SECTION 16
DENSE-GRADED MIXES USING ASPHALT EMULSIONS

16.1 Scope
This recommended performance guideline is intended to aid in understanding the preparation and use of asphalt emulsion dense-graded aggregate mixtures.

16.2 Description
This work consists of one or more courses of cold mixed asphalt emulsion coated aggregates. These mixtures may be produced in a central plant, a travel plant, or a road mix operation for immediate use or stockpiled for later use. These mixtures are to be laid cold on a prepared subgrade or previously constructed course.

Dense graded aggregates typically have 100% passing the 38.1 mm (1½ in.) or 60 mm (2 in.) sieve; 35 to 80% passing the 4.75 mm (No. 4) sieve; 25 to 66% passing the 2.36 mm (No. 8) sieve; and 2 to 15% passing the 0.075 mm (No. 200) sieve.

16.3 Applicable Documents

16.3.1 ASTM Documents

- C131 Resistance to Degradation of Small-Size Course Aggregate by Abrasion and Impact in the Los Angeles Machine
- C136 Method for Sieve Analysis of Fine and Coarse Aggregates
- D75 Practice for Sampling of Aggregates
- D140 Practice for Sampling Bituminous Materials
- D977 Specification for Emulsified Asphalt
- D2397 Specification for Cationic Emulsified Asphalt
- D1560 Test Methods for Resistance to Deformation and Cohesion of Bituminous Materials by Means of Hveem Apparatus
- D2172 Test for Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
- D2419 Test Method for Sand Equivalent Values of Soils and Fine Aggregate
- D2489 Practice for Determining Degree of Particle Coating of Bituminous-Aggregate Mixtures
- D3515 Specification for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures
- D3625 Practice for the Effect of Water on Bituminous-Coated Aggregate using Boiling Water
- D3628 Practice for Selection and Use of Asphalt Emulsion
- D4215 Specification for Cold-Mixed, Cold-Laid Bituminous Paving Mixtures
16.3.2 AEMA Documents
- A Basic Asphalt Emulsion Manual (BAEM)

16.4 Asphalt Emulsion
Several factors are taken into consideration when selecting the proper asphalt emulsion type and grade. The gradation, strength, and coating characteristics of aggregate; the method of mixing; and climate conditions during mixing, laying, curing, and compaction are very important.

16.4.1 Coating Ability
The emulsion should have the ability to coat the minus 4.75 mm (No. 4) sieve fraction of the aggregate without undue balling of the fines. With some types of emulsions, mixing water may help in coating the fines and preventing their balling. With dense-graded aggregates, 100% coating of the coarse fraction is not necessary.

16.4.2 Workability
The emulsion should provide a mixture which is workable on the jobsite either when placed directly from the mixing operation or when used out of stockpile.

16.4.3 Grades of Asphalt Emulsion
The most widely used grades of asphalt emulsion for dense-graded mixes are ASTM Grades SS-1, CSS-1, MS-2, CMS-2, and the high float HFMS-2 and HFMS-2s (see ASTM D3628).

When specifically approved by the purchaser, other types of asphalt emulsion may be used if experience has shown that satisfactory performance will result. It is recommended the user agency contact the local emulsion producers as to the most suited emulsion grade used with aggregate in each area. Emulsions can be formulated or modified to improve aggregate mixture characteristics.

16.5 Aggregates
Aggregates for dense-graded mixes may consist of processed or semi-processed crusher, pit, or bank run aggregates. These materials are graded from maximum size down to and including the material passing the 0.075mm (No. 200) sieve.

Samples of the aggregate intended for use should be laboratory tested in accordance with ASTM methods D75, D2419, C131, and C136. Materials for dense-graded mixes include a wide variety of types and grades and should meet one of the gradation specifications of ASTM D3515 Table 1, Dense Mixtures or ASTM D4215.

The sand equivalent test (ASTM D2419) is used to detect the presence of excessive amounts of clay in the aggregate. In general, aggregates with a sand equivalent of 30 or above can be stabilized successfully. Aggregates having a sand equivalent of 20 to 30 are considered marginal, and the success of stabilization will depend upon the type of emulsion used and its ability to coat the clay particles.
In general, stabilization of aggregates with a sand equivalent of less than 20 have not been successful.

Aggregates selected should have a loss within the range of 40 to 60% when tested in accordance with ASTM C131. However, an aggregate with satisfactory use record not conforming to these limits could also be used.

