to buried utilities. When properly crushed and screened, RAP consists of high-quality, well-graded aggregates coated by asphalt cement.

Asphalt pavement is generally removed either by milling or full-depth removal. Milling entails removal of the pavement surface using a milling machine, which can remove up to 50 mm (2 in) thickness in a single pass. Full-depth removal involves ripping and breaking the pavement using a rhino horn on a bulldozer and/or pneumatic pavement breakers. In most instances, the broken material is picked up and loaded into haul trucks by a front-end loader and transported to a central facility for processing. At this facility, the RAP is processed using a series of operations, including crushing, screening, conveying, and stacking.

Although the majority of old asphalt pavements are recycled at central processing plants, asphalt pavements may be pulverized in place and incorporated into granular or stabilized base courses using a self-propelled pulverizing machine. Hot in-place and cold in-place recycling processes have evolved into continuous train operations that include partial depth removal of the pavement surface, mixing the reclaimed material with beneficiating additives (such as virgin aggregate, binder, and/or softening or rejuvenating agents to improve

binder properties), and placing and compacting the resultant mix in a single pass.

Reliable figures for the generation of RAP are not readily available from all state highway agencies or local jurisdictions. Based on incomplete data, it is estimated that as much as 41 million metric tons (45 million tons) of RAP may be produced each year in the United States.[1]

Additional information on recycling of asphalt pavement can be obtained from the following organizations:

National Asphalt Pavement Association
5100 Forbes Boulevard
Lanham, Maryland 20706-4413

Asphalt Institute
Research Park Drive
Lexington, Kentucky 40512

Asphalt Recycling and Reclaiming Association
#3 Church Circle, Suite 250
Annapolis, Maryland 21401

CURRENT MANAGEMENT OPTIONS

Recycling

The majority of the RAP that is produced is recycled and used, although not always in the same year that it is produced. Recycled RAP is almost always returned back into the roadway structure in some form, usually incorporated into asphalt paving by means of hot or cold recycling, but it is also sometimes used as an aggregate in base or subbase construction.

It has been estimated that as much as approximately 33 million metric tons (36 million tons), or 80 to 85 percent of the excess asphalt concrete presently generated, is reportedly being used either as a portion of recycled hot mix asphalt, in cold mixes, or as aggregate in granular or stabilized base materials.[2] Some of the RAP that is not recycled or used during the same construction season that it is generated is stockpiled and is eventually reused.

Disposal

Excess asphalt concrete is disposed of in landfills or sometimes in the right of way. In most situations, this occurs where small quantities are involved, or where the material is commingled with other materials, or facilities are not readily available for collecting and processing the RAP. It is estimated that the amount of excess asphalt concrete that must be disposed is less than 20 percent of the annual amount of RAP that is generated.

MARKET SOURCES

In most cases, recycled hot mix asphalt can be obtained from central RAP processing facilities where asphalt pavements are crushed, screened, and stockpiled for use in asphalt concrete production, cold mix, or as a granular or stabilized base material. Most of these processing facilities are located at hot mix asphalt plant sites, where the RAP is either sold or used as feedstock for the production of recycled hot mix asphalt pavement or recycled cold mix.

The properties of RAP are largely dependent on the properties of the constituent materials and asphalt concrete type used in the old pavement. Since RAP may be obtained from any number of old pavement sources, quality can vary. Excess granular material or soils, or even debris, can sometimes be introduced into old pavement stockpiles. The number of times the pavement has been resurfaced, the amount of patching and/or crack sealing, and the possible presence of prior seal coat applications will all have an influence on RAP composition. Quality control is needed to ensure that the processed RAP will be suitable for the prospective application. This is particularly the case with in-place pavement recycling.

HIGHWAY USES AND PROCESSING REQUIREMENTS

Milled or crushed RAP can be used in a number of highway construction applications. These include its use as an aggregate substitute and asphalt cement supplement in recycled asphalt paving (hot mix or cold mix), as a granular base or subbase, stabilized base aggregate, or as an embankment or fill material.

Asphalt Concrete Aggregate and Asphalt Cement Supplement

Recycled asphalt pavement can be used as an aggregate substitute material, but in this application it also provides additional asphalt cement binder, thereby reducing the demand for asphalt cement in new or recycled asphalt mixes containing RAP.

When used in asphalt paving applications (hot mix or cold mix), RAP can be processed at either a central processing facility or on the job site (in-place processing). Introduction of RAP into asphalt paving mixtures is accomplished by either hot or cold recycling.

Hot Mix Asphalt (Central Processing Facility)

Recycled hot mix is normally produced at a central RAP processing facility, which usually contains crushers, screening units, conveyors, and stackers designed to produce and stockpile a finished granular RAP product processed to the desired gradation. This product is subsequently incorporated into hot mix asphalt paving mixtures as an aggregate substitute. Both batch plants and drum-mix plants can incorporate RAP into hot mix asphalt.

Hot Mix Asphalt (In-Place Recycling)

Hot in-place recycling is a process of repaving that is performed as either a single or multiple pass operation using specialized heating, scarifying, rejuvenating, laydown, and

compaction equipment. There is no processing required prior to the actual recycling operation.

Cold Mix Asphalt (Central Processing Facility)

The RAP processing requirements for cold mix recycling are similar to those for recycled hot mix, except that the graded RAP product is incorporated into cold mix asphalt paving mixtures as an aggregate substitute.

Cold Mix Asphalt (In-Place Recycling)

The cold in-place recycling process involves specialized plants or processing trains, whereby the existing pavement surface is milled to a depth of up to 150 mm (6 in), processed, mixed with asphalt emulsion (or foamed asphalt), and placed and compacted in a single pass. There is no processing required prior to the actual recycling operation.

Granular Base Aggregate

To produce a granular base or subbase aggregate, RAP must be crushed, screened, and blended with conventional granular aggregate, or sometimes reclaimed concrete material. Blending granular RAP with suitable materials is necessary to attain the bearing strengths needed for most load-bearing unbound granular applications. RAP by itself may exhibit a somewhat lower bearing capacity than conventional granular aggregate bases.

Stabilized Base Aggregate

To produce a stabilized base or subbase aggregate, RAP must also be crushed and screened, then blended with one or more stabilization reagents so that the blended material, when compacted, will gain strength.

