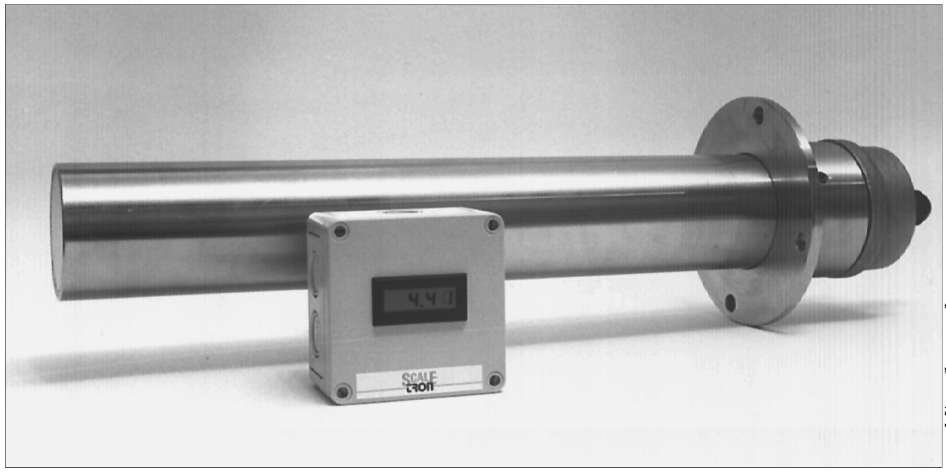
Avoiding moisture problems in aggregate and sand

Moisture meters forewarn of too much or too little water

By Desiree Hanford



Many meters can be connected to computers, allowing operators to make immediate changes to the water-cement ratio.

Water, obviously, is needed to produce various concrete mixes. However, it can be an unwanted addition when present in varying quantities in aggregate and sand.

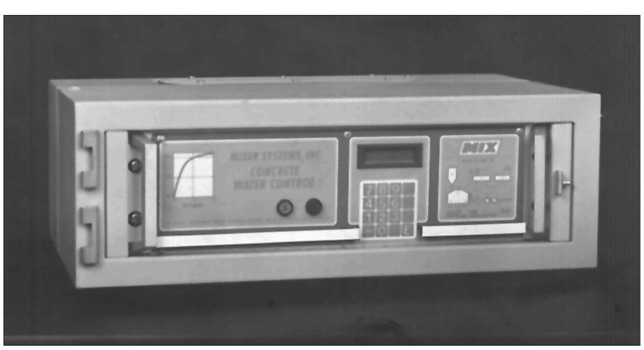
It is vital to know exactly how much moisture is present in aggregate and sand in order to reproduce the proper mix design correctly every time. If, for example, the mix design calls for 1,000 pounds of sand, and the sand has a moisture content of 6%, the operator has to weigh up 1,060 pounds in order to allow for the 60 pounds of water it contains. More importantly, the added water must be subtracted from the batch water to maintain the specified water-cement ratio.

In the past, aggregate moisture was measured by drying a known weight of sand or aggregate in an oven and calculating the moisture from the weight loss. More recently, other methods have allowed speedier measurement. At best, however, these methods are used several times a day; in between, the batch operator either corrects the moisture value by guesswork, the “eyeball” approach, or just leaves the batch alone.

In critical applications, this can result in an erratic product and rejected batches. For example, if the sand’s moisture content decreases by 2% and the operator doesn’t notice, the batching equipment will weigh 2% more sand than needed. This results in a dry batch. If the operator attempts to correct the dry batch by adding more water, the water-cement ratio increases, reducing the concrete’s strength. On-line monitoring of moisture can prevent such a problem by allowing the batching computer to correct for it immediately. The result is a better-quality concrete.

Although composed of several pieces, the term “moisture meter” refers to the complete system. The meter’s sensor is usually the only piece to come in contact with the aggregate and sand. The sensor connects to a display, the batching computer, or both. Some systems allow several sensors to be connected to an intermediate box which has a single display for all the sensors, as well as the outputs for the batching computer. The simplest display is the pointer and dial meter. This, however, is losing favor to the digital readout. One manufacturer offers a graphic display which shows the variation of moisture over a period of time.

A number of different principles are currently used to measure moisture,



As the aggregate hits the meter, the moisture content is measured and digitally displayed.

