PROGRESS REPORT ON SOIL-BITUMINOUS STABILIZATION

Chester McDowell, University of Texas

• SOIL-BITUMINOUS stabilization, or soil-asphalt, as it is often referred to, has not been blessed with testing procedures that are an aid to the development and promotion of this product. This point has been reemphasized at meetings of the HRB Committee on Soil-Bituminous Stabilization during 1969 and 1970. The author does not wish to be any more critical of the work of others than he is of his own inasmuch as he was a prime mover in the development of 2 soil-asphalt test procedures, both of which fall far short of what is needed.

One of those methods was developed in the late thirties and was known as the modified bearing value (1). The second method known locally as the triaxial method (2) for soil-asphalt design was developed in the fifties. Both of these tests were of the waterproofing type and usually indicated the use of leaner mixtures than were realistic unless the "fat point" was crowded. They did not consider voids, percentage of moisture in compaction, aeration, and other pertinent data. Although neither of these 2 methods was very successful, it is believed that they did serve as a useful background in developing a third method that we believe will be far superior to either of them. The development of the large soils gyratory press and techniques in the late sixties for hot-mix black base gave promise that its utilization could improve soil-asphalt testing procedures.

The introduction of the large gyratory press for soils and its use for black-base design have paved the way for investigation of soil-bituminous mixtures, and the results of experiments with this new procedure and equipment constitute the bulk of this progress report on soil-bituminous mixtures. We tried to develop a test procedure employing use of the cohesiometer testing equipment. After doing a lot of unsuccessful work on this phase of testing, we abandoned the investigation in favor of a direct compression test. This report does not include that phase of the investigation.

The purpose of this investigation was to develop improved test procedures and techniques for the evaluation of soil-bituminous mixtures. It is believed that a good start in this direction has been made.

EXPERIMENTS AND RESULTS

For the experiments, a sand-clay soil (66-248-R) having a 5 plasticity index, 79 percent sand sizes, 5 percent silt, and 16 percent clay was selected from near Elgin, Texas. The materials (soil, water, and RC-2) were mixed at room temperature with a kitchen mixer and compacted into specimens having a 6-in. diameter and a 6-in. height. The compaction procedure is similar to test method Tex-126-E except for specimen height and molding temperature. Figures 1 through 5 show some of the testing equipment used. It is recognized that molding temperature is critical, and this is one of the reasons that the use of relatively small specimens (6-in. diameter by 6-in. height) in conjunction with the high efficiency of the gyratory press was selected for use especially for room-temperature molding. Another reason for the use of short specimens evolves from that portion of our procedure requiring pressure-wetting of the specimen at room temperature. It is believed that the shorter the specimen is, the less will be the time required to wet the specimen in the pressure pycnometer. Pressure-wetting temperatures will be discussed more thoroughly in a subsequent section of this report. The results of these tests are shown in Figure 6. Two sets of moisture-density

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Figure 1. Compaction mold and base plate.

Figure 2. Gyratory compaction machine.

Figure 3. Caster-mounted dolly.

Figure 4. Ejection press.

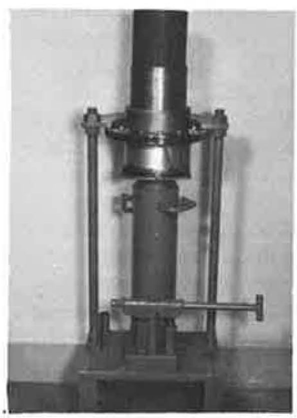


Figure 5. High-speed testing machine.

