# Nuclear Gauge Field Technician Certification

**2023 version**

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## Why are you here?

- **Proper testing practices**
  - How to verify gauge is working
  - How to determine correction factors for asphalt testing
  - How to test
- **Where to test**
  - Determine Lots
  - Determine random testing locations

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# Contact Information

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# Setting Up the Gauge to Test

Before we test we need to make sure that:

- The gauge is working accurately
- Determine Correction Factors if testing on asphalt.

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# Standard Count

- Keep a log of your standard counts!
- Standard counts provide a quick reference check to ensure that the gauge is operating correctly.
- A standard count must to be taken **daily** on the reference standard block.

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# Standard Count

Keep a daily log of all Standard Counts.

**Max Variation day to day:**

- 1% for density
- 2% for moisture.

Place the reference standard block on the surface you are about to test.

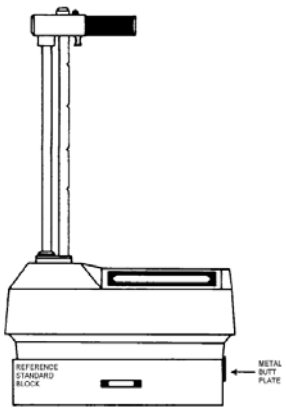


*Figure 3-3. Standard Count Position*

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# Standard Count

| Moisture Count | |
|---|---|
| Yesterday | 1251 |
| Today | 1271 |

$$\%\,VAR = \frac{Old - New}{Old} \times 100$$

$$= \frac{1251 - 1271}{1251} \times 100$$

$$= 1.5\% < 2\%\ OK$$

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# Standard Count

If a standard count log has **NOT** been kept or if your **FIRST** standard count fails, do the following:

1. Take five new counts
2. Average the first four
3. Compared with the 5th reading
4. Check if the reading is within the required limits.

If the standard count still fails, call your Regional RSO.

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# Standard Count

Example:

- Count 1: Density – 1650 Moisture – 632
- Count 2: Density – 1640 Moisture – 630
- Count 3: Density – 1630 Moisture – 628
- Count 4: Density – 1625 Moisture – 632
- Count 5: Density – 1624 Moisture – 630

Average 1636.25

Average 630.5

$$Density = \frac{1636.25 - 1624}{1636.25} \times 100\% = 0.75\% \qquad Moisture = \frac{630.5 - 630}{630.5} \times 100\% = 0.079\%$$

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# Asphalt Test Strips

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# Test Strip Calibration (Asphalt)

TDOT Standard specifications 407.15.

- Nuclear Gauge readings are not valid on Asphalt until the gauge is correlated to the mix and project location. A new test strip shall be required for each project and each mix design used on the project (for mix types that require density testing as noted above). Uncorrelated gauges shall not be used for acceptance or assurance testing.

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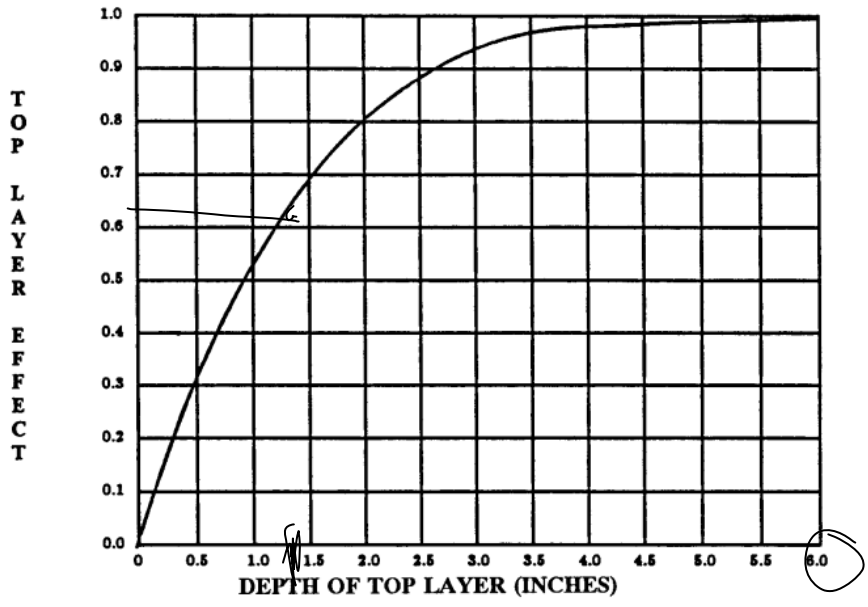


