# OFFICE MEMORANDUM

**DATE:** April 25, 1996

**TO:** District Engineers
District Field Engineers
District Soils and Materials Engineers
Materials Supervisors
Resident/Project Engineers

**FROM:** Paul F. Miller, P.E.
Engineer of Construction

Calvin Roberts, P.E.
Engineer of Materials and Technology

**SUBJECT:** **JOINT CONSTRUCTION AND MATERIALS AND TECHNOLOGY INSTRUCTIONAL MEMORANDUM 1996 - E**
Procedure for Establishing Maximum Unit Weight and Desirable Moisture Content on Crush and Shape Projects

This past construction season a question came up several times as to whether the Michigan One-Point Cone Test or the Michigan Modified T-180 Test should be used to establish the Maximum Unit Weight (MD) on the crushed material (CM). The choice between tests was questioned due to the small amount of bituminous material in the CM.

Because the CM mixture varies so much on a typical project, and there is no accurate method to determine the amount of bituminous material in the mixture, the Michigan Modified T-180 will be used to establish the MD on crush and shape projects. This is the test that will be used, regardless of how much bituminous material is in the CM mixture.

Another issue that affects the performance of the finished crush and shape project is the amount of moisture in the CM mixture prior to, during and after paving. As a guideline, to help you determine the maximum amount of water that would be desirable in the CM prior to paving, the following formulas can be used:

Step 1. $$DD = \left( \frac{WD}{(\%M + 100)} \right) \times 100$$

The DD for the above formula is derived from the T-180 test by:

1. Determine the WD.
2. Run a "Speedy" on the material from the mold for %M.
3. Divide the WD by the %M, plus 100 x 100.

Step 2. $V_s = \dfrac{DD}{1000 \times 2.65}$

Step. 3 $\%M_m = \left( \dfrac{(1.0 - V_s)^* \times 1000}{DD} \right) \times 100$

| | | |
|---|---|---|
| $V_s$ | = | Volume of solids $m^3$ ($ft^3$) |
| WD | = | Wet Density in $kg/m^3$ ($lbs/ft^3$) |
| DD | = | Dry Density in $kg/m^3$ ($lbs/ft^3$) |
| 1000 kg (62.4 lbs) | = | Density of 1 $m^3$ ($ft^3$) of water |
| 2.65 | = | Average Bulk Specific Gravity of Michigan Base Aggregates (use actual value, if known) |
| %M | = | Result of "Speedy" run on T-180 sample |
| $\%M_m$ | = | The maximum amount of water this CM mixture can hold at 100% of the T-180 and would be the saturation point |

* This term $(1.0 - V_s)$ assumes the sample is saturated, with no air voids.

## MOISTURE & DENSITY DETERMINATION
## NUCLEAR METHOD

EXAMPLE: Metric Units

$$DD = \left( \frac{2342}{(6.2 + 100)} \right) \times 100 = 2205$$

$$V_s = \frac{2205}{(1000 \times 2.65)} = 0.83$$

$$\%M_m = \left( \frac{(1.0 - 0.83) \times 1000}{2205} \right) \times 100 = 7.7\%$$

U.S. Units

$$DD = \left( \frac{146.3}{(6.2 + 100)} \right) \times 100 = 137.8$$

$$V_s = \frac{137.8}{(62.4 \times 2.65)} = 0.83$$

$$\%M_m = \left( \frac{(1.0 - 0.83) \times 62.4)}{137.8} \right) \times 100 = 7.7\%$$

The guideline for the in-place moisture content at the time of paving should not be more than 75% of the saturation point (%$M_m$). The %$M_m$ will vary on a typical project on a ratio of about 2.5% for every 160 kg/m$^3$ (10 lbs/ft$^3$) change in the MD.

Anytime while pounding the T-180 and free water appears, the material is considered saturated and the grade should be aerated.

Engineer of Construction

for Engineer of Materials and Technology

PCB:CR:plr

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Subject Index: Density Testing

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Michigan Department of Transportation
0582BM (04/2001)

# MOISTURE AND DENSITY DETERMINATION

NUCLEAR METHOD

M·DOT METRIC

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* SEE REVERSE SIDE

| DATE | CONTROL SECTION ID | JOB NUMBER | ROUTE NO. or STREET | GAUGE NO. |
|---|---|---|---|---|
| | | | | |

| DENSITY INSPECTOR | CERTIFICATION NO. | PROJECT ENGINEER (MDOT) | PROJECT MANAGER | PROJECT MANAGER PHONE NO. |
|---|---|---|---|---|
| | | | | |

## DETERMINATION OF IN-PLACE DENSITY

| TEST | | WET DENSITY | | | MOISTURE | | | DRY DENSITY | | | LOCATION OF TEST | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ORIGINAL | RECHECK | COUNTS (DC) | TEST DEPTH mm | WET DENSITY kg /m³ | COUNTS (MC) | MOIS-TURE kg/m³ | MOIS-TURE % | DRY DENSITY kg /m³ | MAX DENSITY kg /m³ | PERCENT OF COM-PACTION | STATION | DISTANCE FROM ℄ m LEFT | DISTANCE FROM ℄ m RIGHT | DEPTH BELOW PLAN GRADE m | ITEM OF WORK * |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
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## DETERMINATION OF MAXIMUM DENSITY (Soil & Bituminous)

| TEST NO. | MOIS-TURE % | VOLUME MOLD m³ | DENSITY DETERMINATION: WET SOIL + MOLD Kg | MOLD Kg | WET SOIL Kg | COMPACTED SOIL WET Kg/m³ | MAX DENSITY Kg/m³ | OPTIMUM MOISTURE % |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| T-180 | 6.2 | .001028 | 6.658 | 1.250 | 2.408 | 2342 | 2342 | |
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**NOTE:**
To convert (ft³) to (m³):
Vol. (ft³) x 0.02832 = Vol. (m³)