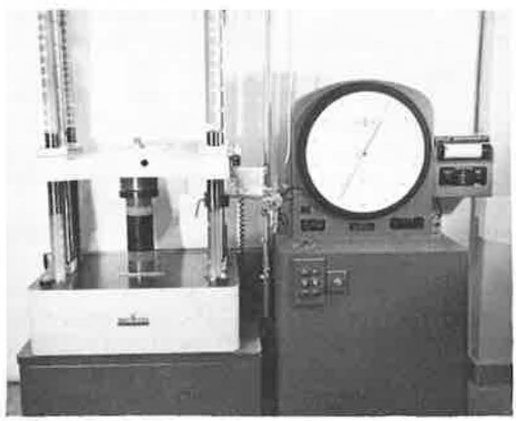
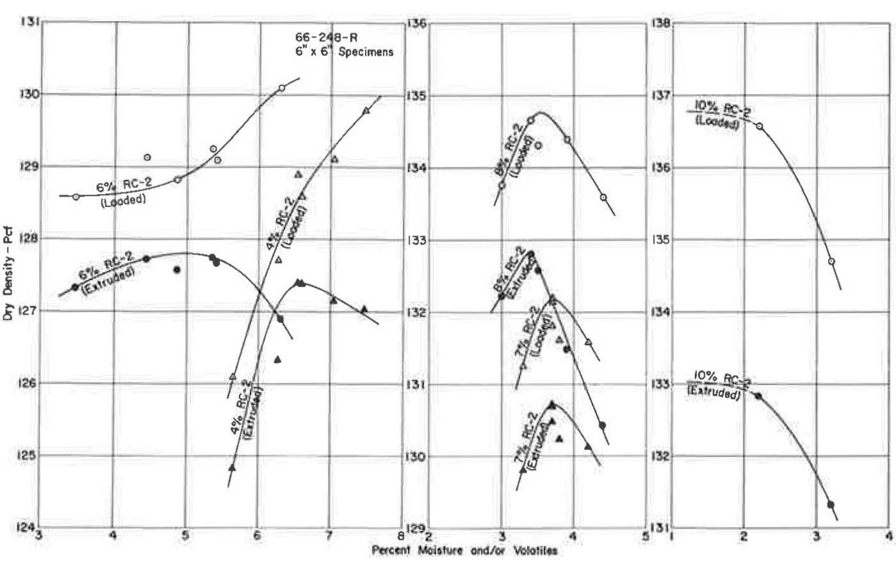


Figure 6. Density-moisture curves.



curves are shown: one with the specimen held under a load of 500 psi and the other after the specimen is extruded and its height measured after rebound. It was interesting to note that some of the leanest mixtures would not produce a reasonable optimum moisture content when measured in a loaded condition but did when measured after extrusion. Apparently certain mixtures, i.e., 4 and 6 percent, hold water tenaciously enough that little is squeezed out under load. The use of percentages of water in excess of optimum for extruded specimens was unreasonable because rebound cracked specimens so badly that low compressive strengths were obtained. We made hundreds of specimens and used more than a thousand pounds of mixtures before we found out part of what was happening to compaction rebound.

One of the important problems in soil-asphalt testing is to determine the desirable amount of moisture to add without doing an extensive amount of testing. For the soil tested, we have discovered an easy way to make this determination. Figure 7 shows that optimum moisture content can be determined by merely subtracting the percentage of stabilizer to be used from the optimum moisture content of the raw soil. It is hoped that this moisture-density relation will remain the same for other soils and other asphalts. Only a continued investigation will verify the workability of the method for all soil-asphalt mixtures. The percentage of air voids at optimum moisture content when plotted against percentage of asphalt reveals an S-shaped curve containing 2 hooks (Fig. 8). The left hook at slightly more than 6 percent (where the curve steepens) indicates the point in richness at which the mixtures begin to be capable of being compacted easier than are leaner mixtures. As asphalt content is increased, compaction (removal of voids) continues until a reversing curve hook shows danger that voids are being overfilled at about 9 percent. It would seem that the best percentage of RC-2 in this case would range between 6.5 and 9 percent. It is also interesting to note that, if the minimum void content in percentage obtained is increased by 5 percent (the average difference between laboratory-gyratory molding and field cores found on black-base projects) and this line shown in Figure 9 is projected horizontally to the voids curve and then downward, the use of 7.3 percent is suggested in this case.

Mixtures containing 0, 2, 4, 6, 7, 8, 9, and 10 percent RC-2 were mixed at room temperature and at optimum moisture, molded as previously described, and cured in a 140 F drying oven for 5 days. After dry-curing, the specimens were cooled to room temperature, placed in plastic bags, and then pressure-wet as described in test method Tex-119-E except that room temperature wetting without restrainers was used. Many tests were run that showed that some cutback asphalts are too soft to withstand pressure-wetting at 140 F (Fig. 9). Wetting with restrainers produced what is believed to be false high compressive strengths for very lean mixtures because of firm restraint. Had we known these facts we could have saved the effort in making a ton or two of these mixes.

