DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING SERVICES
Transportation Laboratory
5900 Folsom Blvd.
Sacramento, California 95819-4612

DETERMINING THE IN-PLACE DENSITY AND RELATIVE COMPACTION OF ASPHALT CONCRETE PAVEMENT

CAUTION: Prior to handling test materials, performing equipment setups, and/or conducting this method, testers are required to read "**SAFETY AND HEALTH**" in Part 6 of this method. It is the responsibility of the user of this method to consult and use departmental safety and health practices and determine the applicability of regulatory limitations before any testing is performed.

OVERVIEW

This test method is used when determining the average in-place density and relative compaction of asphalt concrete (AC). It may be applied to AC which has a compacted thickness of at least 30 mm. All test data and related information is recorded on Form TL-3112.

This test method is divided into the following parts:

1. Standardization and Calibration of the Nuclear Device in the Backscatter Mode
2. Correlation with Core Densities
3. Test Site Selection
4. Determining In-Place Density by the Nuclear Device
5. Determining Test Maximum Density (FTMD)
6. Calculating Relative Compaction

Readings taken with a nuclear device can be influenced by other objects, and especially other nuclear sources in the immediate area. The device must be at least 1.5 m from any object and at least 7.6 m from any other nuclear source unless appropriately shielded.

PART 1. STANDARDIZATION AND CALIBRATION OF THE NUCLEAR DEVICE IN THE BACKSCATTER MODE

A. SCOPE

Proper maintenance and calibration of the nuclear density device are essential to acquiring reliable measurements of the in-place density of compacted asphalt concrete. This part of the test method adds specific minimum requirements to the standardization and calibration procedures suggested and/or recommended by the device manufacturer.

B. APPARATUS

1. Nuclear device designed to determine the density of material by the backscatter method. The device shall contain:

   a. A sealed high-energy gamma source such as cesium or radium.

   b. A gamma detector such as a Geiger-Mueller tube(s).

   c. An electronic counting device capable of recording the amount of gamma radiation reaching the gamma detector during controlled periods of time.

2. Reference standard provided by the manufacturer.

3. Calibration standards.

   a. A set of three or more standards having a range in densities that spans the expected density of the asphalt concrete to be tested.

   b. The standards shall be rectangular in shape with smooth surfaces of sufficient size to not change the count rate if enlarged in any dimension. Dimensions of approximately 610 mm long by 430 mm wide and a minimum depth of 230 mm have proven satisfactory.

   c. Calculate the density of each standard using the measured volume and mass of the standard.

   d. Acceptable standards include:

      (1) Standards made of nonsoil materials which have been calibrated per CT 111.

      (2) The set of six Caltrans Standard Density blocks maintained by Caltrans at the Transportation Laboratory in Sacramento.

      (3) Standards made of nonsoil materials which are available from the manufacturers of nuclear density devices and traceable to NIST.

C. GENERAL REQUIREMENTS AND PRECAUTIONS

1. Follow the manufacturer's instructions for warm-up and operation of the nuclear device.

2. Each nuclear device should be calibrated annually. The interval between calibrations must not exceed 15 months. Calibrate in accordance with the manufacturer's recommended procedures and any additional requirements stated in this test method.

3. Recalibrate nuclear devices when the standard count exceeds the range shown on the most recent count-ratio/density table or the range preset in the device and after the replacement or adjustment of any component except batteries. The operator must ensure that the device is within the appropriate calibration parameters.

4. During the annual calibration of a device, compare the standard count, the average count on each block, and the count-ratio for each block with the values determined during the previous calibration. Any changes in count or count-ratio which do not coincide with the changes expected from normal decay of the nuclear source are cause for concern. If this occurs, take whatever steps are necessary to confirm that the new values are correct.

   NOTE: Prolonged high temperatures may adversely affect the instruments electronics (usually indicated by a lack of display).

D. DETERMINING STANDARD COUNT

Determine the standard count for the nuclear device at the beginning of each days testing.

1. After the warm-up, and with the source rod in the “safe” position, take twelve 1-min counts or three 4-min counts and record these readings in the log book for the device.

2. Average the twelve 1-min or three 4-min counts to determine the “standard count” for the device. Record the standard count in the log

book and on all test data forms for that days testing.

3. The standard count must be within 3 standard deviations of the standard count-used to prepare the most recent count-ratio/density table or within the range preset in the device. If it is not, establish a new standard count and prepare a new count-ratio/density table or have the device checked and/or repaired.

E. CALIBRATION

Calibrate the nuclear device in accordance with the manufacturer's recommended procedures and the following requirements:

1. Determine the standard count in accordance with Part 1, Step D of this test method.

2. The count readings on each calibration standard will be a minimum of two sets of four 1-min counts or two 4-min counts. When taking 1-min counts, determine the average for each set of four.

3. Prior to taking the second set of four 1-min counts, or the second 4-min count, raise the source rod to the "safe" position and then reset the source rod to the proper test position.

