



SECTION 7 AGGREGATE MIXES

• Click here to see video



The Transportation Research Board (TRB) defines stabilization as “the modification of soils or aggregates by incorporating materials that will increase load carrying capacity, firmness and resistance to weathering displacement.” Soil stabilization with asphalt emulsion is very adaptable to stage construction where additional courses or lifts are added with increased traffic loading. Asphalt emulsion can be excellent for stabilization through its cementing and waterproofing properties.

Advances in asphalt emulsion technology make it possible for emulsion mixes to be used in a wide variety of pavement construction, rehabilitation and maintenance applications. [Table 7-1 Major Uses of Asphalt Emulsion Mixtures](#) lists the major uses of asphalt emulsion mixes.

Table 7-1 Major Uses of Asphalt Emulsion Mixtures

Mixture Use	Purpose of Emulsion Treatment
As a construction aid	To facilitate the construction of the pavement and in some cases provide a working platform.
Upgrading of marginal aggregates	To improve an aggregate to the quality of a good untreated granular base.
As a temporary wearing surface	To provide a surface that may be used until a permanent surface of hot mix asphalt or high type emulsion mix is placed.
To reduce the total pavement thickness	To increase the strength of pavement materials and reduce the required pavement structure thickness from that required using untreated materials
Open-graded base and surface mixes	To produce a high quality mix for heavy traffic load applications. These mixes have good flexibility and resistance to permanent deformation.
Dense-graded wearing surface	To produce a mix for stable surfaces course that will not develop rutting and shoving.
Pavement subbase	Allow for the use of lesser quality aggregates to produce an acceptable subbase layer. For this application, sands, silty sands and poorer graded sand-gravels can be used.
Immediate use and stockpile maintenance mixtures	Provide workable patching mixtures that can be designed for immediate use or for long term storage.

7.1 Asphalt Emulsion Mixtures

There are three types of asphalt emulsion-aggregate mixtures: dense-graded, sand and open-graded. Dense-graded mixtures have aggregates that are graded from the maximum size down to and including material passing the 75 μ m (No. 200) sieve. They

include a wide variety of aggregate types and gradations and can be used for all types of pavement applications.



Sand emulsion mixtures are produced by treating bank-run sands, poorly graded sand-gravels and “dune” or “sugar” sands with asphalt emulsions. Sand mixes are generally restricted to fine granular sands and silty sands low in clay content. Sand mixes have provided good performance as subbase and base layers when produced with the proper emulsion grades. For these mixes, the emulsions typically used are slow setting and high float medium setting, with harder or “h” grades preferred.

Open-graded mixtures provide high air voids to drain water through the mix. These mixtures have been used very successfully for both base and surface courses. Because of the relatively simple plant equipment required and high mix production rates possible, these mixes are economically attractive when a high quality mix is required for heavy traffic loading. In some cases, the long-term performance of open-graded mixes has been comparable to hot mix asphalt. These mixes have shown good resistance to fatigue, reflection cracking, rutting and shoving.

7.2 Mixture Design

A mix design is required for asphalt emulsion-aggregate mixes. It is essential that trial mixes be prepared in the laboratory to determine the grade and percent of emulsion and mixture properties of workability, stability and strength. The emulsion mixture’s susceptibility to water damage should be determined. Asphalt emulsion-aggregate mixture design is described in **SECTION 10 MIX DESIGN METHODS**.

Although general guidelines are presented in **SECTION 5 SELECTING THE RIGHT TYPE AND GRADE**, for asphalt emulsion selection, some personal judgment may be required. The decision on selecting a type and grade of emulsion must not only consider the characteristics of the aggregate but also of the asphalt residue—hard or soft base, containing solvent, polymer modified — and the curing rate of the emulsion (medium or slow setting).

7.3 Aggregates

The characteristics of the aggregate in any emulsion mix are very important in obtaining good mixture properties and performance. Aggregate makes up 90 to 95 percent by weight of an emulsion mixture. A wide variety of aggregate types and gradations may be used successfully for emulsion mixes. **Table 7-2 Aggregates for Dense-Graded Emulsion Mixtures**, **Table 7-3 Aggregates for Open-Graded Emulsion Mixtures** and **Table 7-4 Aggregates for Sand Emulsion Mixtures** show some of the typical gradations and other aggregate properties for densegraded, opengraded, and sand emulsion mixes, respectively. Certain standards must be maintained for the quality of the aggregates, including the amount of material finer than 75 μm (No. 200) sieve, the plastic fines content and durability. The mineral aggregates should be tested by the methods listed in **Table 7-5 Aggregates Evaluation Procedures**.