After the wetting, the ends of the plastic bags were folded over the ends of the specimens, and porous stones were placed on the specimen ends. After they were placed in triaxial cells, the specimens were placed in a 140 F oven for 24 hours before being tested in unconfined compression at a rate of loading of 0.15 in./min. The results of compression tests are shown in Figure 10. The rising half of the strength curve covers the range of RC-2 that is desirable to use (Fig. 8).

A few specimens were made of mixtures that had been aerated 30 to 90 min and that had molding moisture replaced. Densities obtained were lower than those obtained from fresh mixtures as indicated by the voids shown by Figure 8. Although densification was reduced several pounds per cubic foot, it was gratifying to see that no strength loss accompanied this loss in density due to aeration. It would seem that consideration of a practical working moisture content is essential before a selection is made of percentage of asphalt to be used. For instance, the optimum moisture for 9 percent RC-2 is 1.8 percent, but, as lower percentages of RC-2 are used, the optimum moisture increases to as high as 4.3 percent for 6.5 percent RC-2. It may be that conditions are such that the soil cannot be dried enough to be compatible with the use of high amounts of stabilizer. On the other hand, water may be high priced in the deserts where the use of rich mixtures may be most practical.

Previous portions of this report pertain primarily to mix design. Because success of asphalt-treated bases depends greatly on compaction, it is necessary that proper

Figure 7. Relation of percentage of RC-2 and optimum moisture.

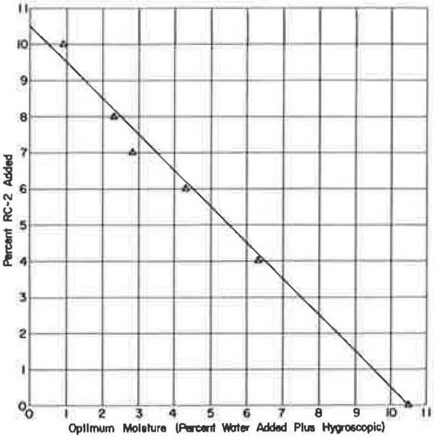


Figure 8. Relation of voids and percentage of RC-2

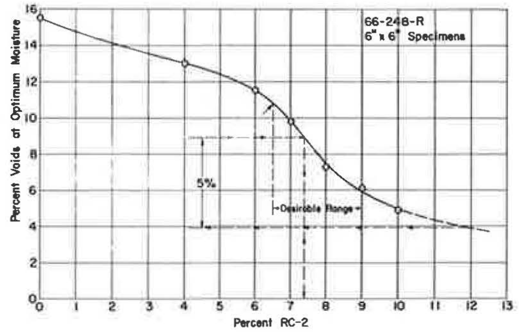


Figure 9. Detrimental effects on specimens containing 6 percent RC-2 when pressure-wet with hot water.

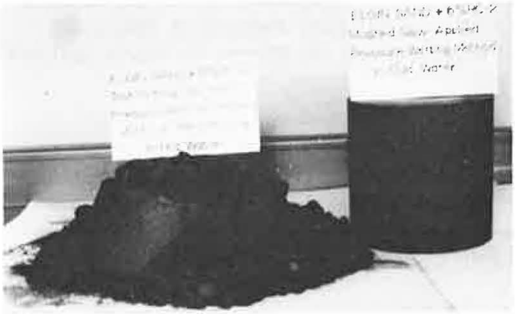


Figure 10. Relation of unconfined compressive strength and percentage of RC-2.

