National Cooperative Highway Research Program

May 2023

Announcement of NCHRP Synthesis Topics

The National Cooperative Highway Research Program (NCHRP) is supported on a continuing basis by funds from participating member states of the American Association of State Highway and Transportation Officials (AASHTO), with the full cooperation and support of the Federal Highway Administration, U.S. Department of Transportation. The NCHRP is administered by the Transportation Research Board (TRB) of the National Academies of Sciences, Engineering, and Medicine. The NCHRP is an applied contract research program that provides practical and timely solutions to problems facing highway and transportation practitioners and administrators.

NCHRP syntheses are state-of-the-practice reports prepared under contract by outside individuals or firms. These reports seek to document current practice within state departments of transportation (DOTs), to identify ongoing and recently completed research, to learn what problems remain largely unsolved, and to organize and document the useful information acquired. They do not undertake new research, nor do they contain policy recommendations. Syntheses document and describe current practice in a given area and highlight practices that are viewed as successful by many of the state DOTs surveyed in developing the synthesis or that are characterized as such in the literature reviewed by the synthesis author.

Nominations of others and self-nominations for panel members should be submitted by June 30, 2023, through the MyTRB portal.

You will be asked to log in to MyTRB. If you do not already have an account, you will be asked to quickly create one using your email and a password. **Scroll down to synthesis projects beginning with 20-05/Topic 55-01.** To ensure proper consideration of nominations, please provide all of the information requested. A current resume or CV is necessary to determine relevant knowledge and experience.

Before nominating yourself to serve as a panel member, please review our Conflict of Interest Resource page and policy.

Communication to determine an individual's interest and availability in serving will be made from this office only after we have matched available expertise (e.g., knowledge and experience as presented in the resume) with that required by the nature of the project.

NCHRP is also seeking principal investigators for the new synthesis topics. To formally express interest in authoring a topic, a two-page Letter of Interest and professional resume or CV are required. The fixed-price fee is $55,000. Please submit Letters of Interest to the Letters of Interest Submission Portal.

The Letter of Interest and professional resume or CV should convey a concise idea of the principal investigator's knowledge of the topic and related work and experience in the subject area. **The deadline for Letters of Interest is August 28, 2023.** During panel meetings held in Fall 2023, scopes of work will be finalized and principal investigators chosen.

Information about panel nominations and Letters of Interest for the new synthesis topics can also be found at the synthesis website: https://www.trb.org/SynthesisPrograms/SynthesesNCHRP.aspx

National Cooperative Highway Research Program Synthesis Topics

(Titles are HYPERLINKS)

Synthesis Topic 55-01
State DOT Use and Policies on Implementation of Corrosion Resistant Reinforcing Bars

NCHRP Staff: Sandra Larson, consultant

Throughout the United States there is widespread use of deicing chemicals during the winter months to prevent the buildup of snow and ice on roadway surfaces and bridge deck slabs. While deployment of deicing chemicals is an effective strategy for maintaining safe, reliable, ice-free roadway surfaces, this practice can lead to chloride contamination in bridge components, including decks, parapets, sidewalks, headers, backwalls, and bridge seats. Bridge components can also be subject to natural sources of chloride, particularly in coastal environments where they may be exposed to seawater, spray, and mist. Chlorides migrate through the concrete cover and become concentrated at critical levels. As a result, corrosion of the reinforcement is initiated. This results in concrete spalls, costly repairs, and eventually replacement of bridge components.

To meet this challenge, we can design and construct bridges using corrosion resistant reinforcing bars, which will delay the onset of corrosion and the subsequent deterioration of bridge decks and other structural elements. Additionally, more corrosion resistant reinforcing bars can be utilized versus typical corrosion resistant reinforcing bars. Material producers have been meeting this challenge by developing more corrosion resistant reinforcing bars with different coatings, with different steel compositions, and by employing other alternate materials.

The objective of this synthesis is to document practices used by state departments of transportation (DOTs) related to the use of corrosion resistant reinforcing bars.

Information to be gathered includes (but is not limited to):

- Types of reinforcing bars used. Examples might include, but are not limited to:
    - Black steel;
    - Epoxy-coated steels;
    - Galvanized steels;
    - Steels with multi-layer coatings (e.g., galvanized plua epoxy);
    - Alloy steels, such as low-carbon chromium steel;
    - Various grades of austenitic, martensitic or duplex stainless steels;
    - Stainless steel cladded steels; and
    - Fiber-reinforced polymer with various incorporated fiber materials, such as glass, carbon, basalt, etc.
- Bridge components that utilize different types of corrosion resistant reinforcing bars;
- Materials typically specified for specific element types;
- Concrete cover provided on bridge components in conjunction with alternate materials;
- Types, strengths, and permeability of concrete specified for various reinforcing bars;
- Timeframe DOTs have used for different corrosion resistant reinforcing bars, including how those bars performed, and how the agencies measured the performance (i.e., have agencies seen better performance from their bridge decks);
- Conditions DOTs specified when using various corrosion resistant reinforcing bars;
- Information on life-cycle cost analysis used to justify the selection of an alternate corrosion resistant reinforcement, including any parameters;

- Information on any challenges with dissimilar metals and materials;
- Modifications to standard design practices utilized when specifying different corrosion resistant reinforcing bars (i.e., adjustments to account for differences in yield or ultimate tensile strengths, modulus of elasticity, etc.); and
- Written policies that govern the application of the various corrosion resistant reinforcing bar types.

Information will be gathered through a literature review, a survey of state DOTs, and follow-up interviews with selected DOTs for the development of case examples. Information gaps and suggestions for research to address those gaps will be identified.

Information Sources (Partial):

- Innovative Bridge Materials at Maine DOT: Use of FRP Composites. TRB 102nd Annual Meeting 2023 Presentation.
- Fiber Reinforced Polymer Reinforcing. Florida DOT, Fiber Reinforced Polymer Reinforcing (fdot.gov).
- Stainless Steel Coated Rebar for Chloride Resistant Concrete Highways and Bridges. NCHRP IDEA 20-30/IDEA 240.
- Structural Fiber Reinforcement to Reduce Deck Reinforcement and Improve Long-Term Performance, https://www.ugpti.org/resources/reports/details.php?id=989.
- Laboratory Characterization of Fiber-Reinforced Polymer Reinforcement Material Properties and Surface Treatment Behavior in Concrete, Virginia Transportation Research Council.
- Identification of Commercially Available Alloys for Corrosion-resistant Metallic Reinforcement and Test Methods for Evaluating Corrosion-resistant Reinforcement, Virginia Transportation Research Council.
- Investigation of the Corrosion Propagation Characteristics of New Metallic Reinforcing Bars, Virginia Transportation Research Council.
- Testing of Selected Metallic Reinforcing Bars for Extending the Service Life of Future Concrete Bridges: Summary of Conclusions and Recommendations, Virginia Transportation Research Council.
- Corrosion-Resistant Stainless Steel Strands for Prestressed Bridge Piles in Marine Atmospheric Environments, Virginia Transportation Research Council.
- Bridge Deck Service Life Prediction and Costs. Virginia Transportation Research Council.
- Optimal Approach for Addressing Reinforcement Corrosion for Concrete Bridge Decks in Illinois. FHWA-ICT-22-005, ICT-22-005, UILU-2022-2005, https://doi.org/10.36501/0197-9191/22-005.
- Harkers Island Bridge Replacement: Material Characterization and Structural Performance, North Carolina Department of Transportation.
- Cost and environmental analyses of reinforcement alternatives for a concrete bridge, https://doi.org/10.1080/15732479.2019.1662066.
- Field Investigation of Bridge Deck Reinforced with Glass Fiber Reinforced Polymer (GFRP) Rebar. Minnesota Department of Transportation, http://mndot.gov/research/reports/2020/202005.pdf.