Compatibility of the aggregate with the asphalt emulsion is important and should be determined. The mineral composition of the aggregate can have a significant influence on the performance of the mix. Therefore, as previously noted, it is necessary to pre-

pare trial mixtures in the laboratory. A laboratory evaluation is completed to determine if the blending of an imported aggregate is necessary.



Table 7-2 Aggregates for Dense-Graded Emulsion Mixtures

Sieve Size	Semi-Processed Crusher, Pit or Bank Run	Processed Dense-Graded Asphalt Mixtures, Percent Passing by Weight				
		100	—	—	—	—
50 mm (2 in.)	—	100	—	—	—	—
37.5 mm (1-1/2 in.)	100	90-100	100	—	—	—
25.0 mm (1 in.)	80-90	—	90-100	100	—	—
19.0 mm (3/4 in.)	—	60-80	—	90-100	100	—
12.5 mm (1/2 in.)	—	—	60-80	—	90-100	100
9.5 mm (3/8 in.)	—	—	—	60-80	—	90-100
4.75 mm (No. 4)	25-85	20-55	25-60	35-65	45-70	60-80
2.36 mm (No. 8)	—	10-40	15-45	20-50	25-55	35-65
1.18 mm (No. 16)	—	—	—	—	—	—
600 µm (No. 30)	—	—	—	—	—	—
300 µm (No. 50)	—	2-16	3-18	3-20	5-20	6-25
150 µm (No. 100)	—	—	—	—	—	—
75 µm (No. 200)	3-15	0-5	1-7	2-8	2-9	2-10
Sand Equivalent, Percent	—	35 min.	35 min.	35 min.	35 min.	35 min.
Los Angeles Abrasion @ 500 Revolutions	—	40 max.	40 max.	40 max.	40 max.	40 max.
Percent Crushed Faces	—	65 min.	65 min.	65 min.	65 min.	65 min.

Table 7-3 Aggregates for Open-Graded Emulsion Mixtures

Sieve Size	Base			Open-Graded Surface Course
	Coarse	Medium	Fine	
37.5 mm (1-1/2 in.)	100	—	—	—
25.0 mm (1 in.)	95-100	100	—	—
19.0 mm (3/4 in.)	—	90-100	—	—
12.5 mm (1/2 in.)	25-60	—	100	—
9.5 mm (3/8 in.)	—	20-55	85-100	100
4.75 mm (No. 4)	0-10	0-10	—	30-50
2.36 mm (No. 8)	0-5	0-5	0-10	5-15
1.18 mm (No. 16)	—	—	0-5	—
75 µm (No. 200)	0-2	0-2	0-2	0-2
Los Angeles Abrasion @ 500 Revolutions	40 max.	40 max.	40 max.	40 max
Percent Crushed Faces	65 min.	65 min.	65 min.	65 min.

7.4 Additives

Two additives used in emulsion mixes are portland cement and hydrated lime. These additives can be very effective in obtaining higher early strength and reducing the water susceptibility of emulsion mixes, particularly those produced with sand and sand-

gravel aggregates. The amount of cement and lime used typically has been from 1- 2 percent by weight of dry aggregate. Although initially added dry, these materials are now being added in a slurry form or as cement-water or lime-water mixtures. Laboratory testing is required to determine if the additives are of sufficient benefit to justify the increased cost.



Table 7-4 Aggregates for Sand Emulsion Mixtures

Sieve Size	Total Percent Passing		
	Poorly-Graded	Well-Graded	Silty Sands
12.5 mm (1/2 in.)	100	100	100
4.75 mm (No. 4)	75-100	75-100	75-100
300 μ m (No. 50)	—	15-30	—
150 μ m (No. 100)	—	—	15-65
75 μ m (No. 200)	0-12	5-12	12-20
Sand Equivalent, percent	40 max.	40 max.	40 max.
Plasticity Index	65 min.	65 min.	65 min.

