Full-Scale Asphaltic Construction in the Research Laboratory

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The broad gap between research on asphaltic concrete specimens prepared in laboratory bench-type equipment and test roads or public highways has been narrowed by providing full-scale paving equipment in a research facility. This facility permits asphaltic concrete pavement construction under conditions of control which cannot be reached in field operations. The use of this equipment is described. Controls for all major construction variables are described and special techniques are detailed where appropriate. Methods include: large-scale aggregate handling, screening and gradation blending to laboratory tolerances; realistic drying and mixing, with close temperature controls; accurate measurement and recording of hot-mix temperatures throughout the mixing, placing, and rolling cycle; controlled steel- and rubber-wheeled compaction; sampling techniques for evaluation tests.

● WHENEVER something new appears, it is probably the result of a determined, well-planned research and development effort. If these developments are to be made rapidly and efficiently, the progress through the normal research sequence, from fundamental and exploratory to development, and finally to the field, must proceed without bogging down. The transitions between the early phases are straightforward, although they may require great effort and ingenuity.

The gap between the laboratory and the field is another matter. It is often the major obstacle limiting progress, although a large effort may be made to span it. Progress in asphalt paving research has been limited in this way; and the subject of this discussion is the progress in overcoming the problem.

Before a development is field tested, it should be explored by laboratory tests correlated with field performance. However, this is not always possible because correlated tests are not available. Even with good correlation, the test method may be questionable under any conditions except precisely those used in the correlation.

Sometimes it is impossible to develop a correlation because field conditions contain unknown factors not included in the test method. In this case, the development state in the laboratory is minimized in favor of development work in the field. However, this method also has serious disadvantages. For example:

1. The cost may be prohibitive because of the size or number of tests that must be made to give significant answers.
2. It may be impossible to cope with the uncontrollable or unknown variables.
3. Most field tests should be successful: failures are not good for public relations.
4. Field testing is slow and the rate of progress may not be fast enough.

A third alternate is to turn to functional tests which simulate field conditions as closely as possible under controlled conditions. An example of this is the successful use of test engines by the lubricating oil researchers.

This way has been chosen to bridge the gap between asphalt concrete (AC) laboratory work and field testing of finished pavements. The method is a stepping stone similar to the pilot plants used to develop large-scale chemical plant designs. It consists of making test sections with a small-size, full-scale hot mix plant and paving facilities in order to learn more about the methods of constructing AC pavements. Most of the problems connected with field testing are removed by controlling carefully all of the variables, including climatic conditions. The scale is large enough to prevent similtude problems. Figure 1 shows procedure used for this work.

