# SOIL-EMULSIFIED ASPHALT AND SAND-EMULSIFIED ASPHALT PAVEMENT

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## SYNOPSIS

In a paper entitled, "Recent Developments in the Design and Construction of Soil-Emulsion Road Mixtures"[1] presented at the 1940 meeting of the Highway Research Board, four essential steps in the stabilization of cohesive soil with emulsified asphalt were discussed It was there pointed out that proper dehydration of the soil-emulsified asphalt mixture after placing and compaction, which is essential in satisfactory construction, can be best obtained by placing the soil-emulsified asphalt mixture in thin layers and permitting each layer to dehydrate before placing the next layer It was further explained that this practice of layer construction and layer dehydration was relatively new, but that the results had been satisfactory, and that by the use of this method, superior results were obtained and the length of time necessary for construction greatly shortened During the last year, this method of construction has been used on several large projects with successful results, and data are presented showing typical results obtained in the field where this method of construction was followed

In the 1940 paper referred to, the stabilization of sand with emulsified asphalt was briefly described Since then much additional research work has been carried on, both in the field and in the laboratory In this work the suitability of sands for bituminous treatment was determined by the Florida Bearing Value Method and the efficiency of treatment was determined by a modification of the Florida Bearing Value Method, in which the bearing value of emulsified asphalt-sand mixtures was determined using the sand from the project or blends of the sand and filler with varying quantities of emulsified asphalt tested at various temperatures The results of these tests seem to justify the conclusion that sands are satisfactory for use if the Florida Bearing Value is greater than 25 lb, when the sands are tested prior to mixing with emulsified asphalt, and also if the mixture shows a bearing value by the Modified Florida Test Method of more than 100 lb at 140° F on tests after emulsified asphalt is mixed with the sand The data are believed to justify the conclusion that untreated sands which are below the minimum allowable stability can usually be made suitable for use by the addition of fine non-cohesive filler

### FIELD DEHYDRATION OF EMULSIFIED ASPHALT-SOIL MIXTURES

In the construction of stabilized base using emulsified asphalt-soil mixtures, it is essential that efficient dehydration be obtained after the base has been placed and compacted and before the construction of a wearing surface. When this type of base is constructed in thick layers dehydration was found to be slow, particularly under unfavorable weather conditions. With single layers 4 in. or more thick the time required for uniform dehydration throughout the depth frequently involved serious constructional delays, or in some instances resulted in the surface being placed upon the base before it was uniformly dried throughout Experience over the last seven years has indicated that an emulsified asphalt stabilized base should be dried to a maximum moisture content of approximately 25 per cent of Proctor Optimum, before surfacing, if entirely satisfactory results are to be obtained. It was also discovered that by placing the emulsified asphalt-soil mixture in layers of 2 in or less and allowing each layer to dry after compaction, the thin layers dried quickly and the total construction time could be greatly reduced

[1] *Proceedings*, Highway Research Board, Vol 20, p 856.

This practice has been followed on most emulsified stabilization work during the last two years. Data from two recent projects are included here as typical results obtained where layer construction is practiced.

Table 1 shows average results obtained on a job built under summer weather conditions, during July and August 1941, in which a 6-in emulsified asphalt stabilized base was constructed on an airport runway. Half of this base was constructed in a single layer of 6 in. in compacted thickness. The other half of the runway was constructed by placing and compacting in three separate layers, and allowing each to dry to approximately 25 per cent of Proctor Optimum before placing the next layer On this project the Proctor Optimum moisture content was approximately 17 per cent In order to secure proper mixing 22 per cent of moisture was found necessary, including the water of emulsification Where the mixture was laid in a single 6-in layer and compacted at Proctor Optimum moisture, 17 to 19 days was necessary for drying to 25 per cent of Proctor Optimum. When placed in three 2-in. layers uniform dryness well below the allowable 25 per cent of Proctor Optimum moisture was accomplished in 7 days and in 17 days the moisture content was down to 1 9 per cent at the bottom against 4 25 per cent allowable (25 per cent of Proctor Optimum)

Another typical project was one begun on October 8 and completed on December 18, in a period of cool weather with considerable rain and cloudiness This project consisted of three runways, two 150 ft wide and one 200 ft. wide, all 4,000 ft in length, together with taxiways The emulsified asphalt stabilized base was 6 in in compacted thickness and was constructed in three layers. The Proctor Optimum moisture averaged approximately 13½ per cent. The maximum allowable moisture content after drying (25 per

