

TECH NOTE NO: 11  
TITLE: Measurement of Water Content in Fresh Concrete Using the Microwave Method  
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## **1. Introduction**

Shortly after the institutionalization of microwave ovens into every household across the United States, concrete researchers realized that such a device could quickly evaporate the free water out of a fresh concrete sample. Now, almost two decades later, the method is still being investigated for its validity in estimating the water/cement (w/c) ratio in fresh concrete much quicker than the standard ASTM oven drying method. This information can be useful in attempting to forecast a hydrated concrete's compressive strength.

## **2. Testing Procedure**

Although there is currently no finalized ASTM for this test (ASTM has a work item out on it), the American Association of State Highway and Transportation Officials (AASHTO) has a standard method for testing designated as T318-02 and entitled "Water Content of Freshly Mixed Concrete Using Microwave Oven Drying". The procedure outlined in this standard requires a microwave oven, a glass tray, a balance, a metal scraper, a grinding pestle, and a fiberglass cloth. Initially, the fiberglass cloth and glass tray are measured together and recorded as the tare weight. Next, a sample of approximately 1500g of fresh concrete is wrapped in the cloth and weighed. The tray and wrapped specimen are then placed inside of the microwave at a power of 900W for a period of approximately 5 minutes. After this first drying cycle, the mortar is broken free from the coarse aggregates with the scraper and then the mortar is ground into powder using the pestle. After being rewrapped and placed in the microwave for another 5 minutes, the specimen is stirred with the scraper and the mass recorded. The specimen is then rewrapped for another 2 minutes in the microwave. If the mass change is less than 1g then the final mass is recoded, if not then 2 minute cycles are repeated until this stoppage criterion is met. The water content is easily calculated as the mass of the lost free water (change in dried specimen from the fresh specimen) over the initial mass (fresh specimen minus the tare weight). If the cement content is known from the batch ticket,

then the w/c ratio is easily calculated and the test's usefulness as a quality control tool for the field may be realized.<sup>1</sup>

### **3. Experimental Evaluation**

Early experiments (ca 1987) conducted by Naik and Ramme acknowledged that an ideal test for analyzing w/c ratio in the field must be quick (less than 15 minutes to perform), simple to perform, cheap, independent of both chemical and mineral admixtures and accurate within a 95% confidence level.<sup>2</sup> The proposed AASHTO T318-02 easily satisfies the first three criterion. The latter two, however, are not so easily satisfied. Emerging admixtures would need to be tested to quantify their effect, if any, on the testing results and the confidence level is highly dependent on proper testing procedures and is highly susceptible to human error.

The quickness of the test is of little concern as original tests were reported to take less than an hour (usually around 20 minutes)<sup>2</sup> while later tests were consistently conducted in less than 15 minutes<sup>3</sup>. T318-02 stipulates the use of a microwave with a 900 watt power setting<sup>1</sup>, a requirement observed and reported in tests taking less than 15 minutes<sup>3</sup> but not in the earlier tests<sup>2</sup>. Nagi and Whitting even concluded that the total testing time, including sampling and weight checking twice during drying, should be approximately 16 minutes.<sup>3</sup> The simplicity of the test is inherent in its lack of mechanical parts and user dependent variables (any field worker can use both a microwave and scale accurately). This test can be performed anywhere a powered microwave can be found, a small order for any contractor. Compared to most standard tests, requiring specialized testing equipment, the microwave oven test is inexpensive as all required apparatuses and materials are readily available.

Naik and Ramme experienced an average of 14 percent error when testing samples with no specific aggregate moisture information available (typical values were used). To isolate these errors, several tests were run which included a remix with exact moisture content information for the aggregate; another for a mix with oven dry aggregates, no cement, and eight different water contents; and a final round with oven dried aggregates and eight different w/c ratios. The percent errors for these results were 2-4%, 0.6%, and 3.5%, respectively. These results were better than those of the original test, showing that knowing about aggregate moisture contents is crucial for producing accurate results. The tests also showed that cement content was not causing the errors, although the mixes without cement yielded more accurate results. Another variable investigated by Naik and Ramme was the time of testing and test duration. When conducting tests 30 minutes after mixing as well as at a lower microwave power, the total moisture loss was equivalent to that of the standard test, showing its independence of these variables. In the end, Naik and Ramme concluded this method accurate with less than a 5% error at testing w/c ratios of hand mixed fresh concrete when the exact moisture content of the aggregate is known.<sup>2</sup>

Later research, conducted by Nagi and Whitting, compiled field data as well as new laboratory data to evaluate the robustness of this testing method. A variety of concrete mixes, containing various admixtures and cement types including rapid strength gain cements, were tested in the field in Ohio, Kentucky, and Georgia. The report concluded that the test yielded w/c ratios which concurred with batch tickets in most cases although deviations were observed when latex modified concretes were sampled. Fly ash and silica-fume seemed to not affect results. Unlike the field tests, the laboratory test series was more interested in operator effects (precision) rather than accuracy of w/c ratio. The extensive series concluded that any two properly conducted tests on the same material should not differ in water content by any more than 7.6lb/yd<sup>3</sup>, a number easily justified by the size effects of the sampling. In the end, as was the case with Naik and Ramme, Nagi and Whitting concluded the this testing method accurate as a quality control tool in calculating the w/c ratio for an as-delivered mix as long as the cement content, moisture content and absorption of the aggregates is know.<sup>3</sup>

#### **4. Conclusions**

The microwave oven method for determining water content in fresh concrete, having been around for the better part of 20 years, can be used to experimentally deduce an as-received concrete's w/c ratio in the field as long as cement content and information about the aggregate's moisture content and absorption is available. The latter two of these requirements is difficult to know accurately on a truck by truck basis and the aggregate moisture content greatly affects the accuracy of the results, limiting the specification of this test for normal usage.

#### **5. References**

1. American Association of State Highway and Transportation Officials, "Water Content of Freshly Mixed Concrete Using Microwave Oven Drying", T 318-02, Formerly TP23.
2. Naik, T.R., Ramme, B.W., "Determination of the Water Content of Concrete by the Microwave Method", *Cement and Concrete Research*, v 17, n 6, Nov, 1987, pp. 927-938.
3. Nagi, M., Whitting, D., "Determination of Water Content of Fresh Concrete Using a Microwave Oven", *Cement, Concrete and Aggregates*, v 16, n 2, Dec, 1994, pp 125-131.