National Cooperative Highway Research Program

Fiscal Year 2021 **May 2020**

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 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 agencies 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 online from the TRB website by June 30, 2020, at the MyTRB portal at this link: Online Panel Nominations

You will be asked to login to MyTRB. If you do not already have an account, you will be asked to quickly create one using your email and a password. To ensure proper consideration of nominations, please provide all of the information requested. A current resume is necessary to determine relevant knowledge and experience.

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 looking for consultants to perform as synthesis principal investigators. To formally express interest in authoring a topic, a two-page cover letter and professional resume or CV is required. Fixed fee is $45,000. Please submit letters of interest to the Letters of Interest Submission Portal.

A cover letter and resume or CV should provide a panel of topic experts, a concise idea of your knowledge of the topic, and a list of work accomplished in the subject area. **The deadline for letters of interest is August 27, 2020.** Topic panel meetings are anticipated during September and October 2020. During the meetings, scopes of work will be finalized and principal investigators chosen.

The next page shows the new FY2021 synthesis topics.

National Cooperative Highway Research Program Synthesis Topics in the Fiscal Year 2021 Program

(Titles are HOTLINKS)

Synthesis Topic 52-01
State of Practice on Infrastructure Inspections for the Digital Age

NCHRP Staff: Kerry Ahearn

Construction inspection is critical in any transportation project because it ensures conformance with plans, specifications, and material requirements, in addition to environmental, safety, and traffic control standards. Historically, departments of transportation (DOTs) have employed on-site workforces to execute infrastructure inspection using traditional inspection methods. Currently, better and more cost-effective technologies can potentially satisfy the need for efficient inspection and monitoring of critical infrastructure systems such as water delivery systems, wastewater mains, dams, levees, bridges, and roadways. With the latest technological advancements, the construction inspection landscape has been rapidly changing through incorporation of digital sensors, intelligent machines, mobile devices, and new software applications.

The technology innovation program (TIP) at the National Institute of Standards and Technology (NIST) has identified advanced sensing technologies and advanced repair materials for infrastructure (e.g., water systems, dams, levees, bridges, roads and highways) as a critical national need area of civil infrastructure. Unmanned Aircraft Systems (UAS) technology has been used to inspect local infrastructure, monitor ongoing projects, and conduct environmental analysis.

The objective of this synthesis is to document the various technologies used by DOTs to inspect infrastructure projects.

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

- The technologies used for infrastructure inspection
- The different methods used to assess the viability, efficiencies, and return on investment (ROI) of such inspection technologies

Information will be collected through literature review, a survey of 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):

- Chase, S., Edwards, M. (2011). “Developing a Tele-Robotic Platform for Bridge Inspection.” Virginia Transportation Research Council and Mid-Atlantic University Transportation Centers Program.
- FHWA research on the use of RFID tags to track paving materials (https://www.fhwa.dot.gov/publications/research/infrastructure/pavements/14061/index.cfm)
- Heymsfield, E., and Kuss, M. L. (2014). “Implementing Gigapixel Technology to Highway Bridge Inspections.” *Journal of Performance of Constructed Facilities*, 10.1061/(ASCE)CF.1943-5509.0000561, 04014074.
- Gibb, S. P. (2018). “Non-destructive Evaluation Sensor Data Processing and Fusion for Automated Inspection of Civil Infrastructure.” MS Thesis.

* La, H. M., Gucunski, N., Dana, K., and Kee, S. (2017). “Development of an Autonomous Bridge Deck Inspection Robotic System.” *Journal of Field Robotics*, 34(8), 1489–1504. Retrieved from https://onlinelibrary. wiley.com/doi/abs/10.1002/rob.21725, https://doi.org/10.1002/rob. 21725.
* Mulder, G. (2015). “e-Construction,” Iowa Department of Transportation, Presentation on May 27, 2015.

Synthesis Topic 52-02
Current Practices in Bridge Asset Management Decision Making

NCHRP Staff: Jo Allen Gause

State departments of transportation (DOTs) have been transitioning to the AASHTO element inspection system for rating bridge conditions since 2014. This inspection system offers a significant opportunity to improve the timing and cost efficiency of bridge maintenance, rehabilitations, and replacement decisions. However, there is no standard guidance on achieving those benefits.

The new AASHTO element inspection system provides detailed condition data on bridge components that can improve understanding of current conditions. Tools such as AASHTOWare BrM can combine these data with deterioration models to forecast future conditions and recommend optimal plans for an entire portfolio of bridges.

Anecdotal evidence suggests that states and other jurisdictions that receive the new inspection reports are taking numerous approaches to using the data. Many states rely on overall condition ratings reported to the National Bridge Inventory for planning purposes. Still others have begun to incorporate the new inspection data into the planning process.