TABLE 1

DRYING TIME

6-in Emulsified Asphalt Stabilized Base—2-in Layer Construction vs 6-in. Layer

| Layer | Moisture: Proctor optimum | Moisture: After mixing | Date of spreading | Date of testing | Elapsed time, days | Moisture at time of test | Maximum allowable moisture |
|---|---|---|---|---|---|---|---|
| | % | % | | | | % | % |
| Bottom 2-in | 17 | 20–22 | 8– 6–'41 | 8– 8–'41 | 2 | 2 6 | 4 25 |
| Middle 2-in | 17 | 20–22 | 8–14–'41 | 8–16–'41 | 2 | 3 8 | 4 25 |
| Top 2-in | 17 | 20–22 | 8–18–'41 | 8–21–'41 | 3[a] | 2 2 | 4 25 |
| Full 6-in thickness in one layer | 17 | 20–22 | 8– 4–'41 | 8–23–'41 | 19 | 2 6 | 4 25—Top 2 in. |
| | | | 8– 4–'41 | 8–23–'41 | 19 | 3 0 | 4 25—Mid 2 in |
| | | | 8– 4–'41 | 8–23–'41 | 19[b] | 4 2 | 4 25—Bot 2 in |

[a] Total elapsed time for satisfactory drying, 7 days
[b] Total elapsed time for satisfactory drying, 19 days

cent of Proctor Optimum) was 3.38 per cent Due to the unfavorable and variable fall weather conditions the time required for drying each layer ranged from 9 to 16 days, but the work was carried out continuously from runway to runway on first, second, and third layers, enabling this project of approximately 225,000 sq. yd. to be built and dried to a satisfactory moisture content in a total elapsed time of 2 months and 10 days. Based on previous experience, had 6-in. layer construction been used on this project for fall and winter work, at least 4 months time would have been necessary for construction and drying.

These examples typify increased efficiency in dehydration and the saving in time from layer construction.

## SAND-EMULSIFIED ASPHALT PAVEMENT

### *Design of Sand Mixes*

Prior to November, 1940, sand-emulsified asphalt bases were constructed on a number of road projects and on several airports, including those at West Palm Beach, Tallahassee, Pensacola and Eglin Field, Florida, and at Burlington, Vermont. In the design of the mixtures on the earliest of these jobs, absorption and stability tests were run in the same manner as for soil-emulsified asphalt mixtures in which the soil is cohesive, and as described in "Soil Stabilization with Emulsified Asphalt" in the "Proceedings of the Highway Research Board," Volume 15, p. 357. These tests were normally run at 77° F., and it was soon discovered that, due to the lack of cohesive clay in the sand, stabilities at 77° F. were not at all indicative of stabilities at higher temperatures. Some sand-emulsified asphalt mixtures showing good stability at 77° F. were soft and unstable at 140° F. when pressed with the hands, while others with approximately the same stability at 77° F. were firm and stable at 140° F. These observations lead to the conclusion that other test methods must be used properly to evaluate sand-emulsified asphalt mixes.

The use of sand bituminous mixes originated in the Southeastern States and has had its most extensive use there. The Florida State Road Department has given considerable publicity to this type of construction and has published a bulletin describing a "Stability or Bearing Value Test Method" long used by them, and also by some other southern States, in testing untreated sands intended for use in bituminous mixtures. In view of the fact that this Florida Method had behind it long time experience under service conditions, it was decided to utilize this test method as far as possible in connection with the design of sand emulsified asphalt mixtures and in research work connected therewith.

## THE FLORIDA BEARING VALUE TEST METHOD

This method is described in Bulletin No. 3, "Sand Bituminous Road Mix," issued by the State Road Department of Florida, May 1, 1937. The machine used, illustrated in Figure 1, is very simple and inexpensive. The method of test is described in the Bulletin as follows:

"The procedure in conducting this test, at the present time, is to oven dry the sample to constant weight. To 600 g. of the oven dried material, break up all lumps and add 10 5 cc. of water and mix uniformly. The cup is filled with the material and a bearing plate covering the entire surface is placed in the cup and an initial pressure, by hand is given the material The bearing plate cover is then removed and additional material is added and piled conical above the cup and the plate cover is again placed on the material and hand pressure applied The excess above the cup is then removed and a total pressure of 1200 lb is applied The large bearing plate is then removed and the small bearing plate of 1-sq. in area is placed in the center of the cup resting lightly on the surface of the material The lever arm of the machine is then balanced and the constant increasing load applied by allowing the shot to run from the funnel into the bucket until the pressure on the bearing plate is great enough to upset the stability of the material and at failure the load is recorded. The load or the stability is in pounds and is calculated by multiplying the scale reading by 4, which is the lever arm ratio of the machine"

Regarding this method, which is now being used in a number of southern States, the Bulletin offers the following comment:

"This method of test has been used about four years and has proven very successful and valuable in determining satisfactory material for this type of construction It is rather difficult to determine the exact stability that will or will not prove satisfactory; however, from what work we have done we do know that the stability of the material from the project which gave trouble when tested as described above had a value of 6 lb, while materials from other completed projects upon which the mix was entirely satisfactory had values of 25 lb or more; therefore, until further research can be made, we have arbitrarily established 25 lb as a minimum stability."

The Materials Department of the Florida State Road Department cautioned that the test was somewhat difficult in reproducibility, and at the beginning of the work described herein, samples were exchanged with the Florida Department to correlate results with those obtained by them.

A study ofthe Florida Method indicated that the difficulties in reproducibility were probably in considerable measure due to variations in the rate of loading which is not included in the test description and variations in the method of seating the load bearing plate Probably the greatest variations are due to non-uniformity in compaction. It is believed that the method could be much improved by definitely specifying methods of compaction which would produce uniform results. Slight variation of moisture content in the sand also varies results, and this might be improved by compacting the sand at saturation. However no changes could be made in this method without changing the numerical values obtained, and as there is much history behind the values adopted by Florida based on service observations it was thought best to use this test on all untreated sands, as nearly as possible following the description used there.

While the Florida test method was used throughout our research in the testing of untreated sand, a modification of the Florida Method was developed for use on mixtures of sand and emulsified asphalt. In the modified method the rate of loading, method of compaction, and the seating of the load bearing plate were standardized as carefully as possible and reasonable reproducibility was obtained. The same apparatus was used as described in the Florida Method except that the ring container for the specimen being tested is 4 in. in diameter instead of 3 in. and a water bath is provided to maintain the temperature of the sample at 140° F. while the bearing value tests are made. The following is a description of this "Modified" Florida Bearing Value Test.

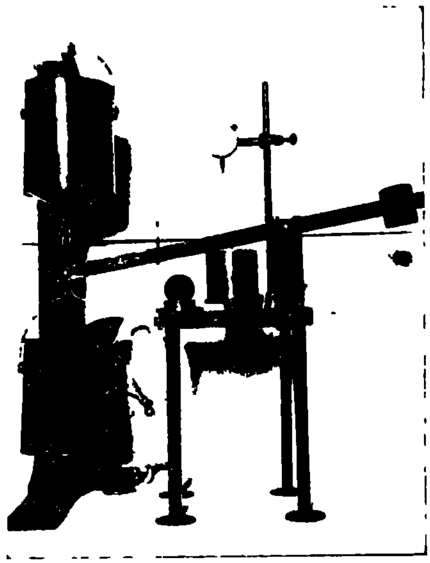

**Figure 1. Machine for Florida Bearing Value Test**

MODIFIED FLORIDA BEARING VALUE TEST

Separate mixtures of each sample of sand or blend of sand and admixture and emulsified asphalt shall be made. The percentage of asphalt emulsion to be used for each mixture shall be determined by applying the following formula.

$$P = 75\ (.05A + .10B + .5C),$$

in which:

A = The percentage of sand retained on the No 10 sieve.

B = The percentage of sand passing a No 10 sieve and retained on No 200 sieve.

C = The percentage of sand passing a No. 200 sieve determined by wet screening.

P = Percentage of emulsified asphalt (55 to 60 per cent residue) based on the weight of sand.

The sand-emulsified asphalt mixtures shall be spread in thin layers in pans, placed in a drying oven and dried to constant weight at 140° F. The mixtures shall be taken from the oven and while still warm, tamped into a cylindrical mold 4 in in diameter by 3 in. high, care being taken to tamp in thin layers so as to get good density. After the mold is tamped full, it shall be placed in a compression machine and compressed until the specimen firmly holds a total pressure of 25,000 lb. (this is equivalent to about 2,000 lb per sq. in ).