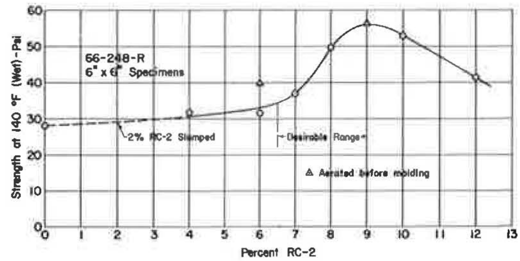
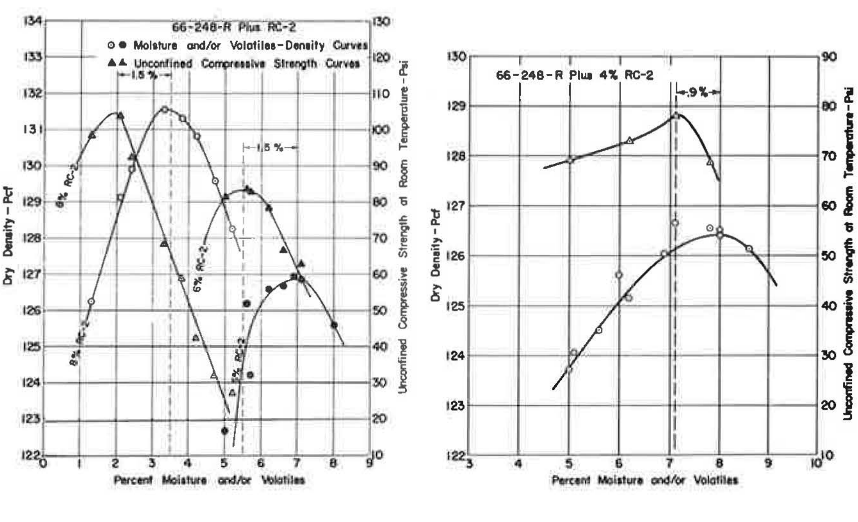


Figure 11. Density-moisture-strength curves (each sample aerated to desired molding moisture content).



aeration of moisture or volatiles or both just prior to compaction be determined. The following simple field test procedure to determine optimum liquid contents for compaction is recommended for use.

1. After field mixing at a liquid content above optimum has been completed, select a 100-lb sample and divide into at least 7 portions of approximately 14 lb each. Place portions where temperature will fluctuate very little.
2. Mold one sample, which has not been aerated, in the gyratory press and determine density as previously described.
3. Place remainder of portions on trays and aerate in the sun or by stirring under a fan until various increments of water and volatiles have been removed and then compact in gyratory compactor.
4. Repeat step 3 for various portions until a moisture-density curve has been completed. (Keep the molding temperature as uniform for all portions as is practical, i.e., ±2 F.)
5. Plot the density data as shown in Figure 11 and select optimum liquid content.
6. When the field mixture is aerated to a liquid content between the optimum liquid content mentioned in step 4 and an amount not to exceed 1.5 percent below the optimum, begin rolling.

The data shown in Figure 11 indicate that compaction at moisture or liquid contents of 0.9 to 1.5 percent below optimum will produce maximum apparent unconfined compressive strengths. There may be some cases where this rule does not apply and, in such cases, both densities and strengths should be determined in the field, and temperatures should be kept as uniform as practical, i.e., ±2 F. [Similar procedures such as that of Marais (3) have been proposed.] Additional samples molded at optimum moisture, air-dried 5 days, and pressure-wet were equally as strong as those molded at a liquid content of 1.5 percent below optimum.

SUMMARY

It is believed that we are beginning to develop some test procedures that can help evaluate soil-bituminous mixtures, inasmuch as they appear to have a realistic approach to determination of the role that the percentage of stabilizer, moisture, volatiles, curing, and compaction play in the building of soil-asphalt bases.

RECOMMENDATIONS

It is recommended that the proposed procedure be used to test several soils of varying characteristics when mixed with several types of asphalt stabilizers. After obtaining these results, we should be able to write adequate test procedures and specifications for construction of soil-asphalt subbases and bases.

ACKNOWLEDGMENTS

The author is indebted to many who have contributed and encouraged the development of this report. The work of the members of the Soils Section and other members of the Materials and Tests Division of the Texas Highway Department, under the able guidance of A. W. Eatman, is gratefully acknowledged. The major factors in making this report possible consist of performance of tests and contribution of advisory consultations by A. W. Smith, C. E. O'Dell, and Clarence Stark of the Soils Section.

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