DEPARTMENT OF TRANSPORTATION
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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 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 Density Device in the Backscatter Mode
2. Correlation with Core Densities
3. Test Site Selection
4. Determining In-Place Density by the Nuclear Density Device
5. Determining Test Maximum Density (TMD)
6. Calculating Relative Compaction

Readings taken with a nuclear density device can be influenced by other objects, and especially other nuclear sources in the immediate area. During compaction testing, the device must be at least 1.5 m from any object and at least 7.6 m from any other nuclear source.

PART 1. STANDARDIZATION AND CALIBRATION OF THE NUCLEAR DENSITY 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 AC. This part of the test method adds specific minimum requirements to the procedures on standardization and calibration recommended by the manufacturer.

B. APPARATUS

1. Nuclear density device designed to determine the density of material by the backscatter method. At a minimum, 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 conforming to California Test 111 or traceable to the National Institute of Standards and Technology (NIST).

C. GENERAL REQUIREMENTS AND PRECAUTIONS

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

2. Each nuclear density device should be calibrated annually. The interval between calibrations must not exceed 15 months.

3. Recalibrate nuclear density 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.

D. DETERMINING STANDARD COUNT

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

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

2. Average the 4-min counts to determine the “standard count” for the device. If the standard count is within the acceptable deviations limit (ADL) stated in California Test 111 for the most recent count-ratio/density table, record it in the logbook and on Line A of Form TL-3112.

   NOTE: For thin lift devices, up to five 4-min counts are allowed to pass the internal statistical test. Record the last accepted count as the standard count in the logbook and on Line A.

3. If an acceptable standard count cannot be established within the ADL or the statistical test limit, return the device for repair and/or calibration.

E. CALIBRATION

Calibrate the nuclear device in accordance with procedures conforming to California Test 111, or procedures recommended by the manufacturer if not applicable to California Test 111. Prior to project use, each calibrated device shall contain the following:

1. An affixed calibration sticker that shows the ID and date of calibration.

2. A calibration data sheet that shows the count-ratio/density table and allowable range in standard counts.

3. A conversion factor that correlates to cores of the project.

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 device on each project. All conversion factor data shall remain with the nuclear density device for the duration of the project. Establish a new conversion factor whenever a change in pertinent criteria such as lift thickness of 10 mm or more, underlying material, material source, mix design, or recalibration of the nuclear density device occurs.

B. TEST STRIP

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

   a. The AC 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. Each 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.

   NOTE: If a contiguous 200 m section cannot be placed because of specific project limitations, Engineers may reduce the Test Strip length, or combine broken segments to achieve as close to 200 m of effective length as possible. The Test Strip can be a portion of the AC work and shall meet the requirements of the contract limitations. In no case shall the required number of test sites for the Test Strip be reduced.

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 density device for each of the test sites. Mark each core to identify the corresponding station as shown on Line J of Form TL-3112. Cores that are damaged during the coring operation must be discarded and replaced by additional cores from the same test site. If additional core(s) cannot be obtained from within the outlined position of the nuclear device, an alternate site should be selected for both nuclear and core testing.

5. Remove all extraneous core material beyond the top layer of AC. 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 to within 0.05 g/cc, exclude all the data from this site.

7. Determine the correlation value for each test site by subtracting the average nuclear density on Line N 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.

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

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

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. If more than three values are excluded, repeat steps 2 through 7 above.

c. Determine the conversion factor by averaging the valid correlation values and record on Line P.

PART 3. TEST SITE SELECTION

A. SCOPE

Reliable test results are dependent on appropriate test site selection. This part of the test method provides the 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 AC placed.

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

C. TEST SITE LOCATION

Determine the locations of the test sites using the following random selection procedures:

1. Determine the number of sites to be tested.

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

   a. Table 1 shall be used when ten sites are to be tested. Each set of ten random numbers in this table has been arranged in sequential order of the stationing.

   b. Table 2 shall 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.

   c. The numbers for transverse location will always be in random order.

3. 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.

4. Arrange the pairs in sequential order based on the longitudinal location. Record the paired numbers on Lines G and H of Form TL-3112.

5. To determine the longitudinal distance from the start station on Line B, multiply the numbers on Line G by the length of the

pavement on Line D. Round up to the next whole number and record on Line I. To determine the station of a test site, add the distance on Line I to the start station on Line B and record the result on Line J.