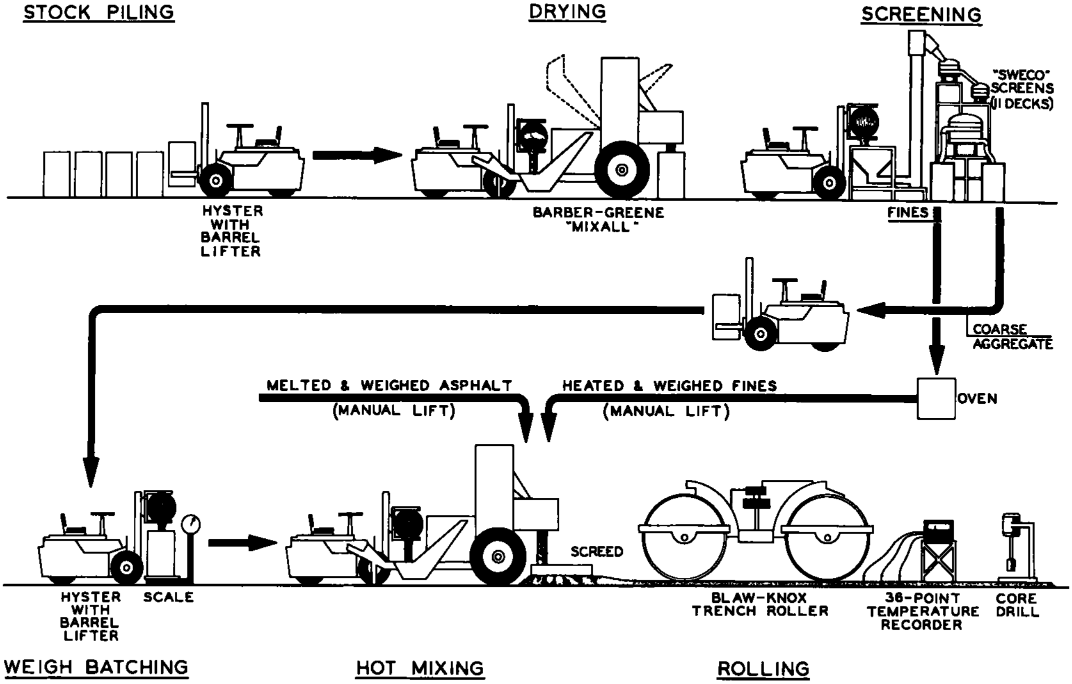

Figure 1. Construction of experimental asphalt pavements.

PROCEDURE USED

As indicated in Figure 1, the aggregates and hot mix are handled in steel drums by a lift truck equipped with hydraulically-operated barrel clamps. The aggregate is dumped directly from trucks into openhead drums and, if required, dried in a mixer. After cooling, it is screened into a number of separate sizes and, as needed, accurately recombined into individual, 300-lb batches. After an individual batch is preheated in the dryer, it is mixed with the required amount of hot asphalt and filler in the pug mill. The resulting batch of hot mix is screeded onto the test area and, along with several other batches, rolled with a trench roller. The temperature of the mix and base is automatically recorded throughout the paving operation. Tests are made both on the finished pavement and on the cores taken with a diamond drill.

CHOICE OF MAJOR EQUIPMENT

Commercially, aggregates are handled by conveyors and hoppers. However, this requires separate equipment at each step and the sequence is not easy to change. For the current purpose it was found best to handle all aggregate and hot mix in openhead drums carried about with a lift truck. In addition to being the lowest cost alternative, this method gave the greatest versatility in operations. The principal requirements on the lift truck were concerned with its ability to pick up an openhead drum of aggregate weighing 1,000 lb, transport it to another location, and pour it into a hopper. The lift truck shown in Figure 2, equipped with hydraulically-operated barrel clamps and a tilt mechanism, met these requirements.

One of the main problems in making experimental pavements is the accuracy with which aggregate gradings in mixes are reproduced. To do this, it is first necessary to screen the aggregates into a number of cuts and recombine them into separate batches. The screens used for this purpose should run continuously without having to change screen sizes at intervals and recycle the fine cut. Also, to keep the cost at a minimum the screens should be operated in series with only one feed elevator. Three screening units, each containing three or four screens (Fig. 3) fill these requirements. The top two units are of 12 in. diameter; the bottom one, handling the fine gradings, of 24 in. diameter. Aggregates can be separated into as many as eleven cuts in one operation with this unit.

It is most important to reproduce the action occurring in commercial hot mix plants as closely as practical to avoid problems of similitude. The dryer should be of the same type as in a commercial plant, large enough in diameter to give the same aggregate wear, and fired with an adjustable open flame. Dust recovery and recycle are needed features on the plant; and the pug mill should be the heat-jacketed, twin-shaft type used in practice. Accurate control of aggregate and mix temperatures is of prime importance. The mixer shown in Figure 4 met these requirements after modifications had been made to collect the dust and to control the temperature of the mix.

The first requirement of the roller was that it be full size and weight so there would be no question of the functional value of the tests. Second, it should have two roller wheels arranged in such a manner that one roller at a time can be used; yet the second wheel must be easily interchangeable with the first on the test area within a minute's time so that more than one wheel can be used in a test. In addition, it should be possible to change the diameters and weights of the two wheels in a few hours without special facilities. The trench roller shown in Figure 5 meets these requirements. The front and rear pair of wheels steer separately so the roller can be operated with one set of wheels offset from the other. As shown in Figure 6, this permits one wheel to run alongside the test area on a ramp while the other wheel is on the test section. Adjustment of the steering permits an interchange of the wheels.

