SECTION 17
SAND MIXES USING ASPHALT EMULSIONS

17.1 Scope

Asphalt emulsion sand mixes shall consist of a fine aggregate and an asphalt emulsion. These mixtures can be applied and compacted at ambient temperatures for the purpose of base or surface stabilization. The materials, general requirements, composition, equipment, and construction procedures will be discussed in this performance guide.

17.2 Applicable Documents

17.2.1 ASTM Documents

- C136 Method for Sieve Analysis of fine and Coarse Aggregates
- D75 Practice for Sampling of Aggregates
- D977 Specification For Emulsified Asphalt
- D2397 Specification For Cationic Emulsified Asphalt
- D2419 Test Method for Sand Equivalent Values of Soils and fine Aggregate

17.2.2 AEMA Documents

- *A Basic Asphalt Emulsion Manual* (BAEM)

17.3 Asphalt Emulsion

Asphalt emulsion for sand emulsion mixes would conform to the following specifications:

- ASTM D997 HFMS-2h, MS-2h, HFMS-2, HFMS-2s, SS-1, SS-1h
- ASTM D2397 CMS-2h, CMS-2, CMS-1, CSS-1, CSS-1h.

When specifically approved by the purchaser, other types of asphalt emulsion may be used, if experience has proven that satisfactory performance will result. Selection of the type and grade of emulsion will depend primarily on the aggregate gradation, the method of mixing the materials, and weather conditions.

17.4 Aggregates

Bank run sands, poorly graded gravel, and dune or sugar sands treated with emulsions have shown good performance as subbase and base course layers where adequately confined by strong binders and surfaces. The use of marginal materials provides an opportunity for the engineer and emulsion supplier to combine their knowledge to provide optimum performance from such materials. Generally, sand mixes are restricted to fine granular sands and silty sands low in clay content. When tested ac-

cording to ASTM D2419, the aggregate should have a sand equivalent not less than fifty percent.

17.5 Mineral Filler

The addition of small amounts of cement or other mineral filler to emulsion treated mixes may assist in early stiffness and stability of the material. However, the addition of too much cement can cause a brittle mix. A ratio of cement to emulsion content on the order of 1 to 5 appears acceptable when this option is used.

17.6 Other Additives

Caution should be exercised if the in-place aggregate has received chemical dust treatments or chemical salts or stabilizers. Such chemical treatments may react with the emulsifier and cause premature separation of the emulsion before complete coating has taken place. In some instances it may be possible to treat aggregates with a small amount of lime to reduce the plastic character of the fines or clay portion of the material passing the 0.075 mm (No. 200) sieve.

17.6.1 Mix Composition

- A proper mix design formulated by a laboratory is essential for good field results. A laboratory analysis will provide a guideline of the approximate percentage of water, asphalt, and mineral filler, although field adjustments may be necessary.
- A representative sample should be submitted to the laboratory in accordance with ASTM D75. A sieve analysis of this sample is run on the aggregate following methods outlined in ASTM C136. Using the Young Method, the pure asphalt requirement can be computed. This formula multiplies the retention of each sieve by a calibration factor to find the surface area. The surface area in conjunction with the Centrifuge Kerosene Equivalent (CKE) California DOT 3038 will yield the amount of residual asphalt required. The Percent Emulsion Requirement is generally between 6 to 15%.
- Trial Mixes — Knowing the emulsion requirement, trial mixes can be made varying the amount of water and mineral filler. Water, is often ne.cessary in a mix as it serves to dissipate surface charges of the aggregate. Mineral filler, normally cement, may be added for early curing strength, resistance to water, and abrasion.
- Compaction — Laboratories with the proper equipment can calculate the time for compaction of the designed mix (California Division of Highways Test Method 301). It is helpful to have this time calculated.

17.7 Preparation of 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 a properly designed and constructed surface drainage system is the first step in building a sound pavement structure. The roadway must first be cleared of all vegetation to a width sufficient to accommodate both windrows and traffic during mix operation and while the mixture cures after mixing.

If the existing road is composed of sand, the structure may itself be stabilized, or alternately the existing grade may be overlaid with an asphalt emulsion sand mix. In either case the work area shall be substantially true to line, grade, and cross section, and have a firm prepared surface before any overlay or mix-in-place operation begins. An important part of this process involves the repair or replacement of unstable areas, including holes and depressions, with sound material equal in quality to the rest of the road bed.

Whether it is a new subgrade or existing aggregate surface, the final step in preparation of the roadbed is compacting the foundation. Where the sandy aggregate has low cohesion, it may be necessary to add water to the grade in order to achieve the shaping and compaction operations. If the existing grade is to be overlaid, and existing surface is loosely bonded, it should be primed prior to placing additional mix on the grade.