6. To determine the transverse distance from the edge of pavement, multiply the numbers on Line H by the width of the pavement on Line E. Round the product to the nearest 0.1 m and record on Line K. Any test site within 0.3 m of the pavement edge should be relocated to 0.3 m from the edge.

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

PART 4. DETERMINING IN-PLACE DENSITY BY THE NUCLEAR DENSITY 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 density device.

B. APPARATUS/MATERIAL

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

   NOTES:

   a. If thickness of an individual layer is greater than or equal to 60 mm, conventional devices shall be used.

   b. If thickness of an individual layer is less than 60 mm, thin lift devices that do not require monographs shall be used.

   c. In multiple layers of similar materials, if the combined thickness of a previously tested layer and a newly placed layer is greater than or equal to 60 mm, conventional or thin lift devices may be used.

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 0.1 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 density 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 density 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 backscatter position. In addition, thin lift devices shall be set to the thin lift mode and measuring lift thickness.

5. Obtain a 1-min count. Record this reading on Line L of 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. Set the device aside and use the straightedge to re-smooth the surface. Do not add sand unless voids are obvious. Carefully turn the device 180 degrees and place it precisely over the initial test position as indicated by the markings on the pavement. Seat the device in accordance with Step 3 and repeat Steps 4 and 5 above.

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

8. Determine the count ratios to the nearest thousandth by dividing nuclear readings on Line L by the standard count on Line A and record on Line M. From the count ratio/density table, determine the density. Record the result to the nearest 0.01 g/cc on Line N.

   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 to within 0.05 g/cc, repeat Steps 2 through 6 at the same site until a set of two measurements that agree to within 0.05 g/cc is obtained. If a valid set of density measurement cannot be obtained within three attempts, select and test a new site 3 m forward in the longitudinal direction and at the same transverse location. Document site change(s) in the "Field Notes and Calculations" portion of Form TL-3112.

10. Average the two densities from the same site and record the result to the nearest 0.01 g/cc on Line N.

11. Calculate the average in-place density (all sites) for the test area by averaging the average densities from each of the test sites on Line N. Record the result to the nearest 0.01 g/cc on Line O.

12. Calculate the corrected in-place density by adding the conversion factor on Line P to the average in-place density on Line O. Record this result on Line Q for calculating the relative compaction in Part 6.

PART 5. DETERMINING TEST MAXIMUM DENSITY

A. SCOPE

The 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 as shown in Figure 5. 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 ± 0.13 mm and an outside diameter of 114.05 ± 1.3 mm and a height of approximately 127 mm. The 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 as shown in Figure 6 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 day's production.

2. When daily production exceeds 5000 tonnes, take additional representative samples from each 5000 tonnes or portion thereof.

3. Determine a LTMD at least once for the following occurrences:

   a. beginning of a project

   b. on every five paving days or every 25 000 tonnes placed, whichever occurs first

   c. change in the AC mix

4. Determine either a LTMD or FTMD for each daily sample.

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

   a. Five consecutive days of LTMD or FTMD do not differ by more than 1 % from their average.

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

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

   d. Upon failing the 1 % average test, untested daily samples following the last valid LTMD shall be tested.

6. TMD determined from each test strip 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-hr 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. Record the result on Line T of Form TL-3112.

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 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. It is permissible to use Method C of California Test 308, provided a correlation is established and a correction factor is applied as follows:

    a. A minimum of three test specimens from the same sample is 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. Record the result on Line R of Form TL-3112.

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 of AC in accordance with 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 determine 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. Determine the Correlation Factor by dividing the averaged LTMD by the averaged FTMD and record on Line S.

8. When LTMD is not used for Line T as described in Part 5E, determine a Correlated FTMD by multiplying the FTMD on Line R to the Correlation Factor on Line S. Record the result on Line T.

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 AC 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 tabletop until it cools.

PART 6. CALCULATING RELATIVE COMPACTION

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

$$RC = \frac{\text{Corrected In-Place Density}}{\text{TMD}^{(1)}} X100$$

(1) Use either the LTMD from Part 5E or the Correlated FTMD from Part 5G.

2. Use the most recent TMD for the lot tested to calculate the RC and record on Line U of Form TL-3112.

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 RC.