SPECIAL FEATURES

The mixer was modified to prevent excess dust loss and to allow good control of the final mix temperature. As shown in Figure 4, the flue and pug mill are completely hooded and discharged through a mechanically-driven centrifugal dust collector that returns the dust to the dryer or to a container as desired.

The thermocouples in the pug mill and in the dryer permit close control of the final mix temperatures provided the firing rate is carefully controlled by means of the flowmeter on the fuel supply. A thermocouple is imbedded in the wall of the pug mill and another extends into the mix. The thermocouple in the dryer is contained in a small chute which collects aggregate as it drops from the top of the rotating drum. This arrangement (Fig. 7) was required to prevent the thermocouple from sensing the temperature of the hot gases in the dryer instead of the temperature of the aggregate.

The wheels on the roller can be preheated by bubbling steam through the water or barium sulfate slurry used for ballast. This reproduces wheel temperatures experienced when a roller has been heated by high air temperatures and by the hot mix being rolled. Pneumatic compaction can be obtained on the experimental test sections by turning the roller end for end and using the pneumatic tires on the outrigger wheels. Tires of either 13.00-24 or 7.50-15 size are used.

The temperature profile in the mix before and during rolling is found from thermocouples buried at different levels in the mix. A special probe containing three thermocouples (Fig. 8) allows a temperature to be recorded at three levels simultaneously. One or more of these probes is inserted in each section being tested. In addition, thermocouples are permanently imbedded in the base at several levels. An example of a set of measurements taken during an experiment is shown in Figure 9.

The rate of heat loss from the unrolled hot mix on the test section can be controlled in several ways, thus simulating different weather conditions. The base may be preheated with a portable oven (Fig. 10), or cooled with dry ice to reproduce base temperatures found in the field. Alternatively, an insulating layer of paper or plywood may be put on the base to restrict the rate of heat loss, thus simulating the effect of a preheated base. The rate of cooling from the top surface is controlled by canvas, glass wool, or by pieces of plywood. The rate of heat loss is adjusted to reproduce the same temperature profiles previously measured under different weather conditions on mixes about to be rolled in the field.

Figure 2. Lift truck pouring hot mix from drum into screed box.

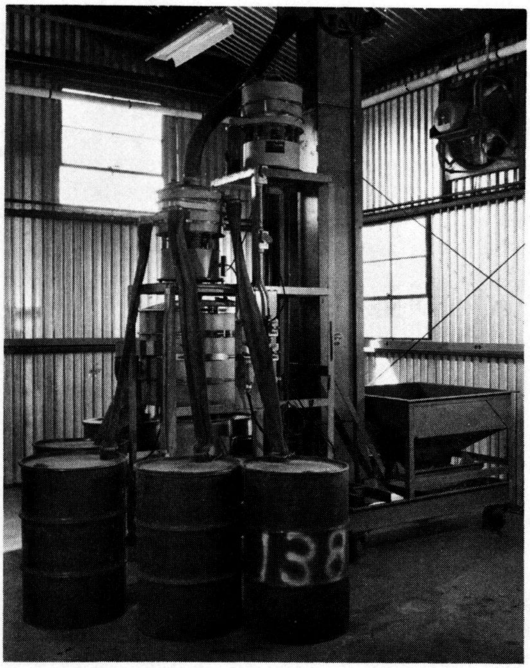

Figure 3. Screening facilities.