**CHART STANDARDS**

| DENSITY | MOISTURE |
|---|---|
| | |

**OPERATING STANDARDS**

| DENSITY | MOISTURE |
|---|---|
| | |

BITUMINOUS MIX DESIGN kg /m³

REMARKS

| | DENSITY INSPECTOR'S SIGNATURE | AGENCY/COMPANY |
|---|---|---|
| | | |

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Michigan Department of Transportation
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# MOISTURE AND DENSITY DETERMINATION

NUCLEAR METHOD

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*SEE REVERSE SIDE

| DATE | CONTROL SECTION ID | JOB NUMBER | ROUTE NO. or STREET | GAUGE NO. |
|---|---|---|---|---|
| | | | | |

| DENSITY INSPECTOR | CERTIFICATION NO. | PROJECT ENGINEER (MDOT) | PROJECT MANAGER | PROJECT MANAGER PHONE NO. |
|---|---|---|---|---|
| | | | | |

## DETERMINATION OF IN-PLACE DENSITY

| TEST | | WET DENSITY | | | MOISTURE | | | DRY DENSITY | | | LOCATION OF TEST | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ORIGINAL | RECHECK | COUNTS (DC) | TEST DEPTH inch | WET DENSITY PCF | COUNTS (MC) | MOIS-TURE PCF | MOIS-TURE % | DRY DENSITY PCF | MAX DENSITY PCF | PERCENT OF COM-PACTION | STATION | DISTANCE FROM £ FT LEFT | DISTANCE FROM £ FT RIGHT | DEPTH BELOW PLAN GRADE FT | ITEM OF WORK * |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| | | | | | | | | | | | | | | | |
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## DETERMINATION OF MAXIMUM DENSITY (Soil & Bituminous)

| TEST NO. | MOIS-TURE % | VOLUME MOLD CU. FT. | DENSITY DETERMINATION: WET SOIL + MOLD g | MOLD g | WET SOIL g | WET SOIL lbs. | COMPACTED SOIL WET PCF | MAX DENSITY PCF | OPTIMUM MOISTURE % |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| T-180 | 6.2 | .0363 | 3658 | 1250 | 2408 | 5.31 | 146.3 | 146.3 | |
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**NOTE:**
To convert (g) to (lbs.):
Wt. (g) ÷453.59 = Wt. (lbs.).
To convert ($m^3$) to ($ft.^3$):
Vol. ($m^3$) ÷0.02832 = Vol. ($ft.^3$).

**CHART STANDARDS**

| DENSITY | MOISTURE |
|---|---|
| | |

**OPERATING STANDARDS**

| DENSITY | MOISTURE |
|---|---|
| | |

BITUMINOUS MIX DESIGN PCF

REMARKS

| | DENSITY INSPECTOR'S SIGNATURE | AGENCY/COMPANY |
|---|---|---|
| | | |

MDOT 0582B (04/2001)

First Page

# DENSITY GUIDELINES

| | % DENSITY | ITEM OF WORK | DEPTH |
|---|---|---|---|
| **Original Ground** | | | |
| Road Embankment Areas (if specified) | 90 | OG | 9" |
| Bridges — Within the limits as shown on the plans | 95 | OG | 9" |
| **Cut Areas** | | | |
| Cuts requiring Sand Subbase | 95 | CS | 9" |
| Cuts not requiring Sand Subbase | 95 | CN | 12" |
| Subgrade for Bituminous Base, Aggregate Base and Concrete Widening | 95 | SG | 9" |
| **Embankments** | | | |
| Regular | 95 | E | |
| Abutments with Piling | 95 | AP | |
| Abutments without Piling — Within the limits for Structure Embankment as shown on the plans | 100 | AN | |
| Foundation Undercut Backfill for retaining Walls, Grade Separations or Bridges | 100 | FB | |
| Backfill for Bridges, Culverts, Sewers, Manholes, Catch Basins, Edge Drains, and Subgrade Undercuts | 95 | B | |
| Subbase | 95 | S | |
| Subbase for Slope Paving | 90 | SP | |
| Aggregate Base — Concrete | 95 | SS | |
| Aggregate Base — Bituminous | 98 | AB | |
| Bituminous Aggregate Base (pulverized Bituminous used as Aggregate Base) | 98 | BAB | |
| Shoulders — Class **AA** | 98 | SAA | |
| Shoulders Class **A** and **B** . | 95 | SA | |
| Bituminous Stabilization | 98 | BS | |
| Bituminous Paving — Base Course | 97 | BB | |
| Bituminous Paving — Leveling Course | 97 | BL | |
| Bituminous Paving — Top Course | 97 | BT | |