4. If the difference between consecutive 4-min counts or sets of four 1-min counts exceeds 1.0 % of the smaller number, take additional counts until a minimum of three consecutive 4-min counts or sets of four 1-min counts agree within 1.0 %. When applicable, the average of these counts will be used to develop the count-ratio/density table.

5. Repeat Steps 2 through 4 on each of the standards and record the readings on the calibration record form.

6. When applicable, calculate the count-ratio for each standard by dividing the average count (Step E.4) by the standard count (Step D.4).

7. Prepare a calibration data sheet that includes the following information:

   a. Device identification number.

   b. Name of calibrator.

   c. Date of calibration and date when the next calibration is due.

   d. Standard count.

   e. Allowable range in standard count (see Part 1, Step D.5).

   f. Count-ratio and calculated density for each standard.

   g. When applicable, a plot or table of count-ratios versus projected densities based on the count ratios and the calculated densities of the standards.

   NOTE: This calibration data sheet must be available prior to use of the device on a project, and must remain with the device at all times.

8. Affix calibration sticker to the device that shows the identification number of the device, date of calibration and name or initials of the person who performed the calibration.

PART 2. CORRELATION WITH CORE DENSITIES

A. SCOPE

This section contains the procedure used to determine a "conversion factor" through the use of a Test Strip. A conversion factor must be developed for each project. All conversion factor data shall remain with the nuclear device for the duration of the project. Establish a new conversion factor whenever a change in pertinent criteria such as material source, mix design, or recalibration of the nuclear device occurs.

B. TEST STRIP

1. The test strip must be constructed in compliance with the project specifications and the following conditions:

    a. The asphalt concrete must be representative of the material to be placed on the project (binder type and content, aggregate source, type and grading), and have a compacted thickness that is within ± 10 mm of the thickness which will be tested on the job. In no case will the lift thickness be less than 30 mm.

    b. The test strip must be at least 200 m long and one traffic lane wide and be placed on subgrade representative of that on the project.

2. Follow the procedure described in Part 3 of this test method to establish a minimum of ten random test site locations on the test strip.

3. Determine nuclear density values at each of the test sites using the procedure specified in Part 4 of this test method.

4. Obtain a set of two cores (100 to 150 mm in diameter) from within the outlined test position of the nuclear device for each of the test sites. Mark each core to identify the corresponding test location as shown on Form TL-3112. Cores that are damaged during the coring operations must be discarded and replaced by additional cores from the same test site.

5. Determine the density of each core in accordance with California Test 308, Method A.

6. Determine the average core density for each test site. If the two core densities from a site do not agree within .05 g/cc, exclude all the data from this site.

7. Determine the correlation value for each test site by subtracting the average nuclear density from the average core density for the site.

8. Determine the conversion factor(s) as follows:

    a. Compute the average and the standard deviation of the correlation values from the test strip.

$$\overline{\chi_v} = \frac{\Sigma\chi_v}{n}$$

$$S_v = \sqrt{\frac{n\sum\chi_v^2 - \left(\sum\chi_v\right)^2}{n(n-1)}}$$

where:

$\overline{\chi_v}$ = average of correlation values

S_v = standard deviation of the correlation values

$\Sigma\chi_v$ = summation of individual correlation values

$\Sigma\chi_v^2$ = summation of the squares of the individual correlation values

$(\Sigma\chi_v)^2$ = summation of the individual correlation values squared n = number of individual tests

b. If any correlation value varies from the average correlation value by more than two standard deviations at the 95 % confidence level, consider this correlation value statistically invalid and exclude it from the data.

c. If the above procedure results in the exclusion of a correlation value, recompute the average correlation value.

d. The conversion factor is the average of the valid correlation values. If the correlation values from more than three of the ten sites are excluded, repeat steps 2 through 8 in this Part 2, Section B. This conversion factor will be added to the average nuclear device density, Part 4, Step C.11, prior to calculating relative compaction, Part 6, Step 1. Enter this factor on Form TL-3112.

PART 3. TEST SITE SELECTION

A. SCOPE

Reliable test results are dependent on appropriate test site selection. This part of the test method provides a procedure for determining the number and location of test sites to be tested within a contiguous and uninterrupted portion of the pavement.

B. TESTING FREQUENCY

1. Test a minimum of ten sites for each 500 tonnes of asphalt concrete placed.

2. For areas containing less than 500 tonnes, test at the rate of one test site for each 50 tonnes of asphalt concrete placed. No area, regardless of size, should be represented by fewer than five test sites.

C. TEST SITE LOCATION

1. Determine the locations of the test sites using random selection procedures.

2. The following method is an example of an acceptable random selection procedure.

   a. Determine the number of sites to be tested.

   b. Randomly select a block of numbers from either Table 1 or Table 2 depending on the number of sites to be tested.

      (1) Table 1 may be used when ten sites are to be tested. Each set of ten random numbers in this table have been arranged in sequential order of the stationing.

      (2) Table 2 is to be used when the number of test sites is something other than ten. The numbers in this table have not been arranged sequentially in order of stationing. This should be done as the numbers are transferred to the test form.

