Jan. 12, 1937. M. A. WECKERLY 2,067,742

PROCESS FOR DETERMINING CHARACTERISTICS OF CONCRETE AGGREGATES

Filed April 8, 1932 2 Sheets-Sheet 1

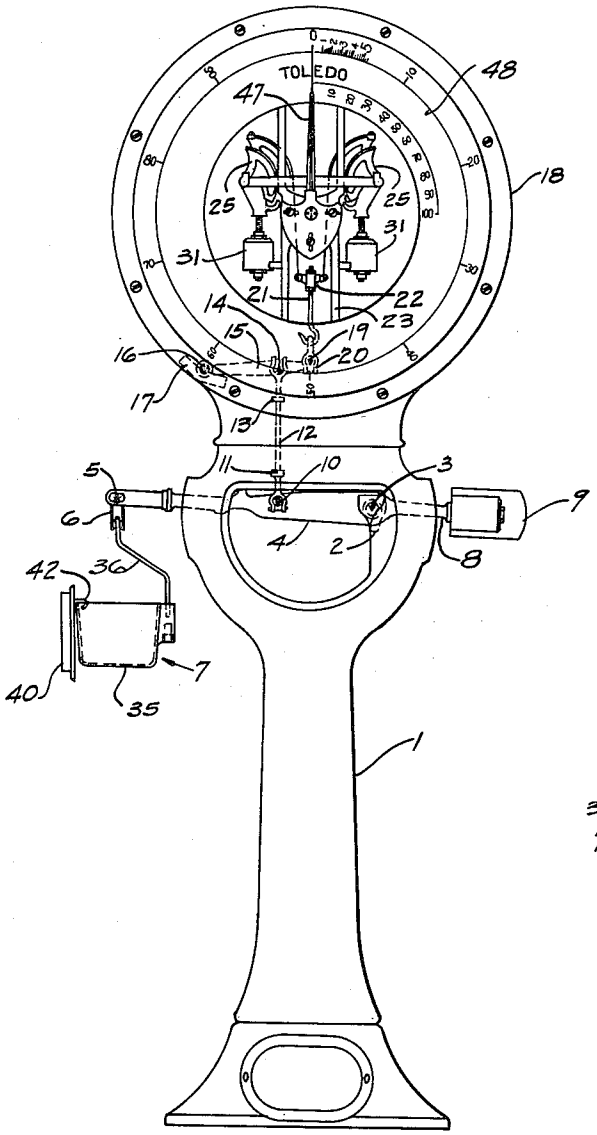


Fig I

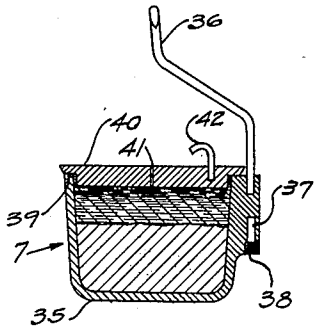


Fig. III

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PROCESS FOR DETERMINING CHARACTERISTICS OF CONCRETE AGGREGATES

Filed April 8, 1932 2 Sheets-Sheet 2

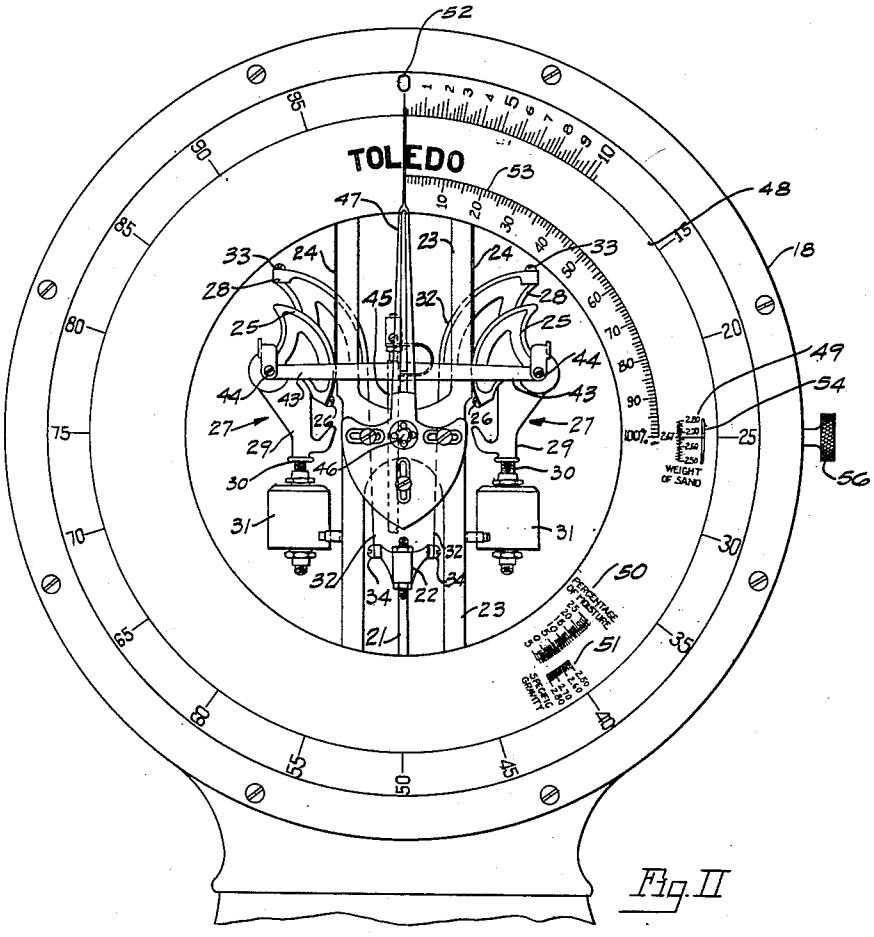


Fig. II

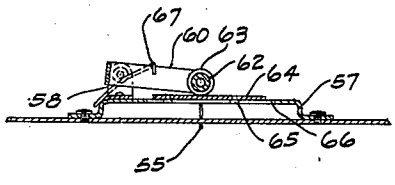


Fig. V

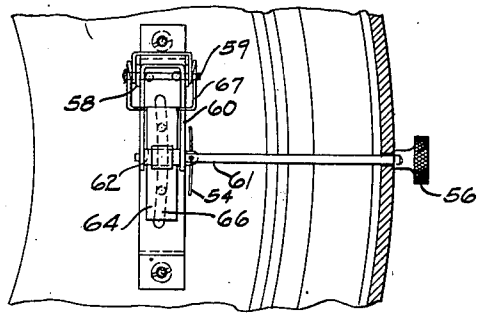


Fig. IV

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UNITED STATES PATENT OFFICE

2,067,742

PROCESS FOR DETERMINING CHARACTERISTICS OF CONCRETE AGGREGATES

Mark A. Weckerly, Toledo, Ohio, assignor to Toledo Scale Manufacturing Company, Toledo, Ohio, a corporation of New Jersey

Application April 8, 1932, Serial No. 603,907

4 Claims. (Cl. 265—44)

This invention relates generally to the art of making concrete in which the ingredients are accurately proportioned independently of the amount of surface moisture contained in the aggregates, and more particularly to the process of determining such moisture content. The presence of variable amounts of free moisture in the aggregates at the time they are utilized is almost universal. Such moisture may be due to precipitation or aggregate washing operations. Variations in these factors, coupled with evaporation under varying atmospheric conditions, cause wide variations in the moisture content of aggregates on different jobs and sometimes result in relatively large fluctuations within short intervals on the same job. Because of the effect of the amount of water used on the strength of concrete, it is desirable that the surface moisture, and at times the absorbed moisture, be accurately determined and compensation for such moisture made in compounding the mix. This invention includes separately and collectively the steps of determining from time to time the percentage of surface moisture and/or absorbed moisture in samples of concrete aggregates.

The invention is also applicable to other materials; in fact, all materials which are insoluble and which do not absorb water or other fluid too rapidly. It has been successfully applied to the determination of surface moisture of grain. This is one of the necessary steps in obtaining the proper temperature for milling. In the following description the fluid is referred to as water. However, it is to be understood that the term embraces the proper fluid for each specific material.

The principal object of this invention is the provision of an improved method for determining the amount of moisture in concrete aggregates and/or other material.

Another object of the invention is the provision of an improved method for determining the specific gravity of such materials as concrete aggregates and the like.

A still further object of the invention is the provision of an improved method for determining the amount of moisture absorbed by such materials.

These and other objects and advantages will be apparent from the following specification, in which reference is had to the accompanying drawings and in which similar reference numerals designate similar parts throughout the several views.