Table 7-5 Aggregates Evaluation Procedures

Characteristics	Method of Test	
	ASTM	AASHTO
Amount of material finer than 75 μ m (No. 200) Sieve in aggregate	C 117	T 11
Unit weight of aggregate	C 29	T 19
Sieve analysis, fine and coarse aggregates	C 136	T 27
Sieve analysis of mineral filler	D 546	T 37
Abrasion of coarse aggregates C 131 T 96 Los Angeles Machine	C 131	T 96
Plastic fines in graded aggregates and soils by use of the Sand Equivalent Test	D 2419	T 176

7.5 Production of Emulsion Aggregate Mixtures

Various methods can be used to produce emulsion-aggregate mixtures. One method is termed “mixed-in- place,” in that the mixture is produced in place, on the roadway. Mixed-in-place production can use one of a variety of mixing procedures, such as a motor grader, rotary mixer, or road-reclaiming machine. This method is often used to strengthen the in-place soils. Mixing may also be completed by more sophisticated equipment, such as by central and travel mixing plants.

There are a number of factors to be considered when selecting the type of emulsion mixture production method. The factors to be considered in determining the most appropriate mixing method should include:

1. Project location
2. Project size
3. Traffic conditions to maintain, or if the road can be closed
4. Whether imported aggregate is necessary to improve the mixture properties

5. Pavement type and thickness
6. Climatic conditions



7.6 Mixed-in-Place Production

Mixed-in-place production will stabilize the existing aggregates directly on the road-bed. A laboratory evaluation will determine if the addition of an imported aggregate will be necessary to improve the mixture properties. If one is used, the imported aggregate is placed on the surface of the material to be stabilized. The aggregate usually is placed in a windrow and the size or volume calculated and controlled to obtain the proper emulsion.

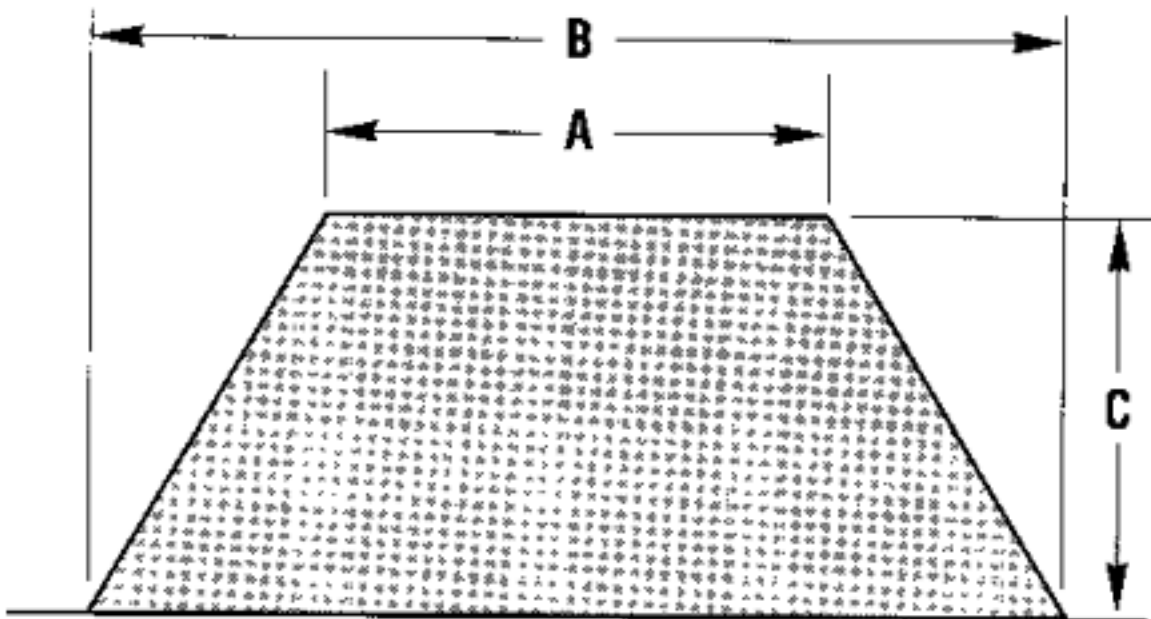


Figure 7-1 Dimensions for Windrow Volume

7.6.1 Application Rates

If the road material and any imported aggregate are being windrowed, the dimensions of the windrow need to be measured as shown in **Figure 7-1 Dimensions for Windrow Volume** and the volume and quantity of aggregate determined.