The objective of this synthesis is to document current DOT practice and experience using the AASHTO element inspection system for rating bridge conditions. The synthesis will also examine how DOTs are using the data from inspection reports.

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

- Current practices for public reporting of bridge conditions
- Current use of AASHTO element data
- Families of deterioration models that are currently in use by DOTs
- Extent to which DOTs have incorporated the AASHTO element data into bridge asset management decision making

Information will be collected through literature review, a survey of 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):

- NCHRP Scan Team, Best Practices in Bridge Management Decision-Making, Scan 07-05 (2009).
- Utah DOT, *Bridge Management Manual* (2017). https://www.udot.utah.gov/main/f?p=100:pg:0:::1:T,V:4379.

Synthesis Topic 52-03
Practices for Ensuring Bridge Surface Smoothness

NCHRP Staff: Kerry Ahearn

Highway structures are one of the most expensive and important assets transportation agencies own and maintain. The travelling public prefers to travel across smooth riding highways, bridges are too often some of the roughest portions of the highway network.

Rough bridge surfaces can produce the following negative impacts:

- Increase in vehicle user costs by accumulative wear and tear on vehicles
- Increase in freight cost resulting from additional damage to goods or packaging costs
- Potential safety concerns with non-uniform tire loads
- Decrease of the life of a structure by increasing dynamic loads
- Reduction of user satisfaction

The objective of this synthesis is to document department of transportation (DOT) practices for ensuring bridge surface smoothness.

Information gathered includes (but is not limited to):

- Equipment utilized for evaluating bridge smoothness
- Index used to evaluate the smoothness
- Length limits of applying bridge smoothness
- Acceptance thresholds
- Localized roughness thresholds
- Funding mechanisms

Information will be collected via literature review, a survey of 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):

- Road Profiler User's Group (RPUG).

Synthesis Topic 52-04
Use of Unmanned Aircraft Systems for Departments of Transportation

NCHRP Staff: Kerry Ahearn

In the last decade, new technologies have transformed all the stages of the construction industry as more industry stakeholders have begun incorporating new technologies into their daily construction activities. One of the main applications that took over the construction industry is Unmanned Aircraft Systems (UAS). UAS has quickly established itself as one of the main applicable and fastest adopted technologies in the construction industry. Many state departments of transportation (DOTs) have embraced its use in a number of applications, including performing jobsite and work safety inspections, measuring stockpiles, monitoring work progress, providing real-time aerial surveying, providing environmental air and ground sampling, and mapping (3D modeling) of construction that cannot be seen from the ground or are in spaces where humans could be at risk.

The objective of this synthesis is to document the use of Unmanned Aircraft Systems (UAS) by state DOTs during construction.

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

- Current use of UAS by state DOTs
- How DOTs procure UAS application services (e.g., DOT staff or outsourcing)
- Identification of potential obstacles of UAS applications by state DOTs (e.g., legal implications, technical expertise, and training)

Information will be collected through literature review, a survey of 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):

- Banks, E., Cook, S. J., Fredrick, G., Gill, S., Gray, J. S., Larue, T., Wheeler, P. (2018). Scan 17-01 -Successful Approaches for the Use of Unmanned Aerial Systems by Surface Transportation Agencies (NCHRP Project 20-68A, Scan 17-01). Retrieved from http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-68A_17-01.pdf.
- FHWA. (2019). Every Day Count Initiative EDC5 - Unmanned Aerial Systems (UAS). (EDC-5). Retrieved from https://www.fhwa.dot.gov/innovation/everydaycounts/edc_5/uas.cfm.
- Harper, C. (2019). Emerging Technologies for Construction Delivery (NCHRP 20-05/Topic 49-02). Retrieved from http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4386.
- MnDOT. (2018). Unmanned Aircraft System POLICY-2071545-v1. (MnDOT Policy OP006). Minnesota Department of Transportation Retrieved from https://www.dot.state.mn.us/policy/operations/op006.html.
- Plotnikov, M., Ni, D., and Collura, J. (2018). The State of the Practice of Unmanned Aircraft Systems in State Departments of Transportation. TRB Committee AV060 Standing Committee on Airfield and Airspace Capacity and Delay. Paper presented at the

97th Annual Meeting of the Transportation Research Board, Washington D.C., United States. https://trid.trb.org/View/1495913.