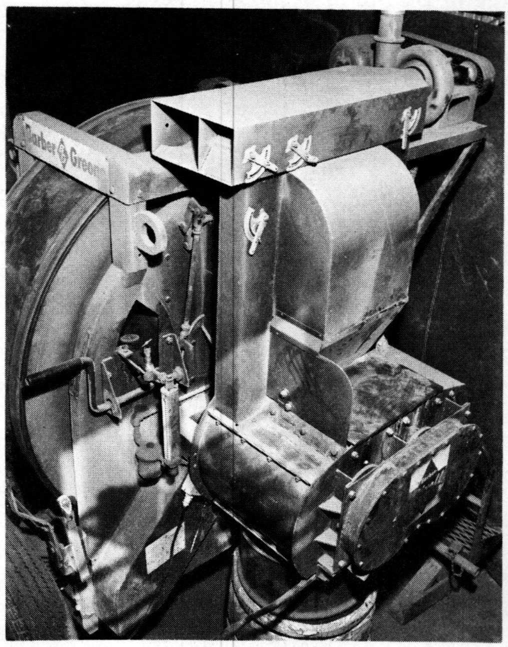

Figure 4. Hot mix plant and dust recovery system.

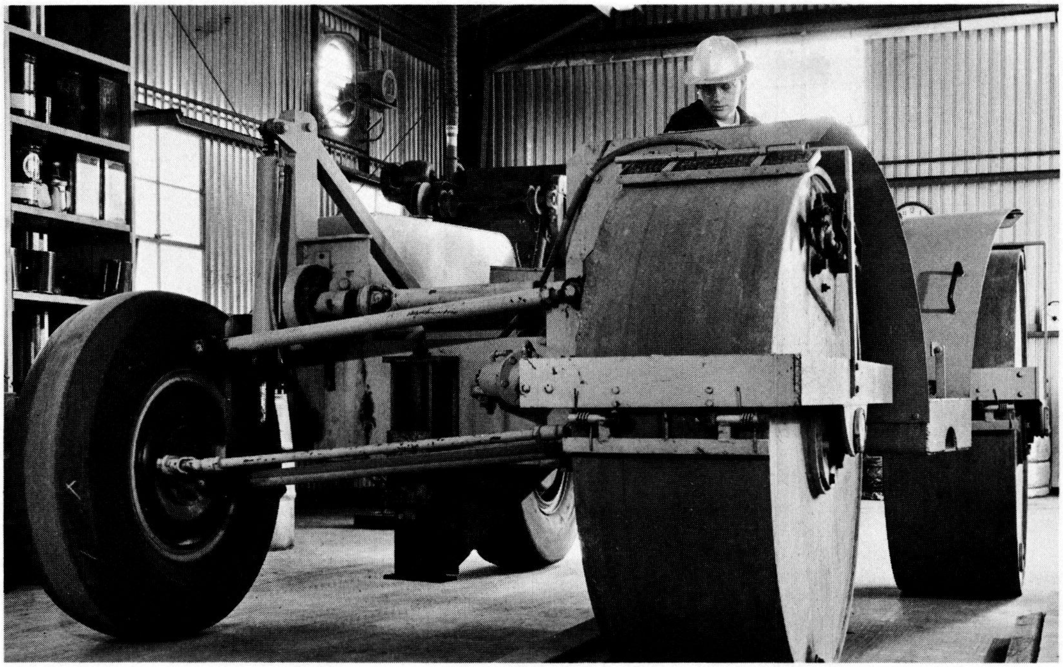

Figure 5. Experimental roller.

Figure 6. Rolling an experimental test section.

Although the equipment is normally housed and used in the building (Fig. 11), it is portable and can be moved into the field where experimental test sections can be made for traffic and durability studies.

The thickness of the AC being rolled is accurately controlled by the height of the screed with respect to the guiderails. This height is easily changed and can be continously varied by using tapered guiderails.

The base on which the experimental pavements are made can be changed to meet the requirements of the experiment. It can be either AC, portland cement concrete, crushed rock, or, if desired, a resilient or unstable base.

PRELIMINARY OPERATION

It has been possible to study as many as six different mixes or rolling temperatures simultaneously in one experiment; at the same time, two different roller weights or two degrees of rolling were also studied.

The temperature of hot mix delivered from the pug mill is within $\pm$ 5 F of the desired temperature; and by proper scheduling, rolling temperatures within $\pm$ 10 F of the desired temperature are obtained.