In the drawings:—

Figure I is a front elevational view of apparatus adapted to carry out the invention.

Figure II is an enlarged view of the weight counterbalancing and indicating means of the apparatus illustrated in Figure I.

Figure III is a cross sectional view of a sample receptacle; and

Figures IV and V are enlarged views of mechanism adapted to manually position an auxiliary indicator.

The process or method hereinafter described is not dependent upon any particular apparatus, but convenient apparatus is shown and described merely to make the description of the process more readily understandable. It comprises a hollow column-like structure 1 provided with integral brackets 2 which support bearings (not shown) upon which rests the fulcrum pivot 3 of a lever 4 of the third order. The other end of the lever 4 has fixed therein a load pivot 5 engaged by a stirrup 6 from which a sample receptacle 7 is suspended. The lever 4 is provided with an extension 8 to which a load box 9 is fastened for the purpose of counterbalancing a part of the dead weight of the opposite end of the lever and the suspended receptacle. A power pivot 10, situated intermediately of the fulcrum and load pivots 3 and 5 respectively, is engaged by a stirrup 11 suspended from the lower end of a connecting rod 12 whose upper end pivotally engages a stirrup 13 engaging a load pivot 14 of a ratio lever 15 fulcrumed by means of a pivot 16 upon bearings supported by a bracket 17 situated in the interior of a hollow watch-case-shaped housing 18 surmounting and fastened to the column structure 1. The power pivot 19 of the lever 15 engages a stirrup 20 secured to a pull rod 21 adjustably fixed in a yoke-like member 22. The guide frame 23 is stationed within the housing 18 and fastened to it at its upper and lower extremities. Flexible metallic tapes 24 secured to the upper frame overlie curved surfaces of fulcrum sectors 25 and are fastened to their lower ends by the screws 26. These fulcrum sectors 25 are a part of the load-counterbalancing pendulums 27 which also comprise power sectors 28, pendulum bodies 29, the thereto secured pendulum stems 30 and weights 31 adjustably mounted upon the stems 30. Flexible metallic ribbons 32 are fastened to the upper ends of the power sectors 28 by screws 33 and overlie their arcuate surfaces. The lower ends of the ribbons 32 are secured to the yoke-like member 22 by screws 34.

The receptacle 7 comprises a body portion 35, cast of non-corrosive material, in which a suit-

ably bent suspension bail **36** is fastened. A cavity **37**, provided in the body **35**, is adapted to be filled with shot or other loading material to adjust the total weight of the receptacle **7** to a predetermined amount. The cavity is closed by a screw plug **38**. The upper edge of the receptacle body **35** is machined to a plane to form a seat for a ledge-like extension **39** of a cover **40**. The surface of the cover which projects into the receptacle body **35** is adjusted by machining so that when in place the capacity of the receptacle is of predetermined volume. A vent hole **41** extends through the cover **40**. The cover is also provided with a suspension hook **42**.

When the receptacle is filled with water to near its upper edge and the cover **40** is placed thereon, some of the water will be forced through the vent until a definite volume remains. This method is vastly superior to measuring the fluid with a graduate or other means, as no mistakes due to misreading graduations or indicia are possible.

When a commodity is placed in the receptacle **7**, the force resulting from its weight is transmitted to the pivot **10**, the rod **12**, the lever **15** and by the rod **21** to the ribbons **32** of the pendulum load-counterbalancing mechanism. These, due to their suspension mounting and connection to the other parts, move upwardly and outwardly until their increased weight moment balances the load in the receptacle.

A pair of so-called compensating bars **43** have a pintle connection at **44** with portions of the pendulum bodies **29** and partake of their vertical reciprocating motion. Midway between the points **44** a rack **45** is pivotally connected to the bars **43** whose teeth mesh with the teeth of a pinion (not shown) which is fastened to a shaft **46** mounted upon ball bearings stationed in bifurcations of the guide frame **23**. To a projecting end of the shaft **46** is fastened an indicator **47** which co-operates with a metallic chart **48** upon which a plurality of series of indicia **49**, **50** and **51**, respectively, are printed. The locations of these series of indicia are calculated so that they are located in predetermined relation to a zero indicium **52**. The weights and proportions of the parts are such that a load of 2 pounds in the receptacle will cause the indicator hand to move from the zero indicium **52** through an angle of 90 degrees. The position assumed by the indicator hand under the influence of a 2 pound load in the receptacle may be called the 2 pound position of the indicator hand.

