Method of Test for

THE MIXING LOSS OF AGGREGATE MATERIAL

DOTD Designation: TR 417-84

METHOD A

Scope

1. This method of test is intended to determine the loss in volume (mixing loss) when two or more shell components, or sand and shell, are measured separately by wet volume, according to predetermined proportions, then mixed on the roadway. Mixing loss (percent shrinkage) is determined based on field conditions of the materials.

Apparatus

2. (a) Metal measure, cylindrical, one-fifth cubic foot or larger.

(b) Scale, 50 pound or more capacity, sensitive to 0.01 lb.

Sample

3. For a one-fifth cubic foot measure, approximately 200 total pounds of material will be required for the test, with components proportioned according to the specified percentages. Material used for the test should be in the same condition, with respect to moisture content and fragmentation of shell, as material to be used in the field.

Procedure

4. (a) Determine the calibrated volume of the measure in accordance with DOTD Designation: TR 640, and record on the work card (Example 1).

(b) Using a work card for each component, determine the average loose unit weight of each component, at field moisture conditions, according to the following procedure:

(1) Weigh and record weight of the empty measure.

(2) Fill the measure to overflowing, using a shovel or large scoop. Discharge the material, using a sharp twisting motion of the shovel, from a height of 2 inches or less above the top of the measure. Take care to prevent segregation of the material.

(3) Strike off the material, using fingers and a straightedge, so that the surface is level with the top rim of the measure. Do not compact the material.

(4) Weigh and record the weight of the filled measure.

(5) Determine the net weight of the material in the measure by subtracting the weight of the measure from the total weight of the filled measure.

(6) Determine the unit weight by dividing the net weight by the volume of the measure.

(7) Make at least three determinations for each component and average the results of these determinations to obtain the average loose unit weight of the component. Record the average loose unit weight of the component on the worksheet (Example 2).

(c) Using a work card for each component, determine the average dense unit weight of each component, at field moisture conditions, according to the following procedure:

(1) Fill the measure in three approximately equal layers. To densify each layer, place the measure on a firm, level foundation, such as a concrete floor, raise alternate sides of the measure about 2 inches from the foundation, and allow it to drop in such a manner as to strike the foundation with a sharp blow. Densify each layer by dropping the measure a total of five times in this manner.

(2) To further densify each layer, raise the measure, in a level position, approximately 6 inches above the foundation and allow it to drop sharply a total of five times.

(3) If, at any time during the densification of the last layer, the level of the material is vibrated below the top rim of the measure, immediately add more material and resume the procedure. When the densification of the last layer is complete, level the surface of the material as described in Step (b).

(4) Determine the net weight of the material in the measure by subtracting the weight of the measure from the total weight of the filled measure.

(5) Determine the unit weight by dividing the net weight by the volume of the measure.

(6) Make at least three determinations for each component and average the results of these determinations to obtain the average dense unit weight. Record the average dense unit weight of the component on the worksheet (Example 2).

(d) Add the average loose unit weight and the average dense unit weight and divide the result by two.

The resulting value is considered to be the unit weight of the component at the point of delivery on the roadway. Record this value on the worksheet.

(e) Multiply the specified percent (by volume) of each component by its unit weight at point of delivery. The values thus obtained are the weights of the components to be mixed (see worksheet). The numerical sum of these weights is called the theoretical unit weight of the mixture. Record the theoretical unit weight of the mixture on the worksheet.

(f) Measure and set aside the weight of each component to be mixed (see work card). Mix the componets thoroughly in such a way as not to segregate the particles. Using another work card, repeat Steps (b) through (c) for the mixture, to obtain an average loose unit weight and an average dense unit weight for the mixture. Record these unit weights in the appropriate space on the worksheet.

(g) Add the average loose unit weight of the mixture and the average dense unit weight of the mixture and divide the result by two (see worksheet). The value thus obtained is called the actual unit weight of the mixture at point of delivery. Record this value in the appropriate space on the worksheet.

