

When did you last review your concrete specifications?

Writing concrete mix specifications to improve durability and sustainability

June 2019

Problem and Solution

Concrete mixes primarily rely on portland cement (ASTM C150) to provide the concrete’s desired performance, which is why traditional concrete mix design specifications emphasize cement usage as a pseudo-metric for strength and durability. These specifications often included minimum portland cement content requirements as a “proof of purchase” for the concrete.

But increased fundamental knowledge from research and growing empirical evidence now show that unintended consequences from this approach make it antiquated. Specifically, it is now known that strict emphasis on minimum cement contents can increase environmental impacts and worsen performance—yet potentially still cost more than modern advanced concrete mixes. Portland cement manufacture produces most of the environmental impacts associated with concrete because it is made by superheating raw geological ingredients to force a chemical reformation. This costly yet necessary process produces carbon dioxide as a primary byproduct. Modern

concrete mix designs, on the other hand, can reduce this environmental impact while maintaining performance requirements by minimizing the quantity of portland cement. These designs do this by replacing some of the cement with supplementary cementitious materials (SCM) such as fly ash, natural pozzolans (both under ASTM C618), silica fume, and slag cement (ASTM C989).



Modern mixes also minimize the required amount of cement paste (cement combined with SCMs and water) in the concrete by optimizing aggregate gradations. Besides reducing the cement content needed for a concrete mixture, SCMs and optimized aggregate gradations also increase

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But What About...?

How do I know that these mixes will give me good performance? *These types of mixes have been tried and tested internationally—including in California by Caltrans—for many years.*

Will these changes in specifications cost me more? *These specifications may reduce initial costs, depending on the relative costs of cement and SCMs at any given time, and are expected to reduce life cycle costs based on better durability.*

Are there any other issues such as constructability with these mixes? *Generally, no. Your concrete suppliers can also provide additives, if needed, to help ensure workability and other constructability properties with little impacts on performance.*

How Others Have Done This

Some cities and counties have reviewed and changed their specifications, including the cities of Davis, Berkeley, and Los Gatos—as well as the University of California, Davis campus. Caltrans has used flexural strength requirements and performance requirements (like shrinkage) for many years, and without minimum cement contents. Local government can use compressive strength as a surrogate for flexural strength. Caltrans has been requiring SCMs as a means to achieve these numerous benefits in their concrete for more than 15 years!

Where to Get More Information

Caltrans specifications (Section 90) are already available on the web:
www.dot.ca.gov/hq/esc/oe/construction_contract_standards/std_specs/2015_StdSpecs/2015_StdSpecs.pdf

A simpler example specification will soon be available on the CCPIC website:
www.ucprc.ucdavis.edu/ccpic/



What can you do with a county road that you can't afford to maintain?

Unpaving to create affordable, safe, smooth gravel roads

March 2017

Problem and Solution

Many rural county road networks were created at a time when funding was greater and rural populations were often larger than they are today. Eventually, surface treatments such as chip seals or thin asphalt were applied to many of these gravel roads to provide them with an all-weather surface. These treated surfaces were also desirable because conventional gravel roads are dusty, often develop washboarding quickly, and have high rates of gravel loss—which result in unsafe and uncomfortable conditions and greater damage to vehicles and crops.

Today funding to maintain these low-volume roads has dried up, and this has led to the frequent development of deep potholes that create dangerous vehicle- and freight-damaging conditions. And while some road networks can be abandoned, most of these roads are still needed to support the economic needs of tax-paying residents, by serving agriculture, forestry, and recreation area access.

A solution to this problem, called *unpaving using engineered gravel roads*, has been

developed in South Africa and has been implemented by UCPRC/CCPIC researchers¹ in several counties in California. *Unpaving* involves pulverizing the existing surface of a gravel road and any granular base layers below it, and importing additional granular material as needed. The grindings and any additional granular material are checked in the laboratory with simple and inexpensive tests to determine the amount of additional fines or clay material that needs to be added—typically less than five percent by total weight of aggregate—to ensure that the now unsealed wearing course will be tightly bound and not susceptible to washboarding or excessive dust. The supplementary gravel and fines are spread on top of the existing road, mixed in place with a recycler (note that recycling depth can often be adjusted to incorporate a small amount of the subgrade material if it is suitable as an alternative to trucking in fines), then shaped with a grader and compacted to finish up with a four to five percent cross-slope. A chemical treatment (stabilizer or dust palliative/fines preserver) can be applied during mixing or after the

¹ The research was originally done by the Council for Scientific and Industrial Research (CSIR) in South Africa by Phil Paige-Green and David Jones. Dr. Jones is now Associate Director of UCPRC and CCPIC.

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But What About...?

Won't the public prefer a chip seal or asphalt-surfaced road? *Experience has shown that the public is happier with a smooth gravel surface than a potholed, treated surface.*

Don't gravel roads washboard quickly and cause a lot of dust? *Traditional gravel road surfaces in California typically use materials ranging from pea gravel to Caltrans Class 2 aggregate base. None of these materials have sufficient plastic fines to glue the stones together, help waterproof the surface, or keep dust down. A small amount of clay provides a low-cost binder for the gravel. As long as water doesn't penetrate the clay—which is prevented by good drainage and maintenance of the cross-slope—it will continue to bind.*

I work in a non-attainment area, so won't the increased dust levels affect my status? *Unpaved roads constructed properly with the right amounts of gravel, fines, and plasticity emit very little dust. The use of an appropriate chemical treatment will all but eliminate dust from passing vehicles and from wind.*

How Others Have Done This

A list of several counties in California and other states who have already worked with CCPIC to implement this strategy will soon be available on the CCPIC website.

Where to Get More Information

NCHRP Synthesis 485 (2016) Converting Paved Roads to Unpaved. Download at: <http://www.trb.org/Publications/Blurbs/173716.aspx>

Webinar at: <http://onlinepubs.trb.org/onlinepubs/webinars/160630.pdf>

There will soon be a CCPIC unpaved roads manual that includes a chapter on unpaving.

Is your asphalt only living half as long as it could?

Writing and enforcing specifications for asphalt compaction

May 2017

Problem and Solution

The cracking life of an asphalt overlay can be shortened by as much as half or increased by as much as double depending on the compaction that occurs between the paver laying down the material while it's still hot and when it becomes too cold to further densify under the rollers.

Most local agencies have asphalt compaction specifications in their contracts as well as inspectors who check the contractors' operations. But following specifications that tell a contractor how to do the compaction, called *method specifications*, typically leads to very poor results because even the most experienced inspector or contractor cannot tell how well or poorly compacted the asphalt is by just watching the compacting operation or looking at the completed surface. In these situations the possible life can be cut in half. On the other hand, a city or county can use quantitative *quality control/quality assurance (QC/QA)* specifications that call for measurement of compaction to determine the extent to which the contractor has met the compaction requirements. The data collected can also

be used to apply a payment reduction if the compaction specification has not been met sufficiently or to give a bonus for exceptional compaction. In addition, it is important that quantitative specifications that rely on nuclear gauges to measure density include requirements to calibrate the nuclear gauge results with cores on each project. Nuclear gauge results that are not calibrated with cores can be highly variable and difficult to defend when used on the thin overlays that make up the majority of city and county work. Results from calibrated nuclear gauges can quickly provide compaction information to the contractor and the owner during paving.



To really determine whether you are getting good compaction on your asphalt,

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Isn't the cost of managing this specification high? *It is pennies on the dollar compared to life cycle cost savings. You don't need to use the full Caltrans HMA specification, and the actual specification language can be very simple and straightforward. The coring and lab testing costs are a small percentage of the cost of the construction contract.*

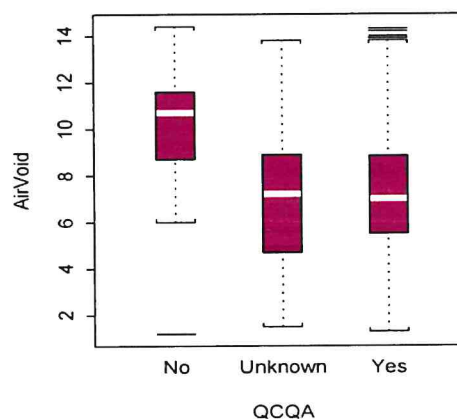
Won't coring damage my new pavement? *Good core patching practice is simple and well-patched core holes will not fail early. There's a choice: have a longer-lasting pavement that has a few patched holes, or have a pavement that ages, gets water-damaged and cracks up early—but without patched holes.*

What can I do to help my contractors meet and exceed the specification and further increase the life of my overlays? *Do not apply the specification to parts of the project where the contractor may find it very difficult or impossible to meet it, particularly where any hand placement or compaction is required. Organize your project bidding and contracting schedule and your construction windows to maximize the time that the contractor has to pave when it is HOT (particularly important for rubberized mixes), and don't pressure the contractor to pave when it is COLD. Allow the contractor to use warm mix additives to extend the time they have to compact. You can have the contractor demonstrate on a trial section that they can meet your specification before proceeding with the job.*

How Others Have Done This

Research has shown that Caltrans reduced its typical air-void content from the 10 to 14

percent range to an average of about 7 percent within a few years of implementing this type of specification in the 1990s, and they continue to get good compaction even on thin overlays. The figure below⁶ shows the results of coring on the state network and the distributions of air-voids from cores for projects built under the Caltrans QC/QA specification with disincentives for measured compaction (shown as Yes), and those built under the previous method specification (shown as No).



Cities and counties in California that use and enforce this type of specification can expect to get similar results, while cities and counties that don't will typically get air-voids in the range Caltrans had before implementing the specification.

Where to Get More Information

Sample specifications prepared specifically for local governments will soon be available on the CCPIC website.

⁶ Figure 3.7 from Lu, Q. and J. Harvey. 2005. *Investigation of Conditions for Moisture Damage in Asphalt Concrete and Appropriate Laboratory Test Methods*. UPRC Report UPRC-RR-2005-15.