Synthesis Topic 52-05
Implementation of Subsurface Utility Engineering for Highway Design and Construction

NCHRP Staff: Jo Allen Gause

Many state departments of transportation (DOTs) have implemented some level of subsurface utility engineering (SUE) as part of their project development and utility coordination processes. SUE is standardized by the American Society of Civil Engineer's CI 38-02 "Standard Guidelines for the Collection and Depiction of Existing Subsurface Utility Data." This standard, while currently being revised, has been instrumental in ensuring more uniform practice of SUE since its development in the 1980s. Nevertheless, DOT implementation has varied considerably with respect to when different quality levels are implemented and how the data collected is integrated into plans and contract documents.

DOT engineers and contractors have been using or soliciting their own SUE studies to mitigate utility conflicts and minimize utility strikes during construction. Contractors sometimes request quality level "A" data (potholing) in areas of utility congestion or where risk of dig-in events are high.

The objective of this synthesis is to document DOT use and practices related to SUE. The synthesis will examine how DOTs use SUE and when SUE is used in the design and project delivery process.

Information will be collected via literature review, a survey of 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):

- ASCE. (2002). Standard Guidelines for the Collection and Depiction of Existing Subsurface Utility Data. Standard ASCE/CI 38-02, American Society of Civil Engineers, Reston, VA.
- Anspach, J., and Murphy, R. (2012). Subsurface Utility Engineering Information Management for Airports. *ACRP Synthesis 34*: *Subsurface Utility Engineering Information Management for Airports,* Transportation Research Board, National Research Council, Washington, D.C.
- Lew, J. (2000). Cost Savings on Highway Projects Utilizing Subsurface Utility Engineering, Report No. FHWA-IF-00-014, Purdue University, Federal Highway Administration, Washington, D.C.
- Singha, S., Thomas, H., Wang, M., and Jung,Y. (2007). Subsurface Utility Engineering Manual, Report No. FHWAPA-2007-027-510401-08, Pennsylvania Transportation Institute, Pennsylvania State University, University Park, PA.

Synthesis Topic 52-06
Agency Inspection and Monitoring of Quality Control Plans for Use in Administering Quality Assurance Specifications

NCHRP Staff: Leslie Harwood

Modern quality assurance (QA) specifications promoted by the Federal Highway Administration (FHWA) recognize the state departments of transportation's (DOT's) responsibility for monitoring the contractor's quality control (QC) activities, conducting agency inspection, and conducting acceptance sampling and testing. Research and training focused on acceptance sampling and testing is currently available, and national, regional, and state certification programs have been developed to support this effort. Research and training on monitoring the contractor's QA/QC and appropriate methods of DOT inspection are more limited.

QA/QC plans are usually written by contractors and approved by DOTs, based on DOT requirements and specifications. Well-developed, proactive QA/QC plans should be used to solve problems, but often they are boilerplate or are developed only to be used to meet agency QA/QC specification requirements. Based on the historical quality of QA/QC plans submitted, some DOTs have even stopped requiring QA/QC plans to be submitted. Research has confirmed the importance of QA/QC and inspection in transportation projects, and further research is needed in the areas of contractor QA/QC, including adequate level of inspection.

The objective of this synthesis is to document the various QA/QC plans and manuals used by DOTs and how QA/QC plans are reviewed and inspected to achieve project specifications.

Information gathered includes (but is not limited to):

- QA/QC plans and manuals used by DOTs
- Input of DOTs into QA/QC plans
- Requirements of contractors regarding QA/QC plans
- DOT compliance review and inspection of QA/QC plans
- DOT monitoring of contractor implementation of QA/QC plans
- Incentives that DOTs are using to achieve effective QA/QC

Information will be collected through literature review, a survey of 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):

- Northeast Transportation Training and Certification Program. (December 2009). Appendix F, Typical "Model Quality Control Plan." Retrieved from https://www.nettcp.com/.
- Federal Highway Administration. (March 2009). *Federal Lands Highway Construction Manual*. Retrieved from https://highways.dot.gov/federal-lands/construction/manual.
- Wight, R., et al. (2017). NCHRP Project 20 68A, Scan 15-01: Developing and Maintaining Construction Inspection Competence. Lawrenceville, NJ: Arora and Associates, P.C. Retrieved from https://trid.trb.org/View/1492889.

- American Association of State Highway and Transportation Officials and National Steel Bridge Alliance: AASHTO/NSBA Steel Bridge Collaboration. (2019). Steel Bridge Fabrication QC/QA Guidelines G4.1-2019. Retrieved from https://www.aisc.org/globalassets/nsba/aashto-nsba-collab-docs/g-4.1-2019-steel-bridge-fabrication-qc_qa-guidelines.pdf.

