Presented at the
11th Annual Meeting of the Asphalt Emulsion Manufacturers Association March 20-23 1984
Orlando Florida.

Proposed Mix Design methods for Asphalt Emulsion Cold Mixes

Jack N Dybalski - Manager-Asphalt Technology
Akzo Chemicals Inc. McCook Illinois

Akzo Chemie America has expended a considerable amount of investigative and developmental effort, during the past five years, toward determining those factors which are most important in developing an acceptable laboratory design method for solvent-f ree asphalt emulsion cold mixes and those factors which control layer equivalency to hot mix.

The Phase I work, reported at the 1982 annual AEMA meeting, detailed results on cold mix/hot mix layer-equivalency factors using the Marshall (ASTMD-1559) Method for specimen preparation and testing. While higher resilient moduli than hot mix were obtained with the cold mix specimens, the use of conventional specimen molds precluded attainment of comparable cold mix specimen densities and voids with resulting lower stabilities.

The Phase II work, reported at the 1983 annual AEMA meeting, detailed results on cold mix/hot mix layer equivalency factors, specimen properties using the Kneading Compaction Method, ASTM D-1561, the Marshall Method, ASTM D-1559, a combination of the two metbods and the effect of various conditions of curing on specimen density, voids, stability and Resilient Modulus. While higher resilient moduli were again obtained with the fully cured cold mix specimens than with the hot mix specimens, neither standard method of specimen preparation could produce specimens with density/voids properties equivalent to hot mix which relates to corresponding lower stabilities. Phase II also offered evidence that obtaining acceptable pavement density and voids with conventional compactive equipment and effort on field installations of cold mix is as easily attained as with hot mix. Attaining stability equivalent to hot mix after compaction does, however, require two to seven days to develop depending upon the design of the mix.

One conclusive result of both the Phase I and Phase II work indicated that when hot mix and cold mix are comparable in asphalt of equal stiffness and other design and cure parameters that equivalent pavement thickness can be used.

Phase III, the current report, utilizes past work and data from 1983 field trials to establish the best method found to date for laboratory specimen preparation and curing with reasonable relevance to time related properties of field applied cold mix.

There are two distinct but interrelated goals to the Phase III work reported here that had to be attained.

The first goal was to obtain data from cold mix field installations that would indicate that density/voids values from compacted solvent-free cold mix systems are equivalent to those values obtainable from a compacted hot mix. Tables I, II and III report the necessary information from three installations completed in 1983. Indicated in this field work are densities of 94% to 96% of maximum theoretical and total air voids in the mix ranging from 3% to 7%. While additional field trials with a greater number of aggregates and asphalts would have been desirable, these three field trials did provide useful data under as diverse conditions as was possible to obtain.

The second goal was to use the field data to develop a laboratory design method that would allow the preparation of test specimens with approximately the same range of densities and voids attainable in the field.

The modification of familiar design methods such as Marshall and Hveem rather than develop a completely new method which might require extensive equipment changes was found to be an easier, more practical course of action to follow It was also the opinion of many surveyed that some modification of known methods would hasten eventual acceptance by user agencies.

The major modifications recommended are reduction in initial compaction of test specimens, a specimen cure sequence and recompaction at the accepted 140^0F test temperature. Since these modifications for use with solvent-free asphalt emulsion cold mixes$_1$ the high mixing and compaction temperatures associated with the preparation of hot mix specimens is completely avoided.

The proposed method modifications as well as copies of ASTM D-1559, D-1560 and D-1561, the current Marshall and Hveem methods and an Emulsified Asphalt/Job Aggregate Cold Mix Test, a proposed ASTM test method not yet published, are included here for your review.

For interim use, contingent upon round-robin verification between laboratories, this paper proposes the modification of the two most popular mix design methods, Marshall (ASTM D-1559) and Hveem (ASTM D-1560 and D-1561) as well as the related Asphalt lnstitute method for laboratory design of solvent-free asphalt emulsion cold mix.

TABLE I

New York

Aggregate Sieve	Passing		
		Emulsion	CSS-lh
		Asphalt	AC-20
3/4"	100		
1/2"	92		
3/8"	77	Moisture, %	5.5
#4	48		
#8	27	Residual A/C, %	4.5
#40	16		
#100	10		
#200	6	Portable Pug Mill	

Laydown	Blaw Knox	2" lift
	Barber-Greene 980	4" lift
Compaction	12 Ton Vibratory	
	1st Pass	off
	2-4	passes on
DENSITY	94% of Maximum Theoretical (60 hours)	

TABLE II

Alaska

Aggregate				
Sieve	Passing		Emulsion	CSS-1
			Asphalt	AC-S
#4	100			
#10	100			
#40	96		Moisture, %	6.0
#50	88			
#80	63		Residual A/C, %	1.5
#200	9			

Portable Pug Mill

Lay Down	Blaw Knox 220	2" lifts 4" to 8" thick
Compaction	Pneumatic 12 ton	2 passes
	Vibratory 15 ton	2 passes
DENSITY	96% of Maximum Theoretical (42 hours)	

TABLE III

Illinois

Aggregate	
Sieve	Passing
1"	100
1/2"	95.4
#4	68.2
#16	37.5
#200	10.6

Emulsion	CSS-1
Asphalt	AC-10
Moisture%	5.8
Residual AC %	5.5

Portable Pug Mill

Lay Down	Blaw Knox	3" and 4" lifts
Compaction	Pneumatic 8 ton	2 passes
	Vibratory 10 ton	2 passes
DENSITY	94% of Maximum Theoretical (46 hours)	

PROPOSED ASPHALT EMULSION COLD MIX DESIGN METHOD
(Modification of the Marshall Method, ASTM D-1559-82)

4.2 Preparation of Aggregate

____ Use standard practice for sampling aggregates, ASTM D-75-82, as applicable.

Use Job Aggregates at average room temperature Determine moisture content of aggregate

4.3 Determination of mixing and compaction temperatures Mixing and compaction shall be done at prevailing room temperatures.