17.8 Aggregate Preparation

Emulsion sand mixtures normally use existing aggregates as they occur in the area of the roadbed or in selected pits in the adjacent areas. If it is convenient, the in-place material may be modified by the addition of other aggregates (sands) to produce improved gradation or stability. Such blending should be based on laboratory evaluation and economics. If the mix is to be prepared in a pit, then blending of aggregates, fillers, or both can be accomplished with hoppers and a belt feeder system.

Where aggregate or filler addition is to be made to existing aggregate on the road surface, the mineral aggregate from the old roadbed should be scarified. The additive material should 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. Mixing with a rotary type mixer shall take place until a uniform mixture of aggregates is obtained.

Aggregate from the old roadbed should be scarified and bladed into one or more windrows for measuring and sampling. These windrows are then mixed together thoroughly before asphalt emulsion is added. When the emulsion is to be combined with the aggregate by a mixing operation on the road, the aggregate shall be positioned on the surface of the roadbed in such a manner as to facilitate processing with the mixing machine equipment.

When the traveling unit has a spray bar and one or more rotating mixers at right angles to the direction of motion of the unit, the aggregate may be spread uniformly over the road surface in a manner representative of the final structural cross section. The machine will then combine emulsion and aggregate in place.

Traveling units having a spray bar and rotating shaft fixed axially to the direction of the motion require the aggregate to be positioned in one or more windrows containing sufficient materials to produce the required thickness of compacted mix.

If the mixing operation is to be performed by spray truck, motor graders, and rotary mixers, the aggregate should be positioned in one windrow along one side of the road bed.

17.9 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.

17.9.1 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.

17.9.2 Central Plant Mix

A central plant mixing operation 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 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 over mixed. 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.

17.9.3 Travel Mixers

The purpose of the travel plant is to leave a uniform, properly coated, asphalt emulsion and 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.

17.9.4 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 0.75 mm (No. 200) material present.

17.9.5 Distributor & Motor Grader Mixing

Asphalt emulsion mixtures may be prepared by applying the 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 con-

tent 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.

Because the fine grained sands (which are to be stabilized) have a low stability, they provide poor working surfaces on which to perform a windrow mixing operation. The grader will tend to disturb the exposed subgrade and thus continually draw subgrade material into the windrow. Once mixed, efforts to spread the windrow must be made with caution or subgrade material will be churned up into the mix.

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.

17.9.6 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.

17.10 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, sand mixes should be placed in a compacted thickness no greater than 50 mm (2 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 requires 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 the best guide in determining allowable placement thickness.

17.11 Compaction

Compaction of asphalt emulsion sand mixtures is intended to consolidate the mixed materials into a state which will eventually produce maximum stability and longest life. This condition has usually been determined in the laboratory.

Besides the aggregate, there are two fundamental components of the mixture whose quantities have been evaluated in the laboratory study, asphalt emulsion and moisture. The design quantity of asphalt emulsion has been added during the mixing process. It is now necessary to compact the mixture at the design moisture content, based on either density or stability. The moisture content of the mixture can be measured on site, or evaluated by experienced personnel. The mixture should be brought to the desired moisture level (or slightly above) during the spreading and conditioning process. Generally, compaction can be achieved with less than 4% moisture in the mix.

Rubber tired rollers are normally used for compaction. Because the tires of the motor grader compact the freshly spread mix their tracks may 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 ridges. If the stabilized emulsion sand mixture becomes too dry before compaction it will be impossible to achieve desired density. When the mixture becomes too dry, some emulsions will set or break, which results in further resistance to the compaction effort.

This breaking may be indicated by the darkening in the color of the mix. Therefore, there is some advantage to begin compaction at a slightly higher moisture level than the design level. Rolling should continue until the desired moisture is obtained before placing the next lift.

If the mix is at too high a moisture content when compaction is attempted, the mat may rut or shove. The upper crust may crack after compaction is apparently completed. This indicates the mix is above optimum moisture for compaction and although the surface may be at the right moisture content, the lower section of the lift is unstable due to high moisture level. Under these conditions, the moisture content must be reduced by further aeration, usually obtained by reblading the mix. After one course is thoroughly compacted, 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 finished rolled. Care should be taken to avoid over compaction.

17.12 Surface Seal

Asphalt emulsion and sand mixtures prepared with 7% or less asphalt emulsion may be expected to need additional surface treatment in order to withstand the abrasion of traffic. A prime or fog seal should be applied within a day or two after compaction is completed. A seal coat should be placed when the mixture is thoroughly cured.

17.13 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.