Before experimental pavements are

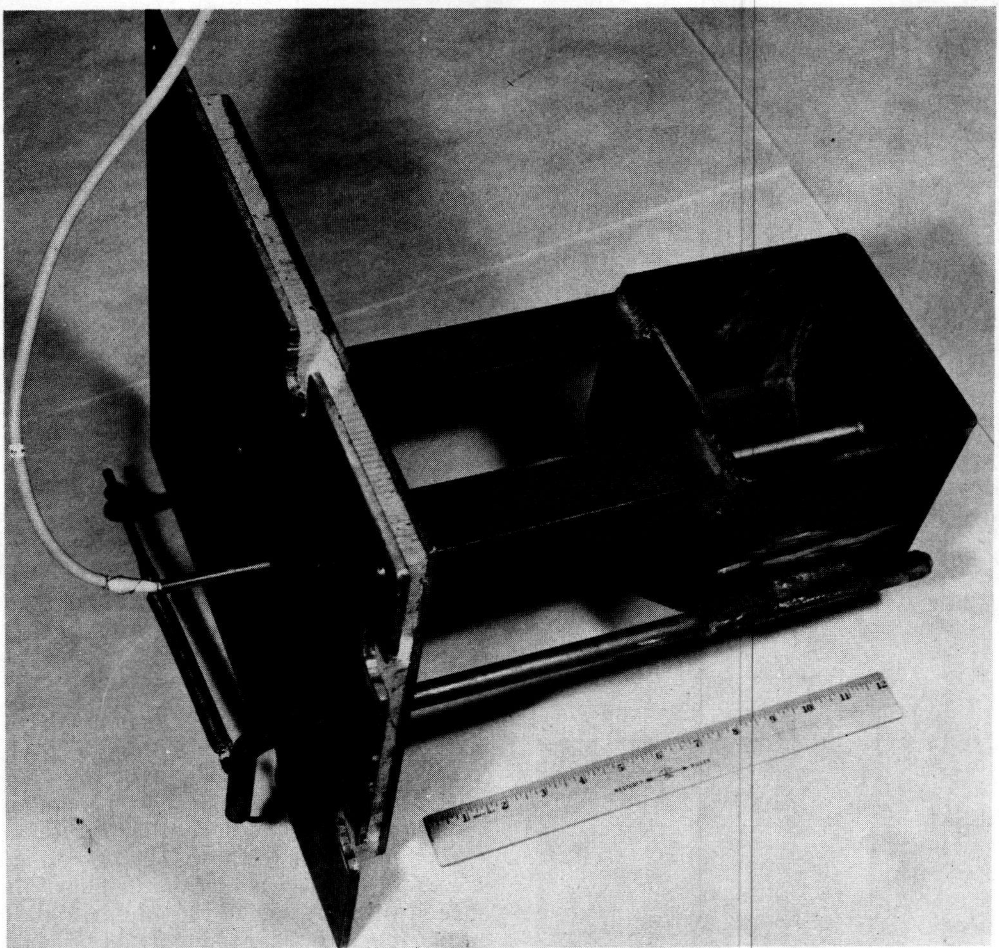

Figure 7. Continuous sampler (contains thermocouple) for sensing aggregate temperature in drier.

cored, they may be photographed, tested for softness, and their permeability measured. The cores may be tested for density, permeability, or stability by the Marshall or Hveem methods. Sometimes Abson extractions are made on the cores and on samples of the hot mix taken for this purpose.

The reproducibility is good, as indicated by the core densities shown in Table 1, which compares cores taken from two separate but closely controlled experiments. A similar spread in individual core densities is found on most field corings. However, when sections are cored to the extent shown in Figure 12, statistically meaningful comparisons may be made.

Examples of the kind of work possible with these facilities are described in another paper ("Behavior of Hot Asphaltic Concrete Under Steel-Wheel Rollers") in this bulletin, and in a report (1) given elsewhere on observed peculiarities in determining core densities.