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# Test Strip Calibration (Asphalt)

- Required for A, BM, BM2, C, C-W, D, and E mixtures
- Each test section shall be 1 paver width/lane width wide and a minimum of 400 SY
  - 9’ wide= 400’ long
  - 10’ wide= 360’ long
  - 11’ wide= 330’ long
  - 12’ wide= 300’ long

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# Test Strip Calibration (Asphalt)

- Step 1: Compact test strip area

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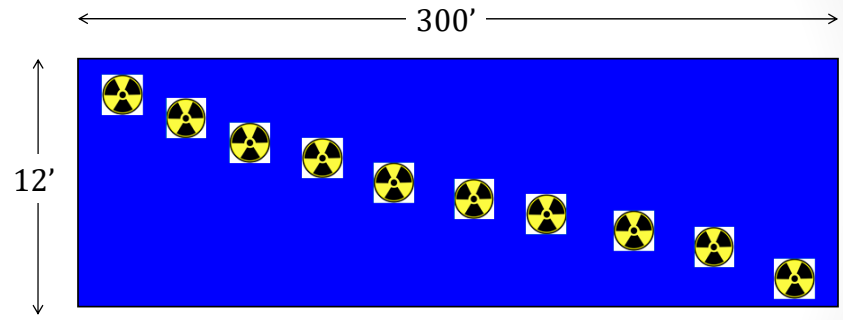
# Test Strip Calibration (Asphalt)




Step 2: Layout ten test strip test locations such that the full length and width of the test strip is covered. Mark test location and test number on pavement with spray paint after running the test. Write down the density (lb/ft$^3$) at every location and mark the location so we can cut cores.

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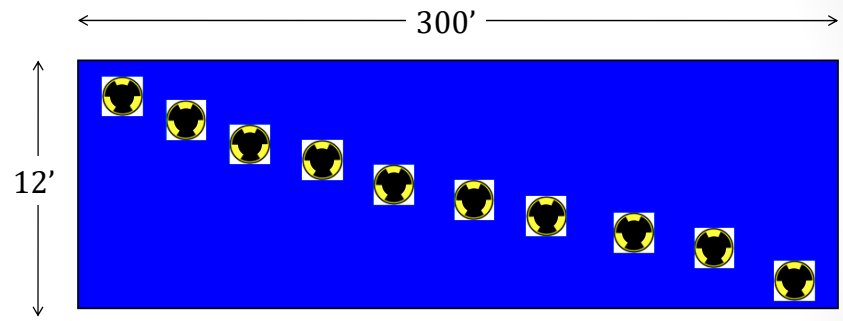
# Test Strip Calibration (Asphalt)




Step 3: Cores shall be cut at same locations as nuclear density tests and tested by TDOT Plant Technician for laboratory density in accordance with AASHTO T166. (NOTE: The contractor’s technician shall not conduct this testing)

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# Test Strip Calibration

- Now we can run the density of the cores in the lab to find the TRUE density of what we tested.


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# Test Strip Calibration (Asphalt)

- Step 5: The nuclear gauge correction factor shall be the difference between the average of ten nuclear gauge readings and the average of ten core density values.

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# Test Strip Calibration

**Nuclear Gauge Results:**

- 140.5 lb/ft$^3$
- 139.7
- 139.3
- 134.3
- 137.8
- 143.1
- 135.4
- 138.1
- 134.1
- 137.6

$\frac{1379.9}{10} = 138.0$

**Core Density:**

- 142.1
- 142.7
- 142.3
- 139.1
- 141.1
- 141.6
- 140.4
- 141.2
- 137.8
- 140.2

$\frac{1408.5}{10} = 140.9$

C.F. = Core – Gauge

C.F. = 140.9 – 138.0 = 2.9 pcf

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# Test Strip Calibration

- What this means is that any time we use THIS nuclear gauge on THIS mix on THIS project, we should add _____2.9_____to our reading.
- This correction factor ONLY applies to THIS PROJECT and THIS MIX DESIGN.