If 2 pounds of material, such as dry sand, having a greater density than water be placed in the receptacle and water be added to fill the receptacle to capacity, as shown in Figure III, the weight of the contents of the receptacle will be sufficient to move the indicator hand beyond the 2 pound position to a point depending upon the additional amount of water in the receptacle. The greater the density of the sand, and hence the higher its specific gravity, the less the bulk of the 2 pound sample and the greater the weight of the water necessary to complete the filling of the receptacle; hence the greater the total weight of the sand and water. The total weight of the contents of the receptacle may be found by solving for any value of specific gravity the following equation:

$$S+W-\left(\frac{S}{\text{sp. gr.}}\right)=T$$

where S is the weight of a specimen of sand, W is the weight of a volume of water equal to the total capacity of the receptacle, sp. gr. is the specific gravity of the sand, and T is the total weight of the sand and water filling the receptacle. Since the weight of the specimen of sand has been taken for convenience as 2 pounds and the weight of a volume of water equal to the total capacity of the receptacle is 2 pounds, the weight of the water which remains in the receptacle with the sand is 2 pounds less the weight of the water which is displaced, that is 2 pounds minus the quantity (1 divided by the specific gravity of the sand multiplied by the weight of the sand).

For sand having a specific gravity of 2.50 the equation becomes

$$2+2-\left(\frac{2}{2.50}\right)=3.2 \text{ pounds}$$

An indicium indicating specific gravity of 2.50, therefore, is placed at the point on the chart to which the indicator hand is moved by a total weight in the receptacle of 3.2 pounds. By similar calculations the proper location for an indicium indicating a specific gravity of 2.60 is determined to be the point to which the indicator hand would be moved by a total weight in the receptacle of 3.23077, the indicium for specific gravity 2.67 is located at a point corresponding to a total weight of 3.250936 pounds, etc.

When it is desired to obtain the specific gravity of a sample of sand the sand is surface dried by subjecting it to moderate heat, care being taken not to drive out the water of crystallization. Enough of the surface dry sand is poured into the dry receptacle **7** to cause the indicator to move through an angle of 90 degrees to its 2 pound position. The receptacle is then filled with water and the cover put on, after which all water adhering to the outside of the receptacle and cover is wiped off. The force exerted by the weight of the contents of the receptacle acts through the lever and pendulum mechanism to cause the indicator hand to move to a position in which it indicates on the group of indicia **51** the specific gravity of the sand in the sample being tested.

In testing sand for surface moisture the size of the sample taken depends upon the specific gravity of the particular sand being tested for moisture. Specific gravities of most sands used as concrete aggregates are near 2.67. For this reason, a "Weighing of sand" mark on the chart at the 2 pound position of the indicator hand is arbitrarily designated "2.67" and when sand having a specific gravity of 2.67 is to be tested for moisture a 2 pound sample is used.

Suppose a 2 pound sample of sand having a specific gravity of 2.67 to be placed in the receptacle and the receptacle to be filled with water as in making a test for specific gravity. If the sand were surface dry, the indicator would move to a position indicating 2.67 on the specific gravity group of indicia, since the amounts of sand and water in the receptacle would be the same as before, and the total weight of the contents would be 3.250936 pounds. Being the position taken by the indicator hand when there is no surface moisture in the sand, this position is marked "0" on the "Percentage of moisture" group of indicia **50**. If a given weight of sand which is not surface dry is placed in the receptacle, the sand and moisture will occupy more space than would be occupied by the same weight of surface dry sand. Therefore, less additional water will be required to fill the receptacle and the total weight of the contents of the receptacle

will be less than it would be if the sand were surface dry; the more surface moisture the sand contains the less will be the weight of added water necessary to fill the receptacle, and hence the less the total weight.

The total weight for moist sand having a specific gravity of 2.67 depends upon the amount of moisture in the sand and is determined according to the equation

$$(S'+X)+W'-\left(\frac{S'}{2.67}+X\right)=T'$$

where S' is the weight of surface dry sand in the sample, X is the weight of moisture in the sample, W' is the weight of a volume of water equal to the total capacity of the receptacle, and T' is the total weight of the sand and water filling the receptacle.