A. 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-device	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.

B. SAFETY AND HEALTH

Prior to sampling, handling materials, or testing, all personnel sampling or testing 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 Density 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 111, 121, 125, 304 and 308

End of Text
(California Test 375 contains 19 pages)

Table 1

Sequential Random Numbers

Longit.	Trans.	Longit.	Trans.	Longit.	Trans.	Longit.	Trans.	Longit.	Trans.
0		1		2		3		4	
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
5		6		7		8		9	
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

Table 2

Table of Random Numbers

Longit.	Trans.	Longit.	Trans.	Longit.	Trans.	Longit.	Trans.	Longit.	Trans.
0		1		2		3		4	
0.576	0.730	0.430	0.754	0.271	0.870	0.732	0.721	0.998	0.239
0.971	0.824	0.858	0.125	0.396	0.095	0.153	0.508	0.749	0.291
0.810	0.159	0.902	0.470	0.997	0.392	0.009	0.420	0.517	0.858
0.081	0.277	0.554	0.627	0.427	0.760	0.937	0.310	0.253	0.761
0.982	0.468	0.225	0.163	0.549	0.405	0.892	0.957	0.640	0.463
0.371	0.359	0.035	0.339	0.860	0.507	0.470	0.080	0.106	0.131
0.165	0.996	0.334	0.921	0.654	0.979	0.285	0.542	0.796	0.996
0.477	0.535	0.794	0.850	0.767	0.187	0.081	0.538	0.358	0.595
0.788	0.101	0.164	0.838	0.021	0.894	0.324	0.871	0.698	0.539
5		6		7		8		9	
0.566	0.815	0.873	0.964	0.942	0.985	0.123	0.086	0.864	0.466
0.901	0.342	0.412	0.641	0.195	0.313	0.396	0.460	0.335	0.212
0.470	0.682	0.667	0.356	0.428	0.117	0.833	0.652	0.909	0.819
0.068	0.242	0.127	0.284	0.759	0.239	0.100	0.259	0.601	0.326
0.874	0.420	0.209	0.862	0.666	0.491	0.523	0.665	0.195	0.887
0.875	0.969	0.552	0.077	0.865	0.333	0.673	0.305	0.058	0.075
0.341	0.688	0.503	0.447	0.545	0.731	0.994	0.307	0.220	0.659
0.123	0.791	0.721	0.137	0.069	0.998	0.798	0.879	0.631	0.422
0.006	0.120	0.914	0.574	0.263	0.176	0.104	0.755	0.432	0.391

State of California • Department of Transportation
Division of Engineering Services
Materials Engineering and Testing Services
Form TL-3112 (Rev. 02/04)

DENSITY AND RELATIVE COMPACTION OF IN-SITU ASPHALT CONCRETE

PROJECT	Tested By	Lot Number	Date
	Aggregate Source		
	AC Mix Number		
	Lane Number		
	Lift Number		
	Lift Thickness, mm		

NUCLEAR DEVICE	**TEST AREA LIMITS**
Date of Last Calibration________________________	(B) Start Station
Model & I.D. ________________________	(C) Finish Station
(A) Standard Count ________________________	(D) Length (C - B), m
Setting/Entered Depth Used* ________________________	(E) Lane Width, m
* Must match value used during correlation.	(F) TMD (test area calc), kg/m^3 where g/cc x 1000 = kg/ m^3

FIELD NOTES AND CALCULATIONS

(Use back if more room is needed)

COLUMN	**RANDOM NUMBER Table # Block #**									
(G) Left (Longitudinal Location)										
(H) Right (Transverse Location)										
TEST SITE LOCATIONS	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
(I) Longitudinal Distance from Start D x G (round up to whole meter)										
(J) Station I + B										
(K) Transverse Distance from Edge E x H (round to nearest 0.1 m)										
(L) Nuclear Reading a										
(Field Count) b										
(M) Count Ratio (L / A) a										
b										
(N) Density (g/cc) a										
(round to nearest 0.01g/cc) b										
Avg.										