- Alternative Reinforcement Products in the Design of Concrete Structures— Durability Performance. Transportation Association of Canada, https://www.tac-atc.ca/sites/default/files/conf_papers/hudecekm_skabars_el-hachar_alternative_reinforcement_products.pdf.
- Toward Non-Corrosion and Highly Sustainable Structural Members by Using Ultra-High-Performance Materials for Transportation Infrastructure [Supporting Dataset] —https://digitalcommons.lsu.edu/transet_pubs/56/.
- Assessment of Bridge Decks with Glass Fiber Reinforced Polymer (GFRP) Reinforcement.— Minnesota Department of Transportation.

Synthesis Topic 55-02
Practices for Collecting, Managing, and Using Light Detection and Ranging (LiDAR) Data

NCHRP Staff: Arefeh Nasri

While collection and use of LiDAR data have become widespread, state departments of transportation (DOTs) often have questions on ways to improve their processes, especially as advances in data governance practices, analysis methods, tools, and technologies expand the potential benefits and challenges of using LiDAR data.

The objective of this synthesis is to document state DOT practices related to collecting, managing, and using LiDAR data.

Information to be gathered includes (but is not limited to):

- Types of projects using LiDAR data, including roadway projects, safety and other analyses, and research;
- Practices for data collection, processing, extraction, storage, and maintenance of LiDAR data;
- Data mining for various types of uses, including addressing challenges such as accuracy levels and integration with software tools; and
- Data management and governance practices.

Information will be gathered through a literature review, a survey of state DOTs, and follow-up interviews with selected DOTs for the development of case examples. Information gaps and suggestions for research to address those gaps will be identified.

Information Sources (Partial):

- *NCHRP Report 748: Guidelines for the Use of Mobile LIDAR in Transportation Applications*, 2013, provided a starting point for many states to establish their LIDAR data collection programs.
- Recent and current documentation of individual state practices, such as Kentucky Transportation Cabinet Project SPR23-634: *Best Practices for Lidar Data Collection and Processing*, 2022-2023.
- Case studies and noteworthy practices documented by FHWA, such as Case Study FHWA-SA-14-078: *Collection and Use of Roadway Asset Data in Utah, 2014.*

Synthesis Topic 55-03
Asset Management Practices for Mechanically Stabilized Earth Walls

NCHRP Staff: Arefeh Nasri

Since its emergence in the 1960s, soil reinforcement has become an indispensable technology in the earth retention in the United States and globally. Mechanically Stabilized Earth (MSE) walls are widely used in transportation projects due to their cost-saving, time-efficient, and resilient nature. However, none of the walls constructed so far have been able to meet the 75-year service-life expectancy. Additionally, design guidelines, construction materials, and protocols have significantly evolved since the technology was first adopted in the 1970s. Therefore, the early MSE walls constructed using outdated design guidelines and construction protocols may be inadequate according to the current state of the practice. As a result, some of these early structures have failed unexpectedly due to their deterioration over time. Deterioration processes in MSE walls may involve different types of mechanisms with different onsets and progress at different rates. Collectively, these mechanisms contribute variably to the overall deterioration rate of a wall during the service life of the wall. State departments of transportation (DOTs) do not have a standard practice for managing their MSE wall assets.

The objective of this synthesis is to document state DOT asset management practices for MSE walls in their inventories.

Information to be gathered includes (but is not limited to):

- Approaches to inventorying and categorizing MSE walls based on their design and construction specifications (with the consideration of specification disparities in the older generations), and their risk level (and any consequences associated with their failure);
- Definition of malfunction or signs of distress, and tools used to evaluate MSE walls performance;
- Performance indicators used for MSE wall inspections;
- Methods of collecting and processing field inspection data;
- Approaches to rating MSE walls based on their vulnerability;
- Proactive mitigation methods used to address older generations of MSE walls and maintenance techniques to deal with walls showing signs of deterioration-related distress; and
- Methods of factoring long-term deterioration of MSE walls into the design and construction of new MSE wall assets.

Information will be gathered through a literature review, a survey of state DOTs, and follow-up interviews with selected DOTs for the development of case examples. Information gaps and suggestions for research to address those gaps will be identified.

Information Sources (Partial):

- AASHTO, (2011). Transportation Asset Management Guide: A Focus on Implementation, American Association of State Highway and Transportation Officials, Washington, DC.

- Draft: Alaska Department of Transportation and Public Facilities. (2013). Retaining Wall Inventory Procedures Manual.
- Alzamora, D. E., and Anderson, S. A. (2009). Review of Mechanically Stabilized Earth Wall Performance Issues. In 88th Annual Meeting of the Transportation Research Board, CD-ROM, 16 pp.
- Bay, J. A., Anderson, L. R., Gerber, T. M., and Maw, R. B. (2010). An Inspection, Assessment, and Database of UDOT MSE Walls. No. UT-09-21, Utah Department of Transportation.
- Brutus, O., and Tauber, G. (2009). Guide to Asset Management of Earth Retaining Structures, prepared as part of NCHRP Project 20-07, Task 259, Transportation Research Board of the National Academies, 120 pp.
- City of Cincinnati. (2015). Retaining Wall Condition Report., Department of Transportation and Engineering, 45 pp.
- CTC and Associates. (2013). Asset Management for Retaining Walls., Minnesota Department of Transportation, Report #TRS1305, 42 pp.
- DeMarco, M., Keough, D., and Lewis, S. (2010). Retaining Wall Inventory and Assessment Program (WIP) National Park Service Procedures Manual. No. FHWA-CFL/TD-10-003, Federal Highway Administration, 188 pp.
- Govindasamy, A.V., Marr, W. A., DiMaggio, J. A., and Morsy, A. M. (2019). Risk-Based Protocol for Asset Management of Metallically Reinforced Mechanically Stabilized Earth (MSE) Walls. Report FHWA-HIF-18-065, Federal Highway Administration (FHWA), Office of Infrastructure, 109pp.
- Jensen, W. (2009). Inspector's Manual for Mechanically Stabilized Earth Walls. No. SPR-P1(09) P320, Nebraska Department of Roads, 36 pp.
- Kim, Y. R., Hummer, J. E., Gabr, M., Johnston, D., Underwood, B. S., Findley, D. J., and Cunningham, C. M. (2009). Asset Management Inventory and Data Collection/ No. FHWA/NC/2008-15, North Carolina Department of Transportation, 286 pp.
- Pennsylvania Department of Transportation. (2010). *Bridge Safety Inspection Manual*, *2nd Edition*, 482 pp.
- Rasdorf, W., Gabr, M. A., Butler, C. J., Findley, D. J., and Bert, S. A. (2015). Retaining Wall Inventory and Assessment System. No. FHWA/NC/2014-10, North Carolina Department of Transportation, 273 pp.
- Ryan, T. W., Hartle, R. A., Mann, J. E., and Danovich, L. J. (2012). Bridge Inspector's Reference Manual, No. FHWA NHI 12-049, Federal Highway Administration, 1,029 pp.
- U.S. Department of Transportation, Federal Highway Administration. Earth Retaining Structures and Asset Management. No. FHWA-IF-08-014.
- Vessely, M. (2013). Geotechnical Asset Management-Implementation Concepts and Strategies. No. FHWA-CFL/TD-13-003, Federal Highway Administration, 74 pp.
- Vessely, M., Robert, W., Richrath, S., Schaefer, V. R., Smadi, O., Loehr, E., and Boeckmann, A.. (2019). *NCHRP Research Report 903: Geotechnical Asset Management for Transportation Agencies, Volume 2: Implementation Manual.* The National Academies Press, Washington DC.
- Walters, B. X., Collins, M. P., Funk, N. E., Vessely, M. J., Widman, B. L., Koonce, J. W., Garlich, M. J., and Thompson, P. D. (2016). *Retaining and Noise Wall Inspection and Asset Management Manual*. Colorado, Department of Transportation, 300 pp.