Since the weight of the sample taken is 2 pounds, the quantity (S'+X) becomes 2 and the quantity S' becomes 2—X. The weight of a volume of water equal to the total capacity of the receptacle is 2 pounds. Therefore, 2 may be substituted in the equation for the quantity W'. Substituting these values in the equation, we have

$$4-\left(\frac{2-X}{2.67}+X\right)=T'$$

but

$$S'=\frac{\text{weight of sample multiplied by 100}}{100+Y}=\frac{200}{100+Y}$$

where Y is moisture in terms of percentage of weight of surface dry sand in the sample, X (the weight of the moisture) is equal to 2—S' (the weight of the sample minus the weight of the sand). Therefore

$$X=2-\frac{200}{100+Y}$$

Substituting this value of X and simplifying, the value of T' becomes

$$2+\frac{125.0936}{100+Y}$$

The indicia 50 on the chart representing percentages of moisture are located by assigning values to Y ranging from 0 to 25. For example, the location of the indicium for 10 per cent of moisture is determined thus:

$$2+\frac{125.0936}{100+10}=3.1372$$

Hence the indicium for 10 per cent of moisture is located at the point to which the indicator hand is moved by a total load of 3.1372 pounds in the receptacle.

If the specific gravity of the sand being tested for surface moisture is below 2.67, it is necessary to use a heavier sample in order that its percentage of moisture may be indicated on the same group 50 of indicia. If the specific gravity of the sand in the sample is higher, a lighter sample is used.

The indicia of the "Weight of sand" group 49 are so located that a weight of surface dry sand in the receptacle sufficient to move the indicator to the indicium corresponding to the specific gravity of the sand plus water sufficient to fill the receptacle when the cover is in place will move the indicator hand to the zero mark on the "Percentage of moisture" group, that is, to the 3.250936 position.

The indicia in the weight of sand group 49 are located by substituting figures representing specific gravities, ranging from 2.50 to 2.80, for "sp. gr." in the equation

$$S''+W''-\frac{S''}{\text{sp. gr.}}=3.250936$$

where S'' is the weight of the sample of surface dry sand, W'' is the weight of a volume of water equal to the total capacity of the receptacle, and sp. gr. is the specific gravity of the sand. Substituting, for example, a value of 2.60 for "sp. gr." and solving for S'', we obtain 2.03277. Using the value 2.60 for "sp. gr." and the value 2.03277 for the quantity S'+X in the equation

$$(S'+X)+W'-\left(\frac{S'}{\text{sp. gr.}}+X\right)=T'$$

we obtain

$$4.03277-\left(\frac{2.03277-X}{2.60}+X\right)=T'$$

But

$$S'=\frac{\text{weight of sample multiplied by 100}}{100+Y}=\frac{203.277}{100+Y}$$

where Y is moisture in terms of percentage of weight of surface dry sand and X is the weight of the moisture and is equal to 2.03277 pounds minus S', that is, the weight of the sample minus the surface dry weight of the sand. Therefore

$$X=2.03277-\frac{203.277}{100+Y}$$

By substituting this value of X and simplifying, the value of T' becomes

$$2+\frac{125.0936}{100+Y}$$

for a sample of sand having a specific gravity of 2.60. This is the same value for T' as was found for a 2 pound sample of sand having a specific gravity of 2.67, thus indicating that the total weight of a 2.03277 pound sample of sand having a specific gravity of 2.60 and containing a certain percentage of surface moisture, with enough water added to fill the receptacle, is the same as the total weight of a 2 pound sample of sand having a specific gravity of 2.67 and containing the same percentage of surface moisture with enough water added to fill the receptacle. Similarly, it can be shown that the value of T' is the same for sand of any specific gravity if the weight of the sample employed is such as to move the indicator hand to the indicium in the "Weight of sand" group 49 corresponding to the specific gravity of the sand. Hence the same "Percentage of moisture" indicia may be used to indicate the percentage of moisture of sand of any specific gravity.

It is sometimes desired to determine the deficiency of absorbed moisture or water of crystallization in aggregates or the amount of moisture which will be reabsorbed by aggregate which has been made bone dry by driving out the absorbed moisture. Therefore, the percentage of moisture group of indicia 50 has been calibrated for a short distance on the minus side of zero. In making a test to determine the amount of moisture which will be absorbed by bone dry aggregate, the procedure is the same as in determining the percentage of surface moisture except that the sample in the receptacle should be covered with water and allowed to stand until maximum absorption has taken place before water is added to fill the receptacle.

