METER
ENVIRONMENT

SOIL SENSORS EVALUATE COLD-IN-PLACE RECYCLING DESIGN AND CONSTRUCTION RECOMMENDATIONS

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MOISTURE IS A KEY FACTOR IN COMPACTION AND CURING

Cold in-place recycling (CIR), a road repair method where the top few inches of existing asphalt is ground up, bound with a recycling agent (or binder), and reused to create a new road surface is appealing because of its potential to save time, money, and the environment. It reduces the amount of new material that needs to be hauled to a site, and because it's a "cold" process it reduces the energy needed for traditional road repair. Below is a summary of how METER soil moisture sensors performed in a CIR study (Cox et al., 2015) initiated by the Dept. of Civil and Environmental Engineering at Mississippi State University which evaluated the moisture aspects of this increasingly popular method in order to develop universal design recommendations.

WHY MEASURE MOISTURE?

Mississippi State researchers wanted to understand moisture considerations when developing universal CIR design recommendations because moisture effects on performance properties vary between different types of binders (cementitious vs. bituminous). Historically, laboratory design protocols have favored one or the other binder's performance with respect to moisture considerations, but in the field, moisture conditions may not necessarily be optimal for any certain binder type (Cox et al., 2015). Thus, study objectives were:

- **Phase 1** Document moisture instrumentation of a cement CIR project.

- **Phase 2** Evaluate moisture's role in compaction.

- **Phase 3** Evaluate moisture–strength and moisture–stability relationships for various curing protocols.

SOIL MOISTURE SENSORS USED IN FIELD TESTING

According to Cox et al., 2015, Mississippi DOT conducted a cement CIR project on US-45 Alt in the summer of 2014. Three METER ruggedized soil moisture sensors with 7.6-m cables were used to measure moisture content and temperature in the CIR layer. Each sensor cable was encased in Kearney AquaSeal in an attempt to seal potential moisture flow paths along the cable as well as add additional protection to the cable. Once cement and water were mixed with reclaimed asphalt pavement (RAP), but before compaction, trenches were dug and sensors were buried near the mid-depth of the loose CIR layer. Data were collected with METER's Em50 data logger during compaction and curing.