$$V_W = \frac{(A + B) C}{2}$$

where

V_W = volume of the windrow, M^3 per linear meter (ft^3 per linear foot) A, B, and C dimensions of the windrow, meters (feet) (**Figure 7-1 Dimensions for Windrow Volume**)

$$W_a = W_1 V_W$$

where

W_a = quantity of aggregate, kg per linear meter (lb per linear foot) of windrow

W_1 = loose quantity of dry aggregate, kg/ml (lb/ft³)



The rate of application for asphalt emulsion along the windrow is determined by:

$$A = \frac{(W_a \times P)}{(100 \times M)}$$

where

A = application rate of asphalt emulsion, liter per linear meter (gal per linear foot)

W_a = quantity of aggregate, kg per linear meter (lb per linear foot)

P = emulsion content, percent by weight of dry aggregate

M = mass (density) of asphalt, kg/l (lb/gal) [obtained from emulsion supplier]

The required forward speed of the asphalt distributor (or of mixing unit, if emulsion being added by it) is determined by the formula:

$$S = D_p / A$$

where

S = forward speed of mixing unit or distributor, m/min (ft/min)

D_p = pump discharge rate, l/min (gal/min)

A = application rate of asphalt emulsion, liter per linear meter (gal per linear foot)

Example: Windrow dimensions of $A = 1.5$ m (4.9 ft), $B = 2.0$ m (6.6 ft) and $C = 0.15$ m (0.5 ft) Emulsion content = 5.9 percent and density = 1.00 kg/l (8.33 lb/gal) Loose quantity of aggregate, $W_1 = 1440$ kg/M³ (go lb/ft³)

Volume of aggregate in windrow:

$$V_W = \frac{(A + B) C}{2} = \frac{(1.5 + 2.0) \times 0.15}{2} = 0.26 \text{ m}^3/\text{m} \text{ (2.8 ft}^3/\text{ft)}$$

Quantity of aggregate in windrow:

$$W_a = W_1 V_W = 1440 \times 0.26 = 374.4 \text{ kg/m (252 lb/ft)}$$

Asphalt emulsion application rate:

$$A = \frac{(W_a \times P)}{(100 \times M)} = \frac{(374.4 \times 5.9)}{(100 \times 1.00)} = 22.1 \text{ l/m (1.86 gal/ft)}$$

Forward speed of distributor or mixer, assuming a constant asphalt pump discharge of 200 l/min (53 gal/min):

$$S = \frac{D_p}{A} = \frac{200}{22.1} = 9 \text{ m/min (29.5 ft/min)}$$



Figure 7-2 Road Reclaiming Machine

7.6.2 Rotary/Reclaimer Mixing

Rotary cross-shaft type mixers have been used for many years for the in-place mixing of asphalt emulsions. These mixers consist of a mobile mixing chamber mounted on a self-propelled machine. The chamber is open on the bottom and inside it is normally a transverse rotating shaft equipped with tines or cutting blades. The depth of cutting and mixing can be varied and is controlled by a depth indicator. The asphalt emulsion may be added either through a spray bar inside the mixing chamber or by an asphalt distributor spraying the emulsion on the surface being processed. Rotary mixers typically have been used for the in-place mixing of aggregates and sandy soils.

With the increase in asphalt pavement recycling and greater thickness of asphalt material, more powerful and heavier machines have been developed called “road reclaimers” (**Figure 7-2 Road Reclaiming Machine**). These machines normally have a reclamation rotor equipped with carbide-tipped tools for more effective pulverization of existing asphalt and other road materials. Liquid additive systems are available for both emulsion and water. This equipment is increasingly being used instead of rotary mixers for the in-place mixing of emulsions. Reclamation and recycling using asphalt emulsion are discussed in **SECTION 9 ASPHALT PAVEMENT RECYCLING**.



