EXPERIMENT NO.- 3

a) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate - **ASTM C128**

b) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate1– **ASTM C127**

c) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate – **ASTM C29**

d) Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying - **ASTM C566**

e) Standard Test Method for Surface Moisture in Fine Aggregate - **ASTM C70**

3 (a) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate

- ASTM C128

INTRODUCTION

- Aggregates generally contain pore.
- With specific gravity of each constituent known, its weight can be converted in to solid volume and hence a theoretical yield of concrete per unit volume can be calculated.

INTRODUCTION Cont'd

- **Bulk specific gravity** is defined as the ratio of the weight of the aggregate (oven-dry or saturated surface dry) to the weight of water occupying a volume equal to that of the solid including permeable pores.
- This is used for-

  - The computation of void in aggregate, and

  - The determination of moisture in aggregate.

INTRODUCTION Cont'd

- **Apparent specific gravity** is the ratio of the weight of the aggregate heating in an oven at 110 ± 5°C for sufficient time to reach a constant mass to the weight of water occupying a volume equal to that of the solid excluding permeable pores.
- This pertains to the relative density of the solid material making up the constituent particles not including the pore space within the particles that is accessible to water.

INTRODUCTION Cont'd

- Absorption values are used to calculate the change in the weight of an aggregate due to water absorbed in the pore spaces within the constituent particles, compared to the dry condition.
- For an aggregate that has been in contact with water and that has free moisture on the particle surfaces, the percentage of free moisture can be determined by deducting the absorption from the total moisture content.

APPARATUS

Balance: Sensitive to 0.1 g or less.

Pycnometer:

A flask or other suitable container of 1000 ml capacity .The volume of the container filled to mark shall be at least 50 % greater than the space required to accommodate the test sample of fine aggregate.

APPARATUS CONT'D

Mold:

A metal mold in the form of a frustum of a cone with dimensions as follows :

- 40 ± 3 mm inside diameter at the top
- 90±3 mm inside diameter at the bottom
- 75±3 mm in height
- 0.8 mm minimum thickness of metal

Tamper:

A metal tamper weighting 350±15 g and having a flat circular tamping face 25 ± 3 mm in diameter.