16.6 Design

The need for a mix design based on both the emulsion and aggregate to be used for the construction project cannot be overstressed. Most emulsion producers, some state, and some consultant laboratories have the equipment and experience necessary to design dense-graded cold mixes. The importance of optimum emulsion content and strength or stability of the resultant mix should be determined in the laboratory. A review of various design procedures described in A Basic Asphalt Emulsion Manual is recommended.

A suggested design procedure follows. Various modifications are included which shorten the laboratory work and still give satisfactory results.

- Select aggregate to be used on the project and obtain representative samples.
- Obtain gradation of aggregate sample.
- Calculate trial residual asphalt content or percent emulsion using formulas:

  Formulas for Determination of Estimated Percent Asphalt Emulsion Requirement

  (A) \[ P = 0.5A + 0.1B + 0.5C \]

  Where:
  \( P \) = Percent by weight of asphalt emulsion based on weight of graded mineral aggregate
  \( A \) = Percent* of mineral aggregate retained on 2.36 mm (No. 8) sieve
  \( B \) = Percent* of mineral aggregate passing 2.36 mm (No. 8) sieve, retained on 0.075 mm (No. 200) sieve
  \( C \) = Percent of mineral aggregate passing 0.075 mm (No. 200) sieve

  (B) \[ P = 0.06A + 0.018 \]

  Where:
  \( P \) = Percent by weight of asphalt emulsion based on weight of graded mineral aggregate
  \( A \) = Percent* passing 4.75 mm (No. 4) sieve
  \( B \) = Percent* retained 4.75 mm (No. 4) sieve

*Expressed as a whole number

- Run laboratory coating tests with aggregate to aid in selection of correct grade of emulsion. To do this weigh 400 grams of aggregate and predetermined percent...
emulsion into mixing bowl. Stir briskly for 6 min. Allow mixture to set for 3 hours and remix for 5 minutes. Then place a portion of mix on plate and immerse remaining portion with water. Decant water and compare coatings. Due to slow setting characteristics, it is not recommended to run immersion tests on SS and CSS type emulsions. Use this same procedure to determine necessity or benefit of adding water to the aggregate at the time of mixing. ASTM D244 describes a coat-ability and water resistance test.

- After selection of proper emulsion grade, make mixture with trial percent emulsion for stability testing. To more rapidly cure mix sample for determination of stability after all moisture is removed from mix, heat and stir mix to 110° C (230° F). Cool and compact for Hveem or Marshall stability determination.
- For stabilized base mixes. Hveem stabilities above the 25 to 30 range are recommended. However, successful experience with local aggregates yielding lower Hveem stabilities has been found.

Generally, Hveem stability of 20 to 25 are satisfactory for low volume roads. A minimum Marshall stability of 500 pounds, 2 to 8% air voids, and 50% minimum coating is suggested in A Basic Asphalt Emulsion Manual.

16.7 General

16.7.1 Preparation of the Roadbed
Every part of the structure contributes to the effective performance of the completed pavement. Careful shaping and compacting of the roadbed in conjunction with properly designed and constructed surface drainage system is the first step in building a sound pavement structure.

The area to be overlaid (stabilized) shall be substantially true to line, grade, and cross-section, and have a firm prepared surface before laying operations begin. An important part of this process involves the repair or replacement of unstable areas with sound material equal in quality to the rest of the roadbed. Holes and depressions in existing surfaces shall be repaired by removing all loose and defective material and replacing with an asphalt aggregate patching material which shall be compacted to produce a tight surface conforming to the adjacent pavement area.

All bumps, waves, and corrugations should be removed. Whether it is a new subgrade or an existing aggregate surface, the final step in preparation of the roadbed is compacting the foundation. When the compacted subgrade is loosely bonded, it should be primed, and when the subgrade is an existing hard surface, an emulsion tack coat should be applied.

16.7.2 Aggregate Preparation
The in-place material may need additional aggregate to make it meet grading requirements of mix design. Therefore, a laboratory evaluation should be made to determine if blending of an imported aggregate is necessary. The materials may be mixed on the roadbed or in another approved area by using portable tillers and motor graders. Where mixing of the aggregate is to be by means other than a travel mixer, any mineral filler or other aggregate to be blended with the natural material shall be spread over
the surface of the scarified material in a uniform quantity, and in such quantity as will provide a mixture meeting the requirements of the predetermined mix design. Such applications shall be made immediately after the scarifying operations; mixing with rotary type mixer shall continue until a uniform mixture is obtained. To combine the correct amount of mineral filler or other aggregate to be added to the natural material, the following procedure can be used:

Mineral aggregate from the old roadbed shall be scarified and bladed into one or more windrows for measurement and sampling. After the proportions of coarse and fine aggregate are adjusted, the total loose aggregate shall be thoroughly and uniformly mixed, and placed into one or more windrows of uniform cross section for final measurement and adjustment.