Synthesis Topic 52-07
Use of Pavement Data Collection Technology for Pavement Data Quality Management and MAP-21 Target Setting

NCHRP Staff: Kerry Ahearn

Pavement data collection technology has been evolving over the past few decades, and increasingly so in recent years. High-precision, high-speed, automated equipment can collect more than 2,000 height measurements across a travelled lane and yield measurements of the pavement surface with sufficient frequency to extract transverse profile, longitudinal profile, cracking, and faulting. This provides important information to better pavement decision making. MAP-21, and successive federal legislation requires state departments of transportation (DOTs) to report pavement data at a 0.10-mile interval and establish pavement performance targets. Most, if not all, state transportation agencies have switched from manual pavement distress survey methods to automated/semi-automated pavement data collection methods in order to meet FHWA requirements. While these agencies gain more data, knowledge, and experience with automated/semi-automated pavement data collection methods, this migration also brings about new challenges. Those challenges include data quality control, data analysis, and decision making, in large part due to the rapidly evolving pavement data collection technology.

The objective of this synthesis is to document the experiences, challenges, and state-of-the-practice solutions used by DOTs in the transition to automated/semi-automated pavement data collection processes and when establishing the associated MAP-21 pavement performance targets.

Information gathered includes (but is not limited to):

- The certification, verification, and audit process of evolving technology used by DOTs
- The compatibility of automated data with historical data
- The challenges in transitioning condition indices used in visual surveys when utilizing automated data
- Differences in reporting the distresses quantities due to issues from image quality, noise, or algorithms
- Different levels of detailed distresses data used to establish pavement performance target

Information will be collected through literature review, a survey of 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):

- FHWA Final Rule for Pavements and Bridges; https://www.federalregister.gov/documents/2017/01/18/2017-00550/national-performance-management-measures-assessing-pavement-condition-for-the-national-highway
-

- All 52 state DOT pavement managers (suggest contacting FHWA Resource Centers or FHWA Field Offices for contacts of state DOT pavement managers; https://www.fhwa.dot.gov/about/field.cfm.
- All 52 state DOT asset management contacts; https://www.fhwa.dot.gov/infrastructure/asstmgmt/amcontacts.
- FHWA Guidance on Development and Approval of State Data Quality Management Programs, https://www.fhwa.dot.gov/pavement/management/pubs/dqmp.pdf.

Synthesis Topic 52-08
Practices for Balancing Safety Investments in a Comprehensive Safety Program

NCHRP Staff: Leslie Harwood

Most state departments of transportation (DOTs) use at least a portion of their Highway Safety Improvement Program (HSIP) funds on systemic safety improvement projects. However, DOTs continue to be challenged in determining how to prioritize projects and allocate funding across the various improvement types (i.e., spot, systemic, and systematic) to maximize safety benefits within their limited safety budgets. The Federal Highway Administration (FHWA) provides guidance to help DOTs determine the appropriate balance of investments between the different project types. Some DOTs choose investments based on a benefit-cost ratio, while others have challenges applying benefit-cost analysis procedures for systemic safety improvement projects. In these cases, DOTs may set aside a portion of their safety funds for systemic or systematic projects.

The objective of this synthesis is to document current DOT practices of identifying and prioritizing highway safety projects.

Information gathered includes (but is not limited to):

- Current state of the practice of prioritizing projects
- Use of separate budgets set aside for safety investments
- Funding allocations across the various improvement types
- Use of benefit-cost analysis for systemic projects, including identifying risk factors, project selection/prioritization, and evaluation of the effectiveness of systemic improvements

Information will be collected through literature review, a survey of 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):

- National Academies of Sciences, Engineering, and Medicine. (2010). Alternate Strategies for Safety Improvement Investments. Washington, D.C.: The National Academies Press. http://nap.edu/14373.
- State Highway Safety Improvement Program Reports. https://safety.fhwa.dot.gov/hsip/reports/.
- FHWA. (2013). Systemic Safety Project Selection Tool. https://safety.fhwa.dot.gov/systemic/fhwasa13019/sspst.pdf.
- FHWA. (2016). Reliability of Safety Management Methods: Systemic Safety Programs. https://safety.fhwa.dot.gov/rsdp/downloads/fhwasa16041.pdf.

Synthesis Topic 52-09
Use of Safety Management Systems in Managing Highway Maintenance Worker Safety

NCHRP Staff: Leslie Harwood

State department of transportation (DOT) employee safety and health programs are vital to the success of a DOT. While the safety of all DOT employees is paramount, maintenance and other field workers are exposed to unique hazards that demand a higher level of management than traditional office-based positions. However, some DOT safety programs include initiatives that are standalone and documented on individual paper reports, which can be difficult to store, sort, and aggregate for critical analysis and improvement.