Figure 7-3 Travel Plant, Hopper Type

7.6.3 Travel Plants

Travel plants are self-propelled pugmill mixing plants that proportion and mix asphalt emulsion and aggregates in-place as they move along the road. The type of travel plant typically used receives aggregate into a hopper from a haul truck, adds and mixes the asphalt emulsion in a pugmill and spreads the mix at the rear by a strike-off screed as it moves forward on the surface being paved (**Figure 7-3 Travel Plant, Hopper Type**). This travel plant has a tank for the storage of asphalt emulsion.

The purpose of the travel plant is to produce a uniform, properly coated asphalt emulsion-aggregate mixture. The asphalt content on travel plants is set by adjusting the gate opening and controlling the volume of aggregate supplied from the feed hopper.

However, travel plants now are available with an aggregate weigh belt system that is interlocked with the asphalt pump to control the addition of emulsion.



7.6.4 Blade Mixing

Blade mixing is the least efficient and precise of the mixed-in-place methods and is primarily applicable when short lengths or small areas are being stabilized. The success of blade mixing is very dependent on the capability of the motor grader operator and, therefore, experienced personnel are required.



Figure 7-4 Blade Mixing Operation

For blade mixing, the asphalt emulsion is applied by an asphalt distributor on a flattened windrow of in-place or imported material immediately ahead of the motor grader. The blade of the motor grader mixes the materials through a series of tumbling and rolling actions ([Figure 7-4 Blade Mixing Operation](#)). If pre-wetting water is required, the water is applied to the material prior to the addition of emulsion and in an amount slightly higher than needed and thoroughly mixed with the aggregate. To assure a more uniform windrow, place the windrow material with a spreader box or windrow sizer. The emulsion required by the material in the windrow must be determined and the emulsion needed per linear meter (foot) of windrow is calculated.

There is a possibility of variation in the gradation of the windrow material in the windrow, requiring a fluctuation in the emulsion demand. Therefore, very close attention

must be given to the appearance of the mix as mixing progresses. It is important that as much uniformity as possible be obtained in the material gradation and emulsion and moisture contents. The mixing operation should consist of as many manipulations with the motor grader as required to thoroughly disperse the emulsion and achieve adequate coating of the aggregate. However, excessive mixing passes should be avoided. The result could be stripping of the asphalt coating from the aggregate with certain combinations of aggregate and emulsion.



When blade mixing, the mold board of the motor grader should give a rolling action to the material. Care must be used to prevent extra material from being taken from the mixing table and incorporating it into the mixture being processed. Also, none of the material should be lost over the edge of the mixing table. After the mixing has been completed, the material should be moved to one side of the roadbed in preparation for spreading.

7.6.5 Spreading and Compacting

The mixture should always be spread to a uniform thickness, whether in a single pass or in several thinner layers, so that no thin areas exist in the final mat. No layer should be thinner than about two times the maximum dimension of the largest aggregate, nor thicker than 150 mm (3 in.). Also, experience has shown sand mixes should be placed in compacted thicknesses of no greater than 50 mm (2 in.). Mixtures that do not require aeration may be spread to the required thickness immediately after mixing.

Breakdown or initial rolling of emulsion mixes should begin just before or as the emulsion begins to break. Breaking is indicated by a noticeable color change from brown to black. When this occurs, there is enough water in the mixture to act as a lubricant for the aggregate particles but not enough to fill void spaces. By this time, the mixture should also be able to support the roller without excessive displacement. If the mixture ruts or shoves during compacting, rolling should be discontinued until there is a reduction in the moisture content to permit proper compaction.

After one course is thoroughly compacted, other courses can be placed on it. The spreading operation should be repeated as many times as required to bring the mat to the proper grade and cross slope. For a smooth top or surface course, the motor grader should be used to trim and level as the rollers complete compaction of the upper layer. When the mat has been shaped to its final required crosssection, finish roll with a steel-wheeled roller until all roller and other marks are eliminated.

The rollers most frequently used for the compaction of emulsion mixes are pneumatic-tired, vibratory smooth steel-wheeled, single or two drum, and static steel-wheeled rollers. With thicker lifts of densegraded mix, vibratory padfoot rollers sometimes are used for breakdown rolling. The rolling equipment and how to be used will depend upon the type, properties and layer thickness of the emulsion mix.