When virgin aggregate is brought in, it shall be deposited in one or more windrows in such quantity and proportions as to provide sufficient total aggregate conforming with the specified gradation, and to produce a finished course of specified thickness.

When a travel mixer is to be used, the prepared in-place material shall be bladed into one or more windrows suitable for the type of travel mixer. Any additional aggregate required to be blended with the windrowed material shall be uniformly distributed over the windrows. These windrows shall contain sufficient material to produce the required thickness of compacted pavement.

If a central mix plant is to be used, the aggregates can be blended with the plant's hopper-belt-feeder systems. From the laboratory evaluation, the correct amount of asphalt emulsion and mixing water, if necessary, to be combined with the aggregates is determined. In a travel plant or road mixing operation, these materials will often be added to the windrowed aggregate; it is vital that the correct application rate be determined and adhered to.

Excess water in the aggregate can be removed through aeration prior to or after mixing with emulsion.

16.7.3 Windrows

Whenever construction requires that the aggregates be placed in windrows prior to mixing and spreading, the roadway must be cleared of all vegetation to a width sufficient to accommodate both windrow and traffic while the mixture cures. Mat thickness is directly proportional to the amount of aggregate in the windrow; accurate control and measurement of the volume of the windrowed material is necessary.

Usually, there is not enough loose material on the road surface to use as the road mix. In this case, it is best to blade the loose material onto the shoulder rather than perform the several operations that are necessary to blend it with the material brought in from other sources.

Sometimes, however, incorporation of the existing material on the roadbed into the mixture is considered practical if it is uniform and enough is available. When this is done, the loose aggregate first must be bladed into a windrow and measured. Next, it
must be made to meet grading specifications by adding other aggregates as necessary.

Finally, the windrow is built up to the required volume with imported material to meet mix specifications. If two or more materials are to be combined on the road to be surfaced, each should be placed in its own windrow. These windrows are then mixed together thoroughly before emulsion is added.

16.8 Mixing

Asphalt emulsion and aggregate may be mixed in place or at a central plant pugmill. The choice of method depends on such factors as:

1. Equipment availability
2. Size of project
3. Aggregate source, type, and cost
4. Anticipated traffic volumes and loads
5. Climatic conditions

The best balance between these factors must be evaluated. Regardless of the mixing method, 100% coating of the coarse aggregate particles is not always achieved, nor is it necessary.

16.8.1 Mixing Moisture

Mixing procedures should aim at achieving a uniform dispersion of the emulsion with a complete coating of the finer aggregate fractions. Toward achieving this uniform dispersion of the asphalt emulsion, it is sometimes necessary to moisten the aggregate before application of the emulsion. The appropriate volume of water to be added should be determined by the mix design, and if required should be added prior to the incorporation of the emulsion.

Mixing of the emulsion should be done at as low a moisture content as possible, because the compaction moisture content is usually lower than the moisture content after mixing. Under poor drying conditions, the removal of surplus moisture could be a costly and time consuming operation.

16.8.2 Central Plant Mix

The use of a central plant is recommended for projects that involve close tolerances and high production. Generally, this type of mixing is done away from the road site, and frequently at the source of the aggregate. Conventional batch and dryer-drum hot mix plants can also be used to produce asphalt emulsion mixes.

The central cold mix plant consists of a mixer and certain auxiliary equipment for feeding the emulsion, water, aggregate and additives to the mixer. The asphalt emulsion central mixing plant generally has no dryer or screens other than a scalping screen to remove oversize aggregate. At the very least, the plant should consist of a pugmill, an emulsion storage tank, a metering pump, units for feeding water and additives, controls for adjusting and monitoring the various components, a conveyor, and a power...
source, a tachometer to aid in maintaining a constant speed on the conveyor belt, and one or more aggregate bins with belt feeders.

The mixer should permit variations in mixing times to ensure that the aggregate is properly coated but not overmixed. Mixing times can be varied in a continuous pugmill plant by changing the angle of the paddles, by varying the height of the endgate, or by changing the location of the asphalt spray bar.

