

Real Time Curing Control and Construction Productivity Research Q&A Report - 3/5/2021

- 1. Question to Dan Zollinger. Can we get some examples of variation in curing compound application rate based on**
In the examples shown in the presentation for Texas, California, and Illinois, the rates were nearly the same (180 sq ft per gallon), yet the EI histories were very different.
- 2. Is there a way to design/place/cure concrete such that controlled cracks will form between a uniform series of point penetrations (i.e. say a pattern of 1/2" holes)?**
You mean as a form of crack control? Probably, especially if it is done in conjunction with the method of curing.
- 3. Expertise- did you consider this? Considering there are less and less young people that want to make this their**
This is one of our key interests as part of this work. Through our early conversations with contractors, one point that has come up is that the labor turnover rate has changed drastically over the last several decades. If we can access historical data as part of our study, we'll be able to answer how are changes in the labor workforce affecting productivity growth
Maybe it's a matter of how much someone would like to understand a given situation and solutions to solve it.
- 4. Were there any results from the monitoring done in El Paso's extreme weather environment? Or recommendations?**
I made a full report for Sundt (if I am not mistaken the government received a copy as well) on the results of the monitoring work carried out there in December. Unfortunately, it was too late to really help them eliminate the cracking issues they had experienced over the last 2 years. The report indicated that the weather conditions were highly variable, and the curing requirements needed to change accordingly to keep up with it. Let me know if you would like a copy,
- 5. Do you have any advice for curing exposed aggregate concrete roadway? We may not be able to use a curing compound because we are trying to match work that was done between 1931 and 1954. Any suggestions would be**
This would be a good application for lithium since it will penetrate the medium and not leave a residue. There are also other alternatives that might work as well such as covered curing. You might be surprised how well this would work out. The point being, this type of instrumentation would be very useful in working out a suitable method of curing.
- 6. Where can you buy the Petra device?**
The device is not commercially available but soon will be; contact me for more info if you would like to pursue something - we'll figure out how to get a setup for you.
- 7. How does a GPR help to assess curing? Are you measuring differences in the dielectric and correlating that to low humidity areas to say certain areas are bad?**
GPR gets us the surface dielectric from point to point and the trend in dielectric with time is related to the EI computed from the base station. Essentially, the correlation is updated every time a GPR scan is done, say every hour. EI is the main parameter to assess the quality of the cure. What's nice about all this is how easy it is to do.
- 8. Will this research be able to look at "quality improvements?" For example, I may have minimal change in how many SY of pavement I can place in a day with given labor, equipment, etc., but now my road may last 40 years vs 20 years before. Will this be captured or evaluated?my road will last 40 years vs . . .**
The answer is yes, both in design and durability. It will have a major impact on fatigue cracking because it will all but eliminate climatic induce cracking damage which has been problematic from site to site and season to season. Joint faulting will become much less to do improved flatness in and around the joints and edges. Seemingly small items will add up to make a huge difference. With the improvements in the performance models we know about, all these features

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That is the goal of our work. Our hypothesis and early findings suggest that the decline in productivity may, in part, be a function of the measurement of output. Productivity measures the following ratio: output/input. Ideally, we should measure output in productivity studies as really an outcome. A mile of paved surface provides a service to users. If that pavement can last twice as long (holding constant the amount of inputs), then this improvement should be reflected in the measurement of productivity. If we can track changing pavement design standards, QC/QA programs, and other

9. What are your thoughts regarding a new curing technology for concrete pavements called internal curing (ASTM C1761)? ARA (Applied Research Associates - Champaign, IL) and work done by Dr. Jason Weiss (Purdue/ Oregon State University) on the benefits of internal curing (full-depth curing).

Internal curing is a great technology, but it is another "static" method of curing that works in some circumstances and won't in others. In other words, it's like any other curing method in that it needs to be managed in addition to be evaluated as to the extra costs to apply it versus other less costly options to accomplish the same objective. Internal curing basically attacks the problem from the bottom up and that impacts the capability of balancing set in the slab versus the energy needed to crack the joints. In my opinion, there is still a need to monitor concrete that is being cured

10. The hardest thing to get the contractor to do is consistency in application of curing compound. They almost always apply it too lightly or not at all at spotty locations. I wish there was a way to stress the importance of a uniform final

One purpose of the GPR will be to assess uniformity; but, as I allude to in the presentation, I think spraying equipment will need to change in order to make significant improvements. I am referring to single nozzle application as a possible

11. Dan, do you think that the climate zone map and Thornthwaite Moisture Index map need to be recalculated and redrawn/updated to reflect recent climate change trends and, if so, might these redrawn maps impact pavement

Interesting question; I understand that the '0' index line moves around from year to year - sometimes to the west and sometimes to the east. Really, the main idea is to realize that some parts of the country are 'dry' while others are 'wet' and that our specifications would reflect this climatic effect.

12. Please describe the crack meter photo.

It has some similarity to a maturity meter but records WS, solar, ambient RH and temp, plus dry bulb and dew point temp below the concrete surface at two positions (which helps us to also infer the RH and temperature profiles in the slab). The meter is positioned on the slab to facilitate the collection of that type of data.

13. Do you recommend application of no shrink admixture?

The answer to this question may lie in the no shrink technology being used but depends on the how the shrinkage or the temperature induce strain varies with the EI and whether or not a critical combination would develop under field conditions. From what I have seen, these types of admixtures do a good job of mitigating crack potential. The EI would perhaps help define the circumstances of where this type of technology would serve the customer very well and others

14. Please explain more the relation between EI and crack potential and saw window. Thanks.

I didn't have the time to explain much on this topic, but it all begins with establishing the EI - shrinkage strain relationship. (I do this regularly on projects that I monitor for quality.) From that relationship, we can estimate the strains associated with the temperature and humidity profiles in the slab (which are also measured by the base station) and tie that back to the amount of warping and curling which leads us to an estimate of the induced stress field in the slab. A comparison to the strength profile over time leads to an assessment of the cracking potential, but we do also need to know something