7.7 Emulsion Plant Mix (Cold)

The central or stationary plant mixing of emulsions allows for the production of very high quality mixes due to more precise control of materials. This method of mixing provides some advantages over hot mix asphalt:

- **Economy** — High production rates are combined with mobility and low capital cost in equipment. This mixing method is ideally suited for projects in remote locations.
- **Low Pollution** — Although some possible dust from stockpiles and hauling, the emissions are very low from central plant cold mix production, hauling, spreading and compaction.
- **Safety** — In high fire hazard areas, such as in forests and grasslands, the possibility of fires is greatly reduced because there is no dryer burner and flame.



Mixing Plants

The production of high quality cold mixes requires a well-controlled operation. The set-up for a central cold mix plant may vary depending on the quality required and the type of mix. However, as a minimum, it is recommended the plant have:

1. a twin shaft pugmill [mixer],
2. a trailer or tank for emulsion storage,
3. metered pumps for emulsion and water and the piping, valves and spray bars for them,
4. one or more aggregate feeder bins,
5. belt conveyors for moving aggregate and mix, and
6. a power source.

The pugmill should allow for variation in the mixing time to ensure proper coating of the aggregate with emulsion. Also, the use of a surge bin or storage silo is desirable for more continuous mixing and improved mix uniformity. Batch type pugmills can be used but the production of these mixes is ideally suited for continuous type mixers (**Figure 7-5 Cold-Mix Continuous Plant**).



Figure 7-5 Cold-Mix Continuous Plant

7.7.1 Laydown and Compaction

For plant produced emulsion mixes, the paving procedures are similar to those used for hot mix asphalt. Base courses may be laid with self-propelled base spreaders or even with a blade. However, selfpropelled pavers are recommended for heavy traffic surface courses. Cold mixes generally are stiffer or not as workable as hot mix asphalt, with open-graded mixtures being the most difficult to place. Proper paver operation is very critical to obtaining a uniform and smooth mat. This includes keeping the paver speed as constant as possible and the level of mix on the augers at a nearly constant depth. If mix sticks to the paver screed or tearing of the mat occurs, a change in the mixing time or the water content can eliminate the problem. The screed should not be heated.

Plant produced emulsion mixes are placed in lifts of 100 mm (4 in.) or more but compaction and curing proceeds quicker with lifts of 50 to 75 mm (2 - 3 in.). For open-graded mixes, the breaking of the asphalt emulsion usually occurs fairly quickly. With open-graded mixes, rolling normally may begin immediately behind the paver. However, the emulsion in dense-graded mixes typically does not break for some time. Because of the higher moisture contents for mixing, a delay in the compaction of dense-graded mixes is usually required. The amount of delay is dependent on the lift thickness and

the curing conditions of air temperature, humidity and wind. The rate of water loss controls when compaction may begin.



Because of the extreme tackiness of open-graded mixes and an initial low stability until obtaining some aggregate interlock, the breakdown rolling is best accomplished with a static steel-wheeled roller. Vibratory rolling of open-graded mixes is not recommended because fracture of aggregate and asphalt bonding can occur. A light “choke” or “blotter” of a coarse sand or fine crusher screenings may be applied after steel-wheeled rolling. The choke or blotter permits rolling with a pneumatic-tired roller and prevents pick-up and damage by traffic. The sand or screenings is applied with a conventional self-propelled chip spreader or sand spinner at the rate of 3.3 to 6.6 kg/m² (6 - 12 lb/yd²).

7.7.2 Precautions

There are precautions that should be taken with cold asphalt emulsion-aggregate mixes to assure good performance:

- Dense-graded mixes normally have good resistance to water damage during construction. However, if rain occurs before the mixture is cured, traffic should be kept off, if possible, or limited until cured and the necessary compaction accomplished.
- The water content should be no more than is required to adequately disperse the emulsion and achieve good mix workability.
- Mixtures should be mixed only enough to properly disperse the emulsion. Overmixing may cause the emulsion to break prematurely or strip from the aggregate.
- For faster curing, place the mix in several thin layers rather than in a single thick lift.
- These mixtures should not be sealed too soon. Entrapped water and petroleum distillates can create problems.
- If raveling occurs under traffic, the loose material should be broomed off as soon as possible to prevent further damage to the surface. If the raveling continues, the surface should be fog sealed with a light application of a slow-setting emulsion (SS or CSS) diluted with water. The rate of application and amount of water for dilution can be varied as required to prevent further raveling and a tacky surface and pickup by traffic.