(O) Average In-Place Density (all sites), g/cc________

After Exclusions (test strips only)__________________

(P) Conversion Factor (device to cores)___________ _

(Q) Corrected In-Place Density (O + P), g/cc_________

(R) FTMD (CT 308 "A" or Corrected "C"), g/cc________________

(S) Correlation Factor (Part 5, G) and Date_________________

(T) LTMD or Correlated FTMD (R x S), g/cc_________________

(U) Relative Compaction (Q / T), %_______________________

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DENSITY AND RELATIVE COMPACTION OF IN-SITU ASPHALT CONCRETE EXAMPLE 1

PROJECT	Tested By Harry Roberts	Lot Number 1- Sublot 10	Date 06-11-2003
25-4567U8	Aggregate Source	ACME Materials, Bristoville	
25-XYZ-555-61.7/87.3	AC Mix Number	QC-123456-AB	
Lyon County in Bristoville from Blue Streak	Lane Number	2-A Line	
Road to Glenn River	Lift Number	3	
	Lift Thickness, mm 55		

NUCLEAR DEVICE	TEST AREA LIMITS
Date of Last Calibration 12-05-2002	(B) Start Station 698+59
Model & I.D. Trox-3440-55555	(C) Finish Station 708+77
(A) Standard Count 2662	(D) Length (C - B), m 1018
Setting/Entered Depth Used* BS	(E) Lane Width, m 3.66
* Must match value used during correlation.	(F) TMD (test area calc), kg/m^3 2440 where g/cc x 1000 = kg/ m^3

FIELD NOTES AND CALCULATIONS

(Use back if more room is needed)

Multiple layers of similar materials. 1st lift of 60 mm (conventional), 2nd lift of 60 mm (conventional) and 3rd lift of 55 mm (similar material with combined thickness of at least 60 mm, thin lift or conventional). Conventional Troxler 3440 was used here for all three lifts.
At station 699+42, the transverse distance was moved from 3.5 to 3.3 (site is now 0.3 meters from edge).

COLUMN		RANDOM NUMBER			Table # 1		Block # 0			
(G) Left (Longitudinal Location)	0.053	0.081	0.095	0.576	0.609	0.669	0.810	0.892	0.971	0.982
(H) Right (Transverse Location)	0.730	0.948	0.726	0.482	0.824	0.899	0.159	0.277	0.468	0.801
TEST SITE LOCATIONS	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
(I) Longitudinal Distance from Start D x G (round up to whole meter)	54	83	97	587	620	682	825	909	989	1000
(J) Station I + B	699+ 13	699+ 42	699+ 56	704+ 46	704+ 79	705+ 41	706+ 84	707+ 68	708+ 48	708+ 59
(K) Transverse Distance from Edge E x H (round to nearest 0.1 m)	2.7	3.3	2.7	1.8	3.0	3.3	0.6	1.0	1.7	2.9
(L) Nuclear Reading a	600	601	587	584	591	598	581	594	587	598
(Field Count) b	594	587	594	587	578	594	591	580	593	586
(M) Count Ratio (L / A) a	.225	.226	.221	.219	.222	.221	.218	.223	.221	.225
b	.223	.221	.223	.221	.217	.223	.222	.218	.223	.220
(N) Density(g/cc) a	2.36	2.35	2.37	2.38	2.37	2.37	2.38	2.36	2.37	2.35
(round to nearest 0.01g/cc) b	2.35	2.37	2.36	2.37	2.39	2.36	2.37	2.38	2.36	2.37
Avg.	2.36	2.36	2.37	2.38	2.38	2.37	2.38	2.37	2.37	2.36

(O) Average In-Place Density (all sites), g/cc	2.37	(R) FTMD (CT 308 “A” or Corrected “C”), g/cc	2.43
After Exclusions (test strips only)	N/A	(S) Correlation Factor (Part 5, G) and Date	1.016 (02-11-2003)
(P) Conversion Factor (device to cores)	0.01	(T) LTMD or Correlated FTMD (R x S), g/cc	2.47
(Q) Corrected In-Place Density (O + P), g/cc	2.38	(U) Relative Compaction (Q / T), %	96.4

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DENSITY AND RELATIVE COMPACTION OF IN-SITU ASPHALT CONCRETE EXAMPLE 2

PROJECT		
25-4567U8 25-XYZ-555-61.7/87.3 Lyon County in Bristoville from Blue Streak Road to Glenn River	Tested By: John Doe	Lot Number: 1- Sublot 1
	Date	01-01-2004
	Aggregate Source	ACME Materials, Bristoville
	AC Mix Number	NONQCQA-123456
	Lane Number	2-A Line
	Lift Number	3
	Lift Thickness, mm	55

