Celebrating the Next Generation of Concrete Surfaces

Fifteen states and three international transportation authorities have reaped the benefits of NGCS, a smooth, safe, quiet concrete surface. Learn how they:

... experienced lower winter accident rates ...

... noticed improved maintenance efforts ...

... achieved IRI numbers consistently as low as the 20s ...

... earned compliments from the driving public ...

Above: Aerial View of I-10 Freeway and Beltway 8 in Houston, Texas. Photo courtesy of Shutterstock.
IT'S BEEN OVER A DECADE since the quietest non-porous concrete pavement surface—the Next Generation Concrete Surface, or NGCS—was introduced. Since then, 15 states and three international transportation authorities have installed NGCS, reaping the benefits of concrete's durability and low maintenance while reducing trade-offs associated with concrete's tire/pavement noise. Friction testing conducted over the last decade has indicated that NGCS is a stable surface with good frictional characteristics. Grooving used as part of the treatment improves lateral stability for vehicles on the roadway and reduces hydroplaning potential. NGCS, therefore, not only has the benefit of decreasing tire/pavement noise by 75 percent, but is shown to provide a smooth, uniform ride and increase driver safety (especially in wet weather conditions).

To celebrate NGCS’ anniversary, here’s a look back at the research, development and testing that went into its creation, plus highlights of its installations around the world.

FINDING A SOLUTION TO ROAD NOISE

Creating quieter roads was not an easy challenge, since historically, the more aggressive surfaces that provided the best friction and safe driving usually were also noisier surfaces. Transverse tining was an early solution for providing traction on concrete pavement. It involved dragging a metal rake laterally across the width of a paved surface. By the early 1970s, the FHWA mandated transverse tining on interstate concrete pavements. However, the method had the unwelcome byproduct of increased tire/pavement noise facilitating the creation of alternative concrete pavement textures in intervening years, most notably NGCS.

NGCS was developed by researchers who had a novel way to examine the physics behind the tire/pavement interface and its associated noise. The American Concrete Pavement Association (ACPA), International Grooving & Grinding Association (IGGA) and the Portland Cement Association (PCA) collaborated with Purdue University, where researchers had custom-designed a 12-foot-diameter circular Tire Pavement Test Apparatus (TPTA). The TPTA is capable of testing numerous pavement surface types in combination with various tire designs. The machine’s curved test-pavement sections remain stationary while tires roll over the test surfaces, a configuration that mimics actual road conditions. Microphones record noise as tires move over the pavement at 30 mph.

Paths of investigation that led to NGCS’ creation focused on diamond ground textures along with the effect of transverse joints on tire-pavement noise level. After evaluating a range of diamond blade and spacer widths (reflecting products and processes already on the market), researchers hypothesized that rather than being dependent upon the geometric configuration of the blades and spacers, as had been assumed at the study’s outset, noise was associated with variability in the fin/land profile height resulting from the grinding process (see Fig. 1). Textures with low variability were quieter than textures with high variability.

To evaluate their hypothesis, a texture with essentially no positive texture was created by diamond grinding a surface to be smooth then imparting additional texture via grooving—a subtractive process. This procedure controlled the land profile, making a “manufactured surface,” and created a negative or downward texture. Noise testing for this surface showed that the uniform fin profile reduced the overall noise level.

Subsequently, various grinding/grooving configurations were developed and tested—first in the laboratory, then in the field—with NGCS as the final product. NGCS is a hybrid texture that resembles...
a combination of diamond grinding and longitudinal grooving. It consists of a uniform land profile design with essentially an all-negative texture (see Fig. 2). Despite the flatter, smoother riding surface, the NGCS still possesses and maintains reliable microtexture (friction) when constructed with quality aggregates. The longitudinal grooves provide substantial macrotexure and increase the resistance to hydroplaning by providing escape channels allowing water to move out of the tire contact patch area.

NGCS is typically constructed as a two-pass operation (where flush grinding occurs first and is followed by a grooving pass) using diamond tipped saw blades mounted on conventional diamond grinding (CDG) and grooving equipment. It can be used for both new construction and rehabilitation of existing surfaces. Typical NGCS specs today involve a first step of flush grinding concrete using 1/8-inch-wide blades with 0.035-inch spacers. The second step involves cutting longitudinal grooves ranging from 1/10 to 1/18 inches wide to a depth of 1/8 - 3/16 at 1/2- to 5/8-inch centers. The grinding process can be accomplished in single lane operations and short lane closures when necessary. It can be quickly and efficiently constructed without impacting other roadway features such as guardrails, barriers or curbs.

**TESTING AND IMPLEMENTATION**

At the time the Purdue work was completed, much of the grinding industry did not believe it was possible to construct this texture in the field with conventional grinding equipment. As a result, it was necessary to conduct a proof of concept in terms of constructability. Additionally, there had never been a field evaluation of the Purdue TPA system, so it was still unknown whether the noise reductions measured in the lab would occur in the field. The Purdue work had been conducted with narrower blades than IGGA members thought practical, so 1/8-inch grinding and grooving blades were substituted.

IGGA contractor member Diamond Surface, Inc. had a specialty-built grinder that allowed grinding an 18-inch-wide pass, which was considered the minimum necessary for the ACPA noise testing equipment to operate. This purpose-built grinder also allowed very quick blade changes (45 minutes vs. 4-6 hours), reducing the hardship of constructing the proof-of-concept test strip. In the summer of 2007, the IGGA funded the construction of the proof-of-concept test strip to verify the efficacy of NGCS, the Purdue TPTA laboratory testing and the substitution of wider blades. The proof-of-concept testing was successful and the Purdue predictions validated, as was the use of wider blades. The original Purdue head configuration, with the exception of the wider blades, is still the NGCS standard today.

After successfully completing the test strip, it was still necessary to grind an actual roadway with conventional surface diamond grinding equipment. This occurred in the fall of 2007 on I-355 in Chicago. Test section construction was accomplished by Quality Saw and Seal who incurred the
cost of constructing both an NGCS and CDG test sections (one lane by 1200 ft of each). These two test sections were constructed along with the National Cooperative Highway Program (NCHRP) 10-67 test sections for “Texturing of Concrete Pavements” research initiative. This allowed the two diamond-ground surfaces to be evaluated along with eleven other concrete textures under evaluation by NCHRP. It also allowed comparison of the NGCS and CDG to most other commonly used concrete textures in a national study conducted by Applied Research and Associates. The report was published in 2009 as NCHRP 630.

The next roadway sections to be constructed were on I-94 at the MnROAD facility in the fall of 2007. They were constructed and donated by Diamond Surface, Inc. Two 500-foot-long by two-lane-wide test sections were constructed, a CDG and NGCS, respectively. These two sections became the MnROAD test cells and began a systematic evaluation of these textures by MnROAD for many years to come, including both low volume road and interstate traffic conditions.

The first conventional project to bid NGCS occurred near Omro, Wisconsin on SR-21 in 2008. As part of their research efforts focused on NGCS, MnDOT later identified poor pavement conditions on other sections of I-94 in 2009 and elected to use NGCS as one of its restoration strategies. International Roughness Index (IRI) values in excess of 200 inches per mile were measured before construction and the road had faulted joints ranging from 1/4-inch to 1/2-inch. In addition to concrete pavement preservation (CPP) strategies (including full- and partial-depth patching, grinding, joint and crack sealing, asphalt ramp paving and striping), the 85-lane-mile section was treated with 633,000 square yards of diamond grinding and 5,333 square yards of NGCS.

The surface’s first large-scale application—and its first use on an urban interstate concrete pavement—occurred in Duluth, Minnesota in the summer of 2010. NGCS work was performed on two segments of the I-35 Duluth Mega Project, for both northbound and southbound lanes. Both segments were located within an ongoing concrete pavement rehabilitation (CPR) project. Repaired sections were equal to 3.7 miles of a four-lane freeway and a total of 104,000 square yards of NGCS were installed.
“Both the 2009 and 2010 NGCS projects performed in Minnesota were great proofs-of-concept,” said Matt Zeller, executive director, Concrete Paving Association of Minnesota. “The surface was a demonstrably quiet concrete pavement and it was well received by the public.”

According to Zeller, the superior performance of NGCS on I-35 inspired its use on another unbonded overlay project on I-35, constructed in 2013 just south of Duluth (near Midway Road/Thompson Hill). Duluth maintenance crews observed that the existing NGCS surface was experiencing a low winter accident rate and held salt well, so they requested incorporation of NCCS into an approximately two-mile section of the roadway under construction, both north- and southbound lanes, which were experiencing a higher-than-expected incidence of winter accidents. IRI measurements taken at the time of the overlay’s completion were quite low—in the 30s and 40s—and after application of NGCS, IRI numbers were lowered still further, into the 20s. Zeller also notes that local drivers are still complimenting the ride quality and low noise of the Midway Road/Thompson Hill pavement in 2019, which he attributes to the benefits of diamond grinding.

In May 2010, the Arizona DOT constructed a two-lane-wide NGCS test section on I-10 eastbound near Avondale, Arizona. On-board sound intensity (OBSI) levels averaged 99.2 dB(A), which was approximately 2.9 dB(A) lower than a CDG section and 4.3 dB(A) lower than test values obtained on the project’s longitudinal tining. The average IRI was 24 inches per mile.

Caltrans has constructed NGCS surfaces at 7 different locations in California and until 2016, California was the largest user of NGCS technology among the states. The state’s early NGCS installations were mostly performed on existing concrete pavement, with an average age of 30 years, and were used to address areas with particular noise sensitivity.

UC Davis, who conducted Caltrans’ quiet pavement program, evaluated NGCS over a four-year period and summarized its findings in a report titled, “Evaluation of Grind and Groove (Next Generation Concrete Surface) Pilot Projects in California.” NGCS was found to be quieter than CDG by approximately 2 dB(A). Lane average OBSI values ranged from 99.5 dB(A) to 101.7 dB(A), with an average of 100.8 dB(A), compared with a range of 100.6 dB(A) to 104.7 dB(A) and an average of 102.8 dB(A) measured on the CDG.

IRI measurements showed that both NGCS and CDG improved smoothness significantly. The average IRI was reduced from 142 inches per mile to 64 inches per mile after CDG and to 49 inches per mile after NGCS.

The Virginia DOT has also conducted extensive evaluation of quiet pavement technologies,
including both CDG and NGCS surfaces. Test results showed NGCS to be approximately 5 dB(A) quieter than the transverse tined concrete used in Virginia. It was also within ½ dB(A) of all quiet asphalt textures except one. Virginia Tech Transportation Institute also reported “NGCS is reliable in terms of noise variability between different locations.”

Recent NGCS work in Minnesota includes a $13 million rehabilitation project performed in the summer of 2015 on I-394. The project scope included removing the existing asphalt overlay, assessing and repairing the exposed concrete (with work including both full- and partial-depth repairs) and constructing NGCS. All repaired areas had joints resealed. A research team from the MnDOT Office of Materials and Road Research conducted OBSI measurements both before and after construction and found a 56 percent reduction in tire/pavement noise compared to the pre-existing asphalt wearing course. A 24 percent reduction was achieved compared to the pre-grind transverse tined surface. Measurements showed an overall reduction of 47 percent in the contiguous 14 segments into which the project was split for the convenience of the test.

Smoothness testing also yielded positive results.

The most recent rehab activity on the comparison section of asphalt pavement was performed in 2016.

The Houston District of TxDOT—the largest DOT district in the state—has incorporated NGCS into several major highways, including I-10, Harris County’s U.S. 290, and the 610 Loop. The city is placing about 3 million square yards of NGCS in total.

One section of I-10 that received NGCS, known as the Katy Freeway, was noteworthy because of its funding. Widened in 2009, the Katy Freeway became the widest freeway in the world at 16 lanes (including service roads) along a three-to-four-mile stretch abutting several small villages. Because about half of the affected roadway was within village jurisdictions and half was within the City of Houston’s jurisdiction, TxDOT proposed that the City of Houston and four of the six affected villages contribute approximately $2 million of that total cost over a five-month term with no interest. Eventually, funding from TxDOT, the City of Houston and four villages was secured and in late winter 2016, the project was let for bid. Transverse grooving was removed and NGCS installed, with construction completed by fall 2017. Noise improved significantly and residents, as well as their mayors, were delighted with the new surface.

David A. Wegner, five-time mayor of one of the villages and current president of Sand Hill Resources, LLC, said that as of 2019 the Katy Freeway NGCS continued to perform well, with residents living near the widened freeway being “quite pleased with the results of the next generation surface.”

“Aerial view of Katy Freeway in Houston, Texas. Photo courtesy of Shutterstock.”

“Pavement profile testing was performed four years after construction and, in terms of smoothness, the pavement surface is performing as well as, or in some cases better than, the asphalt pavement surface to the west.” — Dave Van Deusen, Metro Materials and Pavement Engineer, MnDOT
INTERNATIONAL INSTALLATIONS

Australia

Australia’s Roads and Maritime Services (RMS) first installed trials of NGCS in New South Wales (NSW) in 2012. The surface was installed on existing jointed plain concrete pavement (JPCP) sections of the New England Highway. Additional trials of a modified NGCS were installed along a section of the Hunter Expressway. Road noise tests, as well as skid-resistance and ride-quality tests, conducted on the completed trial surfaces indicated that they were up to 3 dB(A) quieter than densely graded asphalt (the material that had traditionally been used in the region to reduce road noise). NGCS was also shown to cost significantly less than an asphalt-wearing course. Based on the trial project, the RMS in 2013 approved NGCS for use in NSW.

A second trial was installed more recently on a stretch of Australia’s Pacific Highway, known as Nambucca Heads to Urunga (NH2U). In this trial, various blade and spacing configurations were used on four different roadway sections. OBSI testing after project completion led the RMS to conclude that the surface produced comparable noise levels to the traditionally ‘low noise’ 10 mm stone mastic asphalt pavement.

South Korea

In 2014, aided by its Research Institute, Korea Expressway Corp. completed a pilot project using NGCS. Preliminary tests conducted by the Korea Highway Traffic Engineering Institute demonstrated a noise reduction of 1.5-7.5 dB(A). A flatness of 0.88 m/km was achieved and IRI was 0.65 m/km. Improvement of friction forces, tested according to the ASTM E 501 sliding friction test, was an average of 52.7 on the sliding resistance index (SN). The pilot project’s results led to the company choosing NGCS for its long tunnels—which are plentiful, given the country’s mountainous terrain.

Today, NGCS is used in all new South Korean expressway tunnels that are 2 kilometers (1.24 miles) or more in length. So far, nearly 1.5 million square yards—200 lane miles—have been installed. Use of the surface is now expanding to national highways, local roads and bridges due to the surface’s various advantages, such as safety, smooth driving and durability in severe weather conditions.

As of its 10th anniversary, NGCS has been installed in 15 states (see Fig. 3). It has made quieter concrete pavements a reality in the United States and across the globe. Continued adoption of the surface will ensure better driving conditions for countless travelers, for years to come.