7.7.3 Seal Coat

Dense-graded and sand mixes normally require a seal coat for waterproofing and to provide a wearing surface. Chip seals are frequently used for dense-graded mixes but a fog or sand seal may be adequate in some situations. For open-graded mixes, a seal coat is not necessary except when required to prevent water from entering the pavement and going into the underlying base course or subgrade. As with any emulsion surface treatment, seal coats for asphalt emulsion-aggregate mixes need to be properly designed and applied. Do not apply the seal coat until the mixture has completely cured.

7.8 Emulsion Plant Mix (Warm and Hot)



The production of warm and hot plant asphalt emulsion as the binder is somewhat comparable to the production of hot mix asphalt using asphalt cement. However, the mixing time is less and the plant operating temperatures are lower. An advantage of mixing at lower temperatures is the ability to coat large-size and open-graded aggregates with thick films of asphalt. Another benefit is the thorough mixing achieved because initial distribution of the asphalt occurs while the asphalt is emulsified and in a highly dispersed state. Also, this method of mixing significantly reduces the asphalt hardening when compared to conventional hot mix asphalt because of the water vapor produced.

7.8.1 Materials

The aggregates should meet the quality requirements of ASTM, AASHTO, state or federal agency and other acceptable specifications. Other aggregates may be specified provided that local experience shows they have produced acceptable warm or hot asphalt emulsion paving mixtures. The production and blending of aggregates for these mixes requires the same degree of quality control as hot mix asphalt. The asphalt emulsions normally used for warm and hot emulsion mixes are HFMS-2, HFMS-2h or polymer modified grades of these emulsions.

7.8.2 Mixing Plants

The mixing plant may be either a batch or drum mix plant. On batch plants, the pugmill mixing chamber should be vented to allow for steam to escape. The discharge end of the asphalt emulsion circulating pipe should be kept below the surface of the emulsion in the storage tank to prevent foaming. Also, the asphalt transfer system must allow turning off or reducing the heat on all lines, pumps and jacketed asphalt weigh buckets. The temperature of the emulsion should never reach the boiling point of water [100°C (212°F)], and is usually kept below 85°C (185°F).

7.8.3 Mixing and Temperatures

The minimum mixing time needs to be established and is based on the amount of coating of aggregate particles as determined by ASTM D2489, "Test for Degree of Particle Coating of Bituminous-Aggregate Mixtures." The minimum acceptable percentage of coated particles will vary with aggregate gradation, particle shape, surface texture, asphalt content and use of the warm or hot mixed material. Warm asphalt emulsion mixes typically are produced at a temperature of 66 to 104°C (150 to 220°F). For hot emulsion mixes, the production temperature is 104 to 127°C (220 to 260°F).

7.8.4 Construction Methods

Warm or hot emulsion mixes typically are spread with a self-propelled paving machine. In general, the same construction procedures are used for these mixtures as for hot mix asphalt. For hot emulsion mixtures, a minimum delay should occur between discharge from the mixing plant and placement to prevent the mix from becoming stiff and difficult to spread. However, some warm emulsion mixtures, produced with emulsions

having very soft asphalt residues and a small quantity of solvent, may be stockpiled and placed cold.



For warm and hot emulsion mixes, compaction should begin when the mix will support the roller without shoving. For warm mixes, the breakdown rolling can be completed with a self-propelled pneumatic or double drum (tandem) vibratory roller followed by finish rolling with a steelwheeled roller. For hot mixes, rolling should be accomplished with steel-wheeled static and/or vibratory rollers.

7.9 Maintenance Mixtures

- Click here to see video.



One of the most time-consuming maintenance activities is the patching of potholes and other weak or failed areas in the pavement. It is generally agreed that the use of high quality, hot mix asphalt (HMA) is preferred for the best results, even though it generally costs more initially. However, HMA is not available year round in many locations. Therefore, maintenance patching often must be completed using stockpiled cold mixes.

No matter how good the characteristics of the mix, there is no substitute for good construction procedures when patching. Proper preparation of the pothole or other areas to be repaired is essential. The Asphalt Institute publication *Asphalt in Pavement Maintenance*, Manual Series No. 16 (MS-16), provides procedures for making repairs that, if properly followed, will ensure successful results.

Maintenance mixes consist of two types — one for immediate use and the other for up to six months storage or stockpiling.

7.9.1 Immediate Use Maintenance Mixes

Asphalt emulsions can be used very effectively in the preparation of maintenance mixtures for immediate use. The emulsion-aggregate mixture can be mixed in a pugmill and transported to the area where to be used. Although plant mixes are preferred, acceptable mixes can be produced with an asphalt distributor and mixing by cross-shaft mixer or blade at a mixing site. The heating of the aggregate is normally not necessary with emulsions as good coating and adhesion can be obtained without it.

The asphalt emulsions recommended for this purpose are CMS-2, CMS-2h, and HFMS-2s. Other types of emulsions may be acceptable if experience has proven them satisfactory. Aggregates should meet the quality requirements outlined previously for asphalt-aggregate mixtures. The aggregate gradations recommended are given in [Table 7-2 Aggregates for Dense-Graded Emulsion Mixtures](#).

Asphalt emulsions containing small amounts of solvents generally produce the best cold patching mixes. The mixture does not gain full strength, however, until the solvent evaporates. Also, patching mixes should not be placed with an excess amount of mixing water due to the curing time required before the patch can be opened to traffic.



Figure 7-6 Stockpiled Asphalt Emulsion-RAP Maintenance Mix

7.9.2 Stockpile Maintenance Mixes

During the cold weather months, most maintenance mixes used are those stored in stockpiles. These mixes can be produced in late summer or early fall and transported and stored in quantity in remote locations for later use. Mixes are usable for periods up to six months and are workable without the use of heat. A thin crust normally is formed on the surface of the Stockpile, but beneath the crust, the mix still has the characteristics of a freshly made mix.

The production of stockpile maintenance mixes is a relatively simple operation. The basic equipment required for mixing large quantities of mix includes a pugmill mixer and a system for obtaining both the correct amount of aggregate and asphalt emulsion. The control of materials is preferably done by weight. Recommended aggregate gradations for stockpile mixes are given in [Table 7-2 Aggregates for Dense-Graded Emulsion Mixtures](#).

The completed mixture should be stored in a clean area to prevent contamination and not stored in a low area or depression where water could get into the mix. If available, mix storage in a covered area provides the best protection and helps retain mixture workability.

Stockpile life depends considerably on the formulation of the asphalt emulsion. Mix workability comes from using an emulsion that contains some solvent. Stockpile life and workability at low temperatures are in direct proportion to the amount of solvent in the emulsion. The use of solvents in asphalt materials is increasingly being limited by air quality requirements. However, asphalt emulsions normally have less solvent content than the cutback asphalts required for stockpiled mixes. For prolonged stockpiling and to be usable at lower temperatures, a high float medium setting HFMS-2s emulsion is recommended. Other nonstandard grades have also been used with success for stockpiling maintenance mixtures.



7.9.3 Maintenance Mixes Using RAP

Many asphalt pavement overlay projects include cold planing/milling and can produce large quantities of reclaimed asphalt pavement (RAP). There are a number of uses for RAP in pavement applications, and an increasing one is the use of RAP to produce maintenance mixes.

It is recommended that, when possible, cold milling be used for pavement removal. Cold milling can produce RAP material in small enough pieces that would not require further crushing. Stockpile management is very important with RAP. Choose a location to stockpile the RAP where it can be processed and stored for maintenance uses. Separate RAP from sources and quality to create more uniform stockpiles.

Asphalt emulsion is usually added to the RAP by plant mixing. Special emulsion formulations have been developed for RAP maintenance mixes, since softening of the aged RAP asphalt binder is desired. Emulsion contents of 1 - 2.5 percent by dry weight of RAP are typical for these mixes. A mix design is recommended for determining the emulsion content. RAP maintenance mixes are stored in stockpiles (**Figure 7-6 Stockpiled Asphalt Emulsion-RAP Maintenance Mix**) and their handling is very similar to other emulsion maintenance mixes.

These mixes are used successfully for both thin and deep patching, the latter including pothole repair. In areas where coarse, crushed aggregates are not available, the use of RAP usually results in superior maintenance mixes to those produced from local aggregates.