A BUYER’S CHECKLIST FOR MOISTURE METERS

When purchasing a moisture meter, consider the following questions:

- Does it measure compacted aggregate or sand?
- Does it measure only the aggregate or sand in the flow region?
- Does it calculate an average value during the complete flow period?
- Does aggregate or sand temperature affect the reading?
- Is it easily installed?
- Does it need special fittings and equipment such as cables or plumbing?
- Does it require a separate processor box, or is it self-contained?
- If a separate processor box is required, how many sensors will it handle, and what is the total cost per sensor?
- Is the meter compatible with the computer or controller?
- Does the computer or controller require a special input card or software?
- What is the availability of technical backup and service?

but they all have one thing in common: They measure the amount of water within a certain volume around the sensor. Since the moisture value is the ratio of the water weight to the material weight, the weight of material in this certain volume must always be the same if meaningful results are to be obtained. In other words, the density must remain constant. This, however, highlights a problem as the most critical material, sand, has an unpredictable density. When shaken, it occupies more space and therefore has lower density. When compacted, it occupies less space and therefore has higher density. The only time it has a predictable density is when it is heavily compacted, which is why most of the available sensors are designed to fit inside the bin, where the material is compacted even when flowing.

Placement of the sensor inside the bin also is critical. The sand or aggregate slides to the bin's center and drops through the gate opening. The sensor must be placed in the flow region which extends vertically above the gate. If the sensor is outside this region, it cannot measure the material going into the batch.

The sensor design also plays a part during the material flow; the falling material separates and allows air pockets to form. The sensor should slow down the falling material and compact it within the measuring region for best results.

Between batches, when the material is stationary, the sensor will read a "snapshot" of the material in its sensing zone. If this reading is used, an error is likely. As the sensor measures the material passing during the flow period, it will sense dryer and wetter regions. These "hills and dales" can be smoothed by an electronic technique called signal integration. However, this is only partially effective. The best solution is to calculate a true average of the readings during the flow period. Some meters do this by using the gate's electrical signal to activate the averaging process.

Sand is the most critical material for moisture measurement because it can hold the most water. Typical sands will retain a maximum of 10% moisture, making accurate measurement important. Crushed stone typically retains 2% moisture at the most; the larger the stone size, the less water it can hold. This is fortunate because readings from most moisture meters get more erratic as the particle size increases.

MOISTURE METER TYPES

RESISTANCE-BASED METERS

Until a few years ago, the only direct measuring type of meter, the resistance-based method, relied on measurement of the mineral content of the water coating the aggregate or sand. Water, in its pure state, is a nonconductor. Minerals in the material dissolve in the water, which then becomes conductive. The resistance between two electrodes placed in the material can be converted into a moisture reading, which is repeatable if the material is not allowed to dry. If it dries, however, the minerals held within the grains deposit on the surface. These minerals then dissolve and cause an abnormally high moisture reading. Resistance sensors can still give reliable results, however, in situations where the material is freshly washed or is never allowed to completely dry.

A secondary effect in the resistance-based method is the temperature of the material, which causes a change in resistance. Fortunately, this is predictable and can be compensated for. The better resistance sensors have a temperature sensor built into the electrodes. Without this sensor, expect a 2% moisture error on very warm or very cold material.

Resistance sensors are either the single-probe type, which measures the resistance between the probe tip and the bin walls, or the double-blade type, which can be mounted in the flow region above the feed gate. One model hangs below the feed gate so that the material brushes past the probe as it falls.

DIELECTRIC CONSTANT/CAPACITANCE

Dielectric constant, a property of nonconductors, is measured by monitoring the capacitance between two sensor plates, usually at a high frequency. Most sands and aggregates have a dielectric constant between 2 and 5; sand has a constant of about 2.6. Water is between 78 and 80. As water is added to the sand, the dielectric constant increases. The change can be measured and translated into a moisture reading.

Dielectric constant meters are designed for location in various areas. Some can be mounted inside the bin, avoiding stationary material. Others are located in the open space beneath the bin's discharge gate and above the aggregate scale hopper. Falling material hits the sensor and allows the moisture reading to be taken. Placing the meter here ensures that almost all material going into the batcher is measured, while minimizing variations caused by changes of the amount of material inside the bin.

MICROWAVE

Microwave energy is absorbed by water. By sending a microwave beam into aggregate and sand and measuring the amount absorbed or the amount reflected back, the moisture content can be obtained. Although the techniques used differ somewhat, microwave meters are unaffected by the mineral content and impurities in the water and temperature of the material, resulting in consistent and accurate readings which do not require frequent recalibration.

Microwave sensors are designed for insertion through the bin wall, either directly or through a horizontal flange mount which must be welded onto the wall. The sensors must extend into the flow region to avoid the stagnant material near the bin walls.

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