Embankment or Fill

Stockpiled RAP material may also be used as a granular fill or base for embankment or backfill construction, although such an application is not widely used and does not represent the highest or most suitable use for the RAP. The use of RAP as an embankment base may be a practical alternative for material that has been stockpiled for a considerable time period, or may be commingled from several different project sources. Use as an embankment base or fill material within the same right of way may also be a suitable alternative to the disposal of excess asphalt concrete that is generated on a particular highway project.

MATERIAL PROPERTIES

Physical Properties

The properties of RAP are largely dependent on the properties of the constituent materials and the type of asphalt concrete mix (wearing surface, binder course, etc.). There can be substantial differences between asphalt concrete mixes in aggregate quality, size, and consistency. Since the aggregates in surface course (wearing course) asphalt concrete

must have high resistance to wear/abrasion (polishing) to contribute to acceptable friction resistance properties, these aggregates may be of higher quality than the aggregates in binder course applications, where polishing resistance is not of concern.

Both milling and crushing can cause some aggregate degradation. The gradation of milled RAP is generally finer and more dense than that of the virgin aggregates. Crushing does not cause as much degradation as milling; consequently, the gradation of crushed RAP is generally not as fine as milled RAP, but finer than virgin aggregates crushed with the same type of equipment.

The particle size distribution of milled or crushed RAP may vary to some extent, depending on the type of equipment used to produce the RAP, the type of aggregate in the pavement, and whether any underlying base or subbase aggregate has been mixed in with the reclaimed asphalt pavement material during the pavement removal.

During processing, virtually all RAP produced is milled or crushed down to 38 mm (1.5 in) or less, with a maximum allowable top size of either 51 mm (2 in) or 63 mm (2.5 in). Table 13-1 lists the typical range of particle size distribution that normally results from the milling or crushing of RAP. Milled RAP is generally finer than crushed RAP. Studies on pavements in California, North Carolina, Utah and Virginia have shown that before and after milling, the pavement fraction passing a 2.36 mm (No. 8) sieve can be expected to increase from a premilled range of 41 to 69 percent to a postmilled range of 52 to 72 percent. The fraction passing a 0.075 mm (No. 200) sieve can be expected to increase from approximately 6 to 10 percent to a range of 8 to 12 percent.[(3)] Most sources of RAP will be a well-graded coarse aggregate, comparable to, or perhaps slightly finer and more variable than, crushed natural aggregates.

The unit weight of milled or processed RAP depends on the type of aggregate in the reclaimed pavement and the moisture content of the stockpiled material. Although available literature on RAP contains limited data pertaining to unit weight, the unit weight of milled or processed RAP has been found to range from 1940 to 2300 kg/m^3 (120 to 140 lb/ft^3), which is slightly lower than that of natural aggregates.

Information on the moisture content of RAP stockpiles is sparse, but indications are that the moisture content of the RAP will increase while in storage. Crushed or milled RAP can pick up a considerable amount of water if exposed to rain. Moisture contents up to 5 percent or higher have been measured for stored crushed RAP.[(4)] As noted earlier, during periods of extensive precipitation, the moisture content of some RAP stockpiles may be as high as 7 to 8 percent.[(5)] Lengthy stockpiling of crushed or milled RAP should, therefore, be kept to a minimum.

The asphalt cement content of RAP typically ranges between 3 and 7 percent by weight. The asphalt cement adhering to the aggregate is somewhat harder than new asphalt cement. This is due primarily to exposure of the pavement to atmospheric oxygen (oxidation) during use and weathering. The degree of hardening depends on several factors, including the intrinsic properties of the asphalt cement, the mixing temperature/time (increases with increasing high temperature exposure), the degree of asphalt concrete compaction (increases if not well compacted), asphalt cement/air voids content (increases with lower asphalt/higher air voids content), and age in service (increases with age).

Table 13-1. Typical range of particle size distribution for reclaimed asphalt pavement (RAP)

(percent by weight passing).

Screen Size (mesh)	Percent Finer After Processing or Milling
37.5 mm (1.5 in)	100
25 mm (1.0 in)	95 - 100
19 mm (3/4 in)	84 - 100
12.5 mm (1/2 in)	70 - 100
9.5 mm (3/8 in)	58 - 95
75 mm (No. 4)	38 - 75
2.36 mm (No. 8)	25 - 60
1.18 mm (No. 16)	17 - 40
0.60 mm (No. 30)	10 - 35[a]
0.30 mm (No. 50)	5 - 25[b]
0.15 mm (No. 100)	3 - 20[c]
0.075 mm (No. 200)	2 - 15[d]
a. Usually less than 30 percent b. Usually less than 20 percent c Usually less than 15 percent d. Usually less than 10 percent	

The RAP obtained from most wearing surface mixes will usually have an asphalt content in the 4.5 to 6 percent range. The recovered asphalt from RAP usually exhibits low penetration and relatively high viscosity values, depending on the amount of time the original pavement has been in service. Penetration values at 25°C (77°F) are likely to range from 10 to 80 while the absolute viscosity values at 60°C (140°F) may range from as low as 2,000 poises (equivalent to AC-20) up to as high as 50,000 poises or greater, depending on the extent of aging. Viscosity ranges from 4,000 to 25,000 poises can normally be expected from the asphalt cement that is recovered from RAP material.[(6)] Table 13-2 provides a summary of the typical ranges of physical properties of RAP, other than gradation.

Table 13-2. Physical and mechanical properties of reclaimed asphalt pavement (RAP).

Type of Property	RAP Property	Typical Range of Values
Physical Properties	Unit Weight	1940 - 2300 kg/m^3 (120-140 lb/ft^3)
	Moisture Content	Normal: up to 5% Maximum: 7-8%
	Asphalt Content	Normal: 4.5-6% Maximum Range: 3-7%
	Asphalt Penetration	Normal: 10-80 at 25°C (77°F)

	Absolute Viscosity or Recovered Asphalt Cement	Normal: 4,000 - 25,000 poises at 60°C (140°F)
Mechanical Properties	Compacted Unit Weight	1600 - 2000 kg/m^3 (100-125 lb/ft^3)
	California Bearing Ratio (CBR)	100% RAP: 20-25% 40% RAP and 60% Natural Aggregate: 150% or higher

Chemical Properties

Mineral aggregates constitute the overwhelming majority (93 to 97 percent by weight) of RAP. Only a minor percentage (3 to 7 percent) of RAP consists of hardened asphalt cement. Consequently, the overall chemical composition of RAP is essentially similar to that of the naturally occurring aggregate that is its principal constituent.

