There is a graveyard strategically tucked into the campus of the University of Texas. Those who walk the site want to see the decay unfold right before their eyes. It is not as gruesome as one might imagine, but it is all in the name of science—concrete science.

Prof. Kevin Folliard, known all over for his advances in alkali-silica reactivity (ASR), fills this makeshift ASR mortuary with 2-ft by 2-ft by 3-ft block specimens in order to find the next deadly aggregate.

The state of Texas is full of them, hence the need for the examining area in nearby Austin. Roll off from the Rocky Mountains combined with the remnants of when Texas was an ocean floor have created perhaps the largest quarry of highly reactive rock in the world. In the fight against ASR, highly reactive aggregate is a well-known carcinogen. However, through much of the building of the interstate system the gel killer that preys on bridge elements kept its distance. It was not until the mid-1990s when the Texas Department of Transportation (TxDOT) realized it needed to launch an investigation, but the most extreme case of ASR did not pop up until the late summer of 2009, when the Harris County Toll Road Authority turned proactive after the fourth of 10 concrete bridges in the system developed the alarming cracks.

TxDOT thinks it has a solution to ASR, but that solution could suddenly be in short supply.
Before it gets worse

In light of the most recent ASR infection, Harris County Toll Road Authority officials wanted to make sure that prevention was in large supply, and hired Houston-based engineering consultant Walter P. Moore to inspect the entire fleet of bridges.

Walter P. Moore has been going through the assessment process for all 10 bridges and has repaired two, with a third pending.

As feared, Walter P. Moore has found the existence of ASR in the Harris County bridges, mostly in bridge beams, and in some cases they have discovered a condition called delayed ettringite formation (DEF). DEF is a process that causes premature deterioration primarily because of the curing temperatures of the concrete.

“What we are finding is that in the current condition the bridges have adequate load-carrying capacity and they are serviceable,” said Choudhuri. “The key to managing the problem is to manage the moisture.”

Two bridges that have received treatment are the Hardy Toll Road bridge (which consists of 15 spans) over I-45 and the Sam Houston Tollway bridge (nine spans) over Buffalo Bayou. A report also has been completed for the Sam Houston Tollway bridge over U.S. 290, a massive structure that consists of 10 connector bridges and 203 spans.

In most cases, Walter P. Moore has been applying a form of saline sealer before adding appropriate coatings to prevent moisture infiltration.

But how did such an epidemic break out in the system that falls under the Harris County Toll Authority? A couple of factors come into play. First, according to TxDOT Director of Rigid Pavement and Concrete Materials Lisa Lukefahr, you have the bigger and longer factor. Once the 1980s hit, owners were constructing massive bridge structures to serve a booming population of motorists. Longer bridge beams increase the demand for strength, which in turn requires more cement. This heavier dose of cement does not help in the fight against ASR.

The second ASR feeder is the natural greenhouse effect of the city of Houston.

“If you wanted to pick a place that was the best for ASR, [Houston] would be it. Just the mild-to-elevated temperatures combined with the almost constant humidity really is a laboratory condition for accelerating ASR,” Lukefahr told ROADS & BRIDGES.

To emphasize her point, Lukefahr compared Houston to the dry and cooler region of Canada. “It is a rough rule of thumb that if the Canadians see some ASR cracking in seven years, Austin will see it in one. You go to Houston, and maybe you see it in eight months.”

A shortened Class

In March 2000, TxDOT unleashed its counterstrike on ASR through a series of mitigation strategies. The strategy was to hit like an atomic mushroom cloud—every aggregate was treated as if it were highly reactive.

Perhaps the most effective agent in the agency’s arsenal is the use of Class F fly ash. For a while, Texas was overflowing with the additive thanks to lignite-coal-burning power plants scattered across the landscape. It created the perfect scenario: it was cheap and abundant. However, today power plants are starting to blend in PRB coals, which lessen the effectiveness of the product, and the latest clean air movement could label Class F fly ash as a hazardous material. TxDOT was filling mixes with 20% Class F fly ash, but due to the recent diluted effects it is now using as much as 25% of the additive.

The use of ground-granulated blast furnace slag and silica fumes offered up solid alternatives, but both are no longer readily available in the state. TxDOT has experimented with Class C fly ash, which also is the residue of local power plants. However, the parent coal is different, which changes the chemistry.

Basically there is more lime in Class C fly ash than there is in Class F, which raises the pH of the concrete pour solution and dissolves the aggregate that causes the ASR gel in the first place.
TxDOT does have an option to mitigate ASR through the use of a lithium admixture. So far it has not been used on a TxDOT project, but it has been used in the state on foundations for windmill farms. According to Lukefahr, TxDOT has done some verification testing in its laboratory, and the agency remains optimistic about its potential as a good ASR mitigation solution. However, it is not as economical as fly ash.

There are a handful of tests to determine an aggregate’s reactivity, which TxDOT still actively conducts to serve as another level of assurance. Perhaps the quickest is the ASTM C1260 test, which takes 14 days but often exaggerates an aggregate’s potential for ASR. TxDOT runs this on many aggregate sources every year.

There also is another lab test, called the C 1293, which can take up to 18 months to develop. TxDOT also uses an onsite geologist, but he or she can only look at those aggregates that the agency is already suspicious of and has field data that indicates this suspicion. Folliard’s expedition at the University of Texas is yet another option, but is a multiyear study.

TxDOT has reached out to Canada for some ASR advice. Before Canada commits an aggregate to be approved for use in concrete they require the source to go through a multiyear testing program.

So in the midst of shaky supply levels of Class F fly ash and time demands, TxDOT has taken a hard look at risk management. According to Lukefahr, if you consider the thousands of cubic yards of concrete that are produced each year and turn out ASR-free there might not be a need for change.

In addition, most of the ASR cases are linked to precast concrete beams and not so much in projects that involve cast-in-place elements.

“Although we are certainly concerned and we have done a lot of research on how to identify elements and what to do, the reality is the cracks to engineers look a lot worse than they are. That has given us some breathing room to step back and say we know our maintenance costs are going to increase in the future because we do not want this cracking to go unabated, but from the practical side it is not going to hurt us.”

TxDOT has detected ASR in about 1,000 of its bridges, which account for 2% of the state’s entire inventory.

“I think it is important to note that TxDOT has not taken any bridge out of service because of an ASR issue.”

A couple of years ago TxDOT looked into the effectiveness of a water sealant as a way of suppressing ASR. Lukefahr said that as long as that waterproofing layer is maintained there should not be any further expansion of the gel.

“The beam is never going to heal itself, but it is not going to get worse,” she said. R&B