Tech Notes

Concrete Sampling and Testing

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Concrete sampling and testing is an important step in the production process. Through sampling and testing, the plant will know the concrete properties and properly anticipate how the finished product will perform in the field. Without this information, or with incorrect data, the product may be rejected, resulting in financial loss. It is important that samples are taken by a trained technician who fully understands the importance of the final decisions that are based on the test results compiled from each sample. It is important that samples are taken by a trained technician who fully understands the importance of the final decisions that are based on the test results compiled from each sample.

The type and frequency of testing are generally outlined by the engineer in charge in the job specifications. Some or all of the concrete tests mentioned in this TechNote may be required.

Sampling

Proper sampling methods are required to obtain representative test results on fresh concrete. To achieve a truly random unbiased sample, follow ASTM D 3665, "Standard Practice for Random Sampling of Construction." Avoid taking samples from the first and last portions of a batch to obtain a representative sample. Take samples soon after the batch is made to obtain proper temperature and moisture content.
Applicable Standards

- ASTM C172/C172M, "Standard Practice for Sampling Freshly Mixed Concrete"
- ASTM D 3665, "Standard Practice for Random Sampling of Construction"
- CSA A23.2-1C, "Sampling Plastic Concrete"

Testing

Testing for Temperature

When performing temperature tests, it is important to use a good, accurate thermometer that is surrounded by at least three inches of concrete. Take readings quickly, noting that small samples lose heat fast.

Concrete temperatures are affected by the mix-water temperature, aggregate temperatures, cement type and admixture type. Optimum concrete temperatures will aid with setting, early strength development, proper curing and ultimately aid in achieving a higher quality concrete. Hot concrete sets up rapidly, gaining early initial strength but resulting in lower final strengths. Cold concrete can delay curing and stripping time and affect productivity.

Temperature tests are useful, not only in determining concrete performance, but for creating possible cost savings. Mix-water and aggregate temperatures,

boiler energy, curing-equipment energy and building heat may all be adjusted to achieve the optimum curing temperatures. Creating the optimum curing environment can also result in overall energy savings.

Applicable standards

- ASTM C1064/C1064M, "Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete"
- CSA A23.2-17C, "Temperature of Freshly Mixed Hydraulic Cement Concrete"

Testing for Air Content

The main reason for entraining air in concrete is to control damage from freeze thaw cycles. Air tests determine the total content of entrained and entrapped air in concrete. During batching and mixing tiny air bubbles are created in the concrete mix. If the concrete contains an air-entraining admixture, these bubbles remain stabilized in the mix due to the electrostatic binding of air, water and cement. In concrete without air entrainment, all but about 2% of the air content escapes or dissolves after consolidation because the bubbles are not bonded to the water and cement. The remaining air is called "entrapped" air. Entrapped air will not aid in preventing freeze thaw damage.

It is important to introduce air-entraining admixtures early in the mix cycle to maximize their potential. It is also important to carefully control the addition of air entrainment. Too much air will result in considerable strength loss.

Certain properties and materials in fresh concrete have an effect on air content. Some admixtures, coal ash and carbon containing pigments will influence air content. Temperature, aggregate size and the amount of mix water can also have an impact.

The pressure method is used for mixes containing normal to heavy-weight aggregate. Applying a predetermined pressure to a calculated sample volume of concrete squeezes out the air. This results in a pressure drop that corresponds to the percentage of air in the concrete sample. It is important to calibrate your air meter regularly to ensure accurate readings.

Applicable Standards

- ASTM C231/C231M, "Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method"
- CSA A23.2-4C, "Air Content of Plastic Concrete by the Pressure Method"

The volumetric method is used for dry- cast mixes and lightweight concrete. With this method, water is added to a known volume of concrete. The apparatus containing the sample is then agitated to release the air. The amount of water displaced equals the volume of air in the mix.

Applicable Standards

- ASTM C173/C173M, "Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method"
- CSA A23.2-7C, "Air Content of Plastic Concrete by the Volumetric Method"

Testing for Density and Yield

This test is used to determine density (unit weight), yield and air content. After the density is determined, the yield and air content can then be calculated using given formulas.

Density (unit weight) is a measure of weight per unit volume and is expressed in lbs/ft^3 or kg/m^3. The density of fresh concrete is similar to the density of hardened concrete. After the unit weight is determined, yield can be calculated. Yield is the ratio of total weight of mix material batched for a designed volume to the actual concrete density. It can also be expressed as the volume of concrete produced per batch. Yield will indicate if a mix proportioning problem exists.

The density test is also a quick method for checking the air content of concrete. After the density and yield are determined, the air content can be calculated. This method should not replace volume or pressure testing methods for air content measurements. This test is also not appropriate for determining the air content of lightweight concrete.

Applicable Standards

- ASTM C138/C138M, "Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete"
- CSA A23.2-6C-Density, "Yield, and Cementing Materials Factor of Plastic Concrete"

Making and Curing Concrete Test Specimens

This test describes how cylindrical concrete test specimens are made. Cylinder sizes are either 6 in. x 12 in. or the more common 4 in. x 8 in. The size is either specified in job requirements or based on personal preference.

Curing techniques for test samples are important and the method chosen depends on the product and customer specifications. Test specimens are usually cured in a lime-water bath or a moist curing room where temperature and moisture may be controlled Sometimes it is necessary to cure samples in the exact environmental conditions where the product will be installed in order to assess its performance in the field.

A sufficient number of specimens should be made to cover both laboratory and field requirements. For example, making eight cylinders would allow two each for testing stripping strengths, 7-day strengths, 28-day strengths, and two extra for testing shipping strengths.

Applicable Standards

- ASTM C31/C31M, "Standard Practice for Making and Curing Concrete Test Specimens in the Field
- A23.2-3C, "Making and Curing Concrete Compression and Flexural Test Specimens"

Testing for Compressive Strength

One of the most important properties of concrete is its compressive strength. Testing for compressive strength helps determine whether a product meets specified strength requirements, when to strip forms, and when a product is ready for shipping and service. Strength results are also used for evaluating mix designs. Cylinders are usually tested in pairs to verify results and to rule out erroneous information based on unsatisfactory breaks.

The objective of compressive-strength testing of concrete cylinders is to determine the amount of force it takes to break a cylinder of concrete. A test cylinder is placed in a compression-testing machine, and a constant load is applied to the cylinder until it breaks. The compressive strength is calculated based on the applied load and the size of the test cylinder. It is important to center the cylinder between the loading plates and to apply the load at a constant rate.

Loading rates, sample alignment and capping procedures can affect the results. Improper capping or surface irregularities of specimens will cause a non-uniform load, yielding improper results. The proper method for capping is described in ASTM C 617, "Practice for Capping Cylinders." End grinders or rubber caps can also be used to prepare and test concrete test specimens. The type of break of a cylinder needs to be assessed and should be classified according to Figure 2 of ASTM C39. The break type that yields the most accurate reading is the hourglass. Other types may yield erroneous strength values. Compressive testing machines require proper calibration to ensure accurate results and should be re-calibrated according to applicable standards.

Applicable Standards

- ASTM C39/C39M, "Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens"
- ASTM C617/C617M, "Standard Practice for Capping Cylindrical Concrete Specimens"
- CSA A23.2-9C, "Compressive Strength of Cylindrica l Concrete Specimens"

Testing Finished Products

Some government agencies and contracts require test samples to be extracted from the finished products, or in situ testing of the completed structure. This can be done by using core samples or by performing rebound hammer testing.

Applicable Standards

- ASTM C42/C42M, “Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete”
- ASTM C805/C805M, “Standard Test Method for Rebound Number of Hardened Concrete”
- CSA A23.2-14C, “Obtaining and Testing Drilled Cores for Compressive Strength Testing”

Conclusion

Testing provides information to evaluate and adjust mix designs, including the quality and quantity of raw materials used in the concrete mixes. Evaluating test information enables manufacturers to adapt to constantly fluctuating conditions such as seasonal temperature changes and job specifications.

Testing aids in production planning and provides information to increase efficiency, which can positively impact production volumes and on-time delivery. Testing also allows measuring not only of the quality of specific products but also provides a way to follow production and quality trends over time. An ongoing commitment to quality is established by performing the tests described and maintaining a complete record.

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