- Wolf, R. E., Bouali, E.-H., Oommen, T., Dobson, R., Vitton, S., Brooks, C., and Lautala, P. (2016). Sustainable Geotechnical Asset Management along the Transportation Infrastructure Environment Using Remote Sensing. Final Report to U.S. DOT, No. RITARS-14-H-MTU, Michigan Technological University.
- Zekkos, A., Lynch, J., Zekkos, D., Grizi, A., Admassu, K., Benhamida, B., Spino, R. J., and Mikolajczyk, M. (2020). Asset Management for Retaining Walls. Report No. SPR1676, Michigan Department of Transportation.

Synthesis Topic 55-04
Practices and Guidelines for Full-Depth Reclamation (FDR)

NCHRP Staff: Edward Harrigan

Full-Depth Reclamation (FDR) is an in-place recycling method for reconstruction and rehabilitation of flexible pavements that uses existing failed-section materials as the base for a new surface wearing course. By making effective use of the structurally failed pavement, paving projects using FDR are sustainable and cost-effective. Pulverized roadway materials may be blended with stabilizing additives such as emulsion, foamed (expanded) asphalt, calcium chloride, or Portland cement to form a stiff base layer. FDR is a widespread practice, but state departments of transportation (DOTs) have diverse construction practices and quality assurance procedures for the FDR base layer.

The objective of this synthesis is to document current state DOT practices and guidelines for the use of FDR.

Information to be gathered includes (but is not limited to):

- Existing specifications and guidelines related to FDR mix design.
- State DOT classification of FDR types.
- FDR design criteria and consideration of traffic loads and environmental conditions.
- Properties of FDR base used in the pavement design.
- Current practices in FDR construction and quality assurance procedures.
- Mix design and test methods to evaluate FDR quality (e.g., Superpave gyration compaction, modulus, stiffness, curing time, long-term strength gain, etc).
- Selection of stabilization additive (e.g., cement, aggregates, foamed asphalt, emulsion).
- Tests to make time-critical decisions regarding opening to traffic and surfacing of the FDR base (e.g., raveling resistance using a short-pin raveling test and shear resistance using a long-pin shear test).
- Performance and cost effectiveness of different methods used to mitigate cracking in hot mix asphalt (HMA) overlay on the (stabilized) FDR layer, such as crack relief layer, micro-surfacing, chip-seal, etc.
- Potential to utilize quarry byproducts (QB) in FDR.
- Time savings during construction.

Information in this synthesis will be gathered through a literature review, a survey of state DOTs, and follow-up interviews with selected agencies for the development of case examples. Information gaps and suggestions for research to address those gaps will be identified.

Information Sources (Partial):

- Asphalt Recycling & Reclaiming Association (ARRA), Recommended Construction Guidelines for Full Depth Reclamation (FDR) Using Bituminous Stabilization—FDR101," Glen Ellyn, IL, 2017.

- Diefenderfer B., and Apeagyei, A., Analysis of Full-Depth Reclamation Trial Sections in Virginia, VCTIR 11-R23, Virginia Center for Transportation Innovation and Research, Charlottesville, VA, 2011.
- Federal Highway Administration (FHWA), Full Depth Reclamation (Construction Methods and Equipment), Chapter 16, Recycled Materials Policy, 2021.
- Ghasemi, P., Yu, J., Ledtji, P., Williams, R. C., and Jahren, C., Field Investigation of Stabilized Full-Depth Reclamation (SFDR), MN/RC 2018-33, Construction Management and Technology Program, Institute for Transportation, Iowa State University, 2018.
- Hossain, M. S., Nair, H., and Ozyildirim, H. C., Determination of Mechanical Properties for Cement-Treated Aggregate Base, FHWA/VTRC 17-R21, Virginia Transportation Research Council, 2017.
- Howard, I. L., Sullivan, W. G., Anderson, B. K., Shannon J., and Cost, T., Design and Construction Control Guidance for Chemically Stabilized Pavement Base Layers, FHWA/MS-DOT-RD-1 3-20, Mississippi State University (MSU), Mississippi State, MS, 2013.
- Lee, K.W., Wilson, K., and Hassan, S. A., Prediction of Performance and Evaluation of Flexible Pavement Rehabilitation Strategies, *Journal of Traffic and Transportation Engineering* (JTTE), 03.005, 2017.
- Morian, D. A., Solaimanian, M., Scheetz, B. and Jahan, S., "Developing Standards and Specifications for Full Depth Pavement Reclamation", FHWA-PA-2012-004-090107, Pennsylvania Department of Transportation, Harrisburg, PA, 2012
- Scullion, T., Sebesta, S., Estakhri, C., Harris, P., Shon, C., Harvey, O., and Rose-Harvey, K., Full-Depth Reclamation: New Test Procedures and Recommended Updates to Specifications, FHWA/TX-11/0-6271-2, Texas Transportation Institute, The Texas A&M University System, College Station, Texas, 2012.
- Research in Progress: Develop Laboratory Mix Design of Full Depth Reclamation (FDR) Projects Using Foamed Asphalt Binder and Emulsified Asphalt, Texas Department of Transportation (PI: Tom Scullion, Texas A&M Transportation Institute).
- *NCHRP Research Report 960: Proposed AASHTO Practice and Tests for Process Control and Product Acceptance of Asphalt-Treated Cold Recycled Pavements.* Washington, DC: The National Academies Press, 2021, https://doi.org/10.17226/25971.
- *NCHRP Research Report 863*: *Material Properties of Cold In-Place Recycled and Full-Depth Reclamation Asphalt Concrete.* Washington, DC: The National Academies Press, 2017, https://doi.org/10.17226/24902.

Synthesis Topic 55-05
Use and Availability of Supplementary Cementitious Materials for Concrete

NCHRP Staff: Jo Allen Gause

It is common practice to use supplementary cementitious materials (SCMs) in the production of concrete. The use of SCMs as a partial replacement for cement results in more durable, higher performing concrete, lower energy consumption, and reduced green gas emissions. The most common SCMs are industrial byproducts such as fly ash, ground granulated blast-furnace slag (slag cement), and silica fume. There are also some natural pozzolans being used in the concrete industry such as calcined shale, calcined clay, and metakaolin. There are many beneficial effects of using SCMs for both fresh and hardened concretes, including enhanced workability, reduction in bleeding, reduction in the heat of hydration, strength gain with time, and reduced permeability and improved resistance to chemical distress. The level of improvement achieved differs among the SCMs. Although fly ash is the most commonly used SCM, others are also being used due to a shortage of fly ash.

The objective of this synthesis is to document state DOT practices for using SCMs in concrete.

Information to be gathered includes (but is not limited to):

- SCMs permitted by state DOT specifications;
- Process for selecting the types and replacement rates of SCMs;
- Documented benefits of using a particular SCM;
- Alternates adopted when preferred SCMs are not available;
- State DOT policies and guidelines for the use of SCMs (temperature, mixing, etc.); and
- Practices for controlling the quality of SCMs.

Information will be gathered through a literature review, a survey of state DOTs, and follow-up interviews with selected DOTs for the development of case examples. Information gaps and suggestions for research to address those gaps will be identified.

Information Sources (Partial):

- Sutter, L. L. Supplementary Cementitious Materials - Best Practices for Concrete Pavements. FHWA Tech Brief No. FHWA-HIF-16-001. Federal Highway Administration, 2016.
- Al-Shmaisani, S., Kalina, R., O'Quinn, K., Jang, J. K., Rung, M., Ferron, R., and Juenger, M. Supplementary Cementitious Materials: Assessment of Test Methods for New and Blended Materials. Report No. FHWA/TX-21-0-6966-1, Center for Transportation Research, The University of Texas Austin, Austin, 2021.
- Subedi, S., Arce, G. A., Hassan, M. M., Huang, O., Radovic, M., and Hossain, Z. Evaluation of Alternative Sources of Supplementary Cementitious Materials for Concrete Materials. *In Transportation Research Record: Journal of the Transportation Research Board, No. 2676 (6)*. Transportation Research Board, Washington, DC, 2022, pp. 287-301.