      (3) The numbers for transverse location will always be in random order.

   c. Beginning with the numbers at the top of each column, use each successive pair of numbers to determine the longitudinal and transverse distance to each test site.

   d. Arrange the pairs in sequential order of the numbers in the left column and record the numbers on Lines E and F of Form TL-3112.

e. Multiply the numbers on Line E by the length of the pavement to be tested and round up to the next whole number to determine the distance from the starting point. Add the distance from the starting point to the beginning station to determine the station of the test site.

f. Multiply the numbers on Line F by the width of the pavement to be tested. Round the product to the nearest 0.5 m to determine the transverse distance from the edge of the pavement being tested. Any test site within 0.5 m of the pavement edge should be relocated to 0.5 m from the edge.

g. Reference all test sites to identifiable locations; e.g., stationing, edge of pavement, centerline, etc.

PART 4. DETERMINING IN-PLACE DENSITY BY THE NUCLEAR DEVICE

A. SCOPE

This part of the test method describes the appropriate procedures for preparing the test site and taking the reading with a nuclear device.

B. APPARATUS/MATERIAL

1. A calibrated nuclear device with an appropriate conversion factor established for the project material determined in accordance with Part 2 of this test method.

2. Sand that passes a 600-µm sieve obtained from the aggregate blend used for the AC.

3. A straightedge approximately 350 mm long.

4. A distance measuring system capable of locating test sites to the nearest 0.5 m.

C. DETERMINING IN-PLACE DENSITY

1. Determine the test site locations using the procedure in Part 3 of this test method. Observe the surface texture of the pavement. If the surface texture is not representative of the overall pavement surface or if the nuclear device cannot be seated because of irregularities on the pavement surface, then select an alternate test site 3 m forward in the longitudinal direction, keeping the same transverse location.

2. Fill any surface voids with sand passing a 600-µm sieve. Pour a small amount of the sand over the test site. Use a straightedge to work the sand into the surface until the voids are filled and the surface is smooth. Remove excess sand.

3. Place the nuclear device on the test site with its long axis aligned parallel to traffic, and seat it on the pavement by applying a light vertical pressure while working the device back and forth in a short horizontal arc. Press the device on each corner to make sure it is adequately seated and does not rock.

4. Lower the source rod to the appropriate position or set the gage in the appropriate mode for the AC thickness being tested. Use the thin layer mode in lieu of the backscatter mode when using multi-purpose gages such as the Troxler Model 3450 to test AC less than 60 mm thick. The thickness entered into the gage should be the design thickness minus 5 mm. Do not use the "AC" position even if the device is so equipped.

5. Obtain a 1-min count. Record this reading on Form TL-3112. Retract the source rod.

6. Use a marker to outline the base of the device on the pavement immediately after the first reading is taken. Turn the device 180 degrees and place it precisely over the initial test position as indicated by the markings on the pavement. Repeat Steps 4 and 5 above.

7. Repeat Steps 1 through 6 at each test site.

8. For each 1-min count, calculate the count-ratio and determine the density. Record the result to the nearest 0.01 g/cc on Form TL-3112.

   NOTE: Recording the count and calculating the count-ratio is not necessary for devices that are designed to display the density directly.

9. If the two density measurements at a test site do not agree within .05 g/cc, repeat Steps 2 through 7 at the same site until a set of two measurements that agree within .05 g/cc is obtained. If after three attempts a set of density measurements that agree within 0.05 g/cc has not been obtained, select and test a new site 3 m forward in the longitudinal direction and at the same transverse location.

10. Average the two densities from the same site and record the result to the nearest 0.01 g/cc on Form TL-3112.

11. Calculate the average density for the test area by averaging the results from each of the test sites.

12. Apply the proper conversion factor determined in Part 2, Step 8. Record this result for use in calculating the relative compaction, Part 6.

PART 5. DETERMINING TEST MAXIMUM DENSITY

A. SCOPE

The test maximum density TMD is the standard for evaluating the compaction achieved on the roadway. Two procedures are provided, a laboratory procedure (LTMD) and a field procedure (FTMD). The FTMD is normally slightly lower than the LTMD, so a procedure is provided to develop a correlation factor which makes it possible to use the FTMD to calculate relative compaction.

B. APPARATUS

1. Laboratory Procedure.

   a. The required equipment is described in Part 2 of California Test 304 and California Test 308 (Method A).

2. Field Procedure.

   a. Sampling equipment including containers, a square-point shovel and metal buckets (with a capacity of approximately 20 L).

   b. A compression device capable of applying and maintaining a total static load of 133.4 kN. The upper and lower platens shall be in a fixed horizontal position parallel to one another. The loading ram shall have a stroke length of at least 100 mm and when fully retracted the clearance between the upper and lower platens shall be at least 350 mm. The device shall include a pressure control and monitoring system which allows the static load to be gradually increased from 0 to 133.4 kN over a period of approximately 30 s. The hydraulic jack and loading frame shown in Figure 1 are acceptable.

c. Compaction molds and accessories:

(1) Compaction molds (three required) that have an inside diameter of 101.6 ± 0.05 mm and an outside diameter of 114.05 ± 1.3 mm and a height of approximately 127 mm. The stainless steel molds used for California Test 304 meet these requirements.