NUCLEAR DEVICE	TEST AREA LIMITS
Date of Last Calibration 12-05-2003	(B) Start Station 502+60
Model & I.D. Trox-3450-00000	(C) Finish Station 510+70
(A) Standard Count 2662	(D) Length (C - B), m 810
Setting/Entered Depth Used* BS/55 mm	(E) Lane Width, m 3.66
* Must match value used during correlation.	(F) TMD (test area calc), kg/m^3 2440 where g/cc x 1000 = kg/ m^3

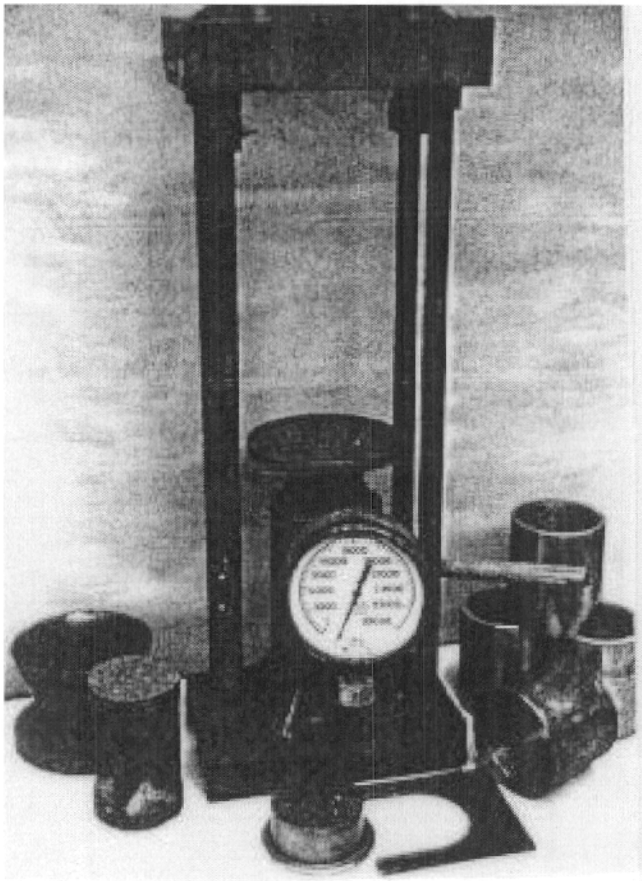
FIELD NOTES AND CALCULATIONS

(Use back if more room is needed)

Multiple layers of similar materials. 1st lift of 55 mm (thin lift), 2nd lift of 55 mm (similar material with combined thickness of at least 60 mm, thin lift or conventional) and 3rd lift of 55 mm (similar material with combined thickness of at least 60 mm, thin lift or conventional). Thin lift Troxler 3450 was used here for all three lifts.
Direct density displaying gage was used. No field count or count ratio is needed.
Table 2 with 8 sites was used for this area which contains 398 tonnes of AC.
At station 509+83, the transverse distance was moved from 3.5 to 3.3 (site is now 0.3 meters from edge).

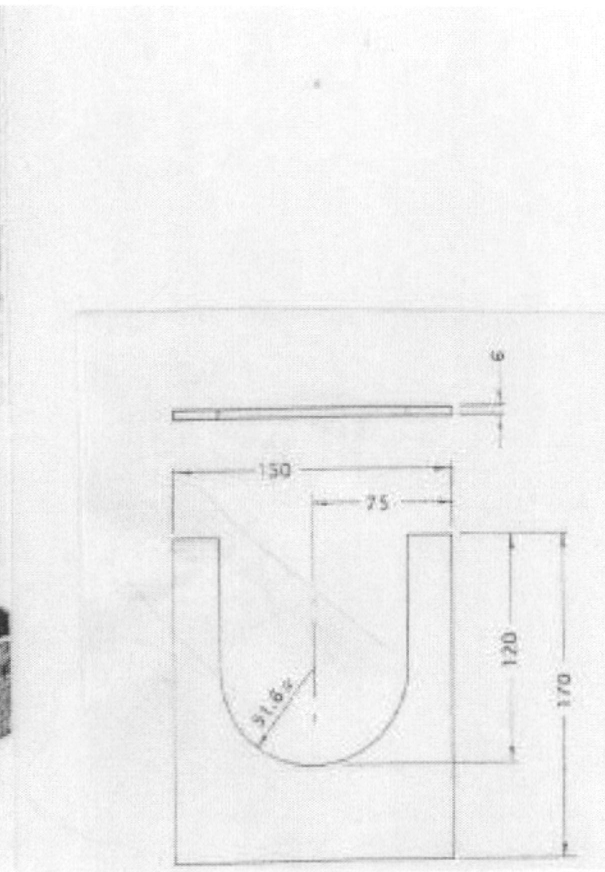
COLUMN	RANDOM NUMBER	Table # 2	Block # 3							
(G) Left (Longitudinal Location)	0.009	0.081	0.153	0.285	0.470	0.732	0.892	0.937		
(H) Right (Transverse Location)	0.420	0.538	0.508	0.542	0.080	0.721	0.957	0.310		
TEST SITE LOCATIONS	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
(I) Longitudinal Distance from Start D x G (round up to whole meter)	8	66	124	231	381	593	723	759		
(J) Station I + B	502+ 68	503+ 26	503+ 84	504+ 91	506+ 41	508+ 53	509+ 83	510+ 19		
(K) Transverse Distance from Edge E x H (round to nearest 0.1 m)	1.5	2.0	1.9	2.0	0.3	2.6	3.3	1.1		
(L) Nuclear Reading a										
(Field Count) b										
(M) Count Ratio (L / A) a										
b										
(N) Density(g/cc) a	2.36	2.35	2.37	2.38	2.37	2.37	2.38	2.36		
(round to nearest 0.01g/cc) b	2.35	2.37	2.36	2.37	2.39	2.36	2.37	2.38		
Avg.	2.36	2.36	2.37	2.38	2.38	2.37	2.38	2.37		