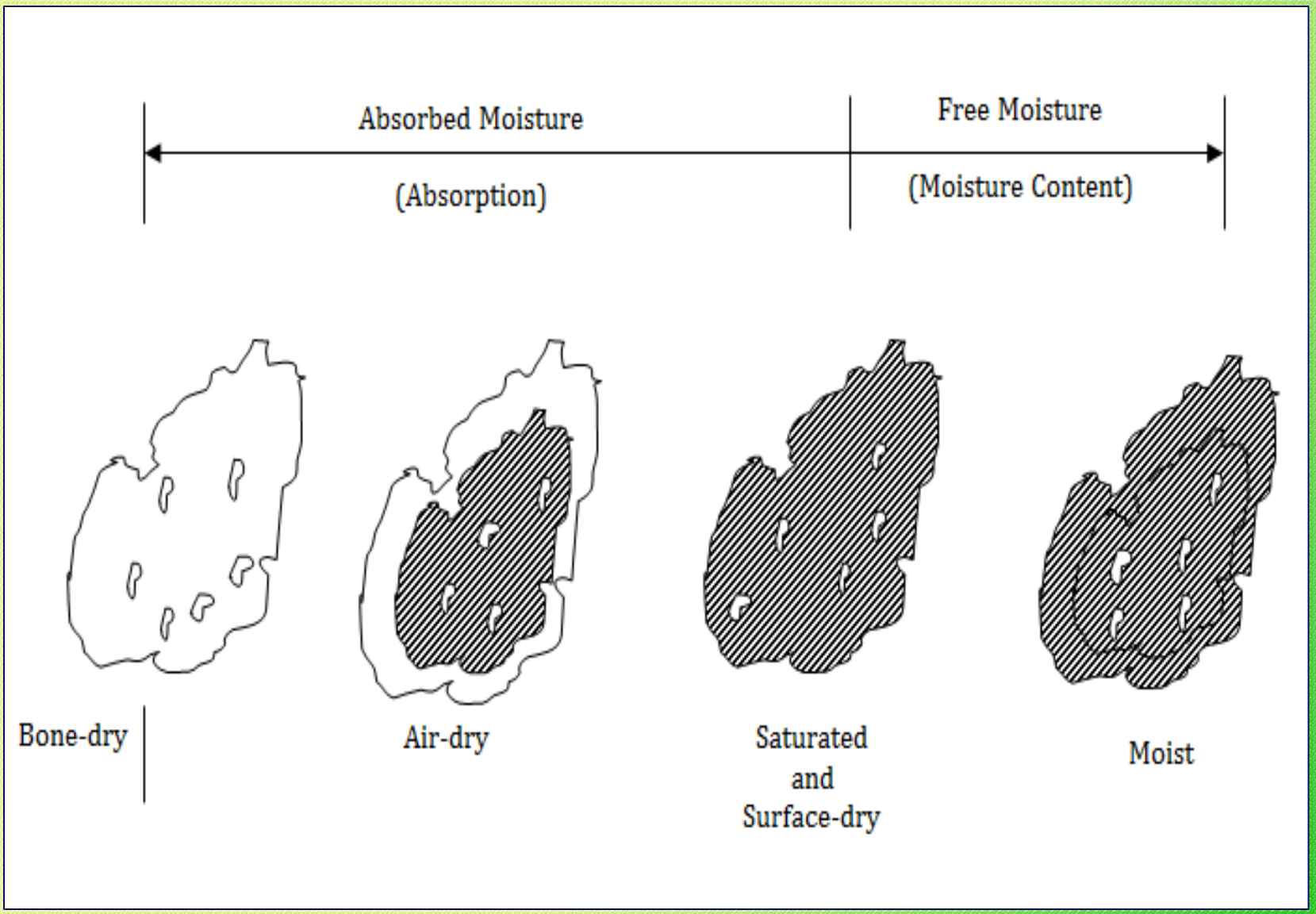

Figure 9.1: Diagrammatic representation of moisture in aggregate

SAMPLING

Test Sample Preparation

- Obtain approximately 1 kg sample of fine aggregate.
- Dry it in a suitable pan or vessel to constant weight at a temperature of 110 ±5°C
- Allow it to cool to comfortable handling temperature, record the weight of the sample
- cover with water, either by immersion or by addiction of at least 6 % moisture to the fine aggregate and permit to stand for 24 ±4 hrs.
- Decant excess water with care to avoid loss of fines, spread the sample on a flat non-absorbent surface exposed to a gently moving current of warm air, and stir frequently to secure homogeneous drying.
- Continue this operation until the test specimen approaches a free –flowing condition.

- **Cone test for surface moisture** –Place a portion of the partially dried fine aggregate loosely in the mold by filling it to overflowing and heaping additional material above the top of the mold by holding it with the cupped fingers of the hand holding the mold.
- Lightly tamp the fine aggregate into the mold with 25 light drops of the tamper.
- Each drop should start about 5 mm (0.2in) above the top surface of the fine aggregate.
- Permit the tamper to fall freely under gravitational attraction on each drop.
- Adjust the stirring height to the new surface elevation after each drop and distribute over the surface.

- Remove loose sand from the vase and lift the mold vertically.
- If surface moisture is still present, the fine aggregate will retain the molded shape.
- Continue drying with constant stirring and test at frequent intervals until the cone of the sand slumps up on the removable of mold.
- When the fine aggregate slumps slightly it indicates that it has reached a surface –dry condition.

- If the first trial of the surface moisture test indicates that moisture is not present on the surface, it has been dried past the saturated surface –dry condition.
- In this case thoroughly mix a few milliters of water with the fine aggregate and permit the specimen to stand in a cover container for 30 minutes.
- Then resume the process of drying and testing at frequent interval for the onset of the surface –dry condition.