Calculations

Calculate the percent shrinkage according to the following formula:

5. (a)

$$\% \text{ Shrinkage} = \frac{(\text{Actual U.W.} - \text{Theoretical U.W.}) \times 100}{\text{Actual U.W.}}$$

Example:

Specified percent, by dry weight	65%	clam shell
	21%	fine sand
	14%	coarse sand

Procedure

REFERENCE	CLAM SHELL	
4. (b)	Average loose unit weight	59.80 lb/ft^3
4. (c)	Average dense unit weight	+ 69.70 lb/ft^3
4. (d)	Unit weight at point of delivery	129.50 ÷ 2 = 64.75 lb/ft^3
	FINE SAND	
4. (b)	Average loose unit weight	70.04 lb/ft^3
4. (c)	Average dense unit weight	+ 88.22 lb/ft^3
4. (d)	Unit weight at point of delivery	158.26 ÷ 2 = 79.13 lb/ft^3
	COARSE SAND	
4. (b)	Average loose unit weight	89.12 lb/ft^3
4. (c)	Average dense unit weight	+ 98.32 lb/ft^3
4. (d)	Unit weight at point of delivery	187.44 ÷ 2 = 93.72 lb/ft^3

WEIGHTS OF COMPONENTS FOR ONE CUBIC FOOT OF MIXTURE

4. (e)	65% x 64.75 lb/ft^3	= 42.09 lb clam shell per ft^3 of mixture
4. (e)	21% x 79.13 lb/ft^3	= 16.62 lb fine sand per ft^3 of mixture
4. (e)	14% x 93.72 lb/ft^3	= 13.12 lb coarse sand per ft^3 of mixture
4. (e)	Theoretical unit weight of mixture	= 71.83 lb/ft^3

UNIT WEIGHTS OF MIXTURE

4. (f)	Average loose unit weight of mixture	77.92 lb/ft^3
4. (f)	Average dense unit weight of mixture	+97.32 lb/ft^3
4. (g)	Actual unit weight of mixture at point of delivery	= 175.24 ÷ 2 = 87.62 lb/ft^3

$$\% \text{ Shrinkage} = \frac{(\text{Actual U.W.} - \text{Theoretical U.W.}) \times 100}{\text{Actual U.W.}}$$

$$\% \text{ Shrinkage} = \frac{(87.62 - 71.83) \times 100}{87.62} = \frac{(15.83) \times 100}{87.62} = 18.0\%$$

Report

6. The percent shrinkage shall be reported to the nearest 1/10 percent.

Normal testing time is 3 days.

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

MATERIALS SECTION

TR 417 WORK CARD

COMPONENT ____________ LAB NO. ____________ SPLIT NO. ____________

LOOSE UNIT WEIGHTS

Weight Measure + Sample	(-)	Weight of Measure	(=)	Net Weight of Sample	(÷)	Volume of Measure	(=)	Loose Unit Weight
______ lb	(-)	______ lb	(=)	______ lb	(÷)	______ ft^3	(=)	______ lb/ft^3
______		______		______		______		______
______		______		______		______		______
______		______		______		______		______

AVERAGE LOOSE UNIT WEIGHT = Total of Loose Unit Weights / No. of Determinations = ______ lb/ft^3 / (No.) = ______ lb/ft^3 (AVE. LOOSE U.W.)

DENSE UNIT WEIGHTS

Weight Measure + Sample	(-)	Weight of Measure	(=)	Net Weight of Sample	(÷)	Volume of Measure	(=)	Dense Unit Weight
______ lb	(-)	______ lb	(=)	______ lb	(÷)	______ ft^3	(=)	______ lb/ft^3
______		______		______		______		______
______		______		______		______		______
______		______		______		______		______

AVERAGE DENSE UNIT WEIGHT = Total of Dense Unit Weights / No. of Determinations = ______ lb/ft^3 / (No.) = ______ lb/ft^3 (AVE. DENSE U.W.)

Example 1 (front)

MOISTURE CONTENT DETERMINATION

(a) Wet Soil + Pan ______ g

(b) Dry Soil + Pan ______ g

(c) Water a-b ______ g

(d) Weight of Pan ______ g

(e) Dry Soil b-d ______ g

$M.C. = \frac{(c)}{(e)} \times 100 =$ ______ %

WEIGHTS OF COMPONENTS FOR THE MIXTURE (METHOD A)

Component	Weight of Comp. for 1 ft^3 Mix	x	Volume of Measure	=	Weight of Comp. for Mix
______	______	x	______	=	______
______	______		______		______
______	______		______		______
______	______		______		______

Example 2 (back)

Louisiana Department of Transportation and Development
Materials Section

PROJ. NO. ____________

DATE ____________

**SAND-SHELL MIXTURES
WORKSHEET FOR
TR 417 - METHOD A**

OPERATOR ____________
CHECKED BY ____________

Specified Percent, By Volume	Component Type	Lab No.
______ %	______	______
______ %	______	______
______ %	______	______
______ %	______	______