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# Test Strip Calibration (Asphalt)

- **A new test strip will be required when:**
  - There is a change in job mix formulas
  - A change in the source of materials occurs
  - A change in the material from the same source is observed
  - There is reason to believe that the test strip density is not representative of the mixture being placed. For example, test results are consistently above 100% density or test results have been consistent for a steady number of days and had suddenly changed significantly.
  - A change in paving or compaction equipment occurs.

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# Acceptance Testing

- Now that the gauge is confirmed to be operating correctly and we have a correction factor we can test.

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# Testing Policy

- Soil/Aggregate
  - Test shall be 1 minute in duration
  - Direct Transmission
  - Rod embedded approximately half the lift thickness being measured.
- Asphalt
  - Tests shall be 15 seconds
  - 4 tests per location, rotate gauge 90 degrees between tests
  - Backscatter Mode, all mixes

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# Aspahlt "four 90s method"

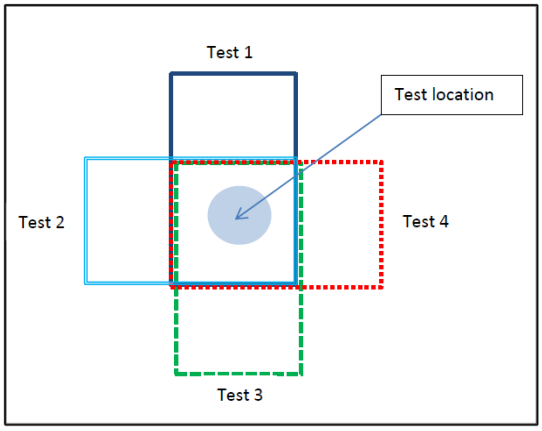


*Figure 1.* Testing at four 90° locations

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# Quality Acceptance Testing: General Procedure

- Identify Density/Moisture Requirements
  - Based on type of material being placed
- Determine Required Lot Size/Number of Tests
- Determine Test Locations
- Perform Test(s)
- Report Results

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# Identify Density/Moisture Requirements

- Acceptance criteria are different for Embankment, Aggregate Base, Asphalt Pavements, Etc.
- This information can be found in the corresponding section in the TDOT specs.
- The target values (soils/aggregate)are determined by TDOT Materials and Tests personnel and will be made available in the proctor density report
- The target values (asphalt) are determined by the JMF and the level of traffic, see **407.15**.

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# Determine Required: Lot Size/Number of Tests

- S.O.P. 1-1: Sampling and Testing Guide
  - Describes the testing frequency for all materials
  - Lists the person responsible for either obtaining the sample of performing the test.
  - Available in PDF format at:

http://www.tdot.state.tn.us/materials/fieldops/sop/default.htm

**(see example in Part Four of S.O.P. 1-1)**



# TDOT Sampling Procedure (Asphalt)

- **SOP 1-1**

| ASPHALT | | | | | | |
|---|---|---|---|---|---|---|
| Asphalt Plant Mix Pavements | Aggregate | Fractured Face Count | Project Inspector | Per project | Coarse aggregate stockpiles | Plus No. 4 (4.75 mm) sieve material, gravel mixes only. |
| | | Glassy Particles by mass | | | | Plus No. 4 (4.75 mm) sieve material, slag mixes only. |
| | All Plant Mix Asphalt | Mix Temperature | | Every 5th load | From the truck prior to leaving the plant and on the roadway prior to deposit into the paver or the material transfer device | Temperatures on the roadway are to be recorded on the delivery ticket. |
| | | 10 Minute Boil Test | | Per day | From the truck at the asphalt plant | |
| | Plant Mix Asphalt (Grading A, B, BM, BM2, C, CW, D, E, E-Shoulder) | Density | | Every 1,000 tons | As soon as practical after compaction | Each lot shall be divided into 5 equal sub-lots, and one test shall be performed per sub-lot. |