Safety management systems (SMSs) allow a DOT to electronically report, manage, control, and audit issues related to employee safety. SMSs allow safety and health divisions in DOTs to become more agile, effective, and knowledgeable about the safety of employees. The use of SMSs varies by DOT; some DOTs have outsourced development of an SMS, some DOTs have developed systems in house, and some DOTs have no formal SMS. The scope and content of each SMS also varies by DOT.

The objective of this synthesis is to document the state of the practice of DOT SMSs, including various system capabilities and related policies and procedures.

Information will be collected through literature review, a survey of 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):

- Al-Shabbani, Z., Sturgill, Jr., R. E., and Dadi, G. B. (2017). “Safety Concepts for Workers from an OSHA Perspective.” Research Report KTC-17-14/SPR15-508-1F. Kentucky Transportation Center, Lexington, KY.
- Hale, A. R., Heming, B. H. J., Carthey, J., and Kirwan, B. (1997). “Modelling of Safety Management Systems.” *Safety Science*, Elsevier, 26 (1-2), 121-140.
- International Organization for Standardization (ISO). (2018). “Occupational Health and Safety Management Systems – Requirements with Guidance for Use.” ISO 45001:2018.
- “Managing for Health and Safety.” United Kingdom Health and Safety Executive (HSE) HSG65, 2013. https://www.hse.gov.uk/pubns/books/hsg65.htm.
- “Recommended Practices for Safety and Health Programs.” United States Department of Labor, Occupational Safety and Health Administration (OSHA). https://www.osha.gov/shpguidelines/.

Synthesis Topic 52-10
Designing and Accommodating Drainage in Pavement Design, Construction, and Maintenance

NCHRP Staff: Kerry Ahearn

Drainage is known to pavement professionals to be an important factor affecting pavement performance and preserving public investment. Numerous studies have been conducted to date that emphasize the importance of drainage. Yet despite this awareness, drainage is not always considered to be a critical component when it comes to design, construction, and maintenance of highway projects.

The objective of this synthesis is to document the current state of the practice by departments of transportation (DOTs) for designing and accommodating drainage in pavement design, construction, and maintenance.

Information gathered includes (but is not limited to):

- Methodologies for assessing drainage needs during the design phase
- Parameters used and documentation methods for drainage assessment during the design phase
- Mechanisms to quantify the benefits of drainage features and methods to document the effectiveness
- Drainage features used
- Methodologies for quantifying the structural capacities of pavement structures designed with sub-surface drainage systems.

Information will be collected through literature review, a survey of 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.

Synthesis Topic 52-11
Use of Smart Work Zone Technologies for Improving the Safety of Workers and Drivers Affected by Work Zone Activity

NCHRP Staff: Jo Allen Gause

Over the last two decades, state departments of transportation (DOTs) across the nation have been incorporating smart work zone technologies to improve their ability to manage work zones more effectively and to improve safety in work zones. Smart work zone technologies been used in a variety of ways to reduce the impact of work zone traffic movement through queue management and route diversion as well as to improve, safety. However, in recent years DOTs have been deploying more advanced dynamic smart technology to improve the safety of workers within the work zone as well as drivers within and upstream of work zone activity.

Examples of dynamic smart work zone technologies include lane merge systems to control vehicles merging in advance of lane closures; speed management systems within and in advance of work zones; use of portable changeable message signs for warning and speed reduction alerts; and warning systems of construction equipment in the roadway.

The objective of this synthesis is to document the use of smart work zone technologies used by DOTs for the purpose of improving the safety of workers and drivers affected by work zone activity.

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

- Dynamic warning systems to provide accurate notifications to drivers
- Automated work zone management systems to direct traffic movement upstream of work zone activity
- Dynamic lane merging systems for merging of traffic in a reduced lane configuration
- Variable speed limit systems to reduce vehicular speed in advance of work zone activity and within a work zone
- Dynamic notification of slow moving vehicles entering and exiting the work zone activity area
- Smart alert technologies integrated with crowdsourcing systems to provide accurate alert notifications to upstream drivers

Information will be collected through literature review, a survey of 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):

- Jawad Paracha and Rachel Ostroff (ICF). FHWA Research and Technology; Coordinating, Developing, and Delivering Highway Transportation Innovations, FHWA-HRT-18-004, Summer 2018: Improving Safety and Mobility: ITS in Work Zones
- FHWA. Every Day Counts (EDC-3), May 2017: Smarter Work Zones.

- Gerald Ullman (TTI) and Jeremy Schroeder (Battelle). FHWA Office of Operations, FHWA – HOP- 14, January 2014: Mitigating Work Zone Safety and Mobility Challenges Through Intelligent Transportation Systems.
- Dr. Denny R. Stephens, Vital Assurance; Dr. Jeremy Schroeder, Athey Creek; and Ms. Rachel Ostroff (ICF). FHWA January 2019: A Framework for Work Zone Activity Data Collection and Management (Version 3).
- Xuanwen Wang, PhD, Rebbeca Katz, MPH, and Xiuwen Sue Dong, DrPH. CPWR Quarterly Report Data Report, Second Quarter 2018: Fatal Injuries at Road Construction Sites Among Construction Workers.