After compaction, the mold shall be placed in a 140° F. oven for at least 2 hr. to bring the temperature to 140° F. It shall be removed from the oven and placed in a 140° F water bath, in the same testing machine used for untreated sand stability tests. The cylindrical plunger (exactly 1 sq. in bottom area) shall be placed on the center of the top of the mix. Load shall be applied at a rate of 92 lb. per sq. in. (23 lb of shot) per min. until a total load of 60 lb. per sq in. is reached. The specimen shall than be allowed to stand under this 60-lb. load for 2 min. The load shall then be increased 10 lb. to the sq. in. in the same manner and the specimen shall be held under the 70-lb load for 2 min and the same procedure of increasing the load in 10-lb. increments and holding the specimen for 2 min. under each increment shall be repeated until failure takes place The load bearing value shall be reported as the greatest load in pounds per square inch which the mixture supported at 140° F. without failure

More than a thousand sands from different projects were tested untreated by the Florida Method and after admixture with emulsified asphalt by the Modified Florida Method The results obtained on a number of these sands are shown in Table 2, together with the mechanical analyses of the sands It does not appear from these mechanical analyses that stability is directly related to grading and this is the conclusion which was reached in Florida State Highway Bulletin 3, previously referred to.

Many of the sands proposed for use and included in the study showed untreated bearing values between 20 and 30 lb and these were believed to be too near the 25 lb. acceptance figure set up by Florida and therefore it was decided that sand should not be considered satisfactory unless it had an untreated bearing value of more than 25 lb. and also showed a value of more than 100 lb by the Modified Florida Test on the sand-emulsified asphalt mixture. In general, it was found that sands which show a bearing value of more than 30 lb. by the Florida Method do give more than a 100 lb. bearing value when tested by the Modified Method at 140° F., but as will be noted in Table 2 there are a number of exceptions in which sands showing untreated stability of more than 30 lb gave unsatisfactory bearing values (less than 100 lb ) when treated with emulsified asphalt Likewise, there were a few sands which gave stabilities of less than 25 lb. untreated by the Florida Method which showed satisfactory bearing value after treatment at 140° F