# TDOT Sampling Procedure

| EMBANKMENT/SUBGRADE | | | | | | |
|---|---|---|---|---|---|---|
| Embankment | Soil | Proctor Density & Optimum Moisture | Project Inspector | As required by material changes | Cuts sampled prior to construction. Borrow pits sampled as required prior to placement. | Submit 50-75 pound sample to M&T. |
| | | Density, Moisture | | Five tests each 10 inches of lift not to exceed 1,500 feet of roadway or 5,000 cubic yards<br><br>Exception: Within 50 feet of a bridge end (deck or box), one test will be performed for each lift. The test will be performed alternately on the embankment and on the backfill material. | During construction, immediately after compaction. | Density tests will not be required for embankment containing more than 50% of plus ¾ inch sieve material. |
| Subgrade Preparation | Soil | Proctor Density & Optimum Moisture | Project Inspector | As required by material changes | May be sampled before grading construction or after grading prior to sub-grade preparation | Submit 50-75 pound sample to M&T. |
| | | Density, Moisture | | Five tests per 10,000 square-yard lot for top 6 inches | Immediately before placing pavement | |
| Subgrade Treatment (Lime) OR Soil-Cement Base | Soil-Cement Mixture OR Soil-Lime Mixture | Proctor Density, Optimum Moisture | Project Inspector | Prior to beginning of construction | At beginning of compaction | Additional tests may be required to account for material changes.<br><br>Submit 50-75 pound sample to M&T. |
| | | Pulverization | | Every 10,000 square yards | After mixing, before compaction | Sieve test requirement. See Standard Specs. 304.06. |
| | | Density, Moisture | | Five tests per 10,000 square-yard lot | Immediately following compaction | |
| | | Thickness | | | After final finish of base | |

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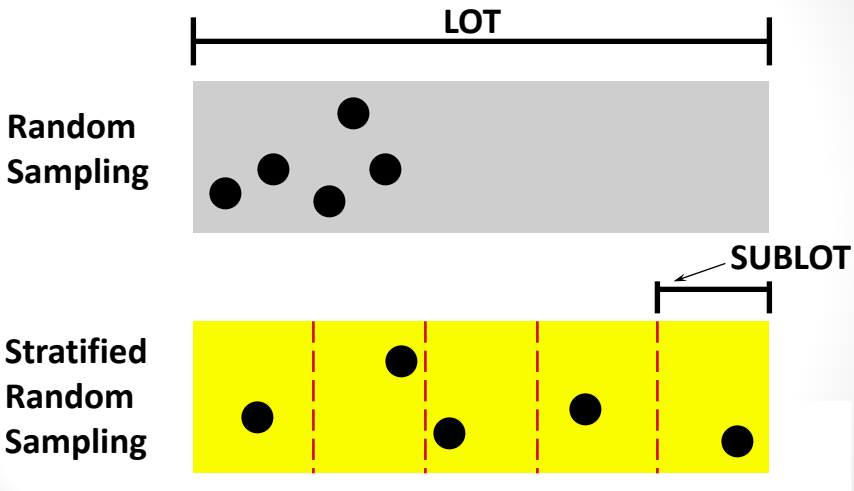
# Lots and Sublots

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# Random Sampling

- Any portion of the population has equal chance of being selected
- Bias is introduced when judgment is used
- Use random number tables or other means.

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# Random Number Table

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| .20 | .68 | .98 | .30 | .27 | .84 | .54 | .31 | .05 | .88 |
| .61 | .17 | .38 | .62 | .55 | .59 | .67 | .73 | .43 | .23 |
| .27 | .38 | .84 | .99 | .72 | .51 | .48 | .81 | .77 | .76 |
| .24 | .38 | .40 | .34 | .76 | .87 | .60 | .75 | .49 | .56 |
| .88 | .52 | .25 | .51 | .79 | .41 | .33 | .08 | .32 | .47 |
| .62 | .36 | .97 | .61 | .28 | .50 | .81 | .29 | .75 | .82 |
| .94 | .83 | .35 | .66 | .42 | .70 | .44 | .30 | .54 | .45 |

**For additional random # tables, see SOP 1-1*

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# Testing Locations

- STEP 1-
  - Determine LOT size, and with known lane width, determine LOT and sublot lengths
- STEP 2-
  - With known beginning station, determine beginning sublot stations

