R&T UPDATE
Concrete Pavement Research & Technology

Clay Ball Prevention and Repair: Stockpile Management is Key

Producing a good quality concrete pavement is the goal of every contractor. Quality can be defined in many different ways, including the aesthetics of the final pavement surface. The nature of pavement material and the difficulty of the outdoor, heavy-construction environment sometimes introduce a practical limitation to perfecting surface aesthetics.

Clay balls (or mud balls) create a surface defect that is typically not a structural problem, but can detract from the surface appearance. Clay balls result from lumps of clay or dirt being mixed into the concrete with the coarse or fine aggregates at the batch plant. The clay or mud "balls up" and is not dispersed throughout the mixture while it is being combined in the mixer. Eventually, these clumps float up to the surface (or very near the surface) when the mixture is being vibrated or consolidated by the slipform paving machine. They also may rise in the mixture during consolidation with hand-held vibrators in small-pour placements. They "float" to the surface during vibration because they weigh less than the aggregates and other particles in the surrounding fresh concrete.

At first, clay balls may not be visible or evident. In time, the voids may be created by the clay particles absorbing water and expanding when frozen to cause a void or popout at the surface, or if traffic loadings break or crack the thin mortar-skin above the clump to expose the clay ball. The distress will usually appear a few weeks or months after paving, but some may not appear until a full winter season of freeze-thaw cycles has occurred.

Prevention

Prevention of clay balls is easy with proper attention to aggregate stockpile management. Stockpile management is the coordination of the aggregate delivery, storage, and loading into the mixing plant, which is a vital aspect of consistent quality concrete production.

Stockpiling — Locating the stockpiles is an important first consideration. A relatively flat area is preferable to facilitate unloading and stockpiling the aggregates. Also, place a pad or aggregate separation layer in the stockpile area. This will minimize contamination of the aggregate from the soil below as well as prevent material loss.

The goal with aggregate stockpiles is to maintain uniform gradation and moisture content, and to prevent aggregate contamination throughout the project. Consistent aggregate will contribute to consistent concrete. A few basic stockpiling concepts include the following:

- Pile the material in lifts
- Complete each lift before beginning the next
- Do not dump material over the edges of a stockpile
- Minimize free fall heights of aggregates to avoid segregation
- Only stockpile as much material as practical

In some cases, the aggregates may be contaminated with clay or soil before arriving on the plant site. Dirty aggregates require washing or cleaning for effective use. In addition to clay ball problems, dirty aggregates can lead to other concrete problems like low strength development.

Portable central-mix plants are usually more susceptible to producing concrete contaminated with clay balls, simply because they are temporarily placed on right-of-way near the project site which may have clay or loose soil underneath the stockpiles. The batch plant or concrete foreman must keep a close eye on stockpile management at portable plant sites.

Stationary ready-mix plants often have a paved surface or bunkers on which the stockpiles are placed or stored, and where the loader operates.


Loader Operation

This reduces the likelihood of clay balls being introduced into the ready-mix concrete.

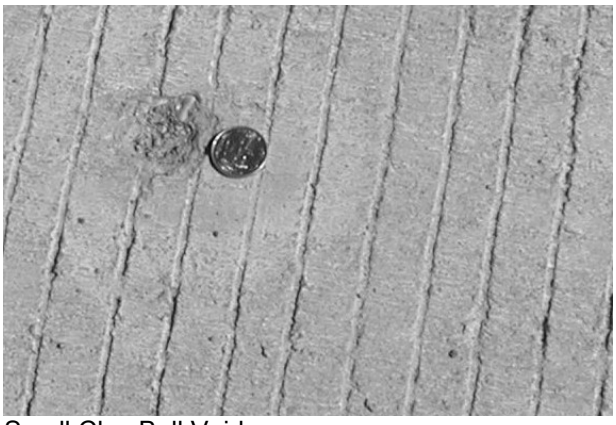
Loader Operator — The loader operator is quite possibly the most important person in the production of consistent quality concrete. The primary functions of the loader operator include:

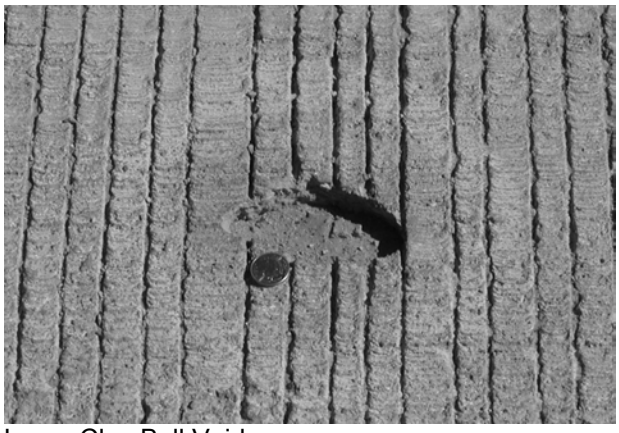
- Working the stockpile to provide uniform water content and gradation, while avoiding segregation
- Minimizing contamination
- Observing and reporting moisture variations
- Adding material to the feed hopper(s) appropriately
- Notifying the plant foreman of aggregate shortages

The loader operator has the key role in preventing clay or mud from being deposited into the feed hoppers. The operator must apply the right amount of down pressure on the loader blade of the front-end loader. Too much pressure or too sharp an angle will cause the front blade to scrape the soil beneath the stockpile, thereby picking up the mud or clay, which will introduce soil particles into the mixture.

Determining Severity

A few small voids caused by clay balls can be ignored as a by-product of the heavy construction process, but many telltale voids in the pavement surface warrants investigation. The size of the voids is also important. If the voids are less than 2 inches in diameter, they do not require repair even if they are numerous. This recommendation is


Small Clay Ball Void


Large Clay Ball Void

similar to the recommendation for pavement with a chert or shale pop-out condition. Most pavement condition index standards (ASTM D 5340 for example) require that there must be more than three (3) popouts or clay ball voids per square yard per slab before they are even counted as a distress.

If a slab contains a few large voids consider repairing them with cementitious- or epoxy-based material. Extreme cases, where many larger voids are evident on the surface, require further analysis to determine whether the concrete (and slab) have enough structural integrity to meet the design expectation or function.

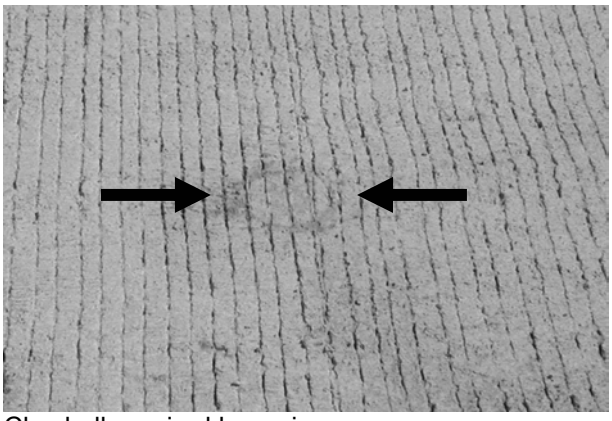
Structural assessment begins by examining the strength records. Compare the strength of cores removed from the pavement with strength information from construction records. Also examine the cores for evidence of where the clay balls are found

in the slab. An assessment of the percentage of contamination is optional, but can be helpful. Unless the in-place strength seems affected, or cores show evidence of many large voids within the lower third of the slab, there is no need for further concern for structural integrity. The lower third of a slab is typically under the most tension under edge and interior loads, and is therefore where structural integrity is of greatest importance.

When the project warrants a more detailed assessment, it may be helpful to determine the percentage of aggregate contamination. A visual inspection of the slabs can provide the number and size of the clay ball voids. The mass of these clay balls is estimated from a typical unit weight of the soil times their volume. Compare the mass of clay to that of the aggregate fraction of the concrete mixture to calculate the percentage of contamination. ASTM C 33 aggregate specifications allow up to 3% contamination of fine aggregates (sand) with "clay lumps and friable particles," and 3 or 5% contamination of coarse aggregates with "clay lumps and friable particles" depending upon the weather region.

Slab removal and replacement is warranted only if the clay balls are very large, very deep, or covering a significant portion of the affected slab(s).

Clay ball repaired by filling (three years old at time)



Clay ball repaired by coring

Repairing

There are two methods to repair clay ball voids: filling or coring. Either method is appropriate for voids more than two inches in diameter. (Repairs are not recommended on smaller voids).

Filling — One option is to simply clean out and fill the affected area with an appropriate repair material. Cleaning involves sandblasting and/or high-pressure water, followed by compressed air. Cementitious, epoxy, and proprietary materials have all been used successfully to fill and repair clay ball voids.

Coring — Another option is to core around the void to create a uniform, partial-depth hole. The coring bit must be larger than the clay ball void and drilled slightly deeper than the depth of the void. The same cleaning methods are necessary to ensure the repair materials bond to the core walls. Core repairs typically use a basic cementitious-based grout or patching mix, similar to those used to fill core holes drilled into pavements for thickness verification.

Materials — Materials with a quick cure time are often required. A good cementitious-based material for this application would meet ASTM C 928, "Standard Specification for Packaged, Dry, and Rapid-Hardening Cementitious Materials for Concrete Repairs." A good epoxy material for this application would meet ASTM C 881 Type 1, Grade 3, Class B and/or C, "Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete."

Consider extending the binder material with filler aggregate (i.e. pea gravel) or fibers to minimize the grout's shrinkage properties. Pay particular attention to the material's salt penetration and resistance to freeze-thaw cycles so that it will meet the intended life of the facility.

***Iowa Method* —** The Iowa Department of Transportation established a method in their Construction Manual for correcting clay balls encountered in concrete paving projects:

> "Correction of any discovered mud balls in a pavement surface shall be as follows:
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> - Any thin concrete skin around the perimeter of the mud ball should be removed so that nearly vertical void walls remain.
> - Each void shall be cleaned by a high-pressure washer, followed by air blasting to dry the void.
> - Voids shall be filled with [an approved material used according to manufacturer's recommendations.]
> - The surface of filled voids shall be given the same texture as the surrounding pavement.
> - A void repair shall be given the proper cure time recommended by the manufacturer prior to opening the roadway to normal traffic.
>
> "If a severe problem with mud balls is suspected on a specific project, formal acceptance by project engineer should be delayed until the following spring. This will allow the winter freeze-thaw cycles and snowplowing activities to expose additional mud balls located adjacent to pavement surface. These newly discovered mud ball areas will then also require corrective measures as stated above."

Performance

Generally, if there is going to be a problem with a surface repair, it will occur within the first year (after a winter cycle). Nonetheless, a five-year performance warranty period is often recommended to provide the greatest degree of assurance to the owner that the pavement will serve its intended function.

Both the filling method and core repair method have been shown to last many years before any appreciable distress is noticed. If a durable patch material is used, and the proper surface preparation and construction techniques are employed, clay ball repairs will last until other pavement distresses develop which may require rehabilitation.

Summary

Clay balls can be prevented by proper stockpile management and by attention to detail at the concrete plant. Having a few clay balls on a concrete paving project does not mean that the pavement is substandard. The extent of the problem must first be assessed before proper repair or remediation techniques can be decided upon. There are two primary methods of repairing a clay ball void: simply filling the void, or coring around it and placing patch material in the core hole. If done properly, clay ball repairs should last as long as the surrounding concrete, giving the owner and users a smooth riding surface for years to come.

References

Construction of Portland Cement Concrete Pavements Participant's Workbook, FHWA HI-02-018, National Highway Institute, Federal Highway Administration, Washington, DC, 2000.

"Inspection and Acceptance of Rapid-Setting Concrete Patching Materials," Materials Instructional Memorandum 491.20, Iowa Department of Transportation, Ames, Iowa, October 2002.

"Mud Ball Repair," Section 9.54, Chapter 9, Iowa DOT Construction Manual, Iowa Department of Transportation, Ames, Iowa, April 2004.

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