____ Mix components and mix and compaction equipment shall be at prevailing room temperature.

4,4 Preparation of mixtures

____ Weigh into separate pans for each test specimen the amount of aggregate required to produce a batch that will result in a compacted specimen 2.5+ 0.05 in. in height (about 1200 g.).

Add amount of aggregate pre-wetting water required - as determined in the "Emulsified Asphalt/Job Aggregate Cold Mix Test

Mix the aggregate and water rapidly and thoroughly until surfaces subjectively appear to be settled.

Add amount of asphalt emulsion required ad determined in the "Emulsified Asphalt/Job Aggregate Cold Mix Test."

Immediately mix wetted aggregate and emulsion vigorously scraping sides and bottom of container for 15-120 seconds or until maximum coating has been attained.

4.5 Compaction of Specimens

____ Immediately after mixing aggregate, water and emulsion, place mixture in mold and rod or spade around and through mixture several times to assure uniformity of the mix in the mold. Remove collar and smooth surface of mix to a slightly rounded shape.

Replace collar, place mold assembly on the compaction pedestal in the mold holder and apply 30 blows of the compaction hammer to each side of the specimen. An automatic compaction hammer device is satisfactory.

Place fitted filter paper on both ends of specimen.

____ Allow compacted mixture to cure in mold at room temperature for 16-18 hours on wire grid.

___ Place mold containing compacted mixture on wire grid in a forced-air oven for 48 hours at 140 F.

Immediately from oven, while hot, recompact specimen with three 40,000 pound double-plunger static loads using a 30 second relaxation period between applied loads

Remove specimen trom mold and allow to cool to room temperature.

____ Weigh, measure and test specimen according to ASTM D-1559-82 "procedure".

Note: When using the kneading compactor, 50 blows of the compacting foot at the 3.4 MPA (500 psi) mode is sufficient for initial compaction. Follow the same procedure for specimen curing and recompaction as outlined above. Heating of mix, components and equipment is not required.

Revised
December 983

EMULSIFIED ASPHALT/JOB AGGREGATE COLD MIX TEST

Scope

.1 This test may be used to identify the adequacy of slow setting grade of emulsified asphalt to mix with and coat a dense and fine graded job aggregate. It is a laboratory method of screening emulsion candidates of mixing with and coating job aggregates and is not to be construed as a mix design method.

Applicable Documents

1 ASTM Standards:
D-8 Dense Aggregate
D-1073 Fine Aggregate
D-698 Moisture/Density

2 AASHTO Standards
T-99 Moisture/Density

Significance and Use

I The conditions of test are designed to identify the adequa~y of emulsified asphalt, stow-setting grade (CS~D2397 and 5~fl977) for mixing with and coating dense-graded aggregate and fine-graded aggregate.

Summary of Method

\- A weighed amount of dry job aggregate is hand-mixed witb a weighed amount of water for pre-wetting the aggregate The wetted aggregate isthen hand mixed with a weighed amount of emulsified asphalt of known asphalt cement content until maximum coating of the job aggregate is obtained. (Mix time is usually 15-20 seconds). The adequacy of emulsified asphalt for mixing with job aggregate is determined by using various amounts of water and emulsified asphalt until a maximum coating of the job aggregate is obtained. This coating is rated as good, fair or poor.

Apparatus

.1 Containers 1000 ml. glass beaker, a one (1) quart. (1.0 litre) friction-top metal can, or 1000 ml stainless steel beaker or bowl.

.2Mixing tool a steel spatula or its equivalent, having a blade approximately 8" (203.2 mm) in length.

.3 Balance capable of weighing 1000 g. to within ~ 0.1 g.

Procedure

.1 Weigh 300 g of dry job aggregate into the container and add water basis dry weight of aggregate. Immediately begin to mix vigorously for one minute or until all aggregate surfaces subjectively appear to be wetted. (As a guide, 2% to 8% water for dense-graded aggregate and 4% to 12% water for fine-graded aggregate. (The natural moisture in a job aggregate may be used in the test if pre-determined. Additional water may then be added, if necessary, to obtain the desired level of water to be used for prewetting the aggregate.)

.2 Add the emulsion and immediately begin to mix vigorously, scraping sides and bottom of container, for 15 to 120 seconds or until maximum coating has been attained. As a guide, basis dry weight of aggregate, 3% to 7% Asphalt Cement (A/C) residue for dense aggregate and 4% to 8% A/C residue for fine aggregate. Example: 8% emulsion at 60% solids would be equivalent to 4.8% asphalt cement residue in the mix.

.3 If mix appears to be too dry and insufficiently coated repeat .1 and .2 using an increased amount of water and/or emulsified as~i~It. If mix appears to be too wet from excessive water and/or emulsified asphalt repeat .1 and .2 using less water and/or emulsified asphalt.

.4 For each job aggregate mix observe and record the amount of aggregate pre-wetting water and asphalt cement residue from the emulsified asphalt and note the one mix which provides the best aggregate coating.

.5 Rate the best coating as good, fair or poor using the ratings as defined in Method D244, "Coating Ability and Water Resistance".

Precision

.1 The usual methods of analysis for precision cannot be applied to this test because it is only semi-quantitative.

Report

.1 Report the observations made in .2 and .3 (Procedure) relating to amount of aggregate pre-wetting water and residual asphalt needed for best obtainable aggregate coating.

.2 Report the maximum coating achieved as good, fair or poor. (D244 "Coating Ability and Water Resistance" Section 51.1.1)

/sla