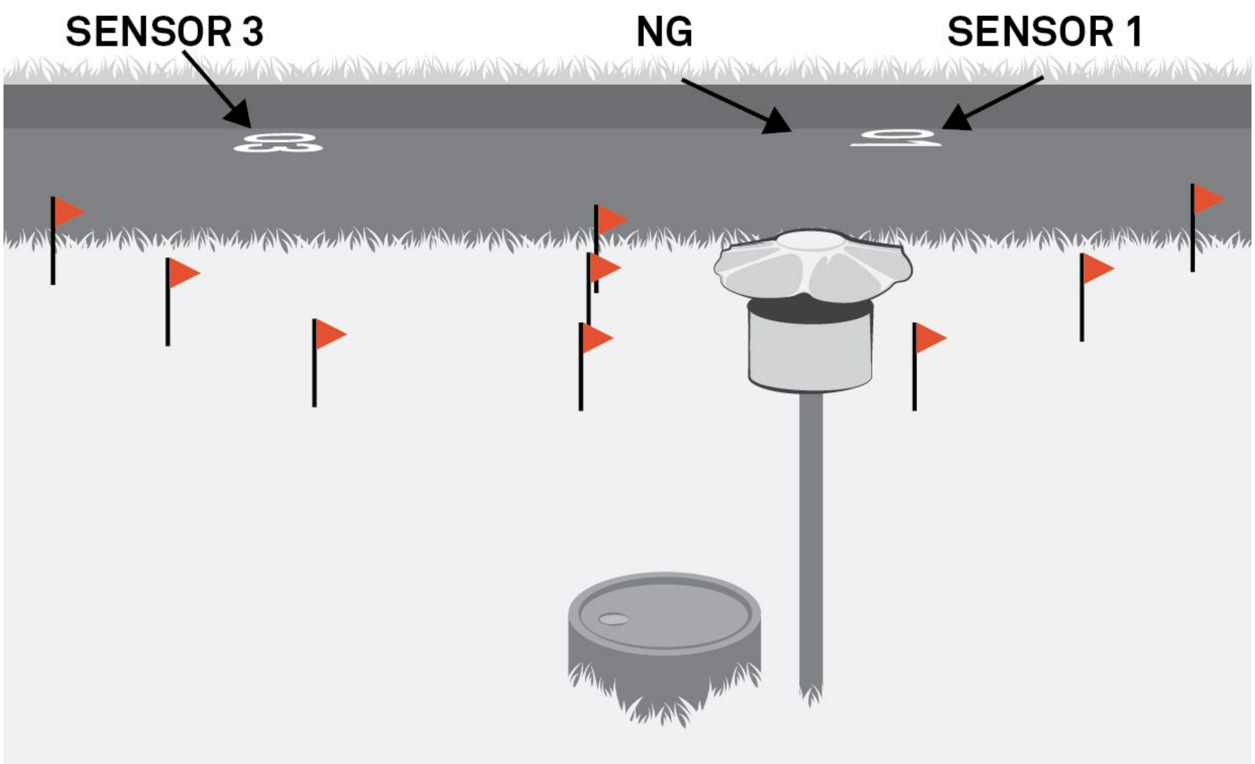

Figure 1. Data acquisition and instrument layout

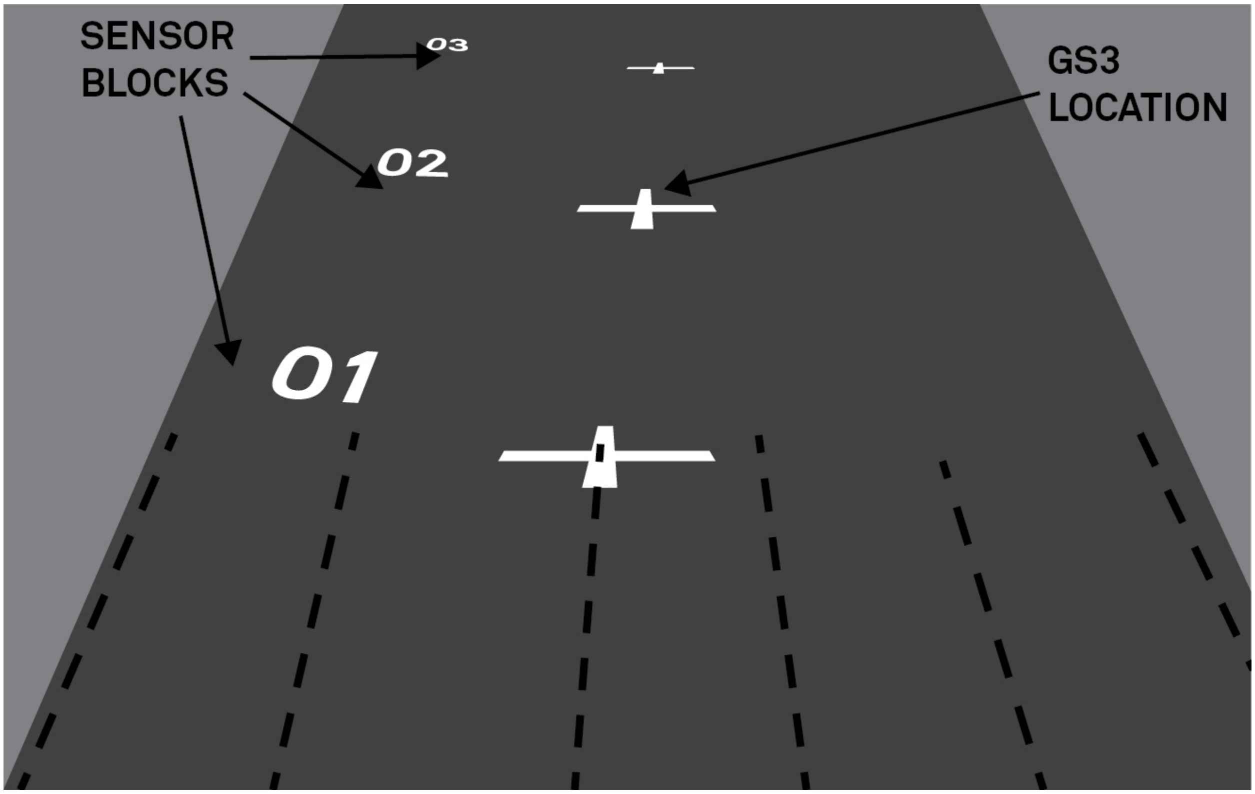

Figure 2. Sensors and coring plan for CIR layer. The crosses indicate sensor locations.

During construction, loose MC samples were obtained at multiple points. Immediately after compaction, three 150-mm-diameter cores were dry cut for compacted MC. Six cores were dry cut at 1, 3, 7, and 14 days. Properties measured on cores were density, unconfined compressive strength (UCS), indirect tensile (IDT) strength, and MC. US-45 Alt fieldwork data are used throughout phases 1 to 3 (Cox et al., 2015).

FIELD DATA DURING COMPACTION AND CURING

Fig. 3a shows the behavior of the probes in the minutes surrounding the compaction. The sensor output illustrates what happens when the MC doesn't change but the density does. Figure 4b shows that directly measured MC dropped from 8.2% to 5.8% during compaction.

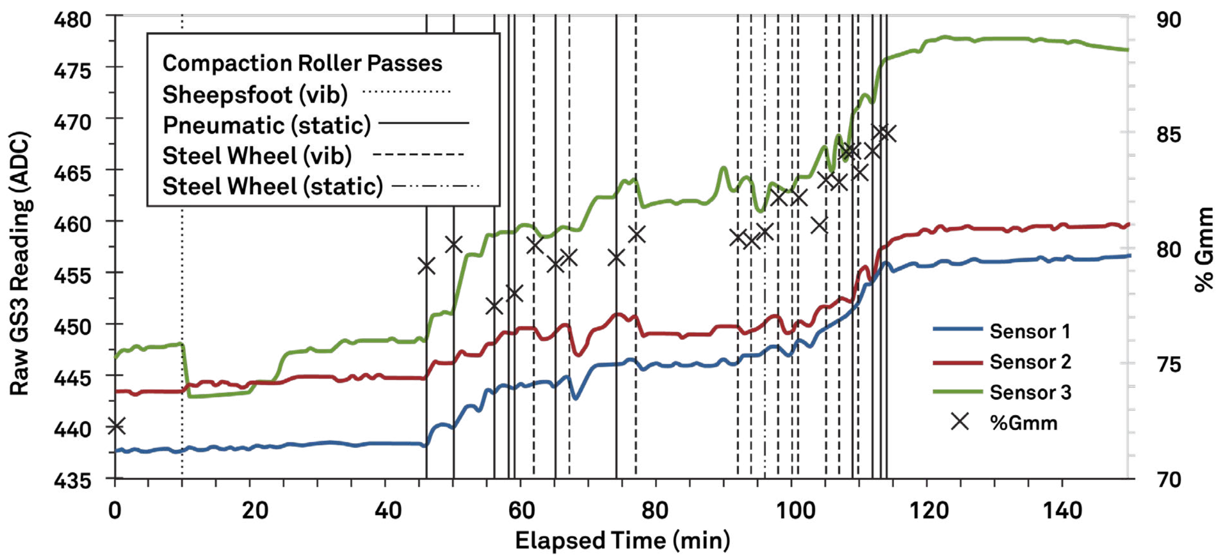

Figure 3a. Unprocessed GS3 moisture data during compaction alongside roller passes and corrected NG densities from Hwy. 45 Alt (Cox et al., 2015)

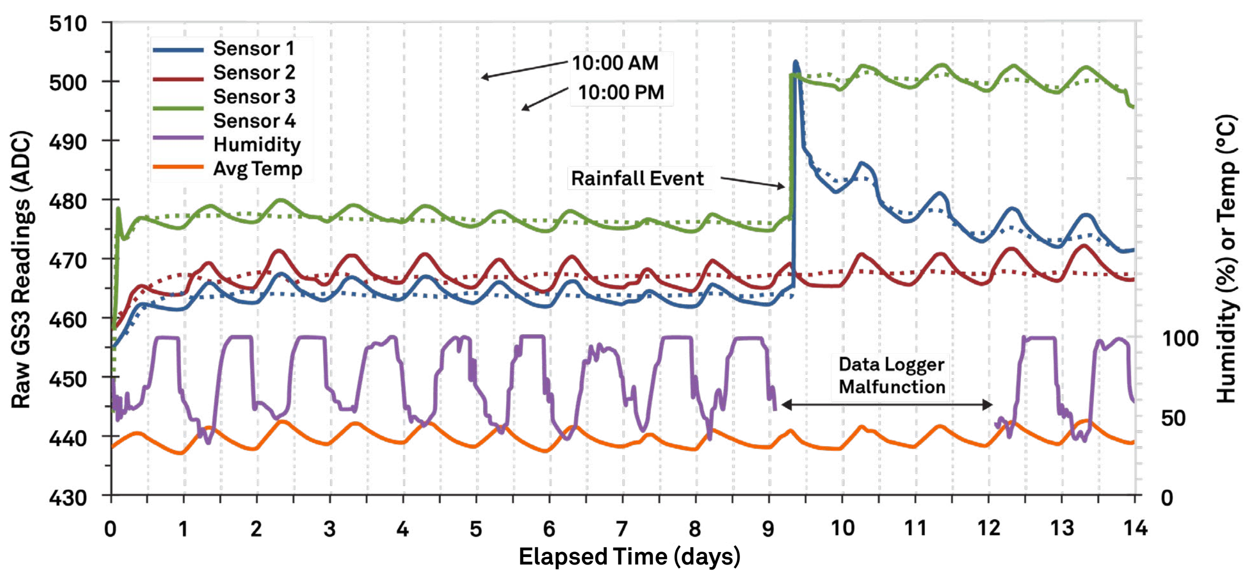

Figure 3b. Unprocessed GS3 moisture data during 14-day curing period alongside temperature and humidity from Hwy. 45 Alt (Cox et al., 2015)

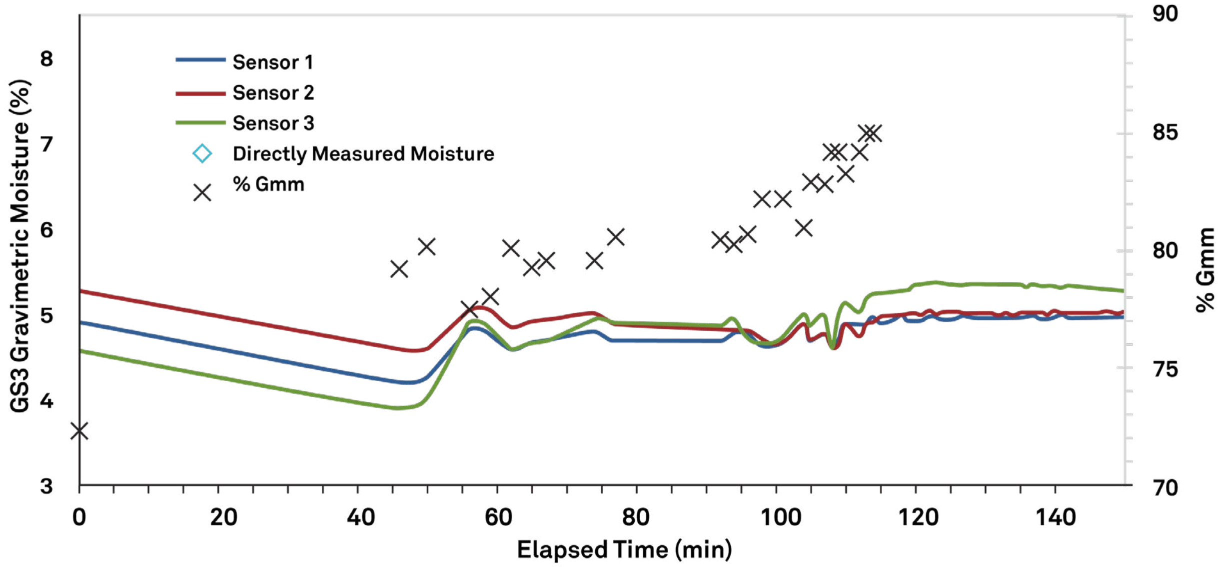

Figure 4a. Processed GS3 gravimetric moisture data during compaction alongside corrected NG densities from Hwy. 45 Alt (Cox et al., 2015)

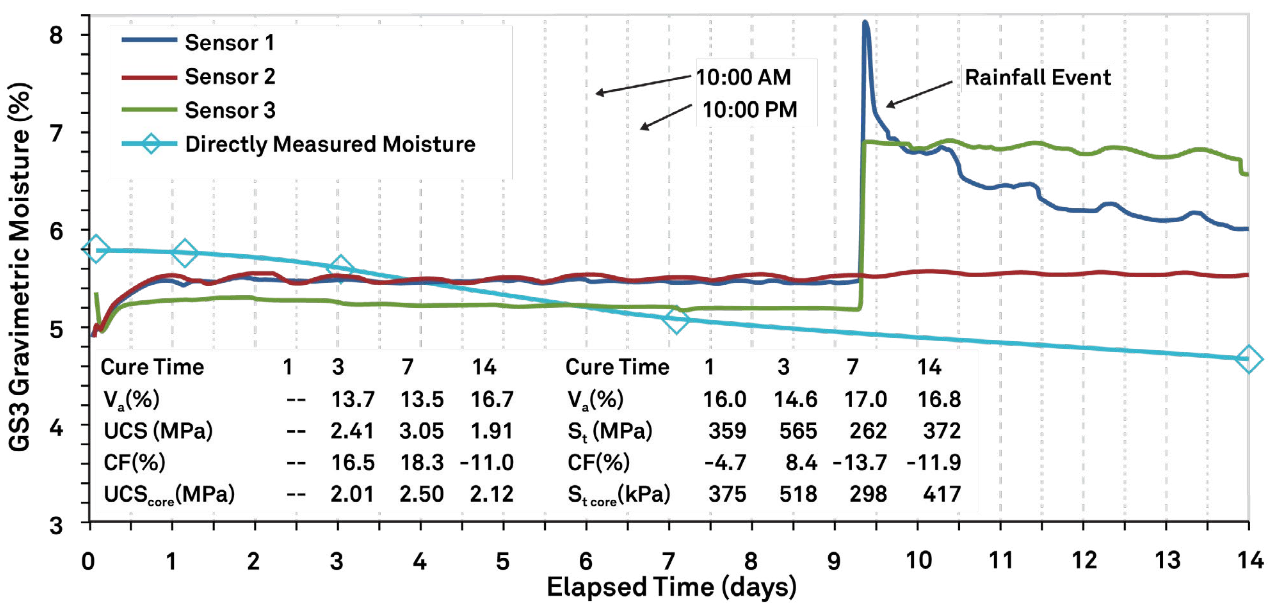

Figure 4b. Processed GS3 gravimetric moisture data during 14-day curing period alongside directly measured core properties from Hwy. 45 Alt (Cox et al., 2015)

SOIL MOISTURE SENSORS SUCCESSFULLY RECORDED DATA

Figures 3a, 3b, 4a, and 4b illustrate that METER soil moisture sensors were successfully installed in a field CIR project and were able to obtain good data not only during curing but also during compaction. For more details about the methods or conclusions of this research, read the full report here.

REFERENCES

1. Cox, Ben C., Isaac L. Howard, and Colin S. Campbell. "Cold in-place recycling moisture-related design and construction considerations for single or multiple component binder systems." *Transportation Research Record: Journal of the Transportation Research Board* 2575 (2016): 27-38.

2. Cox, B.C., I.L. Howard, and R. Battey. In-Place Recycling Moisture-Density Relationships for High-Traffic Applications. Proc., International Foundations Congress and Equipment Expo 2015 (GSP 256). San Antonio, Tex., 2015, pp. 349-358.

3. Doyle, J.D., and I.L. Howard, Linear Asphalt Compactor Operator's Manual. Manual Number CMRC M 10-1, Version 2. Construction Materials Research Center, Mississippi State University, Starkville, 2014

4. Cox, B.C., and I.L. Howard. Merits of Asphalt Concrete Durability and Performance Tests When Applied to Cold In-Place Recycling. Proc., International Foundations Congress and Equipment Expo 2015 (GSP 256), San Antonio, Tex., 2015, pp. 369-379.

5. See full report for a list of all references used in this research.