In addition to the weight graduations and groups of indicia marked "Specific gravity", "Percentage of moisture" and "Weight of sand", the

chart 48 is provided with an arcuate row of graduations 53 for use in making sieve analyses of aggregates. The capacity and arrangement of the sieve analysis row of graduations is such that 2 pounds of sand or other aggregate in the receptacle will bring the indicator hand to the 100 per cent mark. The sample may then be separated by screening into as many parts as desired and when each of the parts so separated is placed in the receptacle the indicator hand will overlie the mark on the arcuate row of graduations 53 indicating the percentage of the whole that is constituted by the part in the receptacle.

Adjacent to the weight of sand series of indicia 49 is a narrow slot 54 through which a pointer 55 projects. The pointer is actuated from the exterior of the housing 18 by a thumb nut 56 and is adapted to be set in registry with any of the graduations and numerals of the "Weight of sand" series of indicia. Secured to the rear of the chart 48, near the slot 54, is a formed sheet metal stamping 57, and near one end of the stamping is riveted a two-armed bracket 58, the arms of the bracket being provided with apertures through which a pintle 59 extends. A U-shaped member 60 is fulcrumed upon this pintle and is provided at the other end of the arms forming the U with apertures through which a stem 61 extends. One end of the stem is driven into the thumb nut 56 and on that portion lying between the arms of the member 60 a roller 62 is fastened. This roller is covered by a section of rubber tube 63 which frictionally engages a plate-like member 64 provided with two short pins 65 which project into an arcuate slot 66 punched in the stamping 57. The center of curvature of the arcuate slot 66 is coincident with the radial point of the several series of indicia on the chart. The pointer 55, previously referred to, is fastened to the plate 64. A spring 67 continuously urges the roller 63 against the plate 64.

To prevent mistakes from occurring should the operator forget the specific gravity determined, which determination will remain good so long as sand from the some source of supply is being used, the pointer 55 is moved into registration with the proper indicium by turning the thumb nut 56, which acts through the roller 62 and plate 64 to position the pointer in a manner which can be readily understood by referring to Figures IV and V.

While the process of my invention can be carried out with the use of the apparatus above described, it can also be carried out by simply weighing the receptacle and its contents on an ordinary scale and figuring the specific gravity, the weight of sand samples to be employed and the percentage of moisture by using the equations and making calculations in the manner explained above.

Having described my invention, I claim:

1. The process of determining the amount of moisture in material which includes the steps of weighing out a definite amount of the moist material, adding water to the said moist material until a definite volume of water and material is obtained, weighing the water and material together, and determining the amount of moisture by employing the weight of the moist material, the weight of a volume of water equal to said definite volume of water and material, the specific gravity of the material and the weight of the definite volume of water and material together as quantities in a computation.

2. The process of determining the amount of moisture in material which includes the steps of weighing out a definite amount of the moist material, adding water to the said moist material until a definite volume of water and material is obtained, weighing the water and material together, and determining the amount of moisture according to the equation

$$(S'+X)+W'-\left(\frac{S'}{\text{sp. gr.}}+X\right)=T'$$

where S' is the weight of moistureless material in the sample, W' is the weight of a volume of water equal to the given volume, sp. gr. is the specific gravity of the material, T' is the total weight of the material and water constituting the given volume, and X is the weight of the moisture in the sample.

3. The process of determining the amount of moisture in concrete aggregate which includes the steps of weighing out an amount of moist aggregate depending upon its specific gravity, adding water to the said moist aggregate until a definite volume of water and aggregate is obtained, weighing the water and aggregate together, and determining the amount of moisture according to the equation

$$(S'+X)+W'-\left(\frac{S'}{\text{sp. gr.}}+X\right)=T'$$

where S' is the weight of the moistureless material in the sample, W' is the weight of the volume of water equal to the given volume, sp. gr. is the specific gravity of the material, T' is the total weight of the material and water constituting the given volume, and X is the weight of the moisture in the sample.

4. The process of determining the amount of moisture adhering to the aggregate comprising the determination of the specific gravity of said aggregate, weighing an amount depending upon the specific gravity into a receptacle having a predetermined weight and predetermined volume, adding water so that a predetermined volume of aggregate and water is obtained, weighing the receptacle, and determining the amount of moisture by employing the specific gravity of said aggregate, the weight of a volume of water equal to the volume of said receptacle and the weight of said predetermined volume of aggregate and water as quantities in a computation.

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