Emulsion cold mixes require shorter mixing time than asphalt concrete mixes. The tendency is to overmix asphalt emulsion mixes which may remove the asphalt from the aggregate. It may also result in premature breaking of the emulsion, causing overly stiff mixtures.

The mix produced at a central plant may be stockpiled for later use. The length of storage time in the stockpile is controlled by the type of asphalt emulsion incorporated into the mix.

16.8.3 Travel Mixers

The purpose of the travel plant is to leave uniform, properly coated, asphalt emulsion aggregate mixture on the roadbed. Aggregates are placed into the hopper of the mixer where they are drawn into the mixing chamber. The emulsion proportioning device is interlocked to ensure a constant blend. The emulsion is added by pumping through a spray bar mounted on the mixing chamber. This method permits the addition of all the emulsion in one application. The forward speed of the mixer should be adjusted so that the material being ejected has a uniform texture.

Injecting the emulsion in one application through the mixing chamber can be done at a lower moisture content than with distributor application. The single application immediately brings the aggregate to optimum mixing moisture where as the first application with a distributor adds only part of the moisture associated with the emulsion.

The travel plant places the mix on grade with proper cross-slope to the design thickness. The mix is then ready for compaction.

16.8.4 Rotary Mixers

Rotary cross-shaft mixing employs a mobile mixing chamber which is self-propelled. The mixing chamber, usually 6 to 8 ft wide, and 2 to 3 ft high, open at the bottom, contains one or more shafts, transverse to the roadbed, upon which mixing blades are mounted. As the shafts rotate rapidly, the mixing tines thoroughly agitate the material in the roadbed. The machine, moving forward, strikes off a uniform course of asphalt aggregate mixture.

Self-propelled rotary mixers are designed to accurately and automatically control the predetermined mixing depth from existing surface grades. This assumes that the rotary mixer is operated at a speed slow enough for the rotor tines to cut their path through the aggregates.
The rotary mixer should produce a mixture with a uniform percentage of asphalt emulsion. If the existing grade is different from final grades and cutting and filling operations are carried out, the depth of the finished material will vary but it should have a uniform percentage of stabilizing agent.

Rotary mixers equipped with built-in spraying systems require that the emulsion application rates be matched accurately with the width and thickness of the course, forward speed of the mixer, and the density of the in-place aggregate. However, when utilizing a rotary mixer not equipped with spraybars, an emulsion distributor, operating ahead of the mixer, applies emulsion to the aggregate. Incremental applications of emulsion and passes of the mixer are usually necessary to achieve the specified mixture.

Most rotary mixers are equipped with spray systems and when using this equipment, the following steps are recommended:

1. Spread the aggregate to uniform grade and cross section with motor graders.
2. Thoroughly mix the aggregate by one or more passes of the mixer.
3. Add emulsion in increments until the total required amount of emulsion is applied and mixed. If the mixer is not equipped with spraybars, the emulsion is to be applied with an emulsion distributor.
4. Make one or more passes of the mixer between applications of emulsion, as necessary for thorough mixing.
5. Maintain the surface true to grade and cross section by using a motor grader during the mixing operations.

Any variation of the mixer along the longitudinal joint will cause a fat area at overlaps and lean areas where the joint is missed. This can also occur when applying emulsion with a distributor because the exact location of the longitudinal joint is difficult to follow or even to find. In the case of the distributor which must make one pass per inch of depth, there is some chance of averaging the error. Subsequent passes of the mixer over the lean or fat area will have little effect of blending the variation.

To eliminate this problem with in-place construction, transverse mixing is essential. This is usually done with multiple passes with a blade. This is then followed by longitudinal mixing. This procedure effectively eliminates lean or fat areas at longitudinal joints as well as areas where a nozzle may have been plugged. This procedure also does an effective job of blending different types of aggregates which may occur in the operation.

The total number of passes of the rotary mixer will depend on the method of adding the emulsion and on the amount of 0.075mm (No. 200) material present.

### 16.8.5 Distributor & Motor Grader Mixing

Asphalt emulsion mixtures may be prepared by applying the asphalt emulsion by a distributor and blade mixing with a motor grader.