UNIT WEIGHTS (U.W.) (From work card)

Component	(Avg. Loose Unit Weight	+	Avg. Dense Unit Weight)	÷ 2 =	Unit Weight at Point of Delivery	x	Specified Percent	=	Wt. of Component To Be Mixed for 1 ft^3 of mix
______	______ lb/ft^3		______ lb/ft^3		______ lb/ft^3		______ %		______ lb/ft^3 of mix
______	______		______		______		______		______
______	______		______		______		______		______
______	______		______		______		______		______

Sum of Component Weights = Theoretical Unit Weight of Mixture [______ lb/ft^3]

(Avg. Loose Unit Weight + Avg. Dense Unit Weight) ÷ 2 = ACTUAL UNIT WEIGHT

MIXTURE (______ lb/ft^3 + ______ lb/ft^3) ÷ 2 = [______ lb/ft^3]

PERCENT SHRINKAGE = $\frac{\text{(Actual U.W.-Theoretical U.W.)} \times 100}{\text{Actual U.W.}}$ = [______ %]

REMARKS ____

Example 2

Method of Test for
THE MIXING LOSS OF AGGREGATE MATERIAL
DOTD Designation: TR 417-84
METHOD B

Scope

1. This method of test is intended to determine the loss in volume (mixing loss) when two or more components of base course or shoulder surfacing material, other than shell or sand and shell, are measured separately, then mixed on the roadway. This procedure provides proportions of components needed to produce a material which meets a specified gradation, such as sand-clay-gravel. Mixing loss (percent shrinkage) is determined based on field conditions of the materials.

Apparatus

2. (a) Metal measure, cylindrical, one-fifth cubic foot or larger.

(b) Scale, 50 pound or more capacity, sensitive to 0.01 lb.

Sample

3. For a one-fifth cubic foot measure, approximately 200 total pounds of material will be required for the test, with components proportioned according to the specified percentages. Material used for the test should be in the same condition, with respect to moisture content, as material to be used in the field.

Procedure

4. (a) Determine the calibrated volume of the measure in accordance with DOTD Designation: TR 640 and record on work card (Example 1, Method A).

(b) Using a work card for each component, determine the average loose unit weight of each component, at field moisture conditions, according to the following procedure:

(1) Weigh and record the weight of the measure.

(2) Fill the measure to overflowing, using a shovel or large scoop. Discharge the material, using a sharp twisting motion of the shovel, from a height of 2 inches or less above the top of the measure. Take care to prevent segregation of the material.

(3) Strike off the material, using fingers and a straightedge, so that the surface is level with the top rim of the measure. Do not compact the material.

(4) Weigh and record the weight of the filled measure.

(5) Determine the net weight of the material in the measure by subtracting the weight of the measure from the total weight of the filled measure.

(6) Determine the unit weight by dividing the net weight by the volume of the measure.

(7) Make at least three determinations for each component and average the results of these determinations to obtain the average loose unit weight of the component. Record the average loose unit weight on the worksheet (Example 3).

(c) Using a work card for each component, determine the average dense unit weight of each component, at field moisture conditions, according to the following procedure:

(1) Fill the measure in three approximately equal layers. To densify each layer, place the measure on a firm, level foundation, such as a concrete floor, raise alternate sides of the measure about 2 inches from the foundation and allow it to drop in such a manner as to strike the foundation with a sharp blow. Densify each layer by dropping the measure a total of five times in this manner.

(2) To further densify each layer, raise the measure, in a level position, approximately 6 inches above the foundation and allow it to drop sharply a total of five times.

(3) If, at any time during the densification of the last layer, the level of the material is vibrated below the top rim of the measure, immediately add more material and resume the procedure. When the densification of the last layer is complete, level the surface of the material as described in Step (b).

(4) Determine the net weight of the material in the measure by subtracting the weight of the measure from the total weight of the filled measure.

(5) Determine the unit weight by dividing the net weight by the volume of the measure.

(6) Make at least three determinations for each component and average the results of these determinations to obtain the average dense unit weight. Record the average dense unit weight of the component on the worksheet (Example 3).

(d) Add the average loose unit weight and the average dense unit weight and divide the result by two. This value is considered to be the unit weight of the component, in field condition, at the point of delivery on the roadway, or the wet unit weight.