No completely satisfactory comparison with field construction has been made because of the paucity of precise data on typical projects. The field conditions and results are difficult to establish and control, except on very special occasions. Nevertheless, the

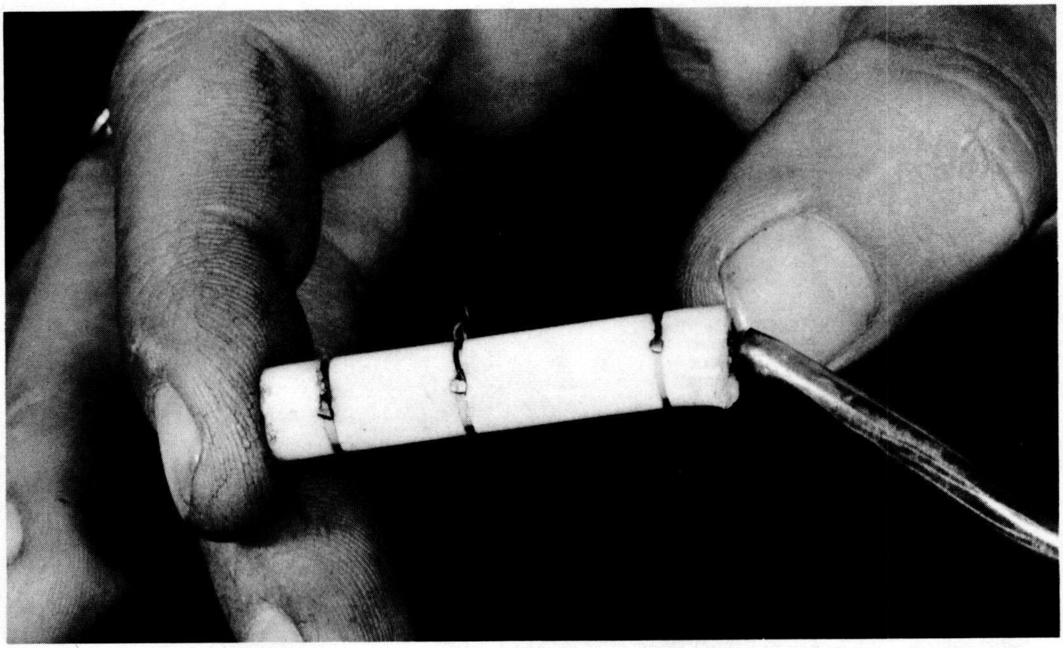

Figure 8. Three-level thermocouple prcbe.

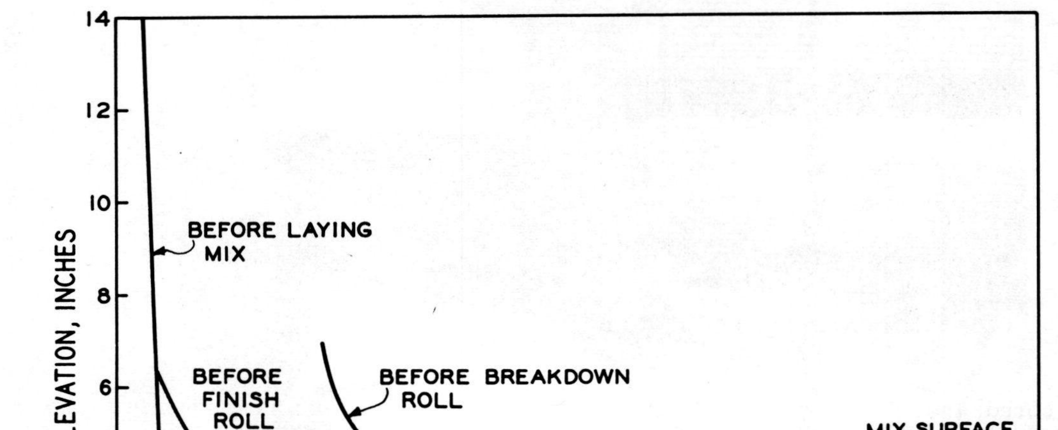

Figure 9. Variation in temperature during rolling of hot asphalt concrete.