(2) A bottom plunger that has an outside diameter of 100.33 ± 0.13 mm and a height of 38 ± 3 mm and is attached to a base plate approximately 130 mm in diameter and 6.5 mm thick.

(3) A top plunger that has an outside diameter of 100.33 ± 0.13 mm and a height of approximately 150 mm.

(4) A spacer that conforms to the dimensions in Figure 2.

(5) An extraction sleeve that conforms to the dimensions in Figure 3.

NOTE: Other sample extraction devices may be used if they do not damage or distort the test specimen.

d. A balance or scale with a capacity of at least 15 kg and an accuracy of 1 g or less that is equipped to weigh the test samples, both in air and while immersed in water, as shown in Figure 4.

e. Miscellaneous accessories including splitting or quartering equipment, gloves, spatula, funnel, scoop, sample weighing container and a thermometer to measure bituminous mix at approximately 100°C.

C. SAMPLING

1. Follow the procedures in California Test 125 to obtain a representative sample of AC.

2. Samples obtained for fabrication in the field should have a mass of approximately 22 kg and be placed in a covered metal bucket to aid in maintaining temperature during transport and fabrication.

D. TEST FREQUENCY

1. Obtain a representative sample of AC from each days production.

2. When daily production exceeds 4500 tonnes, obtain additional representative samples from each 4500 tonnes or portion thereof.

3. Determine the LTMD at least once at the beginning of a project and at any time there is a change in the AC mix.

4. Determine either the LTMD or FTMD of each daily sample.

5. Testing for TMD may be waived for selected daily samples providing each of the following conditions are met:

   a. Five consecutive TMDs do not differ by more than 1 % from their average.

   b. At least one sample is tested for TMD every five paving days, and the TMD of each tested sample does not differ from the average of the previously tested samples by more than 1 %.

   c. Untested TMD samples are retained for subsequent testing if needed.

6. TMDs determined for test strips may be used as daily TMD tests and may be included in the average of

TMD determinations during regular production.

E. LABORATORY PROCEDURE FOR FABRICATING TEST SPECIMENS AND DETERMINING LABORATORY TEST MAXIMUM DENSITY (LTMD)

1. Compact five test specimens from each sample by following the procedures for making stabilometer test specimens in California Test 304. Do NOT include the 15-h curing period specified in “Preparation of Field Control Samples” of California Test 304.

2. Determine the specific gravity of each compacted specimen to the nearest 0.01 g/cc by following the procedures in California Test 308, Method A.

3. Determine the LTMD of the sample to the nearest 0.01 g/cc by averaging the specific gravity values of the five individual specimens.

F. FIELD PROCEDURE FOR FABRICATING TEST SPECIMENS AND DETERMINING FIELD TEST MAXIMUM DENSITY (FTMD)

1. Place a compaction mold on the base and insert a U-shaped spacer between the bottom of the mold and the foot of the base.

2. Place a manila disc in the bottom of the mold.

3. Place the funnel on the mold.

4. If the temperature of the AC sample is 95°C or above, proceed to Step 5. If not, heat the sample in an oven to achieve 100 ± 5°C, then proceed to Step 5.

5. Using a scoop, dip out the appropriate amount of AC based on the following table and immediately place the material into the compaction mold. Use the spatula to work the material into the mold and even out the surface, then remove the funnel.

Specific Gravity of Compacted AC	Mass of Test Portion
Over 2.30	1200 ± 10 g
2.20 - 2.30	1150 ± 10 g
Under 2.20	1100 ± 10 g

6. Place a manila disc on the material in the mold and then seat the follower ram on the disc, taking care to align the follower ram so that it does not contact the top edge of the mold.

7. Position the compaction mold assembly in the compression device as shown in Figure 5.

8. Gradually apply an initial static load of approximately 22 kN, then release

   the initial load and remove the U-shaped spacer.

9. Gradually increase the load over a period of approximately 30 s until a total static load of 133.4 kN is achieved. Hold this total load for 1 min and then slowly release the load.

10. Refer to Precautions and Adjustments in H below before compacting subsequent test specimens. Repeat Steps 1 through 9 until three test specimens have been compacted.

11. Allow the compacted test specimens to cool sufficiently to prevent distortion before removing them from the compaction mold (see Precaution H.3 below).

12. Push the test specimen from the mold using any system that will not damage or distort the specimen. The compression device and follower rams can be used to push the test specimen into the extraction sleeve as shown in Figure 6.

13. Determine the density of each test specimen to the nearest 0.01 g/cc in accordance with the procedures in California Test 308, Method A. Method C is permissible when a correlation is established and a correction factor is applied as follows:

    a. A minimum of three test specimens from the same sample are to be tested by Method A and Method C.

    b. The difference between the average value determined by Method A and the average value determined by Method C is the correction factor to be applied to subsequent Method C test results.

    c. Verify the correction factor periodically and at any time there is a change in the source or grading of the aggregate or a change in the target asphalt content.

14. Determine the FTMD of the sample to the nearest 0.01 g/cc by averaging the specific gravity values of the three individual test specimens.