The first step in the operation is to shape the prepared aggregate into a uniform windrow of a known volume by means of a spreader box, windrow proportioner, or motor grader. The motor grader then lays out a uniform lift of aggregate from the windrow.
onto the road surface or mixing table. If mixing water is required, it is then added at a predetermined rate to the aggregate lift. Next the asphalt emulsion is applied at the predetermined rate by the distributor to the lift of aggregate. The motor grader then folds the aggregate over the emulsion. The motor grader may work this lift back and forth to achieve mixing, or the mixture may be windrowed on the opposite side of the road and another lift of aggregate processed as above. This procedure is repeated until the design quantity of asphalt emulsion has been added to the total windrow of aggregate.

The grading of the aggregate in the windrow may vary and cause asphalt demand to vary. Therefore, as asphalt mixing progresses, close attention should be paid to the appearance of the mix. It is very important that uniformity of grading and moisture content be achieved. Mixing should consist of as many passes with the motor grader as needed to fully spread the emulsion and coat the aggregate particles, and when completed the windrow should be moved to one side of the roadbed in preparation for spreading.

Blades are relatively inefficient mixing devices and the aeration is high. Therefore, a water content higher than that for rotary mixers will be required to assist dispersion of the emulsion and replace relatively high evaporation losses. The mixing moisture will be well above the optimum compacting moisture so that the stabilized material will need drying before compacting.

Windrow mixing requires the close control of grade and cross-section that is required of all in-place construction. In addition, it also requires close control of the grade and cross-section of the exposed subgrade. Variations from either surface or subgrade elevations will result in a non-uniform windrow. If this occurs, the uniform longitudinal application of emulsion to the windrow will result in a varying percentage of residual asphalt.

16.8.6 Secondary Mixing

Sometimes further mixing of the windrowed material may be necessary after the addition of the emulsion. Unless the travel mixer can be used as a multiple pass mixer, this additional mixing usually is done with a motor grader or small rotary mixers. This ensures that all the windrowed material is incorporated into the mix. The number of passes with the motor grader required for this purpose varies with different job conditions. After the mixing operation is completed, the windrow should be moved to one side of the area to be surfaced in preparation for spreading.

16.9 Spreading and Conditioning

Asphalt emulsion mixes gain stability as the water evaporates. It is important not to hinder this process. Therefore, lift thickness may be limited by the rate of fluid loss. The most important factors affecting this dehydration or curing are the type of asphalt emulsion, the mix water content, the gradation and temperature of the aggregate, wind velocity, ambient temperature, and humidity.
Although each job has its own particular combination of these factors, experience has shown that under the best conditions, dense-graded mixes should be placed in a compacted thickness no greater than 75 mm (3 in.).

When multiple lifts are required, some curing time must be allowed between successive lifts. The length of this curing time is a function of the rate of evaporation, and this is a variable. However, an existing lift can normally be overlaid after from 2 to 5 days under good curing conditions.

The mixture should be spread uniformly on the roadbed, beginning at the point farthest from the mixing plant. Hauling over freshly laid material should not be permitted except when required for completion of the work.

Spreading central plant mixes is best accomplished with a self-propelled asphalt paver. However, base spreaders and motor graders also obtain good results.

The mixture should always be spread to a uniform thickness. This is to eliminate the chance that thin spots may occur in the final mat.

Blade spreading should be done in layers, with no layer thinner than about two times the diameter of the maximum particle size. As each layer is spread, compaction should follow at once. Mixtures to be spread with a motor grader are generally placed on a roadbed in windrows. The windrow may be located along the center line of the road or along one side. Because there is a tendency to leave a hump in the road when blade spreading from the centerline windrow, it is better practice to place the windrow to the side for spreading. For a smooth riding surface, the motor grader should be used to trim and level the mix as the rollers complete compaction of the top layer.

Successful placement of cold laid plant mixes require the presence of sufficient fluids. Dry mixes tend to tear beneath the screen or strike-off bar. If the mixture is too dry, the mix water content should be increased. When a self-propelled paver is used, heating the screed in attempts to eliminate this tearing does not help. It actually makes the mix less workable, since it serves to accelerate the drying process.

Because of these variables, local experience is likely to be the best guide in determining allowable placement thickness.

16.10 Compacting

Breakdown rolling of asphalt emulsion mixes should begin just before the emulsion starts to break. Breaking is indicated by a marked color change from brown to black. When this happens, there is enough water in the mixture to act as a lubricant between the aggregate particles but not enough to fill the void spaces. The void spaces can thus be reduced by rolling the mixture. Also, by this time the mixture should be able to support the roller without excessive displacement.