(O) Average In-Place Density (all sites), g/cc	2.37	(R) FTMD (CT 308 "A" or Corrected "C"), g/cc	2.43
After Exclusions (test strips only)	N/A	(S) Correlation Factor (Part 5, G) and Date	1.016 (08-11-2003)
(P) Conversion Factor (device to cores)	0.01	(T) LTMD or Correlated FTMD (R x S), g/cc	2.47
(Q) Corrected In-Place Density (O + P), g/cc	2.38	(U) Relative Compaction (Q / T), %	96.4



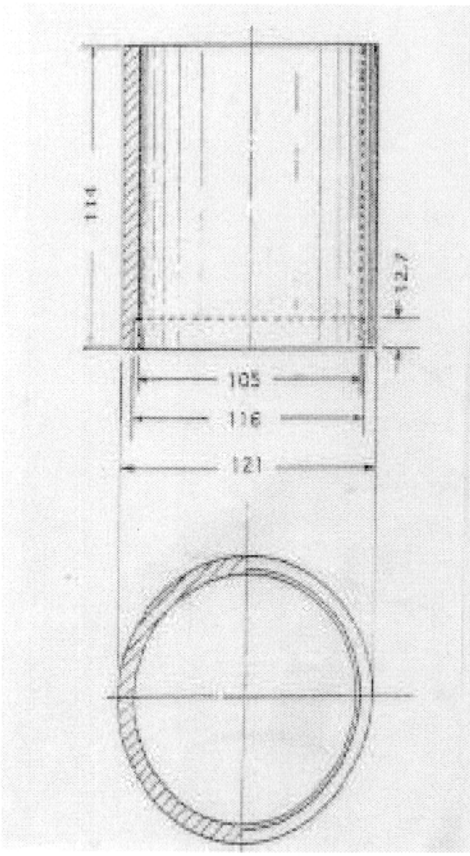
Hydraulic Jack/Loading Frame and Accessories