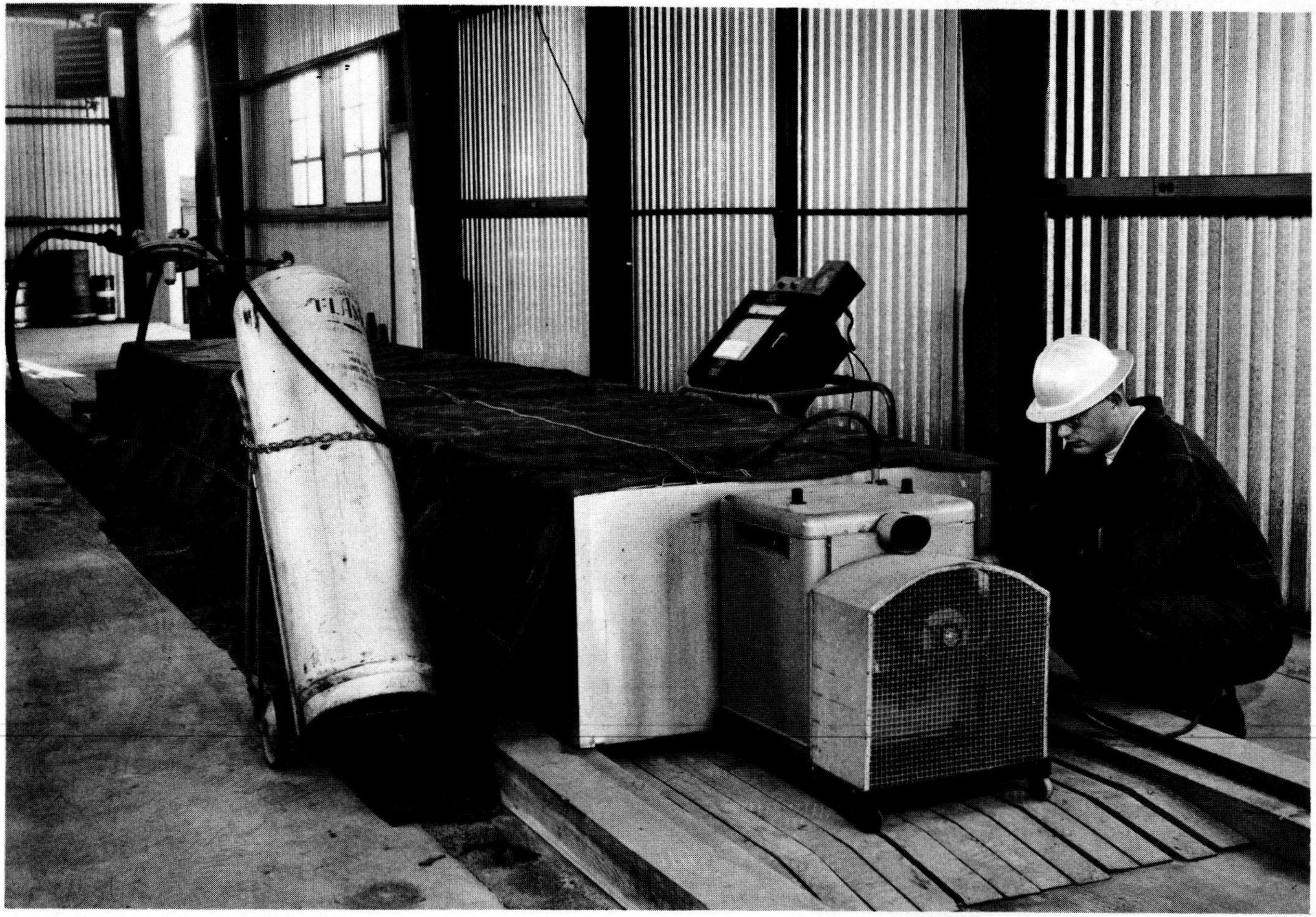

Figure 10. Preheating the base.

Figure 11. Interior of full-scale paving research laboratory.