PROCEDURE

- Partially fill the pycnometer with water.
- Immediately introduce in to the pycnometer 500±10 (***S***) gm of saturated surface – dry fine aggregate prepared and fill with additional water approximately 90% of capacity.
- Roll, invert, and agitate the pycnometer to eliminate all air bubbles.
- Adjust its temperature to 23±2.0ºC, if necessary by immersion in circulating water, bring the water level in the pycnometer to its calibrated capacity.
- Determine the total weight of the pycnometer, specimen and water (***C).***

PROCEDURE CONT'D

- Remove the fine aggregate from the pycnometer, dry to constant weight at a temperature of 110±5ºC, cool in air at room temperature and weigh (***A***).
- Determine the weight of the pycnometer filled to its calibration capacity with water at 23±2.0ºC (***B***).

SAMPLE DATA SHEET

Weight of Oven-dry Specimen in Air, *A* (gm)	Weight of Pycnometer +Water, *B* (gm)	Weight of SSD Specimen, *S* (gm)	Weight of Pycnometer+ Specimen+ Water, *C* (gm)

CALCULATION

Calculate all parameters as per the formulae given in Data Sheet

SAMPLE DATA SHEET

Parameters	Formulae	Calculations	Results
Apparent Specific Gravity, S_a	$\frac{A}{B+A-C}$		
Relative Density (Specific Gravity) (OD), S_d	$\frac{A}{B+S-C}$		
Relative Density (Specific Gravity) (SSD), S_s	$\frac{S}{B+S-C}$		
Absorption, %	$\frac{S-A}{A} \times 100$		
Density (OD), kg/m^3	$997.5 \times \frac{A}{B+S-C}$		
Density (SSD), kg/m^3	$997.5 \times \frac{S}{B+S-C}$		
Apparent density (SSD), kg/m^3	$997.5 \times \frac{A}{B+A-C}$		

RESULT

- Report specific gravity results to the nearest 0.01 and absorption to the nearest 0.1%.

SHORT QUESTIONS??

- What is the distinction between apparent and bulk specific gravity?
- How would the determination of bulk specific gravity of the fine aggregate (surface-dry basis) be affected by the 500 gm sample being drier than the surface –dry condition? Explain. Assume that the aggregate becomes saturated during the test.
- Would the apparent specific gravity be affected in the same manner as in question no.2? Explain.

REPORT

The Report shall include the following information:

- Identification of the aggregate as to source
- Report specific gravity results to the nearest 0.01 and absorption to the nearest 0.1%.

3 (b) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate1– **ASTM C127**

INTRODUCTION

- This test method covers the determination of specific gravity and absorption of coarse aggregate.
- All the terminologies and their uses are same as for the specific gravity and absorption of fine aggregate (Experiment 3a).

APPARATUS

Balance:

Sensitive to 0.05% of the sample weight at any point within the range used for the test, or 0.5 g, whichever is greater.

Sample container:

- A wire basket of 3.35 mm (No.6) or finer mesh ,or a bucket of approximately equal breadth and height, with a capacity of 4 to 7 liter for 37.5 mm (1.5 in.) nominal maximum size aggregate .
- The container shall be constructed so as to prevent trapping air when the container is submerged.

Water tank:

A watertight tank into which the sample container may be placed while suspended below the balance.

Sieves:

A 4.75 mm (No. 4) sieve or other sizes as needed.

SAMPLING

- Thoroughly mix the sample of aggregate and reduce it to the approximate quantity needed.
- Reject all material passing a 4.75 mm (No.4) sieve by dry sieving and thoroughly washing to remove dust or other coatings from the surface.
- If the coarse aggregate contains a substantial of material finer than the 4.75 mm sieve, use the 2.36 mm (No.8) sieve in place of 4.75 mm sieve.

- **The minimum weight of test sample to be used is given below:**

Nominal Maximum size mm (Inch)	Minimum Weight of test sample kg (lb)
12.5 (1/2) or less	2(4.4)
19.0(¾)	3(6.6)
25.0(1)	4(8.8)
37.5(1 ½)	5(11)
50(2)	8(18)
63 (2½)	12(26)
75(3)	18(40)
90(3½)	25(55)
100(4)	40(88)
112(4 ½)	50(100)
125(5)	75(165)
150(6)	125(276)

PROCEDURE

- Dry the test sample to constant weight at a temperature of 110±5ºC, cool in air at room temperature for 1 to 3 hr. for test sample of 37.5 mm (1.5 in) nominal maximum size, or longer for larger sizes until the aggregate has cooled to a temperature that is comfortable to handle (approx. 50ºC).
- Subsequently immerse the aggregate in water at room temperature for a period of 24±4 hr.
- Remove the test sample from the water and roll it in a large absorbent cloth until all visible films of water are removed.
- Wipe the large particles individually.
- A moving stream of air may be used to assist in drying operation.
- Take care to avoid evaporation of water from aggregate pores during the operation of surface drying.