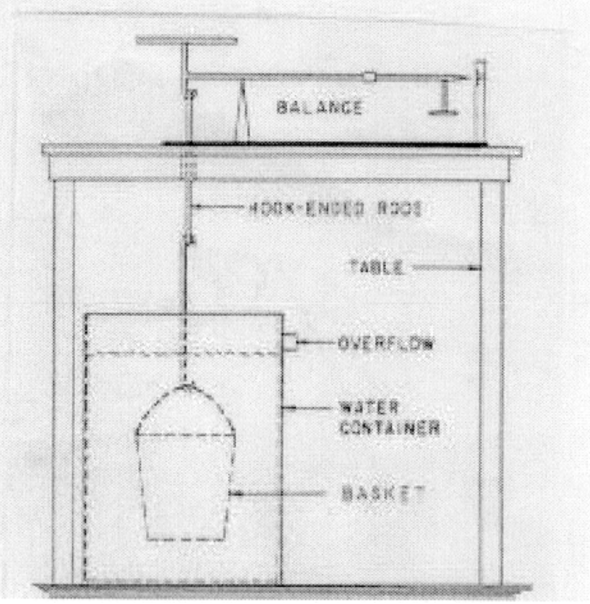
Figure 1



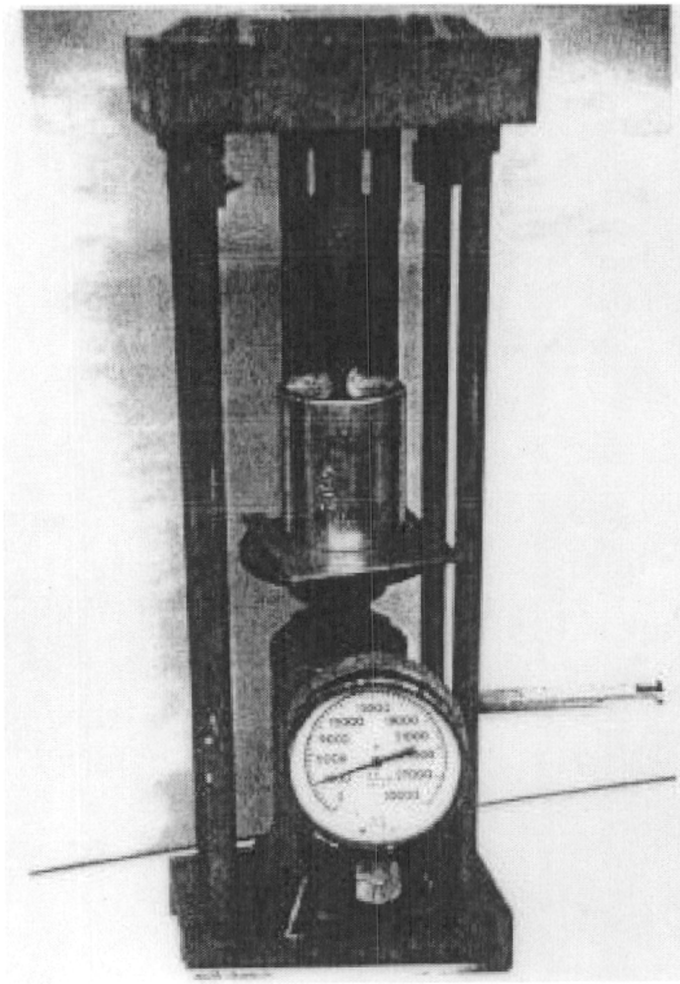
Spacer (All units in mm)

Figure 2



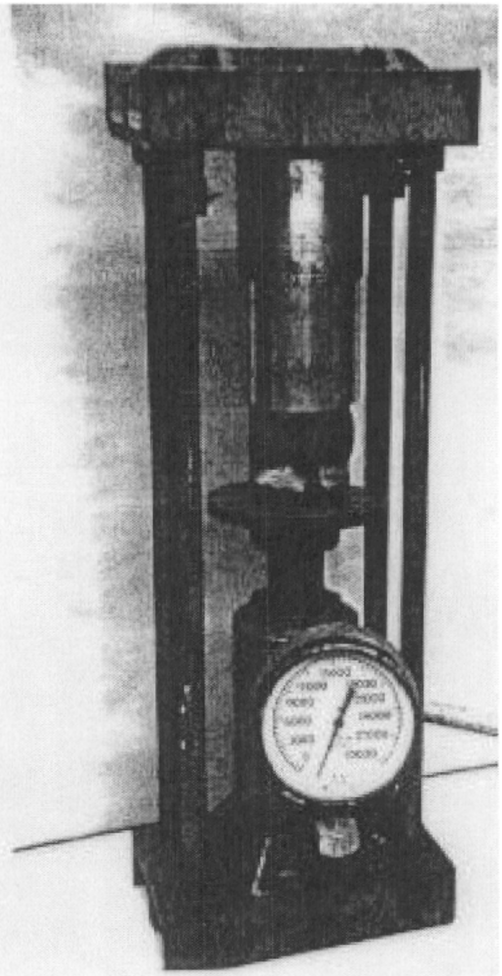


Extraction Sleeve (All units in mm)	Balance for Weighing Samples in Air and in Water
Figure 3	Figure 4



Compaction Mold Assembly in Compression Device

Figure 5



Extraction Sleeve Assembly in Compression Device

Figure 6