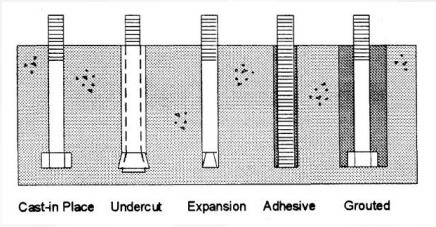
June 19 - 20, 2025
Hollywood, FL



TRANSPORTATION SYMPOSIUM

Post-Installed Anchors for Connection to Concrete Elements

Steven Nolan, P.E.
Senior Structures Design Engineer
State Structures Design Office

3:20pm-4:15pm June 19, 2025

Transportation Symposium Website
SCAN ME

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Schedule

Thursday, June 19, 2025

	Lunch Break 11:45 AM - 1:00 PM				
1:00pm	* D4 Enhancing Safety Culture: A Multidisciplinary Approach Through Traffic Safety Collaboration Tracey Xie (D4) Thomas Miller (D4) Amy Lee Diel	* Surviving Major Project Requirements Bobby Bull (CO) Diane Flowers (CO) Vanita Saini (D4) Auraliz Benitez (D6)	Intro to Roadway Lighting Richard Stepp (CO) Jimmy Frimmel (CO) Ayman Mohamed (D5)	* Community Engagement Success Stories: Building Stronger Connections Across Florida Thuc Le (D4) Mike Miller (D4) John Scarlatos Maj Alam	D6 Noise Walls: Process, Challenges, and Real-World Navigation Kevin Lopez (D6) Sebastian Ruiz (D6)
	Break 1:55 PM - 2:05 PM				
2:05pm	Errors & Omissions Lessons Learned Bing Wang (D4) Ivette Funtanellas (D6)	* Connected & Automated Vehicles Jeremy Dilmore (CO)	Foundation Engineering Innovations: Design, Construction, and Preservation Sasidhar Ayithi (SMO) Rodrigo Herrera (CO) James Greene (SMO)	* Trip Generation Study: Fast-Food & Coffee Shops with Drive-Throughs Gina Bonyani (CO) Drew Roark	* FL Travel Demand Model Forecasting Manual Thomas Hill (CO)
	Networking Break 3:00 PM - 3:20 PM				
3:20pm	* Two-Stage Pedestrian Crossing Innovation Evaluation Tina Russo (D7) Andrew Gray Allie Caldwell (CO)	* Connected Work Zones: Leveraging Technology for Safer and Smarter Roadways Jeremy Dilmore (CO) Nagham Matout EL-Zine W.D. Baldwin	Bridging the Everglades Claudia Vinitskiy-Calvo (D4) Kyle Cheerangie Jermaine Lawrence	Drainage Plans in an 11x17 World Jennifer Johnson (CO) James Worley (CO)	Post-Installed Anchors for Connection to Concrete Elements Steven Nolan (CO)
	Break 4:15 PM - 4:25 PM				
4:25pm	* Digital Delivery Today & Moving Forward Derwood Sheppard (CO) Heather Piorun Cutty Gibson	* NEPA/PD&E Laws & Rules Update Katasha Cornwell (CO)	* D4 Truck Parking Planning Strategies Justin Stroh (D4) Lissy La Paix	* D7 Work Zone Speed Management Michael Zinn (D7) Hossein Amiri	ITS Device Testing MSP Nick Slupecki (D4) Sarely Tejeda (D4)

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Bio

PE in Florida since 2003, current technical lead coordinator for Florida DOT for implementation of FRP, stainless-steel rebar and prestressing, LWC and UHPC for structural applications. 25-years experience with anchorage to concrete, prestressed concrete design, and bridge design specification development.

Incoming Chair of AASHTO P.E.A.S. committee on Concrete Composite Reinforcement (CCR), member of previous TRB committee AKB10-Innovative Highway Structure, voting member ACI Committees 239, 243, 440C & CSAO. Member of ASCE-Structural Engineering Institute, Bridge Engineering Institute, and *fib* (International Federation for Structural Concrete).

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Abstract: Post-Installed Anchors for Connection to Concrete Elements

The design of post-installed anchorage for reinforcing bars and steel fasteners has progressed significantly in the last 25-years. 10-years before the Boston Tunnel ceiling panel anchorage failure in 2006, FDOT had funded research and specification development for concrete anchors under both sustained and transient loads. A renewed national focus on anchorage design, qualification, and installation was born from that Boston Tunnel failure. More recently manufacturers have improved product options and performance, and access to technical guidance, training and certification is much improved and has helped inform updates to national building codes such as ACI CODE-318 and the AASHTO Bridge Design Specifications. This presentation will provide current state-of-the-practice for concrete anchor design and installation, highlighting many of the changes that have been implemented since 2006, focusing on adhesive-bonded, undercut and screw anchors

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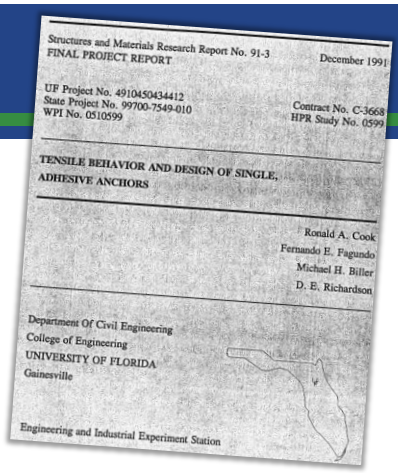
In the early years…

- 1990's FDOT began sponsoring formal research on Adhesive Bonded & Grouted Anchors for Concrete Fastening.
- 1991 Dr. Ron Cook published ***Tensile Behavior and Design of Single Adhesive Anchors***, FDOT WPI 0510599.
- 1991 **ACI 355** committee Task Group began developing a "Design Guide" to provide design examples for comparison of the Concrete Capacity Design (CCD) method to the **ACI 349 Appendix B** 45-degree cone method.


Structures and Materials Research Report No. 91-3
FINAL PROJECT REPORT
December 1991
UF Project No. 4910450434412
State Project No. 99700-7549-010
WPI No. 0510599
Contract No. C-3668
HPR Study No. 0599
TENSILE BEHAVIOR AND DESIGN OF SINGLE, ADHESIVE ANCHORS
Ronald A. Cook
Fernando E. Fagundo
Michael H. Biller
D. E. Richardson
Department Of Civil Engineering
College of Engineering
UNIVERSITY OF FLORIDA
Gainesville
Engineering and Industrial Experiment Station

ACI 355 Task Group for CCD Method Guide
Rich Klingner, ACI 355 Task Group Chair
Pete Carrato
Ron Cook
Rolf Eligehausen
Harry Wiewel
Dick Wollmershauser

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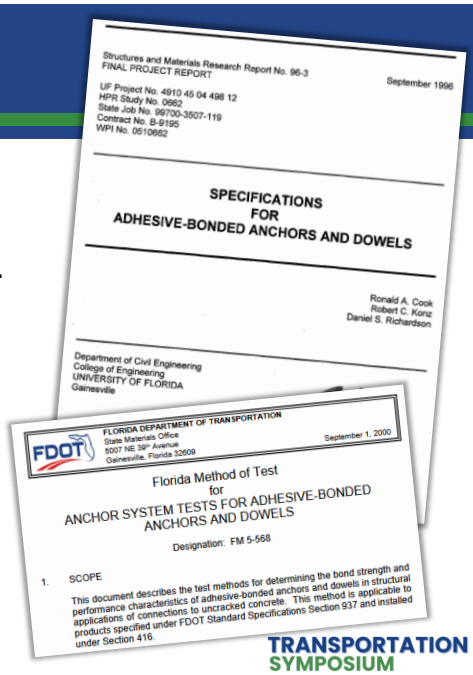
In the early years…

- 1996 Dr. Ron Cook published Specifications for Adhesive-Bonded Anchors and Dowels, FDOT WPI 0510662.
- 1999 **Structures Design Guidelines** updated *(Section 7.15)*
- 1999 FDOT Specifications 416 & 937 introduced and Type "J" epoxy removed.
- 2000 FDOT FM 5-568 Test Method published


Structures and Materials Research Report No. 96-3
FINAL PROJECT REPORT
September 1996
UF Project No. 4910 45 04 498 12
HPR Study No. 0662
State Job No. 99700-3507-119
Contract No. B-9195
WPI No. 0510662
SPECIFICATIONS FOR ADHESIVE-BONDED ANCHORS AND DOWELS
Ronald A. Cook
Robert C. Konz
Daniel S. Richardson
Department of Civil Engineering
College of Engineering
UNIVERSITY OF FLORIDA
Gainesville
FLORIDA DEPARTMENT OF TRANSPORTATION
State Materials Office
5007 NE 39th Avenue
Gainesville, Florida 32609
September 1, 2000
Florida Method of Test
for
ANCHOR SYSTEM TESTS FOR ADHESIVE-BONDED ANCHORS AND DOWELS
Designation: FM 5-568
1. SCOPE
This document describes the test methods for determining the bond strength and performance characteristics of adhesive-bonded anchors and dowels in structural applications of connections to uncracked concrete. This method is applicable to products specified under FDOT Standard Specifications Section 937 and installed under Section 416.

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In the early years…

- 1999 Cook & Konz publish Design Guidelines

DESIGN GUIDELINES FOR ADHESIVE ANCHORS

Ronald A. Cook, Ph.D., P.E. and Robert C. Konz
Department of Civil Engineering, University of Florida
Gainesville, Florida, 32611, USA

ABSTRACT

A design procedure for adhesive anchors loaded in tension in uncracked concrete is presented. The design procedure includes single anchors and the influence of free edges and anchor groups. The design procedure is based on first developing a rational, mean strength behavioral model which fits existing test data then modifying the model to be compatible with Load and Resistance Factor Design. The design of adhesive anchors for shear is not included but is comparable to that used for other types of anchors.

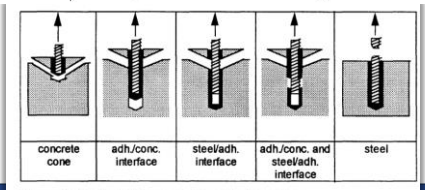

Figure 2: Typical failure modes for adhesive anchors

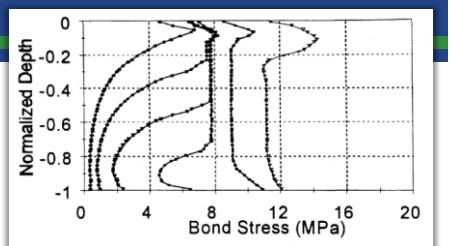

Figure 4 - Bond stress distribution with increasing load

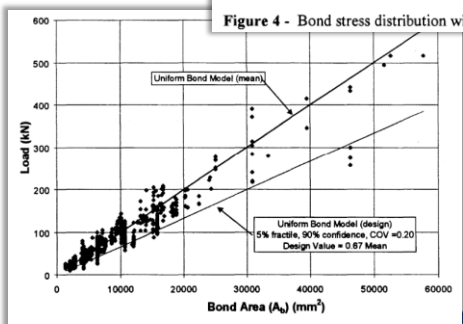

Figure 3: - Comparison of measured loads with the uniform bond model

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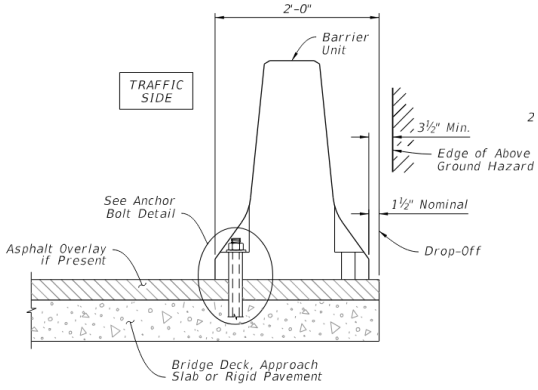
In the 2000's…

- 2002 ***Spec 416 & 937*** updated to include HSHV class anchors
- January 2003 ***SDG 1.6*** updated to include higher strength adhesive class (HSHV), mostly to accommodate for traffic railing retrofits.
- 2002 ***ACI 318*** publishes design criteria for design of post-installed anchors as "**Appendix D**"



TYPICAL SECTION

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July 10, 2006…

- 2006 Boston Tunnel “Big Dig” ceiling panel collapse July 10,
- July 10, 2007 NTSB investigation *Report HAR/07-02* released on the 1-year anniversary of the collapse, recommends revisions changes to acceptance criteria

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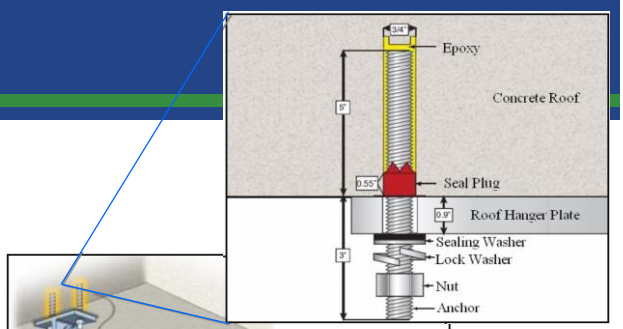
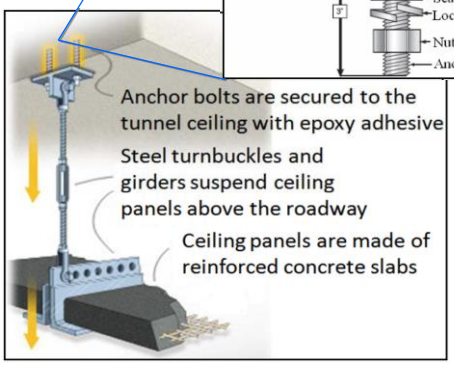
What went wrong…

- Concrete anchorage failed by adhesive pullout under sustained load.
- Construction process failure with use of the “fast set” Pro-poxy adhesive that was not tested for sustained load application.
- Post-installation inspection failure by not identify anchorage creep.





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What went wrong…

- Concrete anchorage failed by adhesive pullout under sustained load.
- Construction process failure with use of an adhesive anchor system that was not recommended for sustained load application.
- Post-installation inspection failure by not identify anchorage creep.

Post accident, thousands of anchor bolts were declared unreliable. A second mechanical expansion anchor bolt was ordered to be added to each suspect bolt, which cost $54 million in the first year.

To date, litigation settlements have totaled over $400 million.

Reference:
https://sma.nasa.gov/docs/default-source/safety-messages/safetymessage-2008-06-01-thebigdigceilingtilecollapse-vits.pdf 11

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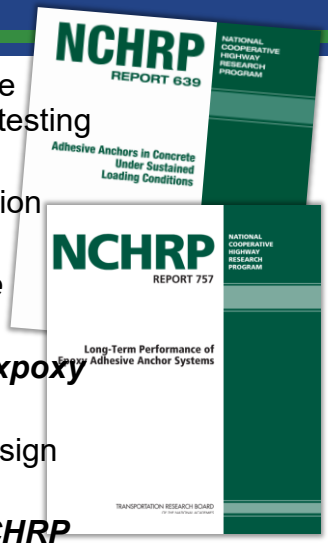
How did the structural community respond

- ACI Committee 355 eventually revises design and acceptance criteria ACI 355.2 (mechanical) and 355.4 (adhesive) anchor testing criteria and includes cracked concrete testing protocols.
- ACI Committee 355 develops inspector and installer certification programs.
- 2009 **NCHRP Report 639** – ***Adhesive Anchors in Concrete Under Sustained Loading Conditions***
- 2013 **NCHRP Project 757 – *Long-Term Performance od Expoxy Adhesive Anchor Systems***
- 2017 ***AASHTO LRFD BDS 8th edition*** adopts ACI 318-14 design criteria for post-installed anchors *(Chapter 17 by this time).*
- 2020 **NCHRP 20-44(04)** – ***Implementing Products from NCHRP Research on Adhesive Anchor Systems***



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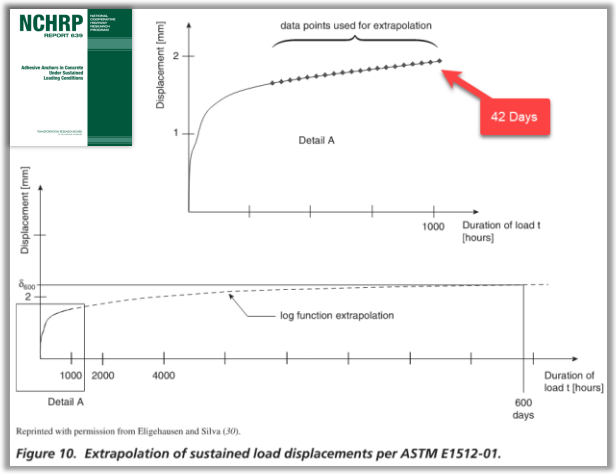
How did FDOT specifically respond

- 2007 FDOT ***SDG 1.6*** reduced the allowable sustained load to 30% of factored design resistance for as an added precaution *(Note that this is less than half of the creep tested values under **FM 5-568** that had been required since 1999)*.
- **NCHRP 20-44(04)**
  Implementing Products from NCHRP Research on Adhesive Anchor Systems

Funds:	$100,000
Research Agency:	Precast/Prestressed Concrete Institute
Principal Investigator:	Roger Becker
Effective Date:	1/22/2019
Completion Date:	9/30/2020



Reprinted with permission from Eligehausen and Silva (*30*).
Figure 10. Extrapolation of sustained load displacements per ASTM E1512-01.

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What has changed over the years?

- 2020 FDOT completes research on baseplate confinement effects for increasing permitted design loads for adhesive anchors.
- 2022 FDOT completes research on baseplate confinement effects for increasing permitted design loads for screw anchors.

For anchors loaded in tension where a compressive restraint or reaction is provided within the projected concrete breakout area, the modification factor **m**, given by Equation 1-6a may be used. For anchors where **c < 8d**, and the compressive reaction is not located between the anchor and the free edge of the concrete, the effects of this modification factor should be neglected.

$\psi_m = 2 - z / (1.5 / h_e)$ [Eq. 1-6a]

- 2024 FDOT adds screw anchor design provisions to SDG 1.6.3 adopting ***AASHTO BDS*** and ***ACI CODE-318 Chapter 17*** design criteria (no creep effects).

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Where are we now?

- Adhesive Anchors still follow FDOT design criteria in ***SDG 1.6.2*** with ***FM 5-568*** testing & qualification criteria.
- Mechanical Anchors (undercut and screw anchors) follow ***ACI CODE-318*** design & ***ACI SPEC-355*** testing and qualification criteria.
- Field acceptance via inspection and random sampling testing for amplified proof loads (lesser of 85% design load or 90% of anchor yield strength)
- Adhesive anchors under sustained loads are limited to prescriptive conditions in ***SDG 1.6.***
- Mechanical anchors require APL (previously IPL) and DSDE approval for usage with ***Developmental Specifications Dev416PIAS*** and **Dev937PIAS**

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Where are we going…

1.6.3 Undercut and Screw Anchor Systems

A. Undercut and Screw Anchors are primarily intended for overhead applications and applications with predominately sustained tension loads (permanent component of the factored tension load exceeds 30% of the factored tensile resistance) where Adhesive Bonded Anchors are precluded. They may be used for anchorages on other applications in lieu of Adhesive Bonded Anchors where appropriate and applicable.

B. EOR's Design Criteria

1. Use the following criteria for providing factored design load(s), bolt diameter, embedment depth and anchor configuration in the Plans for each Undercut Anchor location.
2. The designer must submit a request to the District Specifications Office to use Developmental Specifications Dev416 and Dev937. Contact the SSDE for additional design guidance.
3. Design Undercut and Screw Anchors in accordance with ***ACI CODE-318***, Chapter 17, using the product data provided by the ***ACI CODE-355.2*** product evaluation report, except using a concrete breakout resistance factor of 0.75 for Screw Anchors.

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Where are we going…

- Eventually SDO may recommend adoption of the ***AASHTO BDS*** / ***ACI CODE-318 Chapter 17***, but will need to find a more efficient workflow for Design-Bid-Build projects.

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Where are we going… and why is it taking so long?

- Eventually SDO may recommend adoption of the AASHTO BDS / ACI CODE-318 Chapter 17, but will need to find a more efficient workflow for Design-Bid-Build projects, since:
- The current ***ACI CODE-318*** provisions essentially use a Design-Build model where each adhesive/anchor manufacturer has unique input parameters for the standardized equations for products tested under ***ACI SPEC-355.4*** (adhesives) or ***ACI SPEC-355.2*** (mechanical) and published under independent evaluation Two options exist:
  1. Predesign buy the owner's EOR, which requires either selecting a specific proprietary product and allowing *"Equal or Better"* provisions or using lower bound a values for a range of products for all design parameters. This typically results in very conservative (often impractical) designs, and also requires including all design assumptions in the contract documents.
  2. Even with optimal designs, additional expense is incurred since the contractor must secure a COER, submit for review to the Department before approval of installation can proceed.

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How to stay informed

- Become a friend of the **ACI 355** Technical Committee
- Read ***SDG 1.6:*** *https://www.fdot.gov/structures/structuresmanual/currentrelease/structuresmanual.shtm*
- Visit the ***Developmental Specifications*** webpage: *https://www.fdot.gov/programmanagement/otherfdotlinks/developmental*

Dev416PIAS - Installation of Post-Installed Anchor Systems and Dowels for Structural Applications in Concrete Elements Dev937PIAS - Post-Installed Anchor Systems and Dowels for Structural Applications in Concrete Elements (Materials component)	**Must Be Used Together** This specification includes the use of Undercut Anchor Systems.	Steven Nolan

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Contact Us

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Tallahassee, FL. 1-850-414-4272
Steven.nolan@dot.state.fl.us

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Agency: Department of Transportation
Working Title: ENGINEERING SPECIALIST IV - 55010087
Pay Plan: Career Service
Position Number: 55010087
Salary: $65,353.75 - $84,575.44
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Safety Message

BUCKLE UP.
EVERY TRIP, EVERY TIME!

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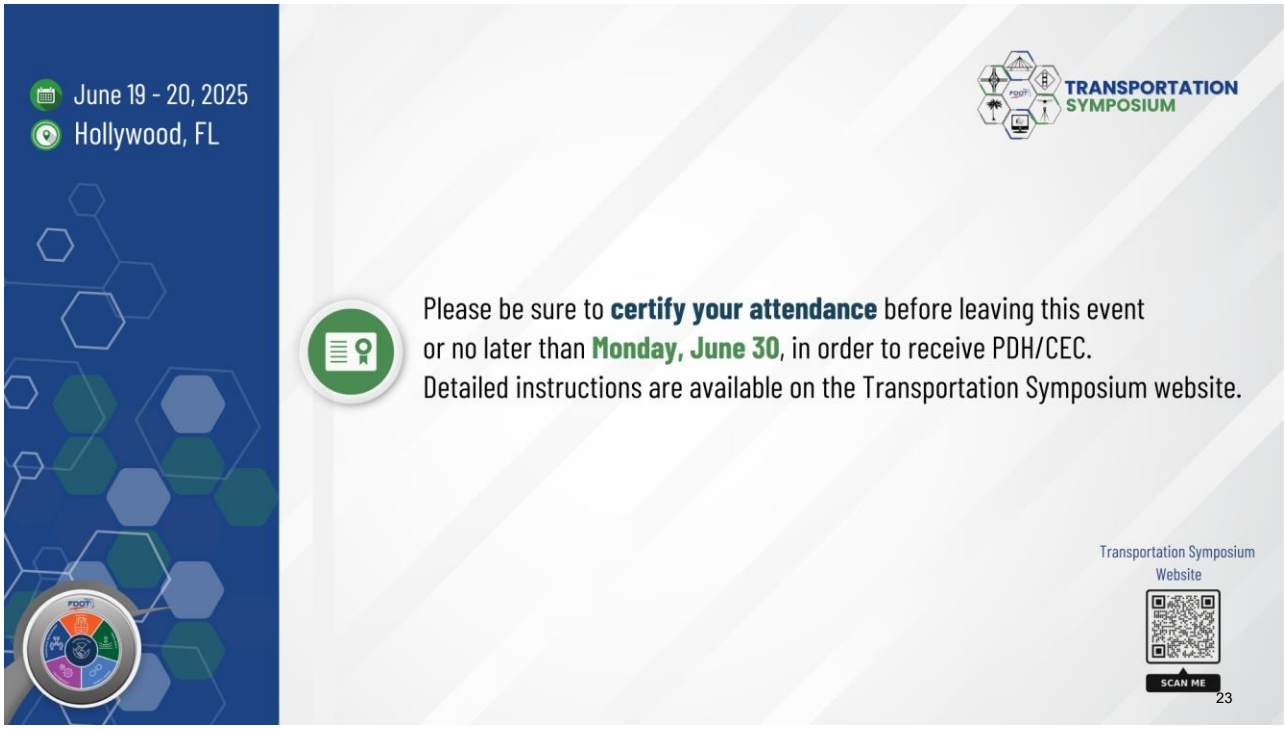
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