G. CORRELATION FACTOR

1. At the beginning of each project and whenever a new LTMD is determined, establish a correlation factor to adjust the FTMD values to correspond with the LTMD values.

2. Obtain a representative sample as instructed in California Test 125.

3. Split or quarter the sample into two representative portions. Submit one portion to the laboratory to determine the LTMD. Use the remaining portion to determining the FTMD.

4. Compact a minimum of five test specimens using the laboratory procedure and five using the field procedure.

5. Determine the density of each specimen to the nearest 0.01 g/cc in accordance with the procedures in California Test 308, Method A.

6. Calculate the average specific gravity for each compaction procedure to the nearest 0.01 g/cc.

7. Divide the LTMD by the FTMD. This value is the correlation factor to be applied to subsequent FTMD values to provide an estimated LTMD value.

H. PRECAUTIONS AND ADJUSTMENTS

1. Preparation and compaction of the test specimens must be done in a timely manner to avoid excessive heat loss.

2. The U-shaped spacer is used during initial loading to allow compression of the test specimen from both ends as it is loaded to 133.4 kN. If the mold makes contact with the base of the bottom plunger before the 133.4 kN load is achieved, discard the specimen and increase the initial load applied prior to removing the spacer for subsequent specimens.

3. Rubberized asphalt concrete must be supported in the mold until the test specimen has cooled. This can best be accomplished by pushing the compacted specimen to the end of the mold immediately after compaction and then allowing the bottom surface to rest on the counter or table top until it cools.

PART 6. CALCULATING RELATIVE COMPACTION

1. Calculate relative compaction (RC) to the nearest 0.1 % as follows:

$$RC = \frac{\text{Average in - place density}}{\text{LTMD}^{(1)}} X\,100$$

(1) or the adjusted FTMD from Part 5, Step G

2. Use the most recent TMD for the project to calculate RC.

3. When the conditions for waiving TMD tests on selected samples are being met, use the average of the five most recent TMD determinations to calculate relative compaction.

PRECISION AND BIAS

Data to establish the following precision statements were obtained from a Caltrans research study reported in Transportation Research Record 1491.

Analysis of these data for a single-operator, single-device and multi-operator, multi-device precision results in the following:

	Density, g/cc	
	Standard Deviation (S)	Acceptable Range of Two Results (D2S)
Single-operator, single device	0.02	0.06
Multi-operator, multi-gage	0.04	0.12

The data consisted of single measurements with the device repositioned after each measurement.

The precision expected for device calibration using multiple counts on test blocks has not been determined, but is expected to be significantly better than that determined using a 1-min count on AC pavements.

Adjusting the measured device densities to correlated core density minimizes any bias.

SAFETY AND HEALTH

Prior to sampling, handling materials, or testing, Caltrans personnel are required to read the entire Part C, Physical Testing, of the Caltrans Laboratory Safety Manual and California Test 121, Administrative Instructions for Use of Nuclear Devices. Personnel should observe the following precautions:

1. Use reasonable care, including wearing heat resistant gloves, when working with hot materials or equipment.

2. Use proper lifting techniques when handling samples and equipment.

3. Exercise caution when assembling and positioning the compaction mold and accessories in the compression device to avoid pinching hands or fingers in the apparatus.

4. When disassembling compaction mold and accessories, exercise care to prevent the ram, base or other internal parts of the apparatus from falling out causing injuries to personnel or damage to the equipment. Users of this method do so at their own risk.

REFERENCES:

California Tests 308, 125, and 304

End of Text
(California Test 375 contains 17 pages)

Table 1

Sequential Random Numbers

0.053	0.730	0.035	0.627	0.231	0.870	0.081	0.137	0.106	0.239
0.081	0.948	0.137	0.163	0.251	0.114	0.285	0.542	0.231	0.291
0.095	0.726	0.164	0.093	0.271	0.505	0.324	0.538	0.253	0.858
0.576	0.482	0.225	0.921	0.396	0.125	0.470	0.414	0.398	0.761
0.609	0.824	0.334	0.417	0.427	0.392	0.522	0.235	0.517	0.463
0.669	0.899	0.356	0.850	0.549	0.760	0.569	0.608	0.640	0.993
0.810	0.159	0.434	0.838	0.690	0.405	0.579	0.977	0.749	0.919
0.892	0.277	0.554	0.375	0.860	0.507	0.751	0.592	0.904	0.501
0.971	0.468	0.576	0.155	0.935	0.806	0.815	0.787	0.986	0.131
0.982	0.801	0.794	0.638	0.997	0.884	0.879	0.871	0.998	0.222
0.068	0.095	0.109	0.548	0.021	0.887	0.100	0.472	0.335	0.683
0.165	0.459	0.127	0.964	0.150	0.169	0.123	0.086	0.348	0.996
0.371	0.996	0.209	0.064	0.159	0.979	0.396	0.355	0.358	0.743
0.470	0.535	0.412	0.356	0.289	0.187	0.423	0.460	0.601	0.595
0.477	0.101	0.587	0.284	0.448	0.894	0.673	0.652	0.698	0.539
0.509	0.815	0.622	0.862	0.654	0.169	0.817	0.259	0.740	0.466
0.566	0.342	0.667	0.843	0.767	0.985	0.833	0.317	0.796	0.212
0.788	0.682	0.757	0.283	0.919	0.962	0.890	0.665	0.864	0.069
0.874	0.242	0.831	0.908	0.942	0.313	0.925	0.404	0.896	0.247
0.901	0.420	0.873	0.218	0.947	0.215	0.928	0.305	0.909	0.326
0.009	0.663	0.157	0.077	0.263	0.239	0.104	0.265	0.058	0.284
0.153	0.592	0.181	0.269	0.369	0.117	0.205	0.217	0.082	0.802
0.399	0.928	0.331	0.447	0.428	0.491	0.441	0.307	0.195	0.146
0.551	0.772	0.503	0.137	0.454	0.333	0.619	0.879	0.220	0.696
0.564	0.875	0.552	0.574	0.659	0.364	0.716	0.755	0.425	0.887
0.629	0.721	0.614	0.486	0.666	0.731	0.798	0.107	0.428	0.075
0.732	0.508	0.638	0.666	0.759	0.998	0.830	0.649	0.432	0.659
0.800	0.420	0.665	0.606	0.865	0.463	0.890	0.841	0.631	0.422
0.892	0.310	0.721	0.933	0.870	0.176	0.917	0.262	0.892	0.391
0.937	0.975	0.914	0.150	0.945	0.390	0.994	0.446	0.919	0.939

Table 2

Table of Random Numbers

0.576	0.730	0.430	0.754	0.271	0.870	0.732	0.721	0.998	0.239
0.892	0.948	0.858	0.125	0.935	0.114	0.153	0.508	0.749	0.291
0.669	0.726	0.501	0.402	0.231	0.505	0.009	0.420	0.517	0.858
0.609	0.482	0.809	0.140	0.396	0.095	0.937	0.310	0.253	0.761
0.971	0.824	0.902	0.470	0.997	0.392	0.892	0.957	0.640	0.463
0.053	0.899	0.554	0.627	0.427	0.760	0.470	0.080	0.904	0.993
0.810	0.159	0.225	0.163	0.549	0.405	0.285	0.542	0.231	0.919
0.081	0.277	0.035	0.339	0.860	0.507	0.081	0.538	0.986	0.501
0.982	0.468	0.334	0.921	0.690	0.806	0.879	0.414	0.106	0.131
0.095	0.801	0.576	0.417	0.251	0.884	0.522	0.235	0.398	0.222
0.509	0.137	0.794	0.850	0.917	0.887	0.751	0.608	0.698	0.683
0.371	0.359	0.164	0.838	0.289	0.169	0.569	0.977	0.796	0.996
0.165	0.996	0.356	0.375	0.654	0.979	0.815	0.592	0.348	0.743
0.477	0.535	0.137	0.155	0.767	0.187	0.579	0.787	0.358	0.595
0.788	0.101	0.434	0.638	0.021	0.894	0.324	0.871	0.698	0.539
0.566	0.815	0.622	0.548	0.947	0.169	0.817	0.472	0.864	0.466
0.901	0.342	0.873	0.964	0.942	0.985	0.123	0.086	0.335	0.212
0.470	0.682	0.412	0.641	0.150	0.962	0.925	0.355	0.909	0.819
0.068	0.242	0.667	0.356	0.195	0.313	0.396	0.460	0.470	0.247
0.874	0.420	0.127	0.284	0 .448	0.215	0.833	0.652	0.601	0.326
0.897	0.877	0.209	0.862	0.428	0.117	0.100	0.259	0.425	0.284
0.875	0.969	0.109	0.843	0.759	0.239	0.890	0.317	0.428	0.802
0.190	0.696	0.757	0.283	0.666	0.491	0.523	0.665	0.919	0.146
0.341	0.688	0.587	0.908	0.865	0.333	0.928	0.404	0.892	0.696
0.846	0.355	0.831	0.218	0.945	0.364	0.673	0.305	0.195	0.887
0.882	0.227	0.552	0.077	0.545	0.731	0.716	0.265	0.058	0.075
0.464	0.658	0.629	0.269	0.069	0.998	0.917	0.217	0.220	0.659
0.123	0.791	0.503	0.447	0.569	0.463	0.994	0.307	0.631	0.422
0.006	0.120	0.721	0.137	0.263	0.176	0.798	0.879	0.432	0.391
0.836	0.206	0.914	0.574	0.870	0.390	0.104	0.755	0.082	0.939

State of California • Department of Transportation
Engineering Service Center
Office of Materials Engineering and Testing Services
Form TL-3112 (Rev. 3/98)

DENSITY AND RELATIVE COMPACTION OF IN-SITU ASPHALT CONCRETE

PROJECT	Tested By	Lot Number	Date
	Agg. Source		
	Asphalt Content (Planned)		
	Lane		
	Layer		
	Total AC Thickness (Planned)	(Measured)	

NUCLEAR DEVICE	TEST AREA LIMITS
Date of Last Calibration ________	(A) Start (Station)
Model & I.D. ________	(B) Finish (Station)
Standard Count (M) ________	(C) Length (B-A)
Depth Setting Used* ________	(D) Width, m
* Must match value used during correlation.	

FIELD NOTES AND CALCULATIONS

(Use back if more room is needed)

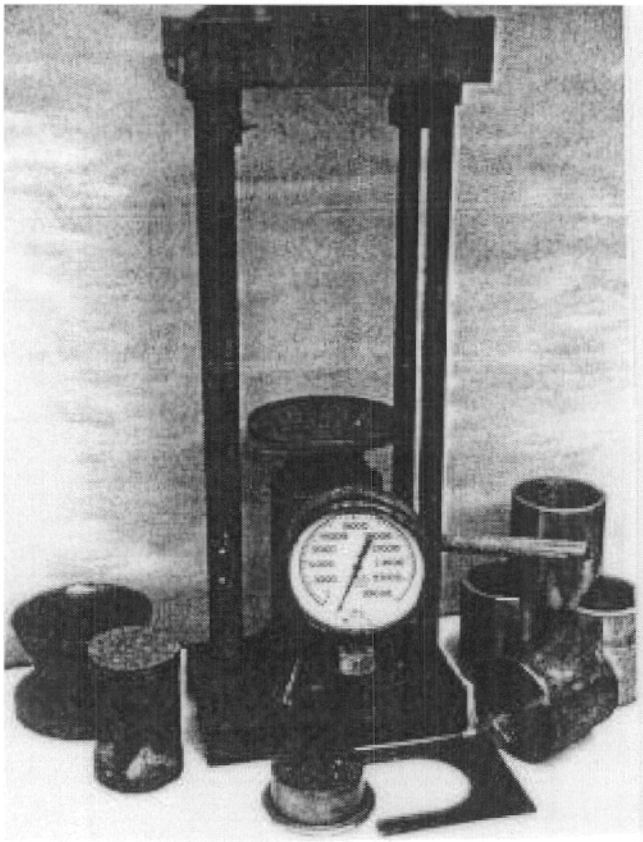
COLUMN	RANDOM NUMBER									
(E) Left (Longitudinal Location)										
(F) Right (Transverse Location)										
TEST LOCATIONS	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
(G) Station (C × E) + A										
(H) Distance From Edge of Mat D × F (Round to nearest 0.5 m)										
(I) Distance From Reference (℄, e. p., Curb)										
(J) Nuclear Reading (Field Count) a										
b										
(K) Count Ratio (J/M) a										
b										
(L) Density a										
b										
Avg.										

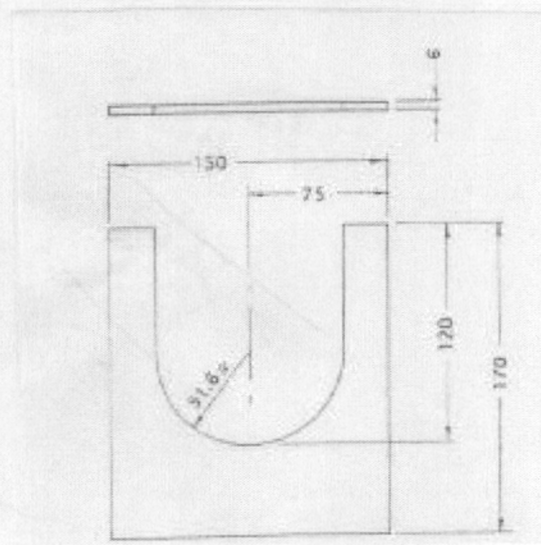
Average In-Place Density (all sites) ________ FTMD ________

(after exclusions) ________

Conversion Factor ________ LTMD (O) ________

Corrected In-Place Density (N) ________ Average Relative Compaction (N/O)



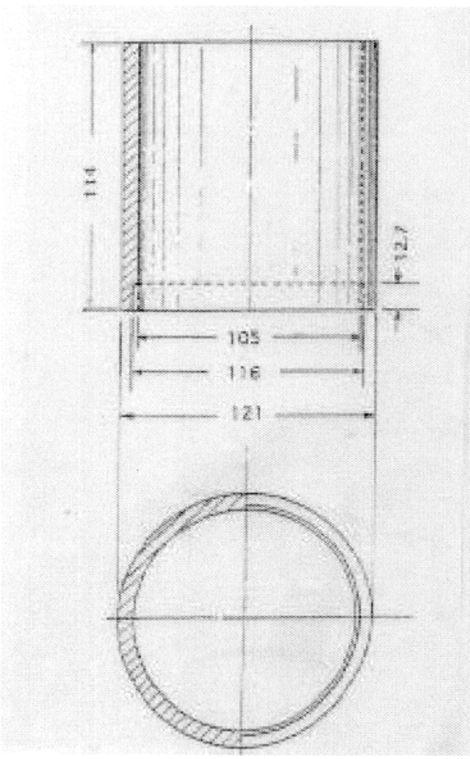


Hydraulic Jack/Loading Frame and Accessories

Figure 1

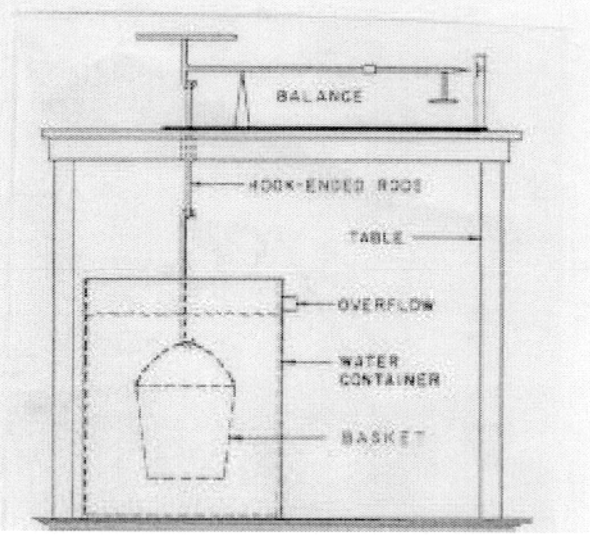
Spacer (All units in mm)

Figure 2



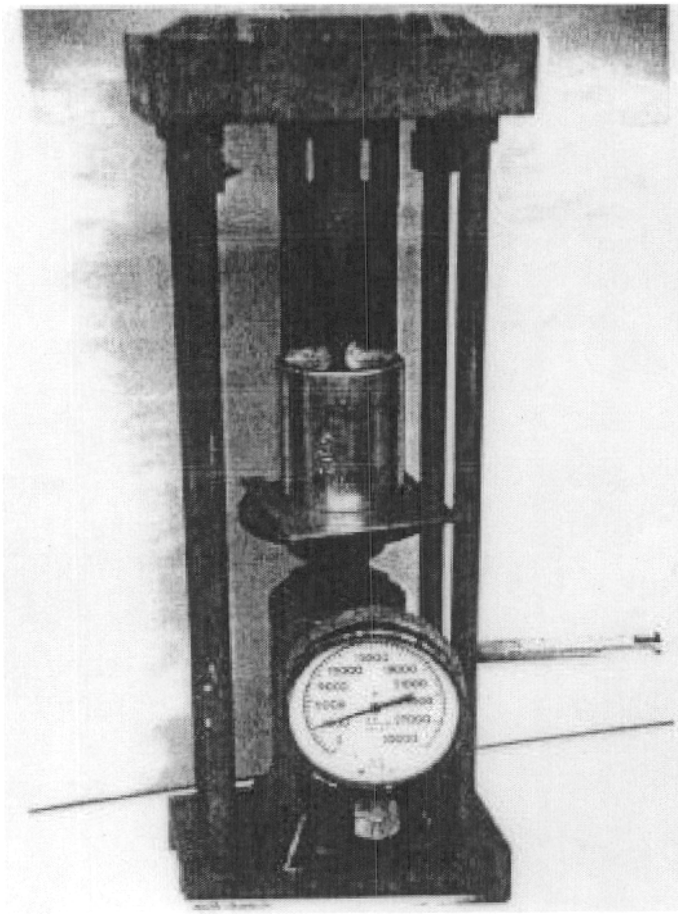
Extraction Sleeve (All units in mm)

Figure 3



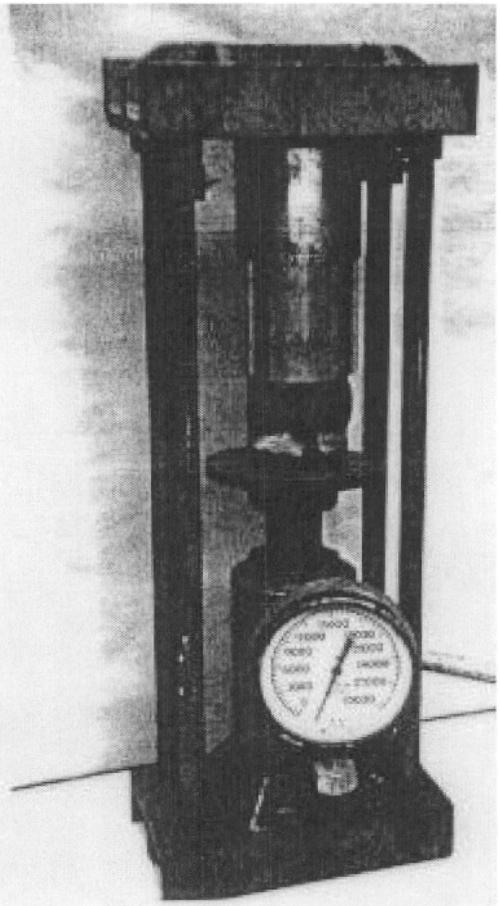
Balance for Weighing Samples in Air and in Water

Figure 4



Compaction Mold Assembly in
Compression Device

Figure 5



Extraction Sleeve Assembly in
Compression Device

Figure 6