Synthesis Topic 55-06
State DOT Certification Programs for Materials Testing Personnel

NCHRP Staff: Sandra Larson, consultant

The Code of Federal Regulations (23 CFR Subpart B) requires that each state department of transportation (DOT) develop a quality assurance program for materials and workmanship that includes the use of qualified sampling and testing personnel. To that end, state DOTs and some groups of state DOTs have developed programs to qualify or certify the personnel performing the testing. The entities that administer the certification programs may be the state DOTs themselves or other entities that have been delegated the authority to administer the certification programs by the state DOTs.

The purpose of certification is to indicate that testing personnel possess a thorough understanding of, and competency in, the performance of their duties. This should lead to reliable test results that enable the states to make a valid acceptance decision and comply with the CFR. The purpose is the same for all state DOTs, but the means to qualify testing personnel to perform specific tests, and applicable DOT regulations, varies between the agencies.

The objective of this synthesis is to document practices used by state DOTs for carrying out the mandated certification programs for materials testing personnel.

Information to be gathered includes (but is not limited to):

- Certification methodology;
- Types of certifications (e.g., concrete, asphalt, soils, aggregate) and levels (e.g., Level I, Level II);
- Training included with each certification program;
- Certification components, such as written and performance exams;
- Test methods and practices included in each certification program;
- Types of exam questions;
- Technology used in administering the exams;
- Development and maintenance of questions included in the written exams;
- Security of exams and question bank;
- Independence of evaluation;
- Recertification process;
- Decertification process;
- Appeal processes;
- Use of external providers;
- Availability to meet demands for the number of testing personnel requiring certification;
- Reciprocity with other state DOTs;
- Variance in methods for testing personnel types and levels; and
- Written program descriptions and requirements for testing certifications.

Information will be gathered through a literature review, a survey of state DOTs, and follow-up interviews with selected DOTs for the development of case examples. Information gaps and suggestions for research to address those gaps will be identified.

Information Sources (Partial):

- Code of Federal Regulations (23 CFR 637.207).
- AASHTO R 25: Standard Practice for Technician Training and Certification Programs.
- ASTM C1077: Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation.
- ASTM C1093: Standard Practice for Accreditation of Testing Agencies for Masonry.
- ASTM D3666: Standard Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials.
- ASTM D3740: Standard Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
- ASTM E329: Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection.
- ISO/IEC 17024: Conformity assessment—General requirements for bodies operating certification of persons.
- Federal Aviation Administration's Advisory Circular, AC 150/5370-10H: Standard Specifications for Construction of Airports.
- AASHTO Accreditation Program Policy on Certifications.

Synthesis Topic 55-07
Stormwater Retrofit Permit Requirements Compliance Through Third-Party Partnerships

NCHRP Staff: Arefeh Nasri

Due to the lack of stormwater control facilities on many existing highways, state departments of transportation (DOTs) are required to retrofit the stormwater conveyance system with improved treatment facilities to comply with regulatory requirements such as National Pollutant Discharge Elimination System (NPDES) stormwater permits, state water quality/stormwater regulations, Endangered Species Act (ESA) consultation, and Total Maximum Daily Load (TMDL) prescribed actions. As stormwater runoff quality and quantity are increasingly being addressed, state DOTs are seeking information on effective watershed-based strategies. To comply with permit requirements in a more cost-effective manner, many state DOTs are partnering with third parties. However, due to the lack of standard guidelines or regulations, state DOTs are devising diverse mechanisms to implement these partnerships.

The objective of this synthesis project is to document practices used by state DOTs regarding stormwater retrofit partnerships with third parties.

Information to be gathered includes (but is not limited to):

- Written state DOT policy for third party-partnerships for stormwater retrofits;
- The existence, type, purpose, and scale of stormwater retrofit partnerships used by state DOTs;
- State DOT performance measures for the partnerships; and
- Identified barriers and benefits of using third-party partnerships.

Information will be gathered through a literature review, a survey of state DOTs, and follow-up interviews with selected DOTs for the development of case examples. Information gaps and suggestions for research to address those gaps will be identified.

Information Sources (Partial):

- Alternative Site Stormwater Management | US EPA (https://www.epa.gov/npdes/alternative-site-stormwater-management)
- December 2014 Sustainable Financing Forum for Faster, Cheaper, Greener Urban Stormwater Retrofits | US EPA (https://www.epa.gov/G3/december-2014-sustainable-financing-forum-faster-cheaper-greener-urban-stormwater-retrofits

Synthesis Topic 55-08
Construction Strategies and Techniques for Bridge Replacements in Complex Scenarios

NCHRP Staff: Sandra Larson, consultant

A significant number of bridges on the national inventory are reaching the end of their service life and are being replaced yearly by state departments of transportation (DOTs). Many of those replacement bridges are on high-speed, high-traffic routes necessitating complex and, in some cases, costly strategies and construction techniques for balancing the mobility of the traveling public and work zone safety while constructing those replacement bridges within the budgetary constraints.

Typical bridge replacement construction strategies and techniques for complex scenarios include:

- Staged construction;
- Construction of the new bridge off the existing alignment and shifting traffic;
- Accelerated Bridge Construction techniques minimizing disruption such as lateral bridge slides;
- Temporary bridges (diversions or runarounds); and
- Closure and full detour.

State DOTs will consider a variety of factors when deciding how to approach the bridge replacement project, such as:

- Existing bridge condition;
- Site characteristics;
- Right-of-way procurement;
- Geotechnical characteristics;
- Hydraulic requirements;
- Geometric requirements;
- Average Annual Daily Traffic ;
- Crash history;
- Detour out-of-distance travel;
- Stakeholder input;
- Initial project cost;
- Asset life-cycle cost;
- Direct costs;
- User costs;
- Contract period strategy; and
- Project delivery method.

The objective of this synthesis is to document practices used by state DOTs for bridge replacements in complex scenarios.

Information to be gathered includes (but is not limited to):

- Construction strategies and techniques state DOTs use to construct bridge replacements to maintain mobility and work zone safety;

- Factors state DOTs consider when choosing the appropriate bridge replacement construction strategies and techniques; and
- Written bridge policies, rubrics, guidelines, and tools state DOTs use for replacement decision making in complex scenarios.

Information will be gathered through a literature review, a survey of state DOTs, and follow-up interviews with selected DOTs for the development of case examples. Information gaps and suggestions for research to address those gaps will be identified.

Synthesis Topic 55-09
Open-Books Pricing Practices for Construction Manager/General Contractor and Progressive Design-Build Projects.

NCHRP Staff: Arefeh Nasri

The use of open-books price negotiations in Construction Manager/General Contractor (CMGC) and Progressive Design-Build (PDB) projects is becoming increasingly popular due to its benefits, such as increased price transparency. It also provides an opportunity for price-informed design decisions, which can potentially retire major risks prior to establishing the negotiated construction price and reduce the size of the contingency pool carried into the final agreement. Many state departments of transportation (DOTs) have experience using open-books negotiations in CMGC and Public Private Partnership (P3) projects, and a handful of state DOTs will have developed procedures for PDB that generally mirror the DB portion of P3 projects. However, there is currently no guidance on how to configure the procedures for open-books price negotiations, how to articulate those procedures in procurement documents, and the effectiveness of the procedures in use.

The objective of this synthesis is to document state DOTs practices related to developing open-books price negotiations for CMGC and PDB.

Information to be gathered includes (but is not limited to):

- State DOT procedures for open-books negotiation in CMGC and PDB processes;
- Open-books process for risk allocation and contingencies' establishment;
- Open-books implementation policies and procedures in state DOTs (including utilization of an Independent Cost Estimator; and
- State DOT procedures for utilizing the "off ramp" in CMGC and PDB if an impasse on price is reached or if the agreed price exceeds the available funds.

Information will be gathered through a literature review, a survey of state DOTs, and 5 to8 follow-up interviews with selected DOTs for the development of case examples. Information gaps and suggestions for research to address those gaps will be identified.