TABLE 1

PAVEMENT EVALUATION DATA SHOW COMPARABLE RESULTS FOR EQUAL CONSTRUCTION PROCEDURES

Item	Test 01-10A	Test 01-10C
Aggregate	Cache Creek Gravel	
Grading	WB - dense	WB - dense
Asphalt	B-14277	B-14277
Asphalt added (%)	5.60	5.63
Asphalt extracted (%)	5.57	5.66
Extracted pen. at 77 F	45-44-44	44-45-45
Mixing temp. (F)	352	340
Breakdown temp. (F)	263	262
Roller passes:		
400 lb/lin in.	6	6
Pneumatic	4	4
300 lb/ lin in.	2	2
Core Densities (pcf):		
1	140.07	139.11
2	140.94	140.67
3	140.81	140.51
4	140.37	140.75
5	142.15	142.02
6	140.66	141.69
Average	140.83	140.79

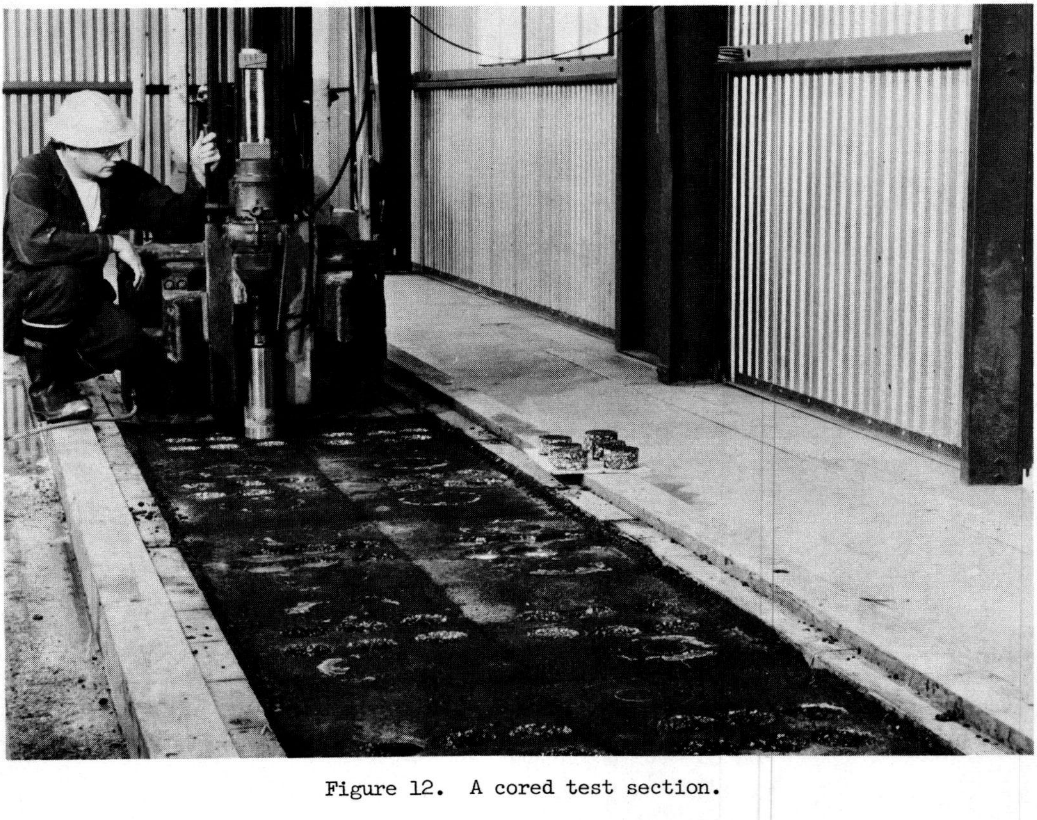

Figure 12. A cored test section.

experiments on construction behavior of hot mixes made with these facilities are giving information that is being applied directly to field problems without intermediate field testing. The procedures used are realistic and carefully controlled so there is more confidence in them than in the full-scale field tests.

REFERENCE

1. Hein, T.C., and Schmidt, R.J., "Density Changes in Asphalt Pavement Core Samples." Preprint, ASTM Annual Meeting, Atlantic City, N. J. (June 21-26, 1959).