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# Testing Locations

- STEP 3-
  - Using random number table, or calculator, select 5 numbers.
- STEP 4-
  - Multiply a random number by the sublot Length.
- STEP 5-
  - Add to beginning sublot stations to determine longitudinal testing locations. *A second random number is used to find transverse location for S&A*

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# Testing Locations

STATIONS

- A "station" is a unit used in roadway construction to indicate a longitudinal location along the roadway.
- One station = 100 feet
- i.e. Station 1+00 equals 100 feet

  Station 4+50 equals 450 feet

  Station 105+60 equals 10,560 feet

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# Example Problem

- Situation
  - Placing D-mix, lane is 12 feet wide
  - Spread Rate is 132.5 lb/yd$^2$
  - Beginning Station 100+00

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# Asphalt Lots and Sublots

| Spread (lb/SY) | Lot/ Sublot | Mat Width (Feet) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 4 | 6 | 8 | 9 | 10 | 11 | 12 | 14 | 15 | 16 |
| 132.5 | Lot | 34000 | 22600 | 17000 | 15100 | 13600 | 12300 | 11300 | 9700 | 9100 | 8500 |
| | Sublot | 6800 | 4520 | 3400 | 3020 | 2720 | 2460 | 2260 | 1940 | 1820 | 1700 |
| 154.5 | Lot | 29100 | 19400 | 14600 | 12900 | 11700 | 10600 | 9700 | 8300 | 7800 | 7300 |
| | Sublot | 5820 | 3880 | 2920 | 2580 | 2340 | 2120 | 1940 | 1660 | 1560 | 1460 |
| 226 | Lot | 19900 | 13300 | 10000 | 8800 | 8000 | 7200 | 6600 | 5700 | 5300 | 5000 |
| | Sublot | 3980 | 2660 | 2000 | 1760 | 1600 | 1440 | 1320 | 1140 | 1060 | 1000 |
| 254.25 | Lot | 17700 | 11800 | 8800 | 7900 | 7100 | 6400 | 5900 | 5100 | 4700 | 4400 |
| | Sublot | 3540 | 2360 | 1760 | 1580 | 1420 | 1280 | 1180 | 1020 | 940 | 880 |
| 282.5 | Lot | 15900 | 10600 | 8000 | 7100 | 6400 | 5800 | 5300 | 4600 | 4200 | 4000 |
| | Sublot | 3180 | 2120 | 1600 | 1420 | 1280 | 1160 | 1060 | 920 | 840 | 800 |
| 310.75 | Lot | 14500 | 9700 | 7200 | 6400 | 5800 | 5300 | 4800 | 4100 | 3900 | 3600 |
| | Sublot | 2900 | 1940 | 1440 | 1280 | 1160 | 1060 | 960 | 820 | 780 | 720 |
| 345 | Lot | 13000 | 8700 | 6500 | 5800 | 5200 | 4700 | 4300 | 3700 | 3500 | 3300 |
| | Sublot | 2600 | 1740 | 1300 | 1160 | 1040 | 940 | 860 | 740 | 700 | 660 |
| 460 | Lot | 9800 | 6500 | 4900 | 4300 | 3900 | 3600 | 3300 | 2800 | 2600 | 2400 |
| | Sublot | 1960 | 1300 | 980 | 860 | 780 | 720 | 660 | 560 | 520 | 480 |

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# Example Problem (cont.)

- STEP 1- Determine Lot Length
  - 1,000 Ton lot
  - 132.5 lb/yd2
  - 12-feet wide
  - Begin Station = 100+00
  - From Table
    - Lot Length = 11,300 feet
    - Sublot Length = 2,260 feet

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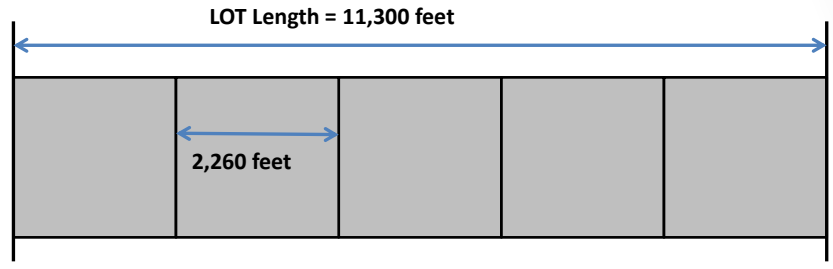
# Example Problem (cont.)