(e) Determine the volume of each component according to the following procedure:

(1) Multiply the specified percent by dry weight to be used in the mixture by the sum of (100 + M.C.). This value is considered to be wet weight of each component to be incorporated in the mix in order to obtain 100 lb (dry weight) of mixture.

(2) Divide the wet weight of the component by the wet unit weight of the component. This is the volume of the component to be used in the mixture.

(f) Determine the theoretical unit weight according to the following procedure:

(1) Add the volumes of all components to obtain the theoretical total volume of the mixture.

(2) Divide the sum of all wet weights determined in Step (e) by the theoretical total volume of the mixture. This is called the theoretical unit weight.

(g) Divide the volume of each component by the theoretical total volume of the mixture and multiply the result by 100. This value is the percent by volume of each component to be incorporated in the mixture. The sum of these percentages must total 100.0 percent. (The percent by volume is reported for roadway mix purposes).

(h) For each component, measure and set aside the weight of wet material determined in Step 4 (e)(1). Mix the components thoroughly in such a way as not to segregate particles. Using another work card, repeat Steps (b) through (c) for the mixture, to obtain an average loose unit weight and an average dense unit weight for the mixture.

(i) Add the average loose unit weight and the average dense unit weight of the mixture and divide the result by two. The value thus obtained is called the actual unit weight of the mixture at point of delivery.

Calculations

5. Calculate the percent shrinkage according to the following formula:

$$\%\ \text{shrinkage} = \frac{(\text{Actual U.W.} - \text{Theoretical U.W.}) \times 100}{\text{Actual U.W.}}$$

Example:

Specified percent, by dry weight

20% gravel at 1% M.C.
15% sand at 4% M.C.
30% binder at 6% M.C.
35% ballast at 5% M.C.

Procedure

REFERENCE **GRAVEL**

4. (b)	Average loose unit weight	96.68 lb/ft^3
4. (c)	Average dense unit weight	+103.06 lb/ft^3
4. (d)	Wet unit weight	199.74 ÷ 2 = 99.87 lb/ft^3

SAND

4. (b)	Average loose unit weight	79.68 lb/ft^3
4. (c)	Average dense unit weight	+ 99.00 lb/ft^3
4. (d)	Wet unit weight	178.68 ÷ 2 = 89.34 lb/ft^3

BINDER

4. (b)	Average loose unit weight	73.11 lb/ft^3
4. (c)	Average dense unit weight	+ 95.07 lb/ft^3
4. (d)	Wet unit weight	168.18 ÷ 2 = 84.09 lb/ft^3

BALLAST

4. (b)	Average loose unit weight	$104.48\ lb/ft^3$
4. (c)	Average dense unit weight	$+118.58\ lb/ft^3$
4. (d)	Wet unit weight	$223.06 \div 2 = 111.53\ lb/ft^3$

4. (e)(1) **WET WEIGHTS OF COMPONENTS FOR 100 LB (DRY WEIGHT) OF MIXTURE**

20% gravel	x (100 + M.C.) = (.20) x (100 + 1) =	20.20 lb gravel
15% sand	x (100 + M.C.) = (.15) x (100 + 4) =	15.60 lb sand
30% binder	x (100 + M.C.) = (.30) x (100 + 6) =	31.80 lb binder
35% ballast	x (100 + M.C.) = (.35) x (100 + 5) =	36.75 lb ballast
4. (f)(2) Sum of wet weights		= 104.35 lb (100 lb dry wt.)

VOLUMES OF COMPONENTS FOR 100 LB (DRY WEIGHT) OF MIXTURE

4. (e)(2)	GRAVEL	$20.20\ lb \div 99.87\ lb/ft^3 = 0.202\ ft^3$
	SAND	$15.60\ lb \div 89.34\ lb/ft^3 = 0.175\ ft^3$
	BINDER	$31.80\ lb \div 84.09\ lb/ft^3 = 0.378\ ft^3$
	BALLAST	$36.75\ lb \div 111.53\ lb/ft^3 = 0.330\ ft^3$
4. (f)(1)	Theoretical Total Volume of Mixture	$= 1.085\ ft^3$

4. (f)(2) Theoretical Unit Weight of Mixture = $104.35\ lb \div 1.085\ ft^3 = 96.18\ lb/ft^3$