Some of the sands show low untreated

TABLE 2

BEARING VALUE TESTS ON TREATED AND UNTREATED SANDS

| Laboratory No | Origin of sample | Florida method B V untreated sand | Modified Florida bearing value at 140° F with 75 per cent formula Emuls Asph | Sieve analyses per cent passing | | | |
|---|---|---|---|---|---|---|---|
| | | | | No 10 | No 40 | No 80 | No 200 |
| | | lb | lb. | | | | |
| 621–5 | Salisbury, North Carolina | 130 | 160+ | 85 | 44 | 27 | 13 |
| 628–5 | Fortaleza, Brazil | 128 | 160+ | 99 | 84 | 29 | 14 |
| 634–2 | Milton, Florida | 96 | 160+ | 100 | 54 | 25 | 12 |
| 634–3 | Milton, Florida | 92 | 160+ | 100 | 68 | 26 | 12 |
| 628–2 | Natal, Brazil | 92 | 160+ | 99 | 65 | 23 | 12 |
| 648–1B | Lansing, Michigan | 92 | 160+ | 97 | 89 | 26 | 15 |
| 643–1 | Milton, Florida | 86 | 160+ | 100 | 53 | 24 | 11 |
| 633–1 | Beltsville, Maryland | 84 | 160+ | 100 | 79 | 33 | 18 |
| 613–1 | New Albany, Mississippi | 74 | 160+ | 100 | 92 | 40 | 11 |
| 626–1A | Camp Pine, New York | 74 | 160+ | 87 | 35 | 10 | 6 |
| 372–4A | St Petersburg, Florida | 60 | 120 | 100 | 88 | 43 | 6 |
| 649–1 | Grovestone, North Carolina | 58 | 160+ | 81 | 44 | 18 | 7 |
| 643–1B | Winter Haven, Florida | 57 | 160+ | 100 | 83 | 17 | 8 |
| 625–1 | Greenville, Alabama | 56 | 160+ | 100 | 93 | 16 | 9 |
| 648–1A | Lansing, Michigan | 54 | 120 | 96 | 88 | 18 | 8 |
| 124–32A | Meridian, Mississippi . | 52 | 160+ | 100 | 78 | 17 | 10 |
| 628–6 | Bahia, Brazil | 52 | 160+ | 99 | 86 | 48 | 13 |
| 598–5B | Panama City, Florida | 50 | 90 | 100 | 92 | 12 | 5 |
| 643–4B | Winter Haven, Florida | 47 | 150 | 100 | 82 | 18 | 7 |
| 643–2A | Winter Haven, Florida | 46 | 150 | 100 | 84 | 20 | 8 |
| 640–2A | Bartow, Florida | 46 | 150 | 98 | 85 | 26 | 7 |
| 621–3 | Salisbury, North Carolina | 44 | 160+ | 86 | 30 | 11 | 6 |
| 643–4A | Winter Haven, Florida | 43 | 130 | 100 | 82 | 18 | 7 |
| 633–2A | Sanford, Florida | 43 | 130 | 100 | 95 | 34 | 6 |
| 633–3A | Sanford, Florida | 42 | 130 | 100 | 97 | 40 | 7 |
| 635–3A | Kissimmee, Florida | 42 | 160+ | 100 | 99 | 91 | 12 |
| 640–1B | Bartow, Florida | 42 | 130 | 95 | 82 | 21 | 8 |
| 598–7B | Panama City, Florida | 42 | 70 | 100 | 95 | 9 | 4 |
| 335–89A | Coahoma County, Mississippi | 41 | 160+ | 98 | 56 | 14 | 11 |
| 640–3A | Bartow, Florida | 40 | 130 | 95 | 84 | 20 | 8 |
| 124–15A | Meridian, Mississippi | 39 | 160+ | 100 | 68 | 18 | 6 |
| 635–1A | Kissimmee, Florida | 39 | 130 | 100 | 99 | 86 | 10 |
| 598–6B | Panama City, Florida | 39 | 50 | 100 | 92 | 18 | 4 |
| 482–25A | Vero Beach, Florida | 38 | 160+ | 100 | 92 | 31 | 13 |
| 124–31 | Meridian, Mississippi | 38 | 160+ | 100 | 50 | 15 | 7 |
| 223–4A | Naples, Florida | 38 | 150 | 65 | 60 | 26 | 4 |
| 598–6A | Panama City, Florida | 38 | 130 | 99 | 83 | 24 | 5 |
| 598–7A | Panama City, Florida | 38 | 130 | 99 | 88 | 14 | 5 |
| 164–6A | Monroe, Louisiana | 38 | 100 | 98 | 39 | 10 | 8 |
| 632–2A | Beltsville, Maryland | 37 | 160+ | 100 | 66 | 19 | 3 |
| 633–1A | Sanford, Florida | 37 | 130 | 100 | 96 | 39 | 7 |
| 635–2A | Kissimmee, Florida | 37 | 120 | 100 | 99 | 91 | 10 |
| 482–26A | Vero Beach, Florida | 36 | 160+ | 100 | 92 | 31 | 13 |
| 598–5A | Panama City, Florida | 36 | 160+ | 99 | 82 | 17 | 5 |
| 223–3A | Naples, Florida | 36 | 130 | 65 | 58 | 23 | 4 |
| 372–4B | St Petersburg, Florida | 36 | 130 | 89 | 58 | 26 | 3 |
| 635–3 | Kissimmee, Florida | 36 | 100 | 100 | 99 | 91 | 8 |
| 625–1A | Greenville, Alabama | 35 | 160+ | 98 | 54 | 11 | 6 |
| 124–29A | Meridian, Mississippi | 35 | 120 | 100 | 99 | 39 | 9 |
| 632–3A | Beltsville, Maryland | 34 | 160+ | 100 | 58 | 18 | 12 |

