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CONCRETE SOLUTIONS GUIDE

Plug and Play

Sensors Can Save Time, Money, and Materials

Using sensors in concrete is a well-established practice that saves resources, but real-time monitoring of temperature and moisture in concrete also facilitates a smaller cement content in mixes, while improving site safety for workers.

Key Takeaways

Affordable, off-the-shelf sensors can assuage safety concerns, save money, and support adoption of low-embodied-carbon concrete.

When compared to laboratory break tests, on-site monitoring speeds construction site activities and provides real-time validation of strength, further adding value to this decarbonization tool.

Instead of using overdesign calculations, which lead to unnecessarily high cement content in mixes, continuous logging of concrete temperature and strength generates precise data, allowing a reduction of cement content that reduces cost and embodied carbon.

Opportunity

Contractors usually measure the strength of concrete by employing cylinder tests, in which a standard amount of concrete is poured on site and monitored to serve as a proxy for concrete used elsewhere on site. In-situ concrete sensors can improve the accuracy of measurement compared with cylinder tests.

Sensors can be used in any kind of concrete, but they take on particular value in the context of low-embodied-carbon mixes. Low-embodied-carbon mixes typically take longer to cure. Contractors on site might be unfamiliar with their use. Sensors allow real-time monitoring, eliminate on-site guesswork, and deliver confidence. SCMs lower the concrete heat of hydration, which can result in a measurement discrepancy between indirect tests using the same concrete blend and testing the strength of the concrete pour directly.[1] The indirect cylinder test can underperform compared to in-place testing since larger pours generate more heat, which affects cure time. Using sensors to measure the early-age strength of concrete provides real-time information superior to cylinder samples, which in turn allows on-site work to proceed quickly and safely, leading to cost savings.

Real-time monitoring of early-age concrete strength allows contractors to proceed with critical operations like formwork removal, post-tensioning, and shore stripping much sooner than if they were relying on laboratory break tests. Maturity meters allow producers to achieve performance goals with greater reliability and speed.

Considerations

Concrete producers must calibrate the mix design in the lab or field before a contractor can utilize the sensor-based maturity method to measure concrete strength. ASTM specifies sensor types suitable for testing relative humidity (important in flooring applications) and strength.[i] The ASTM standard for on-site measurement requires three sensors for the first 1,000 ft^2, and then at least one sensor for every remaining 1,000 ft^2. A 10,000 ft^2 slab of concrete would require 12 sensors, costing less than $1,000 in total.[2]

[i] Specifications are referenced in ACI 228, ASTM F2170, and ASTM C1074.

Related Solutions

1. Know Your Numbers: Performance-oriented specifications

2. Mix It Up: Supplementary cementitious materials (SCMs)

4. Embrace Circularity: Concrete recycling

5. Carbon as a Service: Sequestering CO_2 in concrete

Types of sensors in the Market

Sensors have been used in the industry for 20 years, becoming more accurate and cost-effective over time. There is a wide range of commercially available products, offering a variety of price points and use cases.[3]

Thermocouples: Usually purchased in an adjustable bundle, these units can be connected to a computer to download and analyze the data once the measurements are completed. Wireless devices have been developed as well that upload the thermocouple measurements to the cloud or a smartphone. Although these sensors can be inexpensive, their accuracy is not as precise as other sensors.

Wired temperature and maturity loggers: These loggers address the deficiencies of thermocouples, and their management poses fewer problems on the jobsite as the external unit is not exposed. On the other hand, these have a limited shelf life and cannot be switched off.

Wired sensors with external wireless transmitters: Both thermocouples and loggers present issues, as they need to be connected to external devices. Wireless transmitters, by contrast, are connected to the end of the wires coming out of the concrete to store and transfer the measurements over a wireless network.

Fully embedded wireless sensors: Measurement data is stored on the sensor and can be download from the fully embedded module through various wireless communication protocols such as Bluetooth.

Notable sensor providers[xi]: CommandCenter, ConcreMode by Doka, Concrete Sensors by Hilti, Con-Cure NEX, Converge, Exact Technology, HardTrack by Wake, HOBO, IntelliRock, AOMS Technologies, Maturix by Sensohive, Maturix Smart Concrete Sensors by Kryton, SmartRock by Giatec, and VOrb by Quadrel.

[xi] Mention of sensor brand does not include endorsement.

Endnotes

1. "ASTM C31: Standard Practice for Making and Curing Concrete Test Specimens in the Field," ASTM International, 2021, **https://www.astm.org/Standards/C31.**

2. Jason Spangler, "Does It Matter How Many Concrete Moisture Tests I Use on Each Flooring Job?" Wagner Meters, last modified February 4, 2021, **https://www.wagnermeters.com/concrete-moisture-test/concrete-info/astm-guideline-rh-sensor/.**

3. Aali R. Alizadeh, "The Best Concrete Sensor in 2020," Giatec, April 30, 2020, **https://www.giatecscientific.com/education/the-best-concrete-sensors-2020.**

Charles Cannon, Valentina Guido, and Lachlan Wright, *Concrete Solutions Guide: Six Actions to Lower the Embodied Carbon of Concrete*, RMI, 2021, http://www.rmi.org/concrete-solutions-guide/.

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