Information Sources (Partial):

- *NCHRP Synthesis 402*: *Construction Manager-at-Risk Project Delivery for Highway Programs*, 2010.
- *NCHRP Report 787*: *Guide for Design Management on Design-Build and Construction Manager/General Contractor Projects*, (2014).
- NCHRP 10-85: A Guidebook for Construction Manager-at-Risk Contracting for Highway Projects, 2013.
- Gransberg, D. D., and Molenaar, K. R., Critical Comparison of Progressive Design-Build and Construction Manager/General Contractor Project Delivery Methods, *Transportation Research Record: Journal of the Transportation Research Board, No. 2673*, National Academies, 2019, pp. 261-268. 10.1177/0361198118822315,

- Gad, G., Davis, B., Shrestha, P. P., and Harder, P., Lessons Learned from Progressive Design-Build Implementation on Airport Projects, *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, 2019.
- Gransberg D. D., Pinto-Nunez, M., and Gransberg, N. J., Pricing Construction Manager/General Contractor Projects: With or Without ICE (Independent Cost Estimator), *Compendium,* Paper No. TRBAM-22-02177, Transportation Research Board of the National Academies, Washington, DC, January 2022.

Synthesis Topic 55-10
Implementation of the Federal Highway Administration (FHWA) Proven Safety Countermeasures

NCHRP Staff: Arefeh Nasri

For decades, public safety has been a top priority for state departments of transportation (DOTs) as they strive to reduce traffic crashes. To support these efforts, the FHWA Office of Safety Programs developed a list of proven safety countermeasures that include brief descriptions, technology sheets, and additional references. These measures have been field-tested and proved to reduce crashes. The initial effort consisted of 9 measures that any state DOT could implement. Today in 2023 there are 28 such measures available.

The objective of this synthesis is to document state DOT practices regarding the identification and implementation of FHWA proven safety countermeasures.

Information to be gathered includes (but is not limited to):

- FHWA proven safety countermeasures tested, implemented, or adopted as standard by state DOTs;
- Performance measures or other methods used to assess the impact of countermeasures after implementation; and
- State DOT modifications made to the proven safety countermeasures after implementation.

Information will be gathered through a literature review, a survey of state DOTs, and follow-up interviews with selected agencies for the development of case examples. Information gaps and suggestions for research and to address those gaps will be identified.

Information Sources (Partial):

- The initial source for information is the FHWA Office of Safety https://highways.dot.gov/safety/proven-safety-countermeasures.
- Literature searches for those states that have already tested or implemented safety countermeasures and have published research on their efforts should be available on TRID (http://trid.trb.org), which includes the Research in Progress database (http://rip.trb.org/).

Synthesis Topic 55-11
Construction Stormwater Program Management, Tracking, Reporting, and Compliance

NCHRP Staff: Jo Allen Gause

State departments of transportation (DOTs) are responsible for maintaining state transportation systems while simultaneously maintaining environmental compliance. State DOT construction activities are required to comply with federal and state National Pollutant Discharge Elimination System (NPDES) Construction General Permit (CGP) requirements. The regulations require state DOTs to implement policies, procedures, and practices to minimize offsite discharges of sediment-laden stormwater to protect downstream receiving water bodies during construction. To obtain permit coverage, regulated construction activities require the development, implementation, and maintenance of project specific Stormwater Pollution Prevention Plans (SWPPPs). The SWPPP provides stormwater-related management requirements and details on the installation, maintenance of structural and non-structural erosion, and sediment control practices to be implemented during land disturbing activities.

State DOTs nationwide are faced with CGP permit implementation challenges as they frequently find themselves needing to be flexible and creative with how to address, track, and report on construction stormwater compliance. There are a diverse range of platforms that provide a variety of tools that assist state DOTs with addressing construction stormwater compliance requirements.

The purpose of this synthesis is to document state DOT practices, tools, and approaches for managing compliance with state and federal construction stormwater permit requirements.

Information to be gathered includes (but is not limited to):

- Type of construction stormwater management program (individual or general);
- Preparation and management of SWPPPs;
- Components of state DOT construction stormwater management programs performed in-house and by consultants (design guidance development, inspections, asset tracking, reporting, etc.);
- Practices for tracking construction stormwater management permit requirements for construction projects;
- Qualifications required by the NPDES permit for designers and inspectors (Professional Engineer, Professional Landscape Architect, Certified Professional in Erosion and Sediment, state certification, etc.);
- Responsible party for the development of design standards for sediment control practices (state environmental agency, state DOT, national/FHWA standards, etc.);
- State DOT experience with regulatory audits for the MS4 or construction stormwater programs;
- Practices for the application of flocculants; and

- Frequency of updating state DOT guidance for erosion and sediment control practices.

Information will be gathered through a literature review, a survey of state DOTs, and follow-up interviews with selected DOTs for the development of case examples. Information gaps and suggestions for research to address those gaps will be identified.

Information Sources (Partial):

- Liu, L., Perez, M. A., Whitman, J. B., Donald, W. N., and Zech, W. C. (2021). SILTspread: A Performance-Based Approach for the Design and Installation of Silt Fence Sediment Barriers, *Irrigation and Drainage Engineering*, 147, 10 [DOI: 10.1061/(ASCE)IR.1943-4774.0001608].
- Kazaz, B., Schussler, J. C., Dickey, L. C., and Perez, M. A. (2022). Soil Loss Risk Analysis for Construction Activities, *Transportation Research Record: Journal of the Transportation Research Board.* [DOI: 10.1177/03611981221075027].
- Kazaz, B., Perez, M. A., and Donald, W. N. (2021). A State-of-the-Practice Review on the Use of Flocculants for Construction Stormwater Management in the United States, *Transportation Research Record: Journal of the Transportation Research Board.* [DOI: 10.1177/0361198121995192].
- Perez, M. A., Zech, W. C., Donald, W. N., Turochy, R. E., and Fagan, B. G. (2019). Transferring Innovative Erosion and Sediment Control Research Results into Industry Practice, *Water* 11(12), 2549 [DOI: 10.3390/w11122549].
- Perez, M. A., Zech, W. C., Donald, W. N., and Fang, X. (2016). Design Methodology for the Selection of Temporary Erosion and Sediment Control Practices based on Regional Hydrological Conditions, ASCE *Journal of Hydrologic Engineering*. [DOI: 10.1061/(ASCE)HE.1943-5584.0001328].

Synthesis Topic 55-12
Bridge Construction Inspection Training Resources

NCHRP Staff: Sandra Larson, consultant

State departments of transportation (DOTs) rely on construction inspectors to verify that contracted construction work on transportation infrastructure projects meets standards and specifications and is in compliance with project plans. Inspectors are trained and certified for expertise in specific areas of construction such as bridge construction.

Effective bridge construction inspection requires technical skills and knowledge specific to bridges. Much of the expertise and experience has been lost through attrition, reducing the ability of less experienced inspectors to be mentored on-site. Furthermore, contracting methods, technology, and means of conducting, documenting, and communicating have also evolved. An aging and changing workforce poses challenges in terms of gaining the knowledge necessary to perform proficient bridge construction inspection.

To develop inspector knowledge, skills, and abilities (KSAs) for effective bridge construction inspection, proper training is needed. The current practice for training inspectors in bridge construction across state DOTs varies greatly. This synthesis will investigate the training approaches, processes, programs, and resources already in place at state DOTs that could be of value to other state DOTs and to bridge owners in training their bridge construction inspectors.

The objective of this synthesis is to document practices used by state DOTs in training and certifying the bridge construction inspection workforce.

Information to be gathered includes (but is not limited to):

- Types of bridge construction inspections and inspector responsibilities;
- Organizational structure for bridge inspection;
- Core competencies (e.g., KSAs) needed to perform bridge construction inspection;
- Types of training used for bridge construction inspection, including classroom-based, on-the-job training, mentoring, and online/virtual-based;
- Mode of training, including instructor-led and self-paced;
- Location of training;
- Amount of training required;
- Opportunities and requirements for bridge construction inspection certification;
- Training opportunities and roadmap for inspector career advancement;
- Written training materials, documents, reports, and curricula, including when materials are revised/updated;
- Resources and tools used for training, including manuals, pocket guides, and checklists;
- Collaborations with local training centers, colleges, and universities to provide training; and
- Performance information on the effectiveness of training.

Information will be gathered through a literature review, a survey of state DOTs, and follow-up interviews with selected DOTs for the development of case examples. Information gaps and suggestions for research to address those gaps will be identified.

Information Sources (Partial):

- *NCHRP Research Report 1027: Guide to Recruiting, Developing, and Retaining Transportation Infrastructure Construction Inspectors* (2023)
- FHWA's *Construction Program Management and Inspection Guide* (2004).
- *Bridge Inspector's Reference Manual, Volume 1,* Publication No. FHWA NHI 12-049 (2012).

Synthesis Topic 55-13
Practices for Operational Traffic Simulation Models

NCHRP Staff: Arefeh Nasri

Transportation modeling applications can be divided into two categories: travel demand forecasting and operational modeling. Travel demand forecasting predicts future traffic volumes for long-term infrastructure investments, while operational modeling focuses on specific problems at a near-term or finer level of detail (such as improving the traffic signal timing along a corridor, identifying the causes of an existing bottleneck, assessing the mobility impacts of a planned construction project, and more). The tools and methodologies used for the two types of modeling are different, with demand forecasting using macroscopic four-step models and operational modeling using mesoscopic or microscopic modeling software. While processes and technical standards for travel demand modeling have been well documented in the previous literature, there is limited information on state departments of transportation (DOTs) practices for operational modeling.

The objective of this synthesis project is to document state DOT processes and procedures for operational traffic simulation models.

Information to be gathered includes (but is not limited to):

- The extent to which state DOTs use traffic simulation models;
- Typical applications of traffic simulation models, including operational corridor studies and work zone planning;
- Methods and guidelines for the development, implementation (including calibration, validation, review, and maintenance), and quality control of simulation models;
- The use of state DOT staff versus outside consultants for model analyses, as well as training processes for modeling software;
- Administrative procedures or protocols that mandate or restrict the use of simulation models;
- Procedures and policies for model scoping;
- Data sources used as inputs for operational models, such as probe data and regional travel demand forecasting model outputs; and
- The use of specialized features and companion tools, such as dynamic traffic assignment and multi-resolution modeling.

Information will be gathered through a literature review, a survey of state DOTs, and follow-up interviews with selected DOTs for the development of case examples. Information gaps and suggestions for research to address those gaps will be identified.

Information Sources (Partial):

- Relevant background information can be found in FHWA's *Transportation System Simulation Manual (TSSM)* (2017) and in the FHWA's Traffic Analysis Toolbox Program.

Synthesis Topic 55-14
Pavement Maintenance Practices for Deteriorated Wide Cracks and Joints

NCHRP Staff: Sandra Larson, consultant

Existing pavement maintenance programs of many state departments of transportation (DOTs) almost exclusively involve two kinds of activities: sealing of relatively narrow cracks (typically less than about 1 inch wide) and patching of potholes (typically several inches in diameter or larger). However, there are many other localized pavement distresses that are of intermediate size that can develop into potholes over time, such as deteriorated cracks also known as wide cracks, cupped or raveled cracks, and spalled joints. Often, deteriorated intermediate cracks and joints are not repaired by DOT maintenance until they have progressed to a point requiring pothole repairs. These deteriorated intermediate pavement cracks or joints are frequently larger than those typically repaired by crack or joint sealing efforts but are smaller than repairs requiring remove-and-replace patching procedures.

Repairs of these types of intermediate pavement distresses with materials such as flexible asphalt-based mastics, sand asphalt, or other patching materials have been shown to delay the development of potholes and to extend pavement service life. Engineered products, such as mastics, typically consist of polymer or rubber-modified asphalt binder systems combined with mineral fillers or fine aggregates. Experience has shown that engineered products can provide substantially better performance than more traditional solutions for deteriorated intermediate distresses, such as sand asphalt. Mastic type materials may be combined with repair techniques such as micro-milling or routing to remove loose pavement material and provide an adequate reservoir to receive the repair material.

State DOTs are developing evaluation and approval programs for assessment of available maintenance materials, and methods of application. Additionally, some state DOTs have increased their use of mastic materials for various pavement maintenance activities and have shown increased interest in the use of new products, such as mastics, along with current practices, such as sand asphalt and patching materials.

The objective of this synthesis is to document practices used by state DOTs for pavement maintenance for deteriorated wide transverse and longitudinal cracks and joints.

Information to be gathered includes (but is not limited to):

- Written policies, definitions, specifications, decision processes, and guidelines related to treatments of wide cracks and joints;
- Experience with all available solutions for wide crack and joint maintenance activities;
- Products and methods utilized;
- Written procedures for acceptance and quality assurance of new or current maintenance materials (e.g., testing, inspection, or traceability);
- Written guidance on maintenance material selection;
- Application records (e.g., year, pavement type, traffic, or condition) from different climatic zones;
- Techniques for evaluating the performance of maintenance treatments for wide cracks;

- Performance records of related pavement maintenance products and techniques for wide cracks;
- Cost data for different treatment methods and materials;
- Cost-effectiveness analysis used to select treatment methods; and
- Impact of different applications and treatments on pavement service life, treatment cost and benefits, and performance measures such as ride quality, noise, and skid resistance.

Information will be gathered through a literature review, a survey of state DOTs, and follow-up interviews with selected DOTs for the development of case examples. Information gaps and suggestions for research to address those gaps will be identified.

Information Sources (Partial):

- ASTM D8260. Standard Specification for Hot-Applied Asphalt Aggregate-Filled Mastic. American Society of Testing and Material, Philadelphia, Pennsylvania, 2020.
- Hajj, R., and Lu, Y., (2021). *Current and Future Best Practices for Pothole Repair in Illinois.* Springfield: Illinois Center for Transportation.
- Tons, E., and Khuri, M. F. *Mastic Asphalt for Maintenance.* Michigan Department of Transportation (MDOT), 1987.
- Michigan Department of Transportation (MDOT), (2019). *Capital Preventive Maintenance Specifications.*
- Minnesota Department of Transportation (MnDOT), (2019). *MnDOT Pavement Preservation Manual.*
- Washington State Department of Transportation (WsDOT), (2020). *Maintenance Manual M 51-01.11.*

Synthesis Topic 55-15
Tracking Safety Leading Indicators to Improve DOT Employee Safety Performance

NCHRP Staff: Trey Joseph Wadsworth

What gets measured, gets improved. With respect to the safety and health of state departments of transportation (DOTs) employees, the primary, historic metric used has been the Occupational Safety and Health Administration (OSHA) recordable incident rate. This incident rate measures how often a state DOT employee sustains an injury that demands more than basic first aid. This metric is important for understanding injury frequency, but it does not assist with programmatic management of the safety, health, and overall well-being of state DOT personnel. Functionally, the OSHA recordable incident metric and others like it are known as lagging indicators, that is, metrics that provide data after an incident as occurred. Recently, public and private sector organizations with high-hazard tasks have turned to safety leading indicators as metrics to manage occupational safety and health. These safety leading indicators provide relevant data prior to an incident occurring, and thus can lead to predictive insights that allow state DOTs to take action to avoid incidents altogether. Research efforts in the private sector have sought to identify, document, and measure the impact of safety leading indicators; however, state DOTs do not have similar, comprehensive studies.

The objective of this synthesis is to document practices used by state DOTs regarding the use of safety leading indicators to track and prevent occupational injuries and other incidents.

Information to be gathered includes (but is not limited to):

- Safety leading indicators used by state DOTs;
- Frequency of safety leading indicators collection;
- Method of data collection, tracking, and storage;
- Roles and responsibilities in the use of leading indicators;
- Results and analyses;
- Benefits and challenges;
- Successful implementation strategies; and
- Written policies and procedures.

Information will be gathered through a literature review, a survey of state DOTs, and follow-up interviews with selected agencies for the development of case examples. Information gaps and suggestions for research to address those gaps will be identified.

Information Sources (Partial):

- Akroush, N. S., and El-Adaway, I. H. (2017). Utilizing Construction Leading Safety Indicators: Case Study of Tennessee. *Journal of Management in Engineering*, 33(5), 06017002.
- Al-Shabbani, Z., Ammar, A., and Dadi, G. B. (2022). Preventative Safety Metrics with Highway Maintenance Crews. *Construction Research Congress 2022*. American Society of Civil Engineer's Construction Institute and Construction Research Council, Arlington, Virginia. March 9–March 12, 2022.

- Al-Shabbani, Ammar, A., Nassereddine, H., and Dadi, G. B. (2021). *Development, Implementation, and Tracking of Preventative Safety Metrics.* Research Report KTC-21-04/SPR19-568-1F. Kentucky Transportation Center, Lexington, Kentucky.
- Guo, H., and Yiu, T. W. (2013). How Traditional Construction Safety Performance Indicators Fail to Capture the Reality of Safety. The 38th Australian Universities Building Education Association Conference, Auckland, New Zealand,
- Hinze, J., Thurman, S., and Wehle, A. (2013). Leading Indicators of Construction Safety Performance. *Safety Science*, 51(1), 23-28.
- Maloney, W. F., Dadi, G. B., Cravey, K., Janusz, C., Liu, H., and Jazayeri, E. (2017). *Improving Site Safety Performance through Operational Excellence*–Volume 2. Construction Industry Institute. Research Team 317, Research Report 317-2, The University of Texas at Austin.

Synthesis Topic 55-16
Use of Sustainable Materials for Erosion and Sediment Control Practices

NCHRP Staff: Arefeh Nasri

Temporary Erosion and Sediment Control (ESC) practices are used in construction to prevent soil loss and reduce sediment-laden stormwater runoff. Plastics are commonly used for ESC due to their availability, durability, and cost, but they are rarely recycled and can break down into microplastics, which are a pollutant of concern. The netting of plastic ESC practices can also entangle wildlife. The Buy America requirement to exclusively use materials that are made in the United States has impacted the supply chain for many ESC products produced overseas, creating a need for state departments of transportation (DOTs) to find alternative—local and/or domestic—sources for construction stormwater management. Many states have or are working toward innovative practices involving reducing plastic-based ESC products and other potentially toxic materials used in ESC.

The objective of this synthesis is to document state DOT use of plastics in ESC practices, as well as state DOT practices aimed at reducing or eliminating the use of plastics and other nonbiodegradable materials for ESC practices.

Information to be gathered includes (but is not limited to):

- Practices for using plastic in ESC;
- Policies and regulations regarding the reduction or prohibition of plastics use in ESC products;
- Enforcement strategies to ban toxic substances from ESC practices;
- Efforts in recycling plastics used in current ESC practices; and
- Use of biodegradable alternative ESC products.

Information will be gathered through a literature review, a survey of state DOTs, and follow-up interviews with selected DOTs for the development of case examples. Information gaps and suggestions for research to address those gaps will be identified.

Information Sources (Partial):

- Fan Liu, Kristina Borg Olesen, Amelia Reimer Borregaard, and Jes Vollertsen, (2019). Microplastics in Urban and Highway Stormwater Retention Ponds. *Science of The Total Environment,* Volume 671.
- Coalition Clean Baltic, (2017). Guidance on Concrete Ways to Reduce Microplastic Inputs from Municipal Stormwater and Wastewater Discharges. Uppsala, Sweden.
- Olesen K.B., Stephansen D.A., van Alst N., and Vollertsen J. Microplastics in a Stormwater Pond. *Water*. 2019; 11(7):1466. https://doi.org/10.3390/w11071466.
- Kelsey Smyth, Jennifer Drake, Yourong Li, Chelsea Rochman, Tim Van Seters, and Elodie Passeport, (2021). Bioretention Cells Remove Microplastics from Urban Stormwater. *Water Research*, Volume 191.
- Fan Liu, Alvise Vianello, Jes Vollertsen, (2019). Retention of microplastics in sediments of urban and highway stormwater retention ponds, Environmental Pollution, Volume 255.

Synthesis Topic 55-17
Practices to Enhance Resiliency of Existing Culverts

NCHRP Staff: Sandra Larson, consultant

State departments of transportation (DOTs) recognize that management and maintenance practices for existing culverts fundamentally influence culvert performance and have subsequent impacts on other assets and overall transportation system performance. State DOTs actively research and implement methods to reduce costs, minimize maintenance, improve performance, and ultimately increase the longevity of culverts.

Climatic, geologic, hydrologic, and topographic conditions across the country are highly varied. Therefore, the needs of state DOTs to reduce culvert degradation impacts and improve resilience are common, yet the approaches may be diverse. Differences in rainfall duration and intensity, extreme flooding event characteristics, seismic susceptibility, slope and embankment stability issues, vulnerabilities to drought or fire, watershed characteristics, and urban development and land uses create different system challenges. Although the demands that state DOTs face vary significantly, commonalities exist, and practices used to enhance the resiliency of culverts can be broadly employed. Currently, there is an awareness gap, as not all state DOTs are aware of management and maintenance practices used by other state DOTs to address and improve the performance and resiliency of their existing culverts.

Culverts were frequently identified and assessed as vulnerable components to extreme events and climate change during a 2013-2015 pilot study (FHWA-HEP-16-079). Documenting priority practices and remedial measures for culvert management and maintenance is an important step in planning for improved system operations, performance, and resilience.

The objective of this synthesis is to document practices used by state DOTs to enhance resiliency of existing culverts.

Information to be gathered includes (but is not limited to):

- Practices to protect inlet and outlet basins from erosion;
- Remedial measures employed, such as using culvert liners;
- Practices addressing accumulation of debris, sedimentation, and clogging;
- Practices for remedial environmental corrections, such as for fish passage;
- Practices addressing embankment overtopping;
- Practices addressing coastal impacts, including inundation and storm surge;
- Practices that mitigate against piping at outlets and soil loss through joints due to pressure heads induced by storm event flooding and inundation;
- Existing post-event response and repair strategies for destroyed and damaged culverts;
- Existing risk-management strategies to assess and prioritize the criticality and vulnerability of culverts, such as real-time monitoring and warning systems;
- Past exposure and historic evaluation of culverts;
- Assessment methodologies to evaluate cost/benefit and lifecycle cost for resiliency improvements; and

- Identification of issues related to specific culvert types and materials that could affect resilience.

Information will be gathered through a literature review, a survey of state DOTs, and follow-up interviews with selected DOTs for the development of case examples. Information gaps and suggestions for research to address those gaps will be identified.

Information Sources (Partial):

- *NCHRP Report 473: Recommended Specifications for Large-Span Culverts* (2002).
- *NCHRP Synthesis 472: FEMA and FHWA Emergency Relief Funds Reimbursements to State Departments of Transportation* (2015).
- *NCHRP Synthesis 474: Service Life of Culverts* (2015).
- *NCHRP Synthesis 581: Rehabilitation of Culverts and Buried Storm Drain Pipes* (2022).
- *NCHRP Web-Only Document 190: Structural Design of Culvert Joints* (2016).
- FHWA-HEP-16-079 - *2013-2015 Climate Resilience Pilot Program: Outcomes, Lessons Learned, and Recommendations* (2016-2017).

Synthesis Topic 55-18
Permitting, Design, and Construction Practices for Aquatic Organism Passage

NCHRP Staff: Jo Allen Gause

State departments of transportation (DOTs) have traditionally designed culverts to convey water under roads according to cost, hydraulic efficiency, and risk criteria. However, this design approach can result in barriers to aquatic organism passage (AOP) as an unintended and undesired consequence. Thus, state DOTs have come under increasing regulatory direction to ensure AOP through culverts.

State DOTs on the West Coast and in the Northeast have been dealing with AOP for some time now, initially motivated by state and federal regulatory requirements, and now sometimes by legal challenge. Design practice in these state DOTs has settled on a suite of generally accepted approaches and practices calling for a higher level of geomorphic and hydraulic design than was formerly the case. Modern AOP design typically entails an interdisciplinary approach relying on various combinations of hydraulic engineers, hydrologists, fluvial geomorphologists, and biologists.

As a result of AOP design, structures have gotten larger, streambed placement and construction is now a routine practice, and 3-sided and open-bottom structures are strongly encouraged by regulators and resource agencies. Project scopes and costs have increased as compared to traditional hydraulic capacity designs. Some state DOTs have elected to address AOP programmatically while others have proceeded on a project-by-project basis. Along with these challenges has come that of institutional capacity: state DOT staffs may not have the numbers, skills, or experience, nor do many of the consultants who have traditionally functioned as extensions of DOT staffs.

The objective of this synthesis is to document state DOT practices and activities in permitting, designing, building, and maintaining culverts that deliver aquatic organism passage.

Information to be gathered includes (but is not limited to):

- Regulatory frameworks under which AOP is provided;
- Experience and process by which AOP has been adopted;
- Balancing prioritization for replacement by condition versus habitat improvement;
- Permitting processes followed by DOTs for AOP regulatory compliance;
- DOT program organization and staffing;
- Design approaches;
- Accommodation of culvert rehabilitation and retrofit;
- Streambed materials specification and procurement;
- Construction practices and experience;
- Maintenance and performance issues;
- Extent of culvert upsizing and cost impacts;
- Associated benefits of increased hydraulic capacity; and
- Relative proportion of culverts designed for AOP.

Information will be gathered through a literature review, a survey of state DOTs, and follow-up interviews with selected DOTs for the development of case examples. Information gaps and suggestions for research to address those gaps will be identified.

Synthesis Topic 55-19
Practices for Managing Selected Ancillary Transportation Assets

NCHRP Staff: Sandra Larson, consultant

State departments of transportation (DOTs) are increasingly expanding transportation asset management activities beyond pavements and bridges, by including selected ancillary transportation assets. Management of ancillary transportation assets are described in state DOTs recently completed and certified transportation asset management plans (TAMPs) and informal TAMPs.

Recent research, including NCHRP 08-36, Task 114, *Transportation Asset Management for Ancillary Structures*, has documented approaches to managing these selected assets, and several state DOTs have developed programs of differing levels of maturity. Additionally, NCHRP 20-05/Topic 54-06, *Ancillary Asset Data Stewardship and Data Models*, focused on which ancillary asset data is collected, and how it is collected, stored, managed, and used.

These selected ancillary transportation assets are identified from state DOT asset hierarchy based on research and features inventories' evaluations. Selected ancillary transportation assets include (but are not limited to):

- Sidewalks and curbs;
- Culverts;
- Drainage systems and environmental mitigation features;
- Overhead sign and signal structures;
- Intelligent transportation system equipment;
- High mast light poles; and
- Network backbone.

The objective of this synthesis is to document practices used by state DOTs for managing selected ancillary transportation assets.

Information to be gathered includes (but is not limited to):

- Selected ancillary transportation assets included in state DOT transportation asset management activities;
- Documented approach for ancillary transportation assets in state DOT TAMPs, as it relates to federally required elements;
- Ancillary transportation assets included in state DOT TAMPs, certified or informal;
- Performance measures and targets for these selected ancillary transportation assets;
- Selected asset management financial planning, including budgets, forecasting capabilities, and specific work/treatment types;
- Selected asset data used for programming decisions, including identification of the decision-maker;
- Identifying how these efforts are tied to broader asset management, maintenance management, and capital programming;
- Life-cycle planning methods and strategies; and

- Risk and resilience strategies.

Information will be gathered through a literature review, a survey of state DOTs, and follow-up interviews with selected DOTs for the development of case examples. Information gaps and suggestions for research to address those gaps will be identified.

Information Sources (Partial):

- FHWA's *Handbook for Including Ancillary Assets in Transportation Asset Management Programs* (2019).
- FHWA's Case Study 7 – Managing Assets Beyond Pavements and Bridges (2020).
- FHWA's HIF-20-067 Case Study 7 – Managing Assets Beyond Pavements and Bridges (TAMP Practices on Other Assets) (2020). (https://www.fhwa.dot.gov).
- NCHRP 08-36, Task 114, *Transportation Asset Management for Ancillary Structures.*
- NCHRP 20-05/Topic 54-06, *Ancillary Asset Data Stewardship and Data Models.*

Synthesis Topic 55-20
Traffic Capacity Level of Service Adaptations and Usage

NCHRP Staff: Arefeh Nasri

The Level of Service (LOS) concept has been used for over 50 years by state departments of transportation (DOTs) for policy setting, planning, analysis, and communication efforts. Individual adoption of the LOS framework by state DOTs has generally been consistent with AASHTO's *Highway Capacity Manual* (HCM). However, some agencies have tailored their respective LOS definitions and applications for local conditions and values (such as adjustment of HCM's hard-edged LOS category definitions). Additionally, there are differences in how state DOTs use big data and modern communication tools in their LOS analyses.

The objective of this synthesis is to document the practices of state DOTs use of the HCM framework for traffic capacity and LOS analyses.

Information to be gathered includes (but is not limited to):

- State DOT use of LOS as a policy, planning, and analysis tool (as a target or a standard);
- How DOTs determine LOS relative to traffic conditions (peak commute hour, annual average daily traffic, etc.) and road conditions (harder boundary edge or softer shoulder);
- Frequency and process of reviewing and updating LOS definitions and applications; and
- Extent to which big data, modern technology, and visual tools have been used for LOS analyses and public communications.

Information will be gathered through a literature review, a survey of state DOTs, and follow-up interviews with selected agencies for the development of case examples. Information gaps and suggestions for research to address those gaps will be identified.

Information Sources (Partial):

- *Highway Capacity Manual, 2010.* Transportation Research Board of the National Academies, Washington, DC.

Synthesis Topic 55-21
Funding and Maintenance of Complete Streets

NCHRP Staff: Arefeh Nasri

State departments of transportation (DOTs) are shifting their focus from autocentric, high-speed facilities to multimodal Complete Streets programs that generally include various newly built features. DOTs must determine which Complete Streets features they will fund and maintain. While recent funding is creating opportunities for constructing Complete Streets, maintaining these new features is more challenging. They present snow removal challenges, compatibility issues with existing components, and serviceability challenges for maintenance crews.

The objective of this synthesis is to document state DOT practices related to the funding and maintenance of Complete Streets projects.

Information to be gathered includes (but is not limited to):

- Existence of state DOT policies that govern Complete Streets projects;
- State DOT funding strategies and/or policies, including cost-sharing arrangements, for the design, construction, and maintenance of Complete Streets features (e.g., new or widened sidewalks, new bike lanes, pavement strips or markings for various users, new bikeways, crosswalk enhancements, pedestrian-scale/bikeway lighting, street furnishings, and wayfinding signage);
- State DOT practices regarding Complete Streets maintenance, including:
    - Development of new maintenance practices (e.g., new team designated to perform Complete Streets maintenance exclusively, or maintenance by equipment);
    - Maintenance agreements with local entities (agencies, cities, or counties) for Complete Streets projects;
    - Special certification and training programs for maintenance staff;
    - Agreements with the manufacturers for equipment repairs; and
    - Policies for acquiring new materials and equipment (e.g., bikeway sweepers, furnishings and lighting standards, maintenance trucks, temporary traffic control equipment, trailers, flatbeds, etc.).
- State DOT policies to ensure equitable distribution of funding for Complete Streets design, construction, and maintenance, and the equity factors considered (including policies regarding equity-priority communities).

Information will be gathered through a literature review, a survey of state DOTs, and follow-up interviews with selected DOTs for the development of case examples. Information gaps and suggestions for additional research to address those gaps will be identified.

Information Sources (Partial):

- https://www.morgan.edu/school_of_engineering/research_centers/urban_mobility_and_equity_center/research/new_research/equitable_complete_streets.html
- https://safety.fhwa.dot.gov/ped_bike/ped_transit/fhwasa21130_PedBike_Access_to_transit.pdf