10000
+ 11300
213+00

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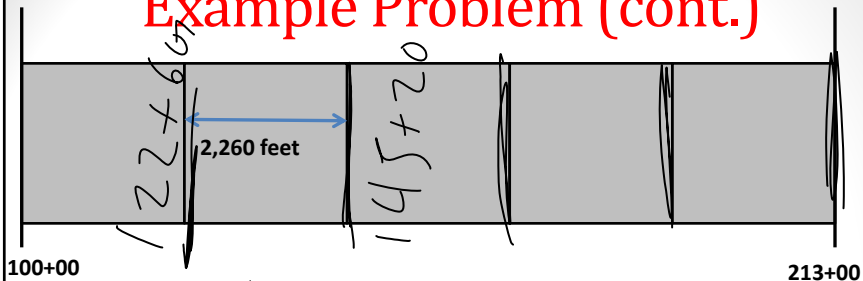
# Example Problem (cont.)




12260
+ 2260
145+20

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# Example Problem (cont.)

- **STEP 1-**

  LOT= 11,300’ SUB-LOT=2,260’

- **STEP 2- (Beginning Station 100+00)**
  - [100+00]+2,260 = 10,000+2,260 = 12,260 = 122+60
  - [122+60]+2,260 = 12,260+2,260 = 14,520 = 145+20
  - [145+20]+2,260 = 14,520+2,260 = 167+80
  - [167+80]+2,260 = 190+40
  - [190+40]+2,260 = 213+00
  - [100+00]+11,300 = 213+00

**End of Lot**

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# Example Problem (cont.)

- **STEP 3-** Using a random number table, select 5 numbers

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **.20** | .68 | .98 | .30 | .27 | .84 | .54 | .31 | .05 | .88 |
| .61 | .17 | **.38** | .62 | .55 | .59 | .67 | .73 | .43 | .23 |
| .27 | .38 | .84 | .99 | .72 | .51 | .48 | .81 | .77 | **.76** |
| .24 | .38 | .40 | .34 | .76 | .87 | .60 | .75 | .49 | .56 |
| .88 | .52 | .25 | .51 | .79 | .41 | .33 | .08 | .32 | .47 |
| .62 | .36 | .97 | **.61** | .28 | **.50** | .81 | .29 | .75 | .82 |
| .94 | .83 | .35 | .66 | .42 | .70 | .44 | .30 | .54 | .45 |

**Random Number Table**

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# Example Problem (cont.)

- **STEP 4-** Determine the distance within each sublot that each test will be located using both the sublot length and a random number.
  - Round to the nearest whole number.

  - Sublot #1 = (2,260' x 0.38) = **859 feet**
  - Sublot #2 = (2,260' x 0.50) = **1,130 feet**
  - Sublot #3 = (2,260' x 0.61) = **1,379 feet**
  - Sublot #4 = (2,260' x 0.76) = **1,718 feet**
  - Sublot #5 = (2,260' x 0.20) = **452 feet**

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# Example Problem (cont.)

- **STEP 5-** Determine where the gauge reading will be taken by adding each length to the start of each sublot.

  - Sublot #1 = (10,000') + 859' = 10,859' = **108+59**
  - Sublot #2 = (12,260') + 1,130' = 13,390' = **133+90**
  - Sublot #3 = (14,520') + 1,379' = 15,899' = **158+99**
  - Sublot #4 = (16,780') + 1,718' = 18,498' = **184+98**
  - Sublot #5 = (19,040') + 452' = 19,492' = **194+92**

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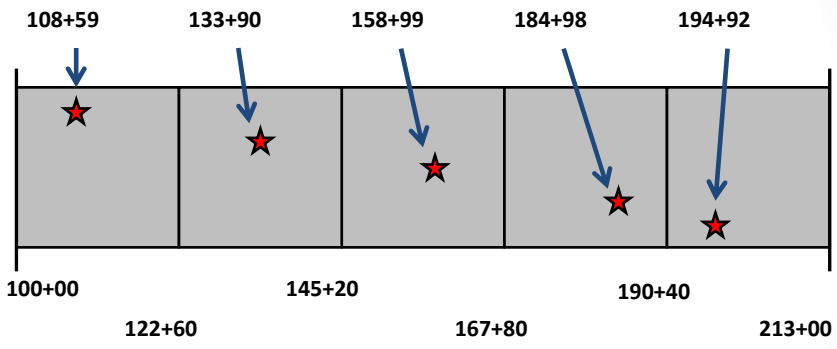
# Example Problem (cont.)