4. (g) **PERCENTS, BY VOLUME, TO BE INCORPORATED IN MIXTURE**

	GRAVEL	$0.202\ ft^3 \div 1.085\ ft^3 \times 100 =$	18.62%
	SAND	$0.175\ ft^3 \div 1.085\ ft^3 \times 100 =$	16.13%
	BINDER	$0.378\ ft^3 \div 1.085\ ft^3 \times 100 =$	34.84%
	BALLAST	$0.330\ ft^3 \div 1.085\ ft^3 \times 100 =$	30.41%
4. (g)	Sum of Percentages	(Must equal 100%)	= 100.00%

UNIT WEIGHTS OF MIXTURE

4. (h)	Average loose unit weight of mixture	$= 90.56\ lb/ft^3$
4. (h)	Average dense unit weight of mixture	$= 112.54\ lb/ft^3$
4. (i)	Actual unit weight of mixture	$= 203.10 \div 2 = 101.55\ lb/ft^3$

$$\%\ Shrinkage = \frac{(\text{Actual U.W.} - \text{Theoretical U.W.}) \times 100}{\text{Actual U.W.}}$$

$$\%\ Shrinkage = \frac{(101.55 - 96.18) \times 100}{101.55} = \frac{(5.37) \times 100}{101.55} = 5.3\%$$

Report

6. The percent by volume (from 4 (g) and the percent shrinkage shall be reported to the nearest 1/10 percent.

Normal testing time is 3 days.

Louisiana Department of Transportation and Development
Materials Section

PROJ. NO. ________ OPERATOR ________

DATE ________ CHECKED BY ________

AGGREGATE MIXTURES
WORKSHEET FOR
TR 417 - METHOD B

COMPONENT DATA / **WET UNIT WEIGHTS (From work card)**

Lab. No.	Specified Percent By Dry Weight	Component Type	Moisture Content (M.C.)	(Avg. Loose Unit Weight)	+	Avg. Dense Unit Weight	÷ 2 =	Wet Unit Weight
____	____ %	____	____ %	(____ lb/ft^3	+	____ lb/ft^3)	÷ 2 =	____ lb/ft^3
____	____ %	____	____ %	(____ lb/ft^3	+	____ lb/ft^3)	÷ 2 =	____ lb/ft^3
____	____ %	____	____ %	(____ lb/ft^3	+	____ lb/ft^3)	÷ 2 =	____ lb/ft^3
____	____ %	____	____ %	(____ lb/ft^3	+	____ lb/ft^3)	÷ 2 =	____ lb/ft^3

WET WEIGHTS AND VOLUMES OF COMPONENTS FOR 100 LB (DRY WEIGHT) OF MIXTURE

Component	Specified Percent, By Dry Weight	x	(100 + Moisture Content)	= Wet Weight	÷	Wet Unit Weight	=	Volume of Components
____	____ %	x	(100 + ____ %)	= ____ lb	÷	____ lb/ft^3	=	____ ft^3
____	____ %	x	(100 + ____ %)	= ____ lb	÷	____ lb/ft^3	=	____ ft^3
____	____ %	x	(100 + ____ %)	= ____ lb	÷	____ lb/ft^3	=	____ ft^3
____	____ %	x	(100 + ____ %)	= ____ lb	÷	____ lb/ft^3	=	____ ft^3
			Sum of Weights	= ____ lb		Theoretical Total Volume	=	____ ft^3

Theoretical Unit Weight of Mixture = $\frac{\text{Sum of Wet Weights}}{\text{Theoretical Total Volume}}$ = ____ lb/ft^3

PERCENTS BY VOLUME, TO BE INCORPORATED IN MIXTURE

Component	Volume	÷	Theoretical Total Volume	x 100 =	Percent By Volume
____	____ ft^3	÷	____ ft^3	x 100 =	____ %
____	____ ft^3	÷	____ ft^3	x 100 =	____ %
____	____ ft^3	÷	____ ft^3	x 100 =	____ %
____	____ ft^3	÷	____ ft^3	x 100 =	____ %
			Sum of Percents	=	____ %

(Must Equal 100.0%)

MIXTURE

(Avg. Loose Unit Weight)	+	Avg. Dense Unit Weight	÷ 2 =	Actual Unit Wt. of Mixture
(____ lb/ft^3	+	____ lb/ft^3)	÷ 2 =	____ lb/ft^3

% Shrinkage = $\frac{(\text{Actual U.W.} - \text{Theoretical U.W.}) \times 100}{\text{Actual U.W.}}$

= $\frac{(\_\_\_\_ - \_\_\_\_) \times 100}{\_\_\_\_}$ = ____ %

REMARKS ________