TABLE 2—CONTINUED

BEARING VALUE TESTS ON TREATED AND UNTREATED SANDS

| Laboratory No | Origin of sample | Florida method B V untreated sand | Modified Florida bearing value at 140° F with 75 per cent formula Emuls Asph | Sieve analyses per cent passing | | | |
|---|---|---|---|---|---|---|---|
| | | | | No 10 | No 40 | No 80 | No 200 |
| | | lb. | lb. | | | | |
| 643–2 | Winter Haven, Florida | 34 | 70 | 100 | 84 | 19 | 7 |
| 482–24A | Vero Beach, Florida | 33 | 140 | 100 | 92 | 31 | 13 |
| 640–2 | Bartow, Florida | 33 | 70 | 100 | 88 | 24 | 5 |
| 624–1A | Alameda, California | 32 | 160+ | 100 | 92 | 26 | 10 |
| 623–1A | Quitman, Mississippi | 32 | 160+ | 100 | 76 | 19 | 10 |
| 621–4 | Salisbury, North Carolina | 32 | 160+ | 100 | 95 | 38 | 7 |
| 642–3A | Greenville, Mississippi | 32 | 160 | 99 | 55 | 16 | 10 |
| 164–4A | Monroe, Louisiana | 32 | 90 | 100 | 87 | 10 | 6 |
| 640–1A | Bartow, Florida | 32 | 70 | 96 | 84 | 19 | 7 |
| 635–1 | Kissimmee, Florida | 31 | 80 | 100 | 99 | 86 | 6 |
| 635–2 | Kissimmee, Florida | 29 | 70 | 100 | 99 | 91 | 6 |
| 643–4 | Winter Haven, Florida | 29 | 60 | 100 | 85 | 18 | 6 |
| 626–1 | Camp Pine, New York | 28 | 160+ | 98 | 39 | 8 | 3 |
| 589–1A | (Lantana) W Palm Beach, Fla | 28 | 160+ | 99 | 81 | 25 | 5 5 |
| 546–6 | Lakeland, Florida | 27 2 | 90 | 100 | 98 | 40 | 4 |
| 482–3 | Vero Beach, Florida | 26 3 | 60 | 100 | 83 | 36 | 5 |
| 571–1 | White House, Florida | 26 | 60 | 100 | 100 | 40 | 4 5 |
| 559–4 | Savannah, Georgia | 25 2 | 70 | 100 | 97 | 15 | 2 |
| 422–3 | Murray, Kentucky | 26 | 160+ | 75 | 32 | 5 | 4 |
| 628–1 | Recife, Brazil | 26 | 120 | 100 | 77 | 8 | 3 |
| 124–32 | Meridian, Mississippi | 26 | 80 | 100 | 76 | 11 | 6 |
| 546–4 | Lakeland, Florida | 25 | 40 | 100 | 98 | 43 | 3 |
| 270–8 | Pascagoula, Mississippi | 25 | 150 | 100 | 98 | 45 | 14 |
| 372–3 | St Petersburg, Florida | 24 8 | 60 | 100 | 98 | 43 | 1 |
| 279–17 | Jackson, Mississippi | 24 6 | 40 | 100 | 98 | 24 | 5 |
| 574–1 | Palatka, Florida | 24 4 | 50 | 100 | 100 | 44 | 2 |
| 623–2 | Quitman, Mississippi | 24 | 120 | 100 | 85 | 20 | 9 |
| 643–3 | Winter Haven, Florida | 24 | 50 | 100 | 82 | 17 | 6 |
| 571–2 | White House, Florida | 22 | 50 | 100 | 100 | 32 | 2 5 |
| 569–3 | Bastwick, Florida | 22 | 60 | 100 | 100 | 39 | 6 5 |
| 561–2 | British Guiana (Airport) | 21 8 | 50 | 100 | 89 | 12 | 4 |
| 597–1 | North Dalles, Oregon | 21 | 160+ | 100 | 99 | 34 | 4 |
| 571–3 | White House Florida | 20 8 | 40 | 100 | 100 | 44 | 5 |
| 545–2 | Fort Myers, Florida | 20 8 | 40 | 100 | 93 | 40 | 2 |
| 537–2 | Avon Park, Florida | 20 5 | 50 | 100 | 73 | 17 | 3 |
| 569–1 | Bastwick, Florida | 20 5 | 40 | 100 | 100 | 20 | 3 5 |
| 627–3 | Chickasaw, Alabama | 20 | 120 | 100 | 65 | 11 | 3 |
| 622–1 | N C. State Highway Dept | 20 | 120 | 88 | 45 | 7 | 2 |
| 124–29 | Meridian, Mississippi | 20 | 50 | 100 | 99 | 35 | 5 |
| 633–3 | Sanford, Florida | 20 | 50 | 100 | 96 | 36 | 4 |
| 633–2 | Sanford, Florida | 20 | 50 | 100 | 94 | 29 | 3 |
| 648–1 | Lansing, Michigan | 20 | 50 | 98 | 87 | 13 | 3 |
| 575–3 | St Augustine, Florida | 19 8 | 50 | 100 | 98 | 47 | 2 |
| 575–5 | St Augustine, Florida | 19 2 | 40 | 100 | 91 | 28 | 2 |
| 573–2 | Norfolk, Virginia | 18 | 70 | 100 | 70 | 5 | 1 |
| 569–2 | Bastwick, Florida | 16 8 | 40 | 100 | 100 | 28 | 3 4 |
| 593–1 | Texas Highway Dept , Austin | 16 | 40 | 100 | 100 | 82 | 1 2 |
| 513–8 | Panama City, Florida | 14 5 | 40 | 100 | 99 | 19 | 4 |
| 580–1 | Camp Blanding, Florida | 12 | 25 | 100 | 85 | 5 | 1 |