Synthesis Topic 52-12
Rehabilitation of Culverts and Buried Storm Drain Pipes

NCHRP Staff: Kerry Ahearn

Departments of transportation (DOTs) are increasing employing asset management strategies in response to federal and state initiatives. Those strategies emphasize the need to preserve assets during their intended service life or, in some cases, to increase their service life. Low-cost and effective treatments applied throughout the asset life are employed prior to significant asset degradation, which would otherwise likely require a high-cost reactionary treatment. Culvert and storm drain pipes are increasingly being identified as an important asset by transportation agencies due to the quantity and the aging of these assets.

Recent research completed as part of NCHRP 14-26 - Culvert and Storm Drain System Inspection Manual developed a comprehensive methodology to assess the condition and provide ratings for buried pipes. Application of methodologies in this document identifies asset deficiencies and may provide input to assist facility owners in prioritizing their maintenance needs. As facility owners identify deficient buried pipes, there will be an overwhelming need for effective rehabilitation methods to restore function or to extend the service life of these assets. While some assets will require complete replacement, many facilities will be good candidates for rehabilitation, using both short-term and long-term rehabilitation or repair methods.

The objective of this synthesis is to collect and summarize rehabilitation practices used by state DOTs for culvert and buried storm drain pipes.

Information gathered includes (but is not limited to):

- Current and emerging rehabilitation methodologies for culvert and buried storm drain pipes
- Methods to restore the structural load carrying capacity of the facility, including both the structure and the surrounding soil

Information will be collected through literature review, a survey of 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):

- Structural Design Methodology for Spray Applied Pipe Liners in Gravity Storm Water Conveyance Conduits, University of Texas, expected completion 2020
- NCHRP 14-26 - Culvert and Storm Drain System Inspection Manual. http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP14-26_FR.pdf.

Synthesis Topic 52-13
Shared Micromobility Policies, Permits, and Practices

NCHRP Staff: Leslie Harwood

Shared micromobility technologies are deploying rapidly in many cities across the United States and internationally. Lacking a standard definition, micromobility technologies can include any personal transportation technology that travels slower than 20 to 30 mph. They can be motorized and are frequently operated on pedestrian- or bicycle-oriented infrastructure. Often, they are bicycles, e-bikes, or e-scooters. The rapid spread of shared micromobility services has led to confusion and concern on the part of cities and states seeking to take advantage of these services while minimizing the negative impacts.

The objective of this synthesis is to document state department of transportation (DOT) policies, permits, and practices with regard to shared micromobility services.

Information gathered includes (but is not limited to):

- DOT definitions of shared micromobility services
- Challenges regarding shared micromobility services facing DOTs
- DOT policies and regulations
- The role of DOTs with regard to shared micromobility services, including coordination with metropolitan planning organizations (MPOs) and municipalities
- Documentation of multi-department support required for the planning, operation, and maintenance of these systems
- Data collection efforts conducted by and/or shared with DOTs
- DOT approaches to using flexible regulatory language that covers future technological advancements in shared micromobility services
- Policies and procedures regarding integration with other mobility options, such as transit, transportation network companies (TNCs), and taxi services

Information will be collected through literature review, a survey of 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):

- U.S. EPA. 1992 Toxics Release Inventory. E.P. Agency, Editor. 1994, Office of Pollution Prevention and Toxics.
- Sandt, L. (2019) Dockless Electric Kick Scooter Systems: What We Know and Don't Know. Paper presented at the 98th Annual Meeting of the Transportation Research Board, Washington, D.C.
- PBOT. (2019). 2018 E-Scooter Findings Report. Available from: https://www.portlandoregon.gov/transportation/article/709719.
- Franklin-Hodge, J. (2018). The Scooter Data Opportunity: Cities Can Shape Their Future if They Act Now. Available from: https://blog.remix.com/the-scooter-data-opportunity-cities-can-shape-their-future-if-they-act-now-90a1e48659e7.

- Remix. Micromobility Policies. 2019 [cited 2019 Feb 14]. Available from: https://airtable.com/shryFFlpUAAD8kwcb/tblitJ04a77dFwYTW?blocks=hide.
- Giambrone, A. Scooter and Bike Companies Say D.C.'s New Rules for Dockless Vehicles are too Restrictive. 2018 [cited 2019 Feb 14]. Available from: https://dc.curbed.com/2018/11/17/18098426/dc-scooters-dockless-bikes-rules-cap-pushback.
- Pineda, P. Lime Pulls Electric Scooters from Tempe, Citing Fees, Liability Burden. 2019 [cited 2019 Feb 14]. Available from: https://www.azcentral.com/story/news/local/tempe/2019/02/11/lime-pulls-electric-scooters-tempe-citing-fees-liability-burden/2842707002/.

