

Indiana Demonstration Project:
Rehabilitation of I-65/I-465 Interchange
with Next Generation Concrete Surface in
Indianapolis, IN
Final Technical Brief
July 2015



FOREWORD

The purpose of the Highways for LIFE (HfL) pilot program is to accelerate the use of innovations that improve highway safety and quality while reducing congestion caused by construction. **LIFE** is an acronym for **L**onger-lasting highway infrastructure using **I**nnovations to accomplish the **F**ast construction of **E**fficient and safe highways and bridges.

Specifically, HfL focuses on speeding up the widespread adoption of proven innovations in the highway community. Such “innovations” encompass technologies, materials, tools, equipment, procedures, specifications, methodologies, processes, and practices used to finance, design, or construct highways. HfL is based on the recognition that innovations are available that, if widely and rapidly implemented, would result in significant benefits to road users and highway agencies.

Although innovations themselves are important, HfL is as much about changing the highway community’s culture from one that considers innovation something that only adds to the workload, delays projects, raises costs, or increases risk to one that sees it as an opportunity to provide better highway transportation service. HfL is also an effort to change the way highway community decision makers and participants perceive their jobs and the service they provide.

The HfL pilot program, described in Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) Section 1502, includes funding for demonstration construction projects. By providing incentives for projects, HfL promotes improvements in safety, construction-related congestion, and quality that can be achieved through the use of performance goals and innovations. This report documents one such HfL demonstration project.

Additional information on the HfL program is at www.fhwa.dot.gov/hfl.

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16. Abstract As a part of the HfL initiative, the FHWA provided a \$2 million grant to the Indiana Department of Transportation (INDOT) to research a variety of concrete surfaces, including the Next Generation Concrete Surface (NGCS) developed by Purdue University. INDOT anticipates that the NGCS would provide a significant reduction in tire-pavement noise and the ability to maintain friction for increased skid and hydroplaning resistance. The overall objective of this project was to improve the traffic flow and relieve the recurring commuting bottlenecks around the I-65 and I-465 interchange. The project involved widening of the I-65 and I-465 mainline and several ramps and construction of a new flyover ramp from westbound I-465 to southbound I-65. The key innovation of this project was the implementation of the NGCS. Three other concrete texturing techniques were implemented to study their effect on noise reduction.			
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SI* (MODERN METRIC) CONVERSION FACTORS				
APPROXIMATE CONVERSIONS TO SI UNITS				
Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
(none)	mil	25.4	micrometers	µm
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in ²	square inches	645.2	square millimeters	mm ²
ft ²	square feet	0.093	square meters	m ²
yd ²	square yards	0.836	square meters	m ²
ac	acres	0.405	hectares	ha
mi ²	square miles	2.59	square kilometers	km ²
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft ³	cubic feet	0.028	cubic meters	m ³
yd ³	cubic yards	0.765	cubic meters	m ³
NOTE: volumes greater than 1000 L shall be shown in m ³				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela per square meter	cd/m ²
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	Newtons	N
lbf/in ² (psi)	poundforce per square inch	6.89	kiloPascals	kPa
k/in ² (ksi)	kips per square inch	6.89	megaPascals	MPa
DENSITY				
lb/ft ³ (pcf)	pounds per cubic foot	16.02	kilograms per cubic meter	kg/m ³
APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
µm	micrometers	0.039	mil	(none)
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
AREA				
mm ²	square millimeters	0.0016	square inches	in ²
m ²	square meters	10.764	square feet	ft ²
m ²	square meters	1.195	square yards	yd ²
ha	hectares	2.47	acres	ac
km ²	square kilometers	0.386	square miles	mi ²
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m ³	cubic meters	35.314	cubic feet	ft ³
m ³	cubic meters	1.307	cubic yards	yd ³
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
TEMPERATURE				
°C	Celsius	1.8C+32	Fahrenheit	°F
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m ²	candela per square meter	0.2919	foot-Lamberts	fl
FORCE and PRESSURE or STRESS				
N	Newtons	0.225	poundforce	lbf
kPa	kiloPascals	0.145	poundforce per square inch	lbf/in ² (psi)
MPa	megaPascals	0.145	kips per square inch	k/in ² (ksi)

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

TABLE OF CONTENTS

INTRODUCTION.....	1
HIGHWAYS FOR LIFE DEMONSTRATION PROJECTS.....	1
PROJECT OVERVIEW.....	2
PROJECT DETAILS.....	3
PROJECT LOCATION AND BACKGROUND	3
PROJECT DESCRIPTION.....	5
PROJECT INNOVATION	5
PROJECT CONSTRUCTION.....	6
INDOT IMPLEMENTATION OF NGCS AND OTHER TEXTURED SURFACES	6
SUMMARY	14
REFERENCES.....	16
ACKNOWLEDGMENTS	17

LIST OF FIGURES

Figure 1. Map. Location of I-65/I-465 interchange in Indianapolis.	3
Figure 2. Map. Construction limits along I-65.	4
Figure 3. Map. Construction limits along I-465.	4
Figure 4. Diagram. Typical section for (a) northbound and (b) southbound I-65.	7
Figure 5. Diagram. Typical section for (a) eastbound and (b) westbound I-465.....	8
Figure 6. Photo. Subbase preparation for concrete paving.	9
Figure 7. Photo. Dowel bar placement and tie bar retrofit.....	9
Figure 8. Photo. Placement of fresh concrete.	10
Figure 9. Photo. Tube rolling of concrete material.	10
Figure 10. Photo. Application of NGCS – first pass.....	11
Figure 11. Photo. Flush ground surface created by first pass of NGCS.	11
Figure 12. Photo. Application of NGCS – second pass.....	12
Figure 13. Photo. Concrete surface with double pass NGCS.	12
Figure 14. Photo. Concrete surface with INDOT’s traditional transverse tining finish.	13
Figure 15. Photo. Concrete surface with longitudinal tining finish.	14
Figure 16. Diagram. Limits of NGCS and other textures along I-65.	15

LIST OF TABLES

Table 1. Traffic data for I-65 and I-465.....	5
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ABBREVIATIONS AND SYMBOLS

AADT	average annual daily traffic
DHV	design hourly volume
FHWA	Federal Highway Administration
HfL	Highways for LIFE
INDOT	Indiana Department of Transportation
IRI	International Roughness Index
NGCS	Next Generation Concrete Surface
OBSI	onboard sound intensity
OSHA	Occupational Safety & Health Administration
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
TPTA	Tire-Pavement Test Apparatus

INTRODUCTION

HIGHWAYS FOR LIFE DEMONSTRATION PROJECTS

Highways for LIFE (HfL) is the Federal Highway Administration's (FHWA) initiative to advance longer-lasting and promote efficient and safe construction of highways and bridges using innovative technologies and practices. The HfL program provides incentive funding to highway agencies to try proven but little-used innovations on eligible Federal-aid construction projects. The HfL team prioritizes projects that use innovative technologies, manufacturing processes, financing, contracting practices, and performance measures that demonstrate substantial improvements in safety, congestion, quality, and cost-effectiveness. An innovation must be one the applicant State has never or rarely used, even if it is standard practice in other States. Recognizing the challenges associated with deployment of innovations, the HfL program provides incentive funding for up to 15 demonstration construction projects a year. The funding amount typically totals up to 20 percent of the project cost, but not more than \$5 million.

The HfL program promotes project performance goals that focus on the expressed needs and wants of highway users. They are set at a level that represents the best of what the highway community can do, not just the average of what has been done. The goals are categorized into the following categories:

1. Safety

- a. Work zone safety during construction—Work zone crash rate equal to or less than the preconstruction rate at the project location.
- b. Worker safety during construction—Incident rate for worker injuries of less than 4.0, based on incidents reported on Occupational Safety and Health Administration (OSHA) Form 300.
- c. Facility safety after construction—Twenty percent reduction in fatalities and injuries in 3-year average crash rates, using preconstruction rates as the baseline.

2. Construction Congestion

- a. Faster construction —Fifty percent reduction in the time highway users are impacted, compared to traditional methods.
- b. Trip time during construction — Less than 10 percent increase in trip time compared to the average preconstruction speed, using 100 percent sampling.
- c. Queue length during construction—A moving queue length of less than 0.5 miles in a rural area or less than 1.5 miles in an urban area (in both cases at a travel speed 20 percent less than the posted speed).

3. Quality

- a. Smoothness—International Roughness Index (IRI) measurement of less than 48 inches/mile.
- b. Noise—Tire-pavement noise measurement of less than 96.0 A-weighted decibels (dB(A)), using the onboard sound intensity (OBSI) test method.

4. User Satisfaction

- a. An assessment of how satisfied users are with the new facility compared to its previous condition and with the approach used to minimize disruption during construction. The goal is a measurement of 4 or more on a 7-point Likert scale.

PROJECT OVERVIEW

As a part of the HfL initiative, the FHWA provided a \$2 million grant to the Indiana Department of Transportation (INDOT) to research a variety of concrete surfaces, including the Next Generation Concrete Surface (NGCS) developed by Purdue University. INDOT anticipates that the NGCS would provide a significant reduction in tire-pavement noise and the ability to maintain friction for increased skid and hydroplaning resistance.

PROJECT DETAILS

PROJECT LOCATION AND BACKGROUND

This project is one of the two projects delivered under INDOT’s “Operation Indy Commute” initiative, which is aimed at strategically opening up recurring commuting bottlenecks. As shown in Figure 1, the project is located on the southeast side of Indianapolis at the interchange of Interstate Routes 65 and 465. To improve the traffic flow around the interchange, several improvements were carried out on the interchange as well as on the stretch of the two interstate routes. Figures 2 and 3 show the limits of construction along I-65 and I-465, respectively. Table 1 summarizes data regarding the traffic for both stretches of interstate routes in terms of the average annual daily traffic (AADT), design hourly volume (DHV), directional distribution, and percent truck traffic.

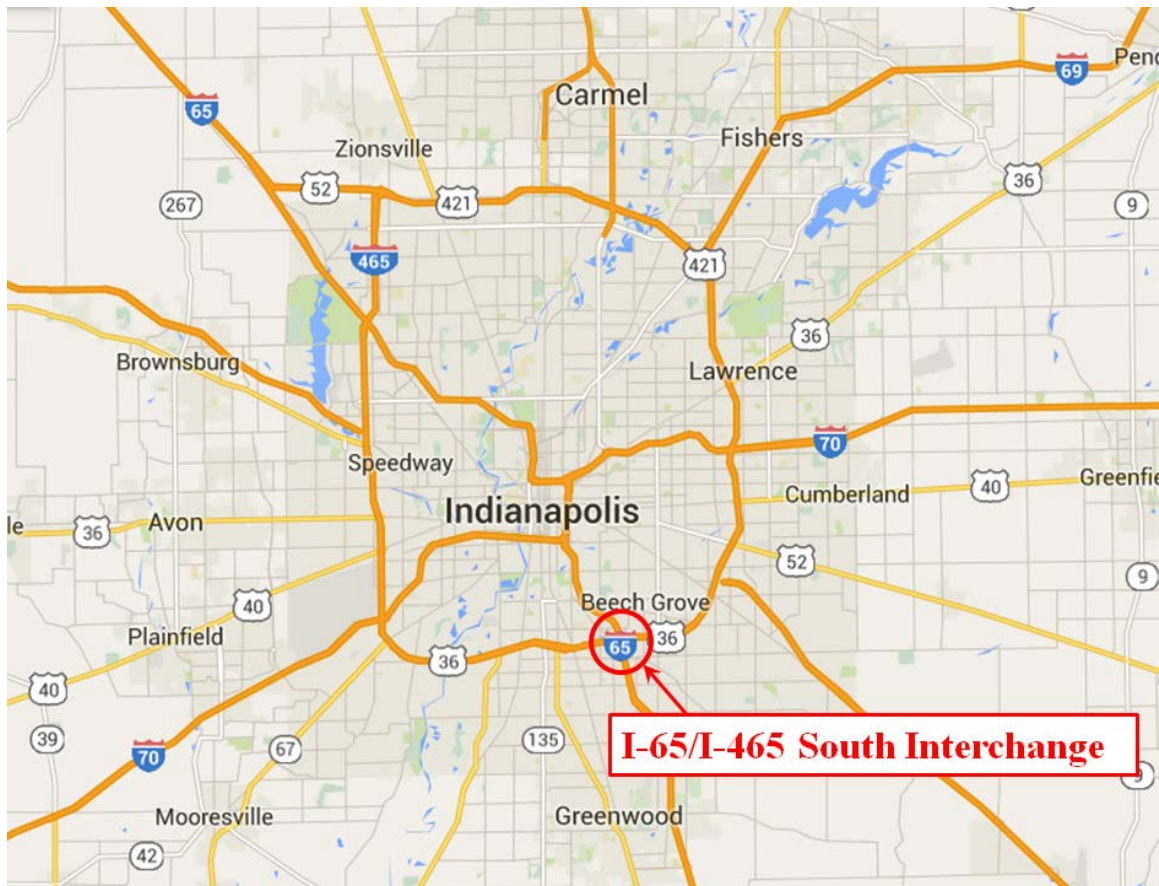


Figure 1. Map. Location of I-65/I-465 interchange in Indianapolis.

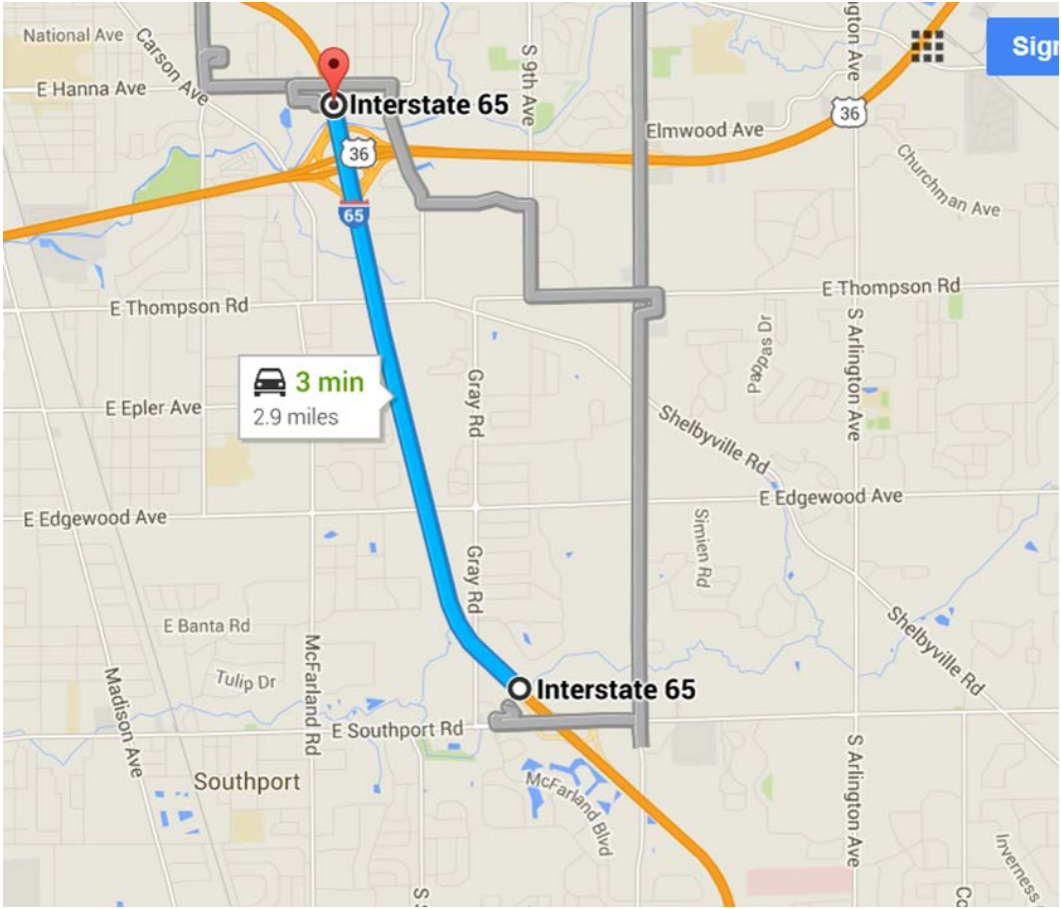


Figure 2. Map. Construction limits along I-65.

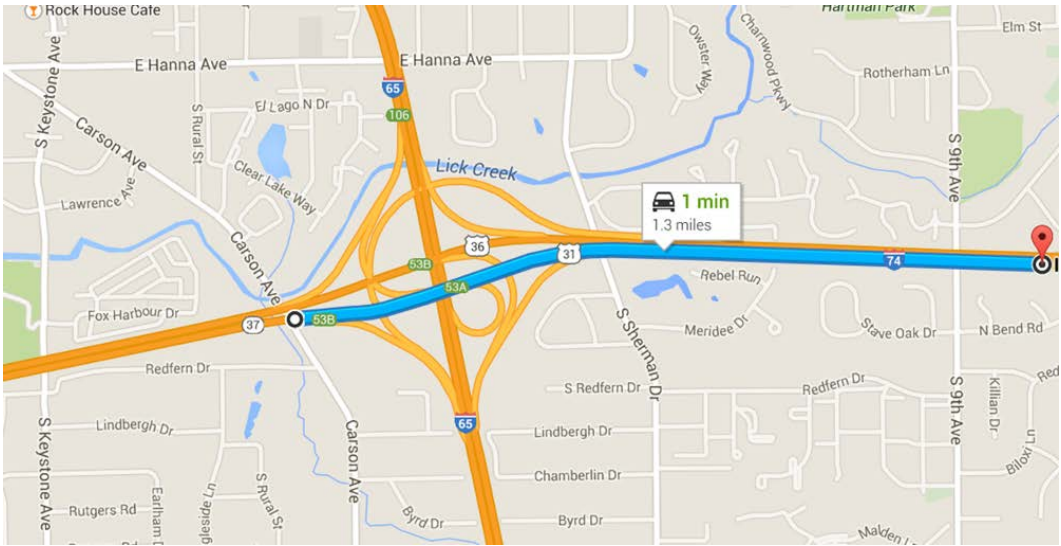


Figure 3. Map. Construction limits along I-465.

Table 1. Traffic data for I-65 and I-465.

Traffic Data	Route	
	I-65	I-465
AADT (2011)	112,550	112,780
AADT (2032)	130,280	130,550
DHV (2032)	9,815	9,771
Directional Distribution	49% northbound/ 51% southbound	51.5% eastbound/ 48.5% westbound
Percent Trucks	19% AADT/15% DHV	17% AADT/13% DHV

PROJECT DESCRIPTION

To relieve the recurring traffic bottlenecks around the I-65 and I-465 interchange, several improvements were carried out as part of this Operation Indy Commute project:

1. Widening and rebuilding the right shoulder of northbound and southbound I-65 between I-465 and Southport Road to provide new lanes.
2. Replacing the I-465 westbound to I-65 southbound loop ramp with a new two-lane flyover ramp.
3. Rebuilding the I-465 westbound to I-65 southbound ramp on a new alignment to accommodate the new flyover ramp.
4. Widening the ramp from northbound I-65 to eastbound I-465.
5. Widening and rebuilding the shoulders for both directions of I-465 between I-65 and Emerson Avenue to provide additional lanes.
6. Replacing the Sherman Drive bridge to allow more lanes of I-465 below.

PROJECT INNOVATION

The key innovation of this project is the implementation of the NGCS, whose precursor was developed using the Tire-Pavement Test Apparatus (TPTA) at Purdue University.⁽¹⁾ The hypothesis of the Purdue study was that the positive, highly nonhomogeneous macrotexture provided by the conventional diamond ground surface and aggravated by traffic wear/tear is responsible for the increased level of tire-pavement noise. To evaluate this hypothesis, the study conceived a surface with no positive texture—a surface that is first ground smooth followed by an additional texture imparted by grooving. Such a “manufactured” surface providing downward or negative texture later became what is currently known as the NGCS.

The Purdue study indicated that the NGCS precursor showed an average decrease of 3 dB in tire-pavement noise when compared to the traditional diamond ground concrete surface. However, the blades used for creating Purdue’s precursor NGCS were not industry standard (0.090 inches and 0.165 inches wide). During the first field implementation of the NGCS at the MnROAD research facility, these non-standard blades were replaced by the industry-standard 1/8-inch-wide blades.⁽²⁾ Using the standard blades allows for achieving the NGCS using the conventional grinding/grooving equipment by modifying the blade configuration. The MnROAD test results

validated that the field implementation of NGCS with standard blades could reproduce Purdue's precursor with similar reduction in pavement noise.

In general, there are two grinding/grooving configurations that can be used to create the NGCS:

1. Single pass NGCS: For this configuration, three smaller diameter blades are stacked between two blades that are approximately 0.08 inches larger in radius. The smaller blades provide the smooth ground surface, and the larger blades provide the grooving for the negative texture with 0.5-inch center-to-center spacing.
2. Two pass NGCS: This configuration first creates a smooth concrete surface using only the smaller diameter blades. Then, a second pass of the grinding equipment is made with the larger blades separated by spacers to create 0.5-inch center spacing.

PROJECT CONSTRUCTION

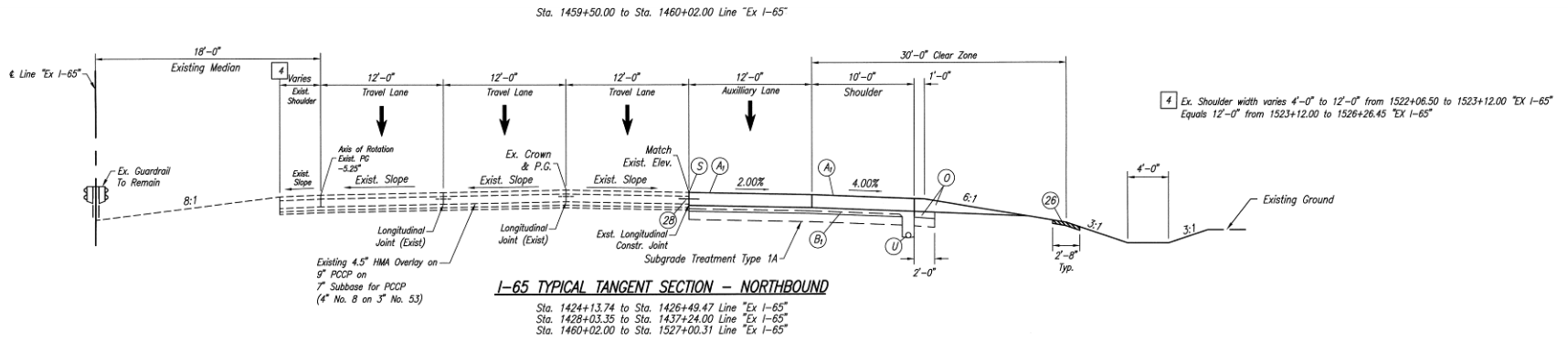
This project was awarded to Walsh Construction, LLC, and construction began in November 2013. All travel lanes were open to traffic, and the contract was considered to be substantially complete on December 20, 2014.

The concrete pavement on the new outside lanes of I-65 and I-465 was paved at a thickness of 14 inches on top of a 7-inch-thick, coarse aggregate subbase with a joint spacing of 20 feet. Figures 4 and 5 show the typical cross sections of the tangent sections of the roadway for I-65 and I-465, respectively. Figures 6 through 9 show some of the pictures taken during the paving operation for the newly placed concrete pavement.

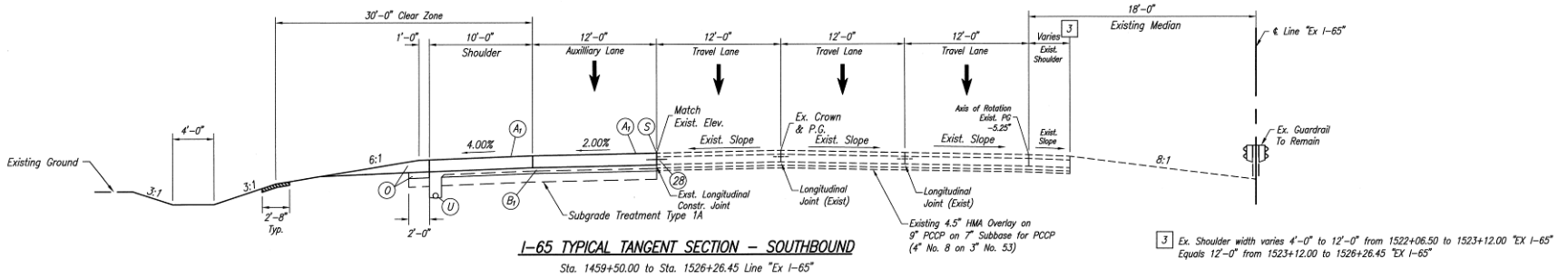
INDOT IMPLEMENTATION OF NGCS AND OTHER TEXTURED SURFACES

INDOT's NGCS was installed using the two pass configuration. The first pass was made with the 1/8-inch-wide blades mounted on a 4-foot grinding head separated by spacers that are 0.035 inches wide. After a flush ground surface had been created with the first pass, a second pass was made to create longitudinal grooves that are 1/8 inch wide, spaced between 1/2 inch and 5/8 inch center to center, and 1/8 inches to 3/16 inches in depth. Figure 10 show the first pass of the NGCS being applied to the concrete surface, and Figure 11 show the resulting flush ground surface. Figure 12 shows the second pass of the NGCS completed on the left one-third portion of the lane and the second pass being applied along the third of the lane in the middle. Figure 13 shows a close-up picture of the NGCS after the double pass operation has been completed.

The NGCS was planned to be installed from station 1494+00 to station 80+00 in the new outside lane of northbound I-65. However, the actual application of the NGCS occurred within different limits, as will be explained later in the document.

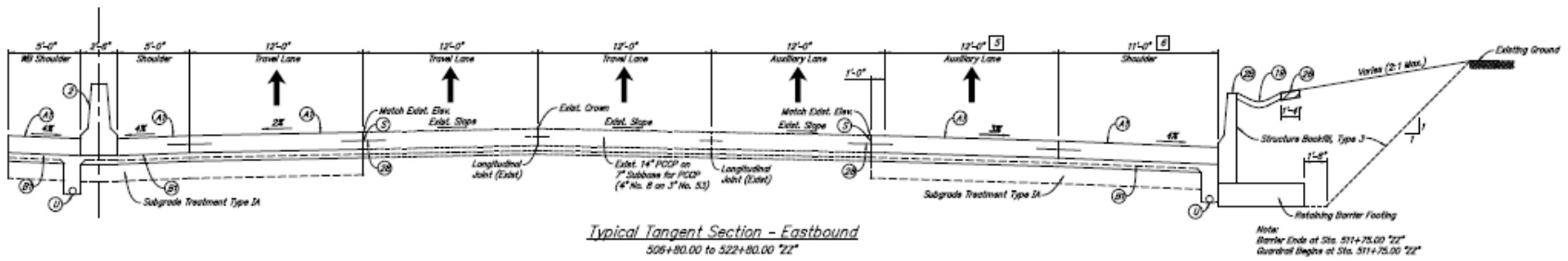


(a)

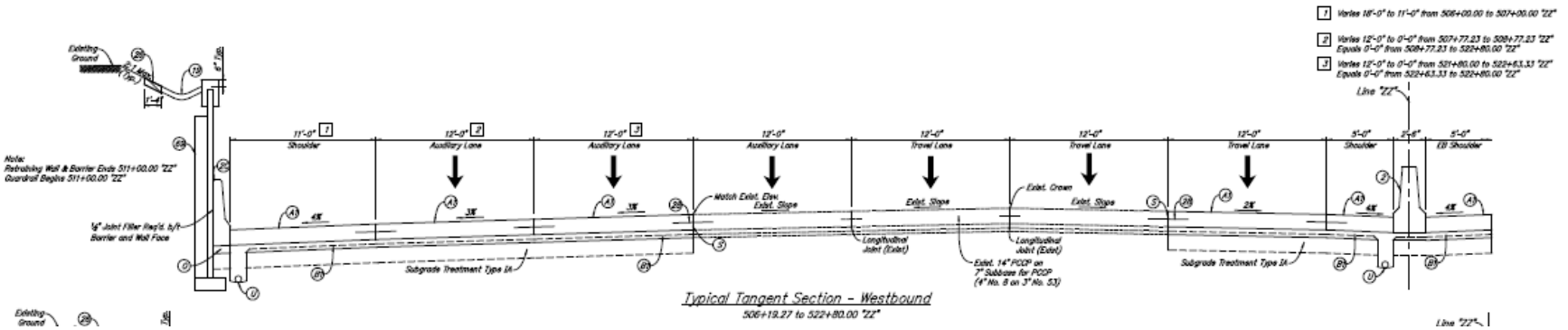


(b)

Figure 4. Diagram. Typical section for (a) northbound and (b) southbound I-65.



(a)



(b)

Figure 5. Diagram. Typical section for (a) eastbound and (b) westbound I-465.



Figure 6. Photo. Subbase preparation for concrete paving.



Figure 7. Photo. Dowel bar placement and tie bar retrofit.



Figure 8. Photo. Placement of fresh concrete.



Figure 9. Photo. Tube rolling of concrete material.



Figure 10. Photo. Application of NGCS – first pass.



Figure 11. Photo. Flush ground surface created by first pass of NGCS.



Figure 12. Photo. Application of NGCS – second pass.



Figure 13. Photo. Concrete surface with double pass NGCS.

In addition to the NGCS, INDOT implemented three other concrete textures so that a comparison can be made in terms of installation cost and pavement noise reduction to evaluate their feasibility as an alternative to the noise walls. These additional textures are:

1. INDOT's conventional transverse tining, installed from station 1494+00 to station 1441+00 in the new southbound outside lane of I-65 (Figure 14). This conventional tining first requires a double thickness burlap drag or a minimum 4-foot-wide turf drag, followed by a tining operation to generate transverse grooves that are between $\frac{3}{32}$ inches and $\frac{1}{8}$ inch in width, between $\frac{1}{8}$ inch and $\frac{3}{16}$ inches in depth, and of the following sequence for spacing: $\frac{5}{8}$ inches, 1 inch, $\frac{7}{8}$ inches, $\frac{5}{8}$ inches, 1 $\frac{1}{4}$ inches, $\frac{3}{4}$ inches, 1 inch, 1 inch, 1 inch, 1 inch, $\frac{3}{4}$ inches, $\frac{7}{8}$ inches, 1 $\frac{3}{4}$ inches, $\frac{7}{8}$ inches, $\frac{3}{8}$ inches, 1 inch, 1 inch, 1 $\frac{1}{4}$ inches, 1 $\frac{1}{2}$ inches, $\frac{7}{8}$ inches, $\frac{3}{4}$ inches, $\frac{7}{8}$ inches, 1 inch, $\frac{7}{8}$ inches, 1 inch.
2. INDOT's modified transverse tining, from station 80+00 to station 1494+00 in the new southbound outside lane of I-65. This tining finish is identical to the above conventional tining, with the only difference being the spacing of the tines that are in the following sequence: $\frac{3}{8}$ inches, $\frac{9}{16}$ inches, $\frac{5}{8}$ inches, $\frac{7}{16}$ inches, $\frac{3}{8}$ inches, $\frac{1}{2}$ inches, $\frac{9}{16}$ inches, $\frac{5}{8}$ inches, $\frac{7}{16}$ inches, $\frac{3}{8}$ inches, $\frac{13}{16}$ inches, $\frac{1}{2}$ inches, $\frac{3}{8}$ inches.
3. Longitudinal tining of concrete surface, was planned to be installed from station 1441+00 to station 1494+00 in the new northbound outside lane of I-65 (Figure 15). The longitudinal tines are $\frac{1}{8}$ inches wide and uniformly spaced at $\frac{3}{4}$ -inch intervals. The depth of the grooves range from $\frac{1}{8}$ inches to $\frac{3}{16}$ inches.



Figure 14. Photo. Concrete surface with INDOT's traditional transverse tining finish.



Figure 15. Photo. Concrete surface with longitudinal tining finish.

As mentioned earlier, the NGCS was planned to be installed between stations 1494+00 and 80+00 in the new outside lane of northbound I-65. However, the maintenance of traffic that was set up within these limits did not provide sufficient room to maneuver the NGCS equipment. Therefore, the section limits for the NGCS and the longitudinal tining were swapped. Figure 16 shows the approximate limits of the four different textures implemented on the new outside lanes of I-65, in relation to project station numbers and other streets. INDOT's conventional transverse tining was applied for all other locations where new slabs of concrete were placed.

SUMMARY

The overall objective of this project was to improve the traffic flow and relieve the recurring commuting bottlenecks around the I-65 and I-465 interchange. The project involved widening of the I-65 and I-465 mainline and several ramps and construction of a new flyover ramp from westbound I-465 to southbound I-65. The key innovation of this project was the implementation of the NGCS. Three other concrete texturing techniques were implemented to study their effect on noise reduction.

REFERENCES

1. Dare, T., Thornton, W., Wulf, T., Bernhard, R., “Acoustical Effects of Grinding and Grooving on Portland Cement Concrete Pavements.” Final Report HL 2009-1, Purdue University’s Institute of Safe, Quiet, and Durable Highways, 2009.
2. Scofield, L., “Development and Implementation of the Next Generation Concrete Surface.” Final Report, American Concrete Pavement Association, 2012.

ACKNOWLEDGMENTS

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