bearing values by the Florida Method and also low bearing value by the Modified Method These could not be considered as satisfactory in their natural condition. Experiments were conducted with admixtures of soil, loess, limestone dust, ground shell dust, crushed shell, powdered limestone, and other materials of which a substantial amount passed the No. 200 sieve. It was found that the addition of these admixtures, sometimes in relatively small quantities, produced satisfactory bearing values in the untreated sand and in the mixture after the addition of emulsified asphalt, and mixtures so prepared gave very satisfactory results.

TABLE 3

EFFECT OF VARIATIONS IN QUANTITY OF EMULSIFIED ASPHALT ON BEARING VALUES BY THE MODIFIED FLORIDA METHOD

(Based on formula shown in description of Modified Florida Method)

| Formula Requirement | Bearing value Modified Florida Method | |
|---|---|---|
| | Sample No 571-2 | Sample No 209-3 |
| % | | |
| 0 | 22[a] | 46[a] |
| 50 | 30 | 110 |
| 60 | 30 | 110 |
| 70 | 30 | 120 |
| 80 | 30 | 130 |
| 90 | 30 | 140 |
| 100 | 30 | 130 |

[a] Test made by Original Florida Method.

Load bearing values in the Modified Florida Test are not greatly affected by the percentage of emulsified asphalt added to the sand up to the full quantity which would be normally used in pavement mixtures. Table 3 shows the effect of varying percentages of emulsified asphalt on the bearing value of mixtures, including tests with poor sand and good sand.

As the quantity of emulsified asphalt used does not critically affect the bearing value of the emulsified asphalt sand base, a quantity should be used which will give the necessary durability and sufficient resistance to abrasion when the base is protected by a light scalcoat as is the usual practice. The formula

$$P = ( 05A + .10B + .5A)$$

has been used over a period of years in densely graded cold mixed asphaltic concrete ranging from fine mixes with 60 per cent passing the No. 10 sieve to densely graded mixes with a maximum sieve size of 1 in. or even more.

From study of a number of sand-emulsified asphalt pavements which have been under service for considerable periods, it was found that the emulsified asphalt content in sand-emulsified asphalt base mixtures should normally be about 75 per cent of the formula requirement or "P" value, and this modification of the formula is shown in the foregoing description of the Modified Florida Test Method. On a number of projects it has been the practice to lay a leaner sand-emulsified asphalt base with an enrichened top. When this is done 60 per cent of the formula quantity as determined has been found satisfactory in the bottom 5 in. of the pavement with 90 per cent of the formula quantity being used in the top 1 or 2 in. All observations and tests indicate that there is no lack of bearing value if 90 per cent of the formula quantity is used throughout, and the use of a leaner bottom course, if practiced, is purely a matter of economy.

## CONCLUSIONS

The following conclusions have been reached:

1. All sands should be tested, untreated, by the Florida Test Method, and after treatment, by the Modified Florida Test Method before being accepted as suitable for use in a sand-emulsified asphalt base.
2. The usual absorption and stability (extrusion) test methods used in

soil-emulsified asphalt mixtures should not be used for designing or pre-judging the qualities of an emulsified asphalt-sand mix.

3. Sands or blends of sand and filler which show an untreated value of more than 25 lb. in the Florida Method, and which also show a minimum 100-lb value when tested at 140°F by the Modified Method, are satisfactory for use.
4. Sands of low stability can be made suitable for use by the addition of fine, non-cohesive fillers.