Asphalt cement is made up of mainly high molecular weight aliphatic hydrocarbon compounds, but also small concentrations of other materials such as sulfur, nitrogen, and polycyclic hydrocarbons (aromatic and/or naphthenic) of very low chemical reactivity. Asphalt cement is a combination of asphaltenes and maltenes (resins and oils). Asphaltenes are more viscous than either resins or oils and play a major role in determining asphalt viscosity. Oxidation of aged asphalt causes the oils to convert to resins and the resins to convert to asphaltenes, resulting in age hardening and a higher viscosity binder.[7]

Mechanical Properties

The mechanical properties of RAP depend on the original asphalt pavement type, the method(s) utilized to recover the material, and the degree of processing necessary to prepare the RAP for a particular application. Since most RAP is recycled back into pavements, there is a general lack of data pertaining to the mechanical properties for RAP in other possible applications.

The compacted unit weight of RAP will decrease with increasing unit weight, with maximum dry density values reported to range from 1600 kg/m^3 (100 lb/ft^3) to 2000 kg/m^3 (125 lb/ft^3).[8] California Bearing Ratio (CBR) values for RAP material containing trap rock aggregate have been reported in the 20 to 25 percent range. However, when RAP is blended with natural aggregates for use in granular base, the asphalt cement in the RAP has a significant strengthening effect over time, such that specimens containing 40 percent RAP have produced CBR values exceeding 150 after 1 week.[9]

Table 13-2 provides a summary of the mechanical properties of RAP discussed in the preceding paragraphs.

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[**Asphalt Concrete (Hot Recycling)**] [**Asphalt Concrete (Cold Recycling)**] [**Granular Base**] [**Embankment or Fill**]

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User Guidelines for Waste and Byproduct Materials in Pavement Construction

[Asphalt Concrete (Cold Recycling)] [Granular Base] [Embankment or Fill] [Material Description]

RECLAIMED ASPHALT PAVEMENT **User Guideline**

Asphalt Concrete (Hot Recycling)

INTRODUCTION

Reclaimed asphalt pavement (RAP) can be used as an aggregate in the hot recycling of asphalt paving mixtures in one of two ways. The most common method (conventional recycled hot mix) involves a process in which RAP is combined with virgin aggregate and new asphalt cement in a central mixing plant to produce new hot mix paving mixtures.[1] A second method (hot in-place recycling) involves a process in which asphalt pavement surface distress is corrected by softening the existing surface with heat, mechanically removing the pavement surface, mixing it with a recycling or rejuvenating agent, possibly adding virgin asphalt and/or aggregate, and replacing it on the pavement without removing the recycled material from the pavement site.[2]

PERFORMANCE RECORD

Although some form of pavement recycling had been practiced as early as 1915,[3] the first sustained efforts to recover and reuse old asphalt paving materials were conducted during 1974 in Nevada and Texas.[4] Bolstered by the sponsorship of the Federal Highway Administration (FHWA), more than 40 states performed and documented RAP demonstration projects between 1976 and 1982.

RAP is now routinely accepted in asphalt paving mixtures as an aggregate substitute and as a portion of the binder in nearly all 50 states. Substitution rates of 10 to 50 percent or more, depending on state specifications, are normally introduced in pavements, and recently developed technology has even made it possible to recycle 90 to 100 percent RAP in hot mix.

Recycled Hot Mix

The use of processed RAP to produce conventional recycled hot mix (RHM) is the most common type of asphalt recycling and is now considered standard asphalt paving practice. There are abundant technical data available indicating that properly specified and produced recycled hot mix asphalt is equivalent in quality and structural performance to conventional hot mix asphalt in terms of rutting, raveling, weathering, and fatigue cracking. Recycled hot mix asphalt mixtures also generally age more slowly and are more resistant to the action of water than conventional hot mix asphalt. (See references 5,6,7,8,9,10, and11.)

The maximum limit for RAP content in RHM produced in conventional hot mix asphalt batch plants is widely considered to be 50 percent, limited by both the heat capacity of the plants and gaseous hydrocarbon emissions. As much as 60 to 70 percent RAP may be processed in drum mix plants. Special plants based on microwave technology have been developed to limit gaseous emissions from hot mix asphalt production using very high RAP contents (up to 100 percent RAP), but the cost of heating is much higher than that of conventional systems. This process was developed in California and has only seen limited use.[12]

Table 13-3 provides a 1996 list of State Department of Transportation (DOT) specification requirements for the use of RAP in hot mix asphalt paving mixtures. Separate requirements are given for mixes produced in batch plants or drum-mix plants. Maximum allowable RAP percentages are shown in Table 13-3 for wearing surface, binder, and base courses.[13]

While all state highway agencies permit the use of RAP in base and binder courses, 10 agencies do not permit the use of RAP in surface courses. These include Alaska, Florida, Hawaii, Louisiana, Maine, Maryland, New York, Oklahoma, Rhode Island, and Tennessee. Louisiana and Maine allow up to 20 percent RAP in shoulder mixes only. Massachusetts does not permit the use of RAP in open-graded friction course mixes.[13] Minnesota permits RAP to be used in surface mixes only on low-volume roads.[5] Oklahoma allows up to 25 percent RAP for low- volume roads (fewer than 1,000 vehicles per day) only. Oregon does not permit RAP use in surface mixes on interstate highways.[13]

States that approve the use of RAP in surface courses generally permit from 10 to 30 percent RAP. Some states permit even higher percentages from approved RAP sources. Allowable binder and base course aggregate substitution rates range from 10 to as high as 70 percent in one state (Arkansas). At least 22 states do not permit the blending or commingling of RAP from different projects into combined stockpiles.[13]

Hot In-Place Recycling

The use of hot in-place recycling (HIPR) has developed rapidly over the past decade, although it is in use only on a limited basis. Simple heater-scarification units, heat reforming systems, and special techniques have been developed for heating, scarifying, rejuvenation, and remixing of up to 50 mm (2 in) in depth of aged old asphalt pavement to

new hot mix quality overlay in one pass.

The Asphalt Recycling and Reclaiming Association (ARRA) recognizes three basic HIPR processes: (1) heater-scarification (multiple pass); (2) repaving (single pass); and (3) remixing.

The first two processes involve removal, rejuvenation, and replacement of the top 25 mm (1 in) of the existing pavement. The remixing process involves incorporating virgin hot mix with the recycled paving material in a pugmill and placement to a depth of 50 mm (2 in).

Table 13-3. State DOT specification requirements for the use of reclaimed asphalt pavement (RAP) in hot mix asphalt paving mixtures.[13]

State	Max. RAP % – Batch Plants			Max. RAP % – Drum Plants			Top Size for RAP
	Base	Binder	Surface	Base	Binder	Surface	
Alabama	40	40	15	50	50	15	2 in
Alaska	–	–	–	–	–	–	–
Arizona	30	30	30	30	30	30	1.5 in
Arkansas	70	70	70	70	70	70	3 in
California	50	50	50	50	50	50	2 in
Colorado	15	15	15	15	15	15	1.5
Connecticut	40	40	40	40	40	40	2 in
Delaware	35	35	25	50	50	30	2 in
Florida	60	50	None	60	50	None	Specs
Georgia	25	25	25	40	40	40	2 in
Hawaii	30	None	None	40	None	None	1.5 in
Idaho	Open	Open	Open	Open	Open	Open	2 in
Illinois	50	25	15	50	25	15	Specs
Indiana	50	50	20	50	50	20	2 in
Iowa	Open	Open	Open	Open	Open	Open	1.5 in
Kansas	50	50	50	50	50	50	2 in
Kentucky	30	30	30	30	30	30	Specs
Louisiana	30	30	None	30	30	None	2 in
Maine	40	40	None	40	40	None	1 in
Maryland	Open	Open	Limit	Open	Open	Limit	Specs
Massachusetts	20	20	10	40	40	10	.75 in
Michigan	50	50	50	50	50	50	Specs
Minnesota	59	50	30	50	50	30	3 in
Mississippi	30	30	15	30	30	15	2 in
Missouri	50	50	50	50	50	50	1.5 in
Montana	50	50	10	50	50	10	2 in
Nebraska	Not Used	Not Used	Not Used	Open	Open	Open	2 in
Nevada	50	50	15	50	50	15	1.5 in
New	35	35	15	50	50	15	Specs
Hampshire	25	25	10	25	25	10	2 in
New Jersey							
New Mexico	Open	Open	Open	Open	Open	Open	1.5 in
New York	50	50	None	70	70	None	2 in
North Carolina	60	60	60	60	60	60	2 in
North Dakota	50	50	50	50	50	50	1 in
Ohio	50	35	20	50	35	20	2 in

Oklahoma	25	25	None	25	25	None	2 in
Oregon	30	20	20	30	20	20	1 in
Pennsylvania	Open	Open	Open	Open	Open	Open	2 in
Rhode Island	30	30	None	30	30	None	1.25 in
South Carolina	30	25	20	30	25	20	2 in
South Dakota	Not Used	Not Used	Not Used	50	50	50	1.5 in
Tennessee	15	Open	None	Open	Open	None	Open
Texas	15	Open	Open	Open	Open	Open	2 in
Utah	Not Used	Not Used	Not Used	25	25	25	2 in
Vermont	Specs.	Specs.	Specs	Specs	Specs	Specs	Specs
Virginia	25	25	25	25	25	25	2 in Open
Washington	Open	Open	Open	Open	Open	Open	Open
West Virginia	Open	Open	Open	Open	Open	Open	Open
Wisconsin	Open	35	20	Open	35	20	Open
Wyoming	50	50	50	50	50	50	2 in

The major advantage of HIPR is the cost savings that it can potentially achieve over conventional recycled hot mix, eliminating the costs associated with transporting, processing and stockpiling RAP. Since only the top 50 mm (2 in) of pavement can normally be reconditioned using this process, HIPR applications are limited to roadways that do not have any structural deficiencies and do no not require additional materials. The major disadvantage of HIPR is the inability to make significant changes to the mix. Pavements that exhibit structural base failure, irregular patching or the need for major drainage or grade improvements are not suitable candidates for HIPR.[(2)]

Not all states have experience in HIPR applications, although HIPR technology is a fairly well accepted practice. There are 32 states that report having some experience with HIPR, although 22 of these states consider their use of HIPR to be experimental. The 10 states that have the most experience with HIPR are Arkansas, Colorado, Florida, Kansas, Maryland, New York, Ohio, Texas, Utah, and Virginia. None of these states has had more than five HIPR projects per year. A survey of these states found that, in general, all have reported good or fair performance.[(2)]

The survey of HIPR experience at the state DOT level further indicated that the use of the three different HIPR processes has been fairly evenly divided, with 13 states having had some experience with heater-scarification, and 16 states each having some experience with either the repaving or the remixing process. Of the 10 states with the most HIPR experience, 5 have used heater-scarification, 4 have used the repaving process, and 6 have used the remixing process.[(2)]

MATERIAL PROCESSING REQUIREMENTS

Recycled Hot Mix

Reclaimed asphalt pavement must be processed into a granular material prior to use in hot mix applications. A typical RAP processing plant consists of a crusher, screening units, conveyors, and stacker. It is desirable to produce either a coarse or a fine fraction of processed RAP to permit better control over input to the hot mix plant and better control of the mix design. The processed RAP used in recycled hot mix asphalt should be as coarse as possible and the fines (minus 0.075 mm (No. 200 sieve)) minimized. Gentle RAP crushing (controlled crusher speed and clearance adjustment on exit gate) is

recommended to minimize the fracture of coarse aggregate and excess fines generation.

Hot In-Place Recycling

In the HIPR process, the surface of the pavement must be softened with heat prior to mechanical scarification. The HIPR process has evolved into a self-contained, continuous train operation that includes heating, scarifying, rejuvenator addition, mixing, and replacement.

ENGINEERING PROPERTIES

Some of the engineering properties of RAP that are of particular interest when RAP is incorporated into new asphalt pavements include its gradation, asphalt content, and the penetration and viscosity of the asphalt binder.

Gradation: The aggregate gradation of processed RAP is somewhat finer than virgin aggregate. This is due to mechanical degradation during asphalt pavement removal and processing. RAP aggregates usually can satisfy the requirements of ASTM D692 "Coarse Aggregates for Bituminous Pavement Mixtures" and ASTM D1073 "Fine Aggregate for Bituminous Pavement Mixtures."[14,15]

Asphalt Content and Properties: The asphalt content of most old pavements will comprise approximately 3 to 7 percent by weight and 10 to 20 percent by volume of the pavement. Due to oxidation aging, the asphalt cement has hardened and consequently is more viscous and has lower penetration values than the virgin asphalt cement. Depending on the amount of time the original pavement had been in service, recovered RAP binder may have penetration values from 10 to 80 and absolute viscosity values at 60°C (140°F) in a range from as low as 2,000 poises to as high 50,000 poises or greater.[16]

DESIGN CONSIDERATIONS

Recycled Hot Mix

Mix Design

The use of processed RAP in hot mix asphalt pavements is now standard practice in most jurisdictions and is referenced in ASTM D3515.[17] The primary steps in the design of mixes include the determination of material properties of RAP and new materials, the selection of an appropriate blend of RAP and virgin aggregate to meet gradation, the selection of an appropriate asphalt cement blend to satisfy specified viscosity and/or penetration requirements, the need to add a recycling or rejuvenating agent to soften the existing binder, and the need to comply with stability, flow, and air voids requirements.

Either the Marshall[18] or the Hveem[19] mix design procedures are used by most state agencies for determining the asphalt cement and acceptable RAP content of recycled paving mixes.[1]

Recycling and rejuvenating agents can be divided into three main types: "super-soft" asphalt cements, napthenic (aromatic) oils, and paraffinic oils. These products consist of organic compounds derived from petroleum extracts during petroleum hydrocarbon processing. ASTM D4552[20] provides a classification of recycling or rejuvenating agents.

Procedures for selecting the quality of asphalt cement or recycling agent are outlined in ASTM D4887.[21] This specification includes a viscosity blending chart, which enables the designer to determine the percentage of recycling or rejuvenating agent (or soft asphalt cement) to add to the total binder in order to achieve a desired value of absolute viscosity for the recycled asphalt cement. The Asphalt Institute's manual on asphalt hot mix recycling also provides trial mix design examples that indicate how to use a viscosity blending chart to design a recycled hot mix.

The Asphalt Institute suggests that when 20 percent or less RAP is used in a mix, no change in asphalt grade is required. However, for mixes with greater than 20 percent RAP, a drop in one grade (softer asphalt cement) is recommended to compensate for the greater viscosity of the oxidized binder.[1] Many states use the same grade of asphalt cement regardless of the RAP content.

The Asphalt Institute's manual on mix design methods for asphalt concrete[22] provides a method to determine necessary mix design characteristics (such as stability, flow, and air voids content) for either the Marshall or the Hveem mix design methods. The final mix design proportions for the recycled hot mix paving mixture will be determined by completing mix design testing using standard procedures to satisfy applicable mix design criteria.

Additional virgin aggregates may be required to satisfy gradation requirements to improve stability and to limit the RAP content in recycled hot mixes. In the production of hot mix, superheated virgin aggregate is needed to provide indirect heat transfer to the RAP while maintaining the proper mix temperature without the generation of "blue smoke."

Structural Design

Conventional AASHTO pavement structural design methods are appropriate for asphalt pavements incorporating reclaimed asphalt pavement in the mix.

Hot In-Place Recycling

Mix Design

Mix design procedures for HIPR are not as well established as those for conventional recycled hot mix. Many states as a minimum require that cores be taken of the candidate pavement to determine in-place pavement properties, including binder content, viscosity, and aggregate grading.[2]

The material properties of the existing asphalt pavement (to at least the depth of scarification) should be determined prior to construction in order to permit any necessary adjustments to aggregate gradation to develop the required voids in mineral aggregate (VMA) and selection of the appropriate viscosity binder. This will require coring of the

pavement to be recycled and laboratory testing of the recovered paving samples.

Unlike conventional recycled hot mix where the RAP is combined with a significant amount of new aggregate material (making up typically between 60 to 80 percent of the RHM), HIPR may involve up to 100 percent recycling of the existing pavement. Consequently, the extent to which the existing pavement can be improved or modified is limited by the condition and characteristics of the old mix.

The amount of rejuvenating agent that can be added through HIRP is limited by the air voids content of the existing asphalt. When the air voids content of the old asphalt mix is too low to accommodate sufficient recycling agent for proper rejuvenation or softening of the old asphalt binder without mix flushing, it may be necessary to add additional fine aggregate or to beneficiate with virgin hot mix to open up the mix or increase the air voids. The selection of the appropriate addition (either fine aggregate or virgin hot mix), and the amount to be added, are determined by Marshall or Hveem mix design methods.

The type of recycling or rejuvenating agent and the percentage to be added to the binder can be estimated using procedures outlined in ASTM methods D4552[20] and D4887.[21] The recycling or rejuvenating agent, if used, should be compatible with the recycled and new asphalt binder.

Structural Design

HIPR is generally considered a rehabilitation technique for addressing superficial pavement distress to a maximum depth of about 50 mm (2 in). The recycled layer is considered to be structurally equivalent to new hot mix asphalt.

CONSTRUCTION PROCEDURES

Recycled Hot Mix

Material Handling and Storage

RAP is produced by milling, ripping, breaking, crushing, or pulverizing types of equipment. To ensure that the final RAP product will perform as intended, inspection of incoming RAP with rejection of contaminated loads (excess granular material, surface treatment, joint sealant, etc.) should be undertaken. Some jurisdictions also require that RAP from a particular project not be blended or commingled with RAP from other projects.

Once processed, RAP can be handled and stored as a conventional aggregate material. However, because of the variability of RAP in comparison with virgin aggregates, many agencies do not permit the blending of RAP from different projects into combined stockpiles. The Asphalt Institute recommends that the height of RAP stockpiles be limited to a maximum of 3 meters (10 ft) to help prevent agglomeration or sticking together of the RAP particles.[1] Stockpiling time should also be minimized to keep the moisture content of RAP stockpiles from becoming excessive.

Experience has proven that conical stockpiles are preferred to horizontal stockpiles and will not cause RAP to re-agglomerate in large piles. RAP has the tendency to form a crust (due

to a solar/thermal effect from the sun) over the first 200 to 250 mm (8 to 12 in) of pile depth for both conical and horizontal stockpiles. This crust tends to help shed water, but is easily broken by a front-end loader, and may help keep the rest of the pile from agglomerating. RAP has a tendency to hold water and not to drain over time like an aggregate stockpile. Therefore, low, horizontal, flat stockpiles are subject to greater moisture accumulation than tall, conical stockpiles. It is not unusual to find RAP moisture content in the 7 to 8 percent range during the rainy season at facilities using low, horizontal stockpiling techniques.[23]

RAP stockpiles are typically left uncovered because covering with tarps can cause condensation under the tarp and add moisture to the RAP stockpile. For this reason, RAP stockpiles are either left uncovered or RAP is stored in an open-sided building, but under a roof.[23]

When large quantities of RAP from different sources are available, it is advisable to keep stockpiles separated and identified by source. Consistent RAP from a "composite" or "blended" pile can be produced using a crushing and screening operation and reprocessing stockpiles that come to the yard from different sources. Material handling machinery, such as front-end loaders and bulldozers, should be kept from driving directly on the stockpile. Agglomerating RAP particles can make it very difficult for the loader to handle the RAP.

Mixing, Placing and Compacting

When RAP is added to hot mix asphalt, measures must be taken to avoid exposing the RAP to temperatures in excess of 427°C (800°:F). Exposure of the RAP to temperatures above this limit can result in excessive hydrocarbon emissions (blue smoke). To reduce this problem, hot mix asphalt plants have been modified to permit the recycling of RAP.[24]

In a batch plant operation, the RAP is usually added to superheated new aggregate at the pugmill. In drum-mix plants, RAP is usually introduced with new aggregate into the drum using a dual feed system. The new aggregate is typically introduced at the hot end of the drum (normally the front end of the drum), while the RAP is introduced at the middle or rear of the drum to prevent overheating damage to the RAP.[25]

In a batch plant, typical RAP substitution rates are limited by the heat capacity of the plant and the ability to superheat the aggregate to temperatures that will produce a suitable mix temperature. This normally limits batch plant blends to between 10 and 30 percent RAP. In a drum mix plant, from 30 to 70 percent RAP can be added, with a practical limit of 50 percent, due to hydrocarbon emission limitations that may be exceeded if excess RAP is introduced.

Quality Control

To produce consistently high-quality recycled hot mix asphalt, the need for systematic quality control of the RAP is essential. The process should be monitored for processed RAP moisture content, gradation, and asphalt cement content.[26] Controlled plant operations have been developed to produce a consistent (homogeneous) RAP. Extraction tests to monitor the RAP gradation and asphalt cement content, and penetration and viscosity tests on the recovered asphalt cement, should be performed regularly to monitor the RAP characteristics for comparison with the job mix formula and enable appropriate adjustments to the mix.

The same field testing procedures used for conventional hot mix asphalt mixes should be

used for mixes containing reclaimed asphalt pavement. Mixes should be sampled in accordance with AASHTO T168,[27] and tested for specific gravity in accordance with ASTM D2726[28] and in-place density in accordance with ASTM D2950.[29]

Hot In-Place Recycling

Mixing, Placing and Compacting

There are three basic HIPR construction processes in use: heater scarification, repaving, and remixing. All involve a specialized plant in a continuous train operation.

Heater scarification involves a plant that heats the pavement surface (typically using propane radiant heaters), scarifies the pavement surface using a bank of nonrotating teeth, adds a liquid rejuvenating additive, then mixes and levels the recycled mix using a standard auger system. The recycled asphalt pavement is then compacted using conventional compaction equipment. The process is limited in its ability to repair severely rutted pavements, which are often overlaid with conventional hot mix asphalt.

Repaving is a more sophisticated process that includes removing (by heating and scarification and/or grinding) the top 25 to 50 mm (1 to 2 in) of the old asphalt pavement, adding and mixing in a rejuvenating agent to improve asphalt viscosity, placing the recycled material as a leveling course using a primary screed, and simultaneously placing a thin (usually less than 25 mm (1 in) but up to 50 mm (2 in) in some systems) hot mix asphalt overlay. Conventional equipment and procedures are used immediately behind the train to compact both layers of material to ensure a monolithic bond between the new and recycled layer.[30]

The remixing process is used when additional aggregates are required to improve the strength or stability of the recycled asphalt concrete. Scarified or milled RAP is blended with rejuvenator and new virgin aggregate or new hot mix asphalt, then placed by a compacting screed. Conventional equipment and procedures are used to place and compact the remixed material.

Quality Control

The initial step in the quality control of hot in-place recycled mixes is in the selection of the pavement to be recycled. Not all pavements are good candidates for this type of recycling. Cores of the pavement being considered for HIPR must be taken during the early planning for the project. The cores should first be visually examined for pavement problems such as delaminations, stripping, or stripping potential, or water in the voids or delaminations. Pavements with delaminations, especially saturated delaminations, in the top 5 cm (2 in) should not be considered for HIPR projects. Also, pavements that have been rutted, heavily patched, or chip-sealed are not good candidates for HIPR projects.

Next, as noted in the Mix Design section, field core specimens should be analyzed in the laboratory to determine (based on the asphalt content, viscosity, and penetration of the recovered binder) the required amount of rejuvenating agent to be added to the mix in order to attain the desired viscosity of the recycled mix. If too much rejuvenating agent (1.0 percent or more by weight of mix) must be added in order to attain this viscosity, the mix should probably not be recycled in place. As a guideline, pavements being considered for

HIPR should not be too severely aged. It is recommended that such pavements have an absolute viscosity lower that 200,000 poises (and preferably below 100,000 poises) in order to be considered for HIPR projects.[31]

Field core specimens should also be evaluated for air voids content during the pavement selection process. An existing pavement being considered for HIPR should have an air voids content in excess of 6 percent, in order to accommodate the addition of a rejuvenating agent without the loss of stability in the recycled mix. If material properties are not completely satisfactory for 100 percent recycling, the addition of 20 to 30 percent by weight of virgin hot mix during recycling should be considered.[31]

Field quality control measures during HIPR operations include monitoring the depth of scarification, the temperature of the recycled mix, the visual appearance and homogeneity of the scarified or milled RAP, the compaction procedure, and the visual appearance of the recycled pavement surface after compaction. Loose samples of the recycled mix should be obtained and extraction tests performed to monitor RAP gradation, asphalt cement and air voids contents, and penetration and viscosity of the recovered asphalt binder for comparison with the job mix formula.[32] The recycled mix should be monitored for in-place density in accordance with ASTM D2950.[29]

UNRESOLVED ISSUES

While the asphalt pavement recycling technologies are well established, there is still considerable need for additional performance information, particularly with regard to creep (rutting resistance), fatigue endurance and durability, and the use of reclaimed asphalt pavement in premium surface course mixes. There is also a need for more correlation of field and laboratory measurements to refine guidelines for laboratory prediction of field performance (for instance, laboratory curing procedures that best simulate field conditions).

Some additional issues that require resolution include:

- further information on the variability of RAP, especially from blended stockpiles;
- validation of SUPERPAVE mix design procedures with mixtures containing RAP;
- an environmental code of practice regarding gaseous emissions from hot mix plant recycling and HIPR;
- the suitability of HIPR for surface-treated and rubberized materials (environmental considerations); and
- evaluation methodologies for structural characterization of HIPR asphalt concrete and CIPR asphalt concrete.

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[**Asphalt Concrete (Cold Recycling)**] [**Granular Base**] [**Embankment or Fill**] [**Material Description**]

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TRT Terms: Waste products as road materials--Handbooks, manuals, etc, Pavements, Asphalt concrete--Design and construction--Handbooks, manuals, etc, Pavements, Concrete--Design and construction--Handbooks, manuals, etc, Pavements--Additives--Handbooks, manuals, etc, Fills (Earthwork)--Design and construction--Handbooks, manuals, etc, Roads--Base courses--Design and construction--Handbooks, manuals, etc, Wastes, Environmental impacts, Recycling

Updated: 04/07/2011

U.S. Department of Transportation

Federal Highway Administration

Gravel Roads

Maintenance and Design Manual

South Dakota Local Transportation Assistance Program (SD LTAP)

November 2000

Introduction

Good gravel road maintenance or rehabilitation depends on two basic principles: proper use of a motorgrader (or other grading device) and use of good surface gravel. The use of the grader to properly shape the road is obvious to almost everyone, but the quality and volume of gravel needed is not as well understood. It seems that most gravel maintenance/rehabilitation problems are blamed on the grader operator when the actual problem
is often material related. This is particularly true when dealing with the problem of corrugation or "washboarding." The problem is often perceived as being caused by the grader but is primarily caused by the material itself. This manual will help provide a better understanding of what makes good surface gravel.

Another important matter to consider is the dramatic change in the vehicles and equipment using low volume roads. Trucks and agricultural equipment are increasing in size and horsepower. The trend is toward even larger machinery. The effect of larger and heavier vehicles
on our paved roads is well understood. There is a definite need to build stronger bases and pavements. But the effect on gravel roads is just as serious and often is not recognized. For this reason, a section on the design of gravel roads is included. The strength of the subgrade and depth of the material needed to carry today's heavy loads must be considered.Proper drainage is also important.

The final section of the manual covers innovations in the gravel road maintenance/ rehabilitation industry. Change is constant in almost every aspect of this modern world and maintaining gravel roads is no exception. There are new ways of stabilizing roads, new methods of dust control, new and different kinds of equipment available for maintenance/ rehabilitation of gravel roads, and even new surface materials such as recycled asphalt being used. Not all of these innovations may be available or practical for every local government entity, but everyone is encouraged to take an objective look at each of them. Then an informed decision can be made about changing the way gravel roads are designed and maintained within a particular jurisdiction.

Good Gradation

Gravel is a mixture of three sizes or types of material: stone, sand and fines. This will be discussed further in the next section.Without a good blend of these three sizes, the gravel will perform poorly. Unfortunately, poor performing gravel will often be blamed on the maintenance operator. But the operator cannot make good gravel out of bad gravel. Bad or poorly graded gravel can not be changed to good gravel without additional costs, but it is often well worth it.

One common practice of improving surface gravel is to add new, clean, virgin fine gravel. Good surface gravel needs a percentage of stone which gives strength to support loads — particularly in wet weather. It also needs a percentage of sand-sized particles to fill the voids between the stones and give stability. But a percentage of good, plastic fines are also needed to bind the material together which allows a gravel road to form a crust and shed water. In many regions of the country, this is a natural clay which gives the gravel a strong cohesive characteristic and keeps a reasonably tight surface especially during periods of dry weather. Some of the fine material in surface gravel will be lost, under traffic action, in the form of dust that rises from the surface and simply blows away. This can be compensated for by specifying a higher percentage of fines in the new gravel. However, no gravel surface will perform like pavement! There will be some loose aggregate or "float"on the surface of virtually all gravel roads. But striving to get as good a material as budgets and local sources allow will improve the performance of a gravel road.

Example of a good blend of material for gravel surfacing. (Courtesy of Road Research Ministry of Roads/Transportation,Sweden)

Benefit of Crushing

In a few cases the gravel may simply be loaded onto trucks without processing. This is often referred to as "bank run" or "pit run" gravel. There are few natural deposits of material that have an ideal gradation without being processed. In some areas of the country it is still common to process gravel simply by screening to a maximum top size. A great benefit is gained from processing the material by crushing. This means that a good percentage of the stone will be fractured in the crushing process. The broken stones will embed into the surface of a gravel road much better than rounded, natural-shaped stone. It also means that the material resists movement under loads better and gives better strength or stability. This will vary throughout the country, but bank run gravels are nearly always improved through the crushing process. Quarry gravels are considered very good material since they are composed of virtually all fractured particles.

Recycled Asphalt

As more of our asphalt pavements wear out, many of them are recycled. This is usually done by milling or crushing. Sometimes the material is available for use on a gravel road. It can be a good surface, but there are pitfalls. In this material, the bituminous portion of the old pavement becomes the binder. When placed on a road in hot weather, the recycled asphalt can take on the characteristic of pavement. But it will be a weak pavement. It will often develop potholes and will be hard to maintain with simple blade maintenance. To help overcome this problem,the material should be placed at a minimum three inch compacted depth and only on a road that has a strong subgrade. A better option is to mix the recycled asphalt 50/50 with virgin gravel. This will generally provide a material that still has a good binding characteristic, but remains workable for maintenance and reshaping. Recycled asphalt has also been mixed with crushed, recycled concrete and the performance has been good.

Section IV: Dust Control and Stabilization

All gravel roads will give off dust under traffic.After all, they are unpaved roads that typically serve a low volume of traffic, and dust is usually an inherent problem. The amount of dust that a gravel road produces varies greatly. In areas of the country that receive a high amount of moisture, the problem is greatly reduced.Arid or semi-arid regions such as the desert southwest and much of the great plains region in the USA are prone to long periods of dry weather. Similar regions around the globe can have similar weather patterns. Dust can really bring complaints in these areas if there are residences located near the road and traffic is high.

The quality and type of gravel also has some effect on the amount of dust. Some limestone gravels can dust severely while some glacial deposits of gravel with a portion of highly plastic clay can take on a strong binding characteristic that will resist dusting remarkably well. Still, in prolonged dry weather, there will be dust! Whether to provide some type of dust control or not can be a hard decision to make. Virtually all methods of dust control require annual treatment.

The cost can be prohibitive if traffic volume is low. On the other hand, if traffic is high, the cost of dust control can more than pay for itself with the benefits of reduced material loss and reduced need for blade maintenance. (28) At this point, many agencies will face pressure to pave the road. It may actually be a good economic decision in the long run, especially if there is good indication that traffic will continue to increase in the future. However, never pave a road before it is ready! There is good information on making this decision in Appendix D.

Types of Stabilizers

Chlorides

These are the most commonly used products across the country. They fall into three categories: Calcium Chloride in flake or liquid form, Magnesium Chloride generally in liquid form, and Sodium Chloride (road salt). Sodium is seldom used and is the least effective. Calcium and Magnesium Chloride can be very effective if used properly. They are hygroscopic products which, in simplest terms, means they draw moisture from the air and keep the road surface constantly damp. They are reasonably simple to use.

Resins

These are products available under various commercial names. The basic composition is lignin sulfonate which is a by-product of the pulp milling industry. The product is sometimes called “tree sap” in the field. These products work best when incorporated into the surface gravel. They then provide cohesion to bind the soil particles together.

Natural Clays

Some regions of the country have excellent deposits of natural clay that

are highly plastic and provide strong cohesion when added in the right quantity to gravel.However, in prolonged dry weather, these roads will seldom be completely dust free. It can be difficult as well to haul the clay onto the road and mix it into the gravel. Because it is highly plastic,it tends to stick to the truck boxes and requires quite an effort to mix with the gravel.

Asphalts

The use of cut-back liquid asphalts to surface-treat gravel roads was once popular for dust control. However, because of the great amount of fuel oil or kerosene in these products, they have been banned in many places. Some emulsified asphalts may work for this purpose, but their use is very limited. The product must be applied with special asphalt application equipment.

Soybean Oil

This product is known technically as Acidulated Soybean Oil Soapstock. It is a by-product of the caustic refining process of soybean oil. It is a biodegradable material that has many of the characteristics of a light petroleum-based oil. It will penetrate a gravel surface and provide a light bonding of the gravel that effectively reduces dust when it is used properly.

Other Commercial Binders

There are too many of these to mention individually. They are marketed under various trade names across the country. It is always wise to try a test section of no more than 1000 feet in length to see how any of these products work with your gravel. One caution: do not use waste products such as crankcase drain oil from engines. This is harmful to the environment and is in violation of EPA rules.

Benefits of Stabilization

Once a road is stabilized there are several benefits. On high volume roads, these benefits can make stabilization very cost effective.

Reduced Dusting

It may be hard to justify the use of any of these products for dust control alone. However, when the products are working well, the added benefit of a stabilized surface that controls the loss of fines through dusting is a great economic benefit.When the fines are lost from a gravel surface, the stone and sand-sized particles that remain will tend to remain loose on the surface, leading to some distresses like washboarding and reduced skid resistance. It will become very hard to maintain. Fresh gravel with a higher percentage of fines needs to be hauled in. This becomes very expensive.

Reduced "Whip Off" of Aggregate

This is another economic bonus to dust control when it is working well. As mentioned earlier, when dust control products are working well, the fine material in the gravel cannot loosen and dust away. This also means that the stone portion of the gravel will tend to remain embedded in the surface and will not be lost to the edge of the road or even whipped off onto the inslope from heavy traffic. Studies have shown that as much as one ton of aggregate per mile is lost each year for each vehicle that passes over a road daily. This means that a road carrying 200 vehicles per day will experience the loss of 200 tons of aggregate per mile each year. (7) Obviously this will vary with the amount of rainfall received, the quality of the gravel and other factors. Retaining aggregate is a good added benefit to dust control.

Reduced Blade Maintenance

A road surface that remains tightly bound and stable will require much less blade maintenance. The manufacturers of some dust control products highly recommend that the surface should not be bladed at all after their products are applied.While extra blading, shaping and mixing is needed to prepare a road for dust control, the overall need for blade maintenance should be greatly reduced. This can be a great savings in equipment expense and labor. A county highway official once commented:"I don't react to dust complaints. All gravel roads have dust. But I do react to high maintenance costs. When we have to regravel a road frequently and do blade maintenance frequently, then it's time to look at stabilizing the surface with Magnesium Chloride. Reduced maintenance is what we're after. Dust control is just a bonus!"

Appendix D: When to Pave a Gravel* Road

by Kentucky Transportation Center, University of Kentucky at Lexington,KY

Contents

- A Word About the Term "Paved"
- Introduction
- Gravel or Paved: A Matter of Trade-offs
- When Should We Pave This Gravel Road? A Ten Part Answer
  1. After Developing a Road Management Program
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  3. When Traffic Demands It
  4. After Standards Have Been Adopted
  5. After Considering Safety and Design
  6. After the Base and Drainage Are Improved
  7. After Determining the Costs of Road Preparation
  8. After Comparing Pavement Life and Maintenance Costs
  9. After Comparing User Costs
  10. After Weighing Public Opinion
- Stage Construction
- Summary
- References

*Gravel as used here may refer to sand and gravel,or to crushed stone.

TRASH COLLECTION LETTER FROM THE CITY OF EL PASO

The TCEQ received a letter dated October 4, 2010, from the City of El Paso Environmental Services Department to confirm the City's policy of not picking up trash via alleys from residential customers. This practice reduces fugitive dust emissions by reducing the traffic on unpaved alleys. The Environmental Services Department anticipates no changes to this policy in the future.

Received
OCT 0 6 2010
Air Quality Division

Dedicated to Outstanding Customer Service for a Better Community

SERVICE SOLUTIONS SUCCESS

THE CITY OF EL PASO TEXAS

October 4, 2010

Ms. Shelley Naik
El Paso SIP Project Manager
Texas Commission on Enviromental Quality
12100 35 Park Circle, Building F
MC-206
Austin 78711-3087

RE: Solid Waste collection in alleyways

Dear Ms. Naik;

As per your request, this letter confirms our current policy of not picking up trash via alley ways from residential customers. All residential customers are required to place their trash bins along their corresponding paved street.

If you have any more questions, please contact Miguel Parra at 915-599-6235.

Sincerely,

Ellen Smyth
Director

Mayor
John F. Cook

City Council

District 1
Ann Morgan Lilly

District 2
Susie Byrd

District 3
Emma Acosta

District 4
Carl L. Robinson

District 5
Rachel Quintana

District 6
Eddie Holguin Jr.

District 7
Steve Ortega

District 8
Beto O'Rourke

City Manager
Joyce A. Wilson

El Paso
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