Because the tires of the motor grader compact the freshly spread mix, their tracks will appear as ridges in the finished mat unless there is adequate rolling between the spreading of each layer. The roller should follow directly behind the motor grader to eliminate these ridge marks.
If at any time during compaction, the emulsion mixture ruts or shoves, rolling should be stopped. Compaction should not be attempted until there is a reduction in fluid content.

After one course is compacted thoroughly, other courses may be placed on it. This operation should be repeated as many times as needed to bring the road to proper grade and crown.

After the mat is shaped to its final required cross-section, it must be finish rolled, preferably with a steel drum roller. Proper timing is of utmost importance in compacting a dense-graded mix. Rolling seals the pavement as it reduces the voids in the mix. If done prematurely, it retards dehydration of the excess water required to facilitate mixing, and thereby greatly extends the time required for the mix to reach design strength. It also is necessary that the mix be allowed to develop strength sufficient to support the rollers. However, if rolling is delayed too long, it will be difficult to achieve good compaction, and in some cases the developing asphalt aggregate bond will be broken.

Because dense-graded mixes are often initially low in stability, it has been found advantageous to use vibratory or static steel drum rollers for breakdown rolling. Vibratory rollers are effective for two passes, but thereafter the asphalt and water in dense-graded mixes will tend to migrate. After the breakdown rolling, a light application of choke aggregate is sometimes spread uniformly on the surface at about 5.4 kg/m² (10 lbs/yd²). This choke aggregate may be coarse sand or 6.3 mm (1/4 in.) screenings. This will prevent pickup of the mix by construction traffic or by additional rolling.

16.11 Seal Coat & Fog Seals

A seal coat should be placed when the road mixture is thoroughly cured.

The use of a fog seal over the dense graded mix helps to prevent any raveling and helps to seal the surface prior to placing a chip seal or other types of surface course. The emulsion (CSS-1 or SS-1) used for fog sealing is typically diluted 1:1 with water.

A dense-graded mixture is more likely to show reflected cracking than an open-graded mixture. Therefore, the use of an asphalt emulsion surface treatment will give some protection from this condition. Also, it will help prevent the entry of water. Sanding may be desirable to prevent pickup.

16.12 Traffic Control

If possible, traffic should not be allowed on the mix until it will support vehicles without undue displacement. When it is not possible to close the road completely, vehicles should be controlled to minimum speeds, without acceleration, deceleration, or sudden braking. Traffic should be directed through the project with such signs, barricades, devices, flagman, and pilot vehicles as maybe necessary for absolute control.

16.13 Weather

Laydown construction should not continue during rainfall, and should not begin when rain is expected. The ambient temperature must be above 21° C (70° F) if possible dur-
ing construction, because this is also the temperature of the mix, and it will not be as easily handled in cooler temperatures.

### 16.14 Precautions

Use a design procedure to determine the optimum emulsion aggregate mixture and moisture content. Use a coating test to determine emulsion and aggregate compatibility and benefit of adding water to aggregate at time of mixing.

Dense graded mixes usually resist water damage during construction. But if it rains, traffic should be kept off until the mixture cures and necessary compaction is accomplished. Use only the mixing water needed to disperse the asphalt emulsion and gain good workability. Too much water will prolong curing and delay rolling.

Do not mix any longer than is necessary to disperse the asphalt emulsion. Overmixing may cause the emulsion to strip from the aggregate or break prematurely. Increasing emulsion content may improve coating but it will also tend to reduce the stability of the mix. It may be better to use a different type or grade of emulsion to improve coating. For faster curing, place asphalt emulsion cold mixes in several thin layers rather than a single thick layer.

Do not seal emulsion cold mix surfaces too soon. Shoving and rutting may occur as a result of excess fluids in the mix during compaction, poor aggregate friction, or a combination of the two eliminated by aerating the mix. Additional compaction will not help.

Early compaction seals the surface and retards further removal of water, or it causes surface cracking and checking. This results in raveling under traffic. It is much better to delay compaction, reduce mix water, add cement or dehydrated lime, open up the grading, or add crushed rock.

If raveling occurs under traffic, the loose material should be boomed off as soon as possible to prevent further damage to the surface. If the raveling is increasing, then asphalt enrichment of the surface may be desirable. This may be done by a single seal coat or light fogging with a diluted SS type emulsion (1 + 1). The intent is to obtain some penetration so as to avoid a tacky surface and potential pickup by vehicle tires. If the raveling is due to an already tacky surface, then a light blotting with sand will be necessary.