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# Soils/Aggregate Example Problem

Situation

- Placing Type A Base Material
- Typical base stone cross-section is 30 Feet
- Beginning Station 100+00

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# Example Problem (Continued)

- STEP 1- (Per SOP 1-1)
  - 10,000 SY LOT
  - LOT Length: 10,000 $yd^2$ x 9 = 90,000 $ft^2$

    90,000 $ft^2$ / 30 ft = 3000 ft length
  - SUB-LOT Length: 3000 ft / 5 = 600 ft

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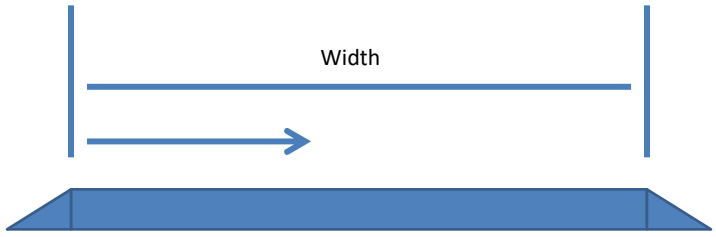
# Soils/Aggregate Continued

- Transverse location must also be random




Transverse Location = Width X Random Number

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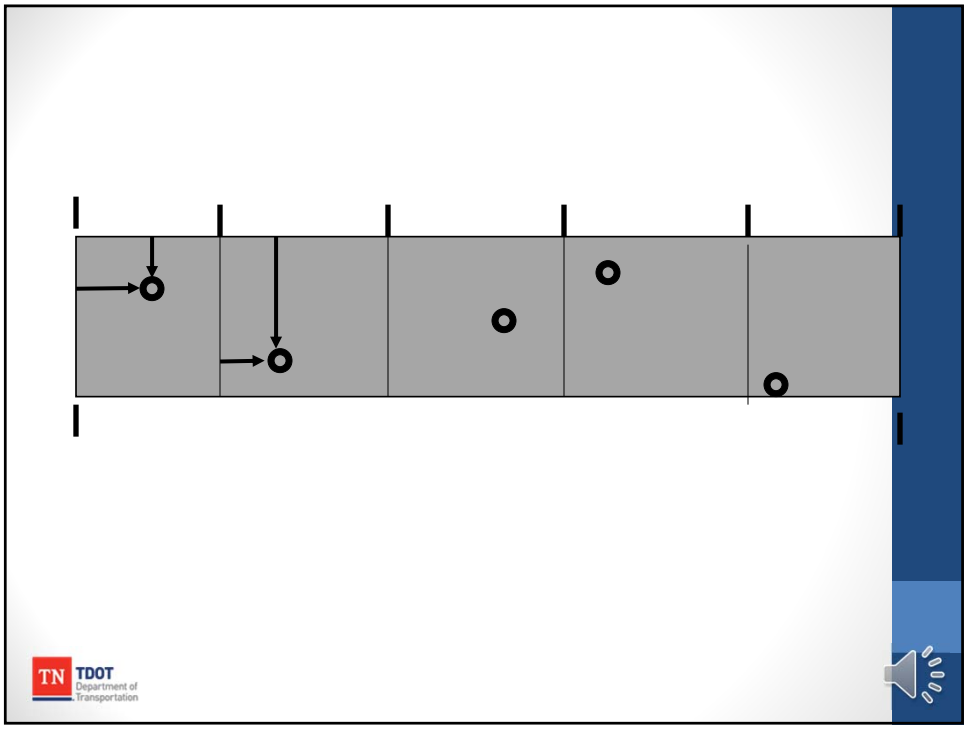
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