PROCEDURE CONT'D

- Weigh the test sample in the saturated surface-dry condition.
- Record this and all subsequent weights to the nearest 0.5 gm or 0.05% of the sample weight, whichever is greater.
- After weighing, immediately place the saturated surface-dry test sample in the sample container and determine its weight in water at **23±2.0˚C**.
- Take care to remove all entrapped air before weighing by shaking the container while immersed.

SAMPLE DATA SHEET

Weight of Basket in Air (gm)	Weight of Basket in Water (gm)	Weight of S.S.D. Sample, B (gm)	Weight of S.S.D. Sample in Water, C (gm)	Oven-dry Weight of Sample, A (gm)

SAMPLE DATA SHEET

Tests	Formulae	Calculations	Results
Apparent Specific Gravity, S_a	$\frac{A}{A-C}$		
Relative Density (Specific Gravity) (OD), S_d	$\frac{A}{B-C}$		
Relative Density (Specific Gravity) (SSD), S_s	$\frac{B}{B-C}$		
Absorption, %	$\frac{B-A}{A} \times 100$		
Density (OD), kg/m³	$997.5 \times \frac{A}{B-C}$		
Density (SSD), kg/m³	$997.5 \times \frac{B}{B-C}$		
Apparent density (SSD), kg/m³	$997.5 \times \frac{A}{B-C}$		

CALCULATION

Calculate all parameters as per the formulae given in Data Sheet

REPORT

The Report shall include the following information:

- Identification of the aggregate as to source
- Report specific gravity results to the nearest 0.01 and absorption to the nearest 0.1%.

RESULT

- Report specific gravity results to the nearest 0.01, and indicate the type of specific gravity, whether bulk, bulk (saturated surface-dry) or apparent.
- Report the absorption result to the nearest 0.1%.

QUESTIONS??

- Discuss the influence of the fineness of the aggregate upon its bulking characteristics when damp.
- Discuss the effect of damp aggregate upon the cement of the mix, the proportions of which were computed for saturated surface dry aggregates (a) if the materials are batched by weight and (b) if batched by stated bulk volume.
- What difficulties arise in the use of aggregates which absorb water? How are they overcome (a) in the laboratory and (b) in the field?

3 (c) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate – ASTM C29

INTRODUCTION

- This test method covers the determination of bulk density ("unit weight") of aggregate in a compacted or loose condition, and calculated voids between particles in fine, coarse, or mixed aggregates based on the same determination.
- This test method is applicable to aggregates not exceeding 5 in. [125 mm] in nominal maximum size.

APPARATUS

Balance: Sensitive to 0.05% of the sample weight at any point within the range used for the test, or 0.5 g, whichever is greater.

Tamping Rod—A round, straight steel rod, 16 mm in diameter and approximately 600 mm in length, having the tamping end, or both ends, rounded to a hemispherical tip

Measure—A cylindrical metal measure, preferably provided with handles. It shall be watertight, with the top and bottom true and even

Shovel or Scoop

SAMPLING

- The size of the sample shall be approximately 125 to 200 % of the quantity required to fill the measure, and shall be handled in a manner to avoid segregation.
- Dry the aggregate sample to essentially constant mass, preferably in an oven at 110 ± 5°C

PROCEDURE

Calibration of Measure

- Fill the measure with water at room temperature and cover with a piece of plate glass in such a way as to eliminate bubbles and excess water.
- Determine the mass of the water in the measure using the balance described in 5.1.
- Measure the temperature of the water and determine its density from Table 3, interpolating if necessary.
- Calculate the volume, V, of the measure by dividing the mass of the water required to fill the measure by its density.

PROCEDURE CONT'D

Selection of Procedure

The shoveling procedure for loose bulk density shall be used only when specifically stipulated. Otherwise, the compact bulk density shall be determined by the rodding procedure for aggregates having a nominal maximum size of 37.5 mm or less, or by the jigging procedure for aggregates having a nominal maximum size greater than 37.5 mm and not exceeding 125 mm

PROCEDURE CONT'D

Rodding Procedure

- Fill the measure one-third full and level the surface with the fingers. Rod the layer of aggregate with 25 strokes of the tamping rod evenly distributed over the surface.
- Fill the measure two-thirds full and again level and rod as above.
- Finally, fill the measure to overflowing and rod again in the manner previously mentioned.

PROCEDURE CONT'D

Rodding Procedure

- Level the surface of the aggregate with the fingers or a straightedge in such a way that any slight projections of the larger pieces of the coarse aggregate approximately balance the larger voids in the surface below the top of the measure.
- In rodding the first layer, do not allow the rod to strike the bottom of the measure forcibly. In rodding the second and third layers, use vigorous effort, but not more force than to cause the tamping rod to penetrate to the previous layer of aggregate.

PROCEDURE CONT'D

- Determine the mass of the measure plus its contents, and the mass of the measure alone, and record the values to the nearest 0.05 kg

SAMPLE DATA SHEET

Aggregate Type	Mass of the aggregate plus the measure, G (gm)	Mass of the measure, T (gm)	Volume of the measure, V m^3	Factor for measure, F (m^{-3})	Bulk specific gravity (dry basis) as per C 127 C 128, W	Density of water, W (kg/m^3)
Coarse (Stone)						998
Fine (Sand)						998

SAMPLE DATA SHEET

Tests	Formulae	Calculations	Results
Bulk density of the aggregate, M (Stone) kg/m^3	$\frac{G-T}{V}$		
Bulk density of the aggregate, M (Sand) kg/m^3	$\frac{G-T}{V}$		
% Voids (Stone) =	$\frac{[S \times W - M]}{S \times W} \times 100$		
% Voids (Sand) =	$\frac{[S \times W - M]}{S \times W} \times 100$		

CALCULATION

Calculate all parameters as per the formulae given in Data Sheet

REPORT

The Report shall include the following information:

- Report the results for the bulk density to the nearest 10 kg/m^3
- 14.2 Report the results for the void content to the nearest 1 %

Lecture-04

a) Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying - **ASTM C566**

b) Standard Test Method for Surface Moisture in Fine Aggregate - **ASTM C70**

1. SCOPE

1.1 This procedure covers the determination of the percentage of evaporable moisture in a sample of aggregate by drying both surface moisture and the moisture in the aggregate. To be used in the field to determine the percentage of surface moisture content in aggregates.

2. APPARATUS

2.1 Balance - Sufficient capacity and sensitive to 0.1 g.

2.2 Drying equipment - Hot plate, ventilated oven, or a ventilated microwave oven.

2.3 Drying pan and necessary hand tools.

3. PROCEDURE

3.1 The minimum test sample mass shall be that in Table 33-1.

3.2 Immediately after obtaining the specimen, weigh to the nearest 0.1 g and record as wet weight (mass). Dry to a constant weight (mass). Constant weight (mass) is achieved when further heating causes, or would cause, less than 0.1 percent additional loss in mass. If using a ventilated oven, set it at 230°F ± 9° (110°C ± 5°). When dry, weigh to the nearest 0.1 g and report as dry weight (mass).

4. CALCULATIONS

4.1 Determine the total percentage of moisture on an oven dry basis as follows:

$$\%\ \text{moisture, Oven Dry basis} = \frac{\text{wet wt.} - \text{Dry wt.}}{\text{Dry wt.}} \times 100$$

4.2 Calculate the percent surface (free) moisture as follows:

$$\%\ \text{surface moisture} = \left(\%\ \text{moisture, Oven Dry basis}\right) - \left(\%\ \text{absorption (from mix design)}\right)$$

NOTE 1: The calculations in Subsection 4.2, for percent surface moisture, does not give exactly the same result as calculating percent surface moisture on a saturated surface dry method as called for by design procedures. However, for the degree of accuracy required, the simpler method is acceptable for field control of aggregate batch weights (masses).

The following examples will illustrate the comparison between the two methods of calculation.

EXAMPLE:

Wet weight	= 100.0 g
(oven) Dry wt.	= 95.0 g
Loss	= 5.0 g
% Absorption from Mix Design	= 2.0

% Surface Moisture, Oven Dry Method

$$= \left(\frac{100.0 - 95.0}{95.0} \times 100\right) - 2.0\%$$

$$= 5.26 - 2.0$$

$$= 3.26\%$$

4. Significance and Use

4.1 This test method is sufficiently accurate for usual purposes, such as adjusting batch quantities of ingredients for concrete. It will generally measure the moisture in the test sample more reliably than the sample can be made to represent the aggregate supply. In rare cases where the aggregate itself is altered by heat, or where more refined measurement is required, the test should be conducted using a ventilated, controlled temperature oven.

4.2 Large particles of coarse aggregate, especially those larger than 2 in (50 mm), will require greater time for the moisture to travel from the interior of the particle to the surface. The user of this test method should determine by trial if rapid drying methods provide sufficient accuracy for the intended use when drying large size particles.

5. Apparatus

5.1 Balance – The balances shall have sufficient capacity, be readable to 0.1 percent of the sample mass, or better, and conform to the requirements of M 231.

5.2 Source of Heat – A ventilated oven capable of maintaining the temperature surrounding the sample at 110 ± 5°C (230 ± 9°F). Where close control of the temperature is not required (see Section 4.1), other suitable sources of heat may be used, such as an electric or gas hot plate, electric heat lamps, or a ventilated microwave oven.

5.3 Sample Container – A container not affected by the heat, and of sufficient volume to contain the sample without danger of spilling, and of such shape that the depth of sample will not exceed one fifth of the least lateral dimension.

5.3.1 Precaution – When a microwave oven is used, the container shall be nonmetallic.

Note 1: Except for testing large samples, an ordinary frying pan is suitable for use with a hot plate, or any shallow flat-bottomed metal pan is suitable with heat lamps or oven. Note Precaution in Section 5.3.1.

5.4 Stirrer – A metal spoon or spatula of convenient size.

8. Calculation

8.1 Calculate total evaporable moisture content as follows:

$$p = \frac{100\,(W - D)}{D}$$

where:

p = total evaporable moisture content of sample, percent;
W = mass of original sample, g; and
D = mass of dried sample, g

8.2 Surface moisture content is equal to the difference between the total evaporated moisture content and the absorption, with all values based on the mass of a dry sample. Absorption may be determined in accordance with T 85, Test for Specific Gravity and Absorption of Coarse Aggregates, or T 84, Test for Specific Gravity and Absorption of Fine Aggregates

% Surface Moisture, Saturated Surface Dry Method (SSD)

$$\%\ \text{surface moisture, (SSD)} = \frac{\text{wet wt.} - \text{SSD wt.}}{\text{SSD wt.}} \times 100$$

$$\text{SSD wt.} = \frac{\text{oven dry wt.} \times (100 + \text{absorption})}{100}$$

$$\text{SSD wt.} = \frac{95.0 \times 102}{100} = 96.9\ g$$

$$\%\ \text{surface moisture, (SSD)} = \frac{100 - 96.9}{96.9} \times 100 = 3.20\%$$

Difference between the two methods is

3.26
- 3.20
.06 %

Table 33-1

Aggregate Nominal Maximum Size Square Opening, Inches	Minimum Weight (Mass) of Test Sample, Pounds (kg)
< 3/8	0.66 (0.30)
3/8	2.2 (1.0)
1/2	3.3 (1.5)
3/4	4.4 (2.0)
1	5.5 (2.5)
1 1/2	11.0 (5.0)
2	16.0 (7.5)
2 1/2	22.0 (10.0)
3	27.5 (12.5)
3 1/2	33.0 (15.0)

NOTE 2: Nominal maximum size is as defined in the Appendix of the Field Materials Manual.

5. REPORT

5.1 Report % SSD on Form #6 in the "Remarks" field.