Synthesis Topic 52-14
Models as Construction Contract Documents

NCHRP Staff: Jo Allen Gause

During the last several years, state departments of transportation (DOTs) have been collaborating with construction contractors and consultants to overcome the challenges to sharing construction information digitally. Now many DOTs have developed procedures for using 3D engineered models during design and have piloted sharing those 3D models with the contractor in a digital format for roadway construction. State DOTs have also been exploring the concept of sharing those 3D models as construction contract documents.

There are numerous technical, procedural, risk management, and legal issues that arise when the construction contract medium changes from paper or "digital paper" (such as 2D PDFs containing plan sheets) to digital 3D models. Since there are not yet any nationally defined standards or guidelines to reference, DOTs have addressed these issues independently, and in different and creative ways.

The objective of this synthesis is to document current practice in DOTs for providing 3D engineered models to highway contractors, in particular as the legal construction contract document.

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

- Approaches to meeting document retention and data security requirements
- Identification of the controlling digital contract documents (sometimes called "model of record")
- Access control for the digital contract documents
- Managing authorized changes to the contractual 3D models
- Scope of using 3D models as contract documents (e.g., all project data reside in the 3D model or the 3D model encompasses part of the contract documents)
- Procedures for quality control and quality assurance of the digital contractual and supplemental data
- Risk mitigation strategies (e.g., partnering and previewing the 3D models in advance of the letting)
- Sample consultant design and inspection scopes of work
- Sample construction special provisions
- Effect on construction bid prices as a result of contractual digital contract documents

Information will be collected through literature review, a survey of 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):

- Model Based Design and Construction (MBDC) Guidelines for Digital Delivery. Utah DOT.

http://maps.udot.utah.gov/uplan_data/documents/DigitalDelivery/Library/MBDC_Guidelines_052219_FINAL.pdf.

- Construction-Ready Digital Terrain Models. SPR 19-576. Funded by the Kentucky Transportation Cabinet and FHWA.
- NCHRP 20-05/Topic 51-01 - Practices for Construction-Ready Digital Terrain Models.
- Automation in Highway Construction Part II: Design Guidance and Guide Specification Manual, HRT-16-031. Funded by the FHWA. https://www.fhwa.dot.gov/publications/research/infrastructure/pavements/16031/16031.pdf.
- Utilizing 3D Digital Design Data in Highway Construction - Case Studies, HIF-17-027. Funded by the FHWA. https://www.fhwa.dot.gov/construction/3d/hif17027.pdf.
- Demonstration of Bridge Project Delivery Using BIM. DTFH6114D00048. Funded by the FHWA.
- 3D Highway Design Model Cost Benefit Analysis. SPR 19-1680. Funded by the Michigan DOT and FHWA. http://www.trb.org/main/blurbs/179035.aspx.
- Construction Inspection for Digital Project Delivery. DTFH6116R00025. Funded by the FHWA. http://iheep2018.com/docs/Presentations/Construction%20Inspection%20Digital%20Project%20Delivery.PDF.
- *Legal Research Digest 58: Legal Issues Surrounding the Use of Digital Intellectual Property on Design and Construction Projects.* (March 2013). Transportation Research Board, Washington, D.C.
- Digital Signing and Sealing of Engineering Documents (NSPE). https://www.nspe.org/resources/digital-signing-and-sealing-of-engineering-documents.

Synthesis Topic 52-15
Measuring Investments and Benefits of Active Transportation Investments When Accomplished as Part of Other Roadway Projects

NCHRP Staff: Leslie Harwood

A variety of stakeholders and interested parties frequently ask state departments of transportation (DOTs) to provide data on active transportation project funding, such as bicycle and pedestrian infrastructure. Currently, DOTs do not use a uniform methodology for tracking these investments and may not track active transportation investments at all when they are accomplished alongside other non-active transportation-related roadway improvements. This is problematic because DOTs often accomplish active transportation improvements as part of other roadway projects to realize the efficiencies inherent in making changes across modes on a roadway at the same time.

As a result of the difficulty in tracking active transportation investments when the project is not 100% dedicated to active transportation, states may be underreporting their investments in active transportation. DOTs may use formulas or other methods to estimate a breakdown of project costs, and splitting the project costs of these improvements may represent an extra burden to contractors, engineers, and DOT staff. However, accurate spending information would help DOTs better understand how to make projects more efficient, increase return on investment (ROI), and provide useful data to evaluate overall project performance.

The objective of this synthesis is to document the methods that DOTs are currently using to track and record their investments in active transportation infrastructure when accomplished as part of other roadway projects.

Information gathered includes (but is not limited to):
- DOT tracking and valuation of active transportation project investments
- Methods of calculating ROI (including how to quantify the impact on communities, long-term mode shifts, commutes, congestion, car crash injuries and fatalities, and air quality)
- Examples of cost savings approaches

Information will be collected through literature review, a survey of 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):

- Bushell, M. A., et al. (November 2013). Costs for Pedestrian and Bicyclist Infrastructure Improvements: A Resource for Researchers, Engineers, Planners and the General Public. http://www.pedbikeinfo.org/cms/downloads/Countermeasure%20Costs_Report_Nov2013.pdf.
- Gotschi, T.. Costs and Benefits of Bicycling Investments in Portland, Oregon. *Journal of Physical Activity and Health*. Vol. 8, Issue: Suppl. 1. Human Kinetics, Incorporated. P.p. S49-S58. 1/2011. https://trid.trb.org/View/1116425.

- Raith, A., et al. (September 28-30, 2011). Australasian Transport Research Forum 2011 Proceedings. Adelaide, Australia. https://www.atrf.info/papers/2011/2011_Raith_Nataraj_Ehrgott_Miller_Pauw.pdf.
- FHWA. (2016). Guidebook for Developing Pedestrian and Bicycle Performance Measures., Document FHWA-HEP-16-037.

Synthesis Topic 52-16
Visualization of Performance Measures

NCHRP Staff: Jo Allen Gause

The MAP-21 and FAST-ACT requirements for state departments of transportation (DOTs) to report performance measures have increased the focus on performance measures as important management, reporting, and communications tools for decision makers. DOTs are challenged to find the best methods to efficiently and effectively visualize performance measures. Visualizations are tools for analyzing, reporting, and communicating the complexities of a transportation system and for synthesizing these intricacies into simple measures that can be easily understood.

The objective of this synthesis is to document current practices and tools used by DOTs to visualize performance measures and how that information is being used to observe and verify trends and set performance targets. The synthesis will capture information on a wide array of reports and dashboards in use as well the accessibility of the underlying data.

Information will be collected through literature review, a survey of 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):

- 50 DOT websites.
- Frank Broen. (July 2017). How Do You Visualize Performance? TRB 9th Visualization in Transportation Symposium. https://youtu.be/Gu5WBzT60hM.
- Evan Enarson-Hering, Hugh Louch, and Larry Anderson. (April 2014). SHRP 2 Tuesdays Webinar. SHRP 2 Community Visioning and Performance Measurement Products (C08 and C02).
- Cambridge Systematics Inc. (March 2016). *SHRP 2 Report S2-C02-RR: Performance Measurement Framework for Highway Capacity Decision Making.* Transportation Research Board of the National Academies, Washington, D.C.

Synthesis Topic 52-17
Use of Rejuvenators in Asphalt Concrete Mixtures Containing High RAP

NCHRP Staff: Jo Allen Gause

The Federal Highway Administration (FHWA) has highlighted the importance of using recycled materials in the highway construction industry, due to the engineering, economic, and environmental benefits. In the case of reclaimed asphalt pavement (RAP), its use continues increasing in highway construction, particularly to reduce the amount of virgin and non-renewable materials, as RAP contains old asphalt binders and aggregates.
Milled asphalt concrete (AC) mixtures are significantly stiffer than fresh mixtures as they have experienced in-service oxidative hardening and other aging-related processes. Thus, although the use of high RAP (more than 25% of the total mixture) in new AC mixtures may increase the rutting resistance of pavements, it may also compromise cracking resistance performance. To avoid this problem, AC mixtures with high RAP contents usually require the use of a softer binder or a rejuvenator.

Not all departments of transportation (DOTs) have experimented with high RAP content mixtures. The common factors preventing the use of more RAP include specification limitations, lack of expertise in processing RAP, lack of availability of quality RAP, and negative prior experiences.

The objective of this synthesis is to document current practices in DOTs to rejuvenate AC mixtures with high RAP contents.

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

- Existing policies and guidelines related to the use of rejuvenators
- Current practices for the use of rejuvenators in AC mixtures with RAP
- Rejuvenation techniques and evaluation methods (e.g., physical, mechanical, chemical, mathematical, and chemical models) and performance metrics

Information will be collected through literature review, a survey of 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:

- Cavalli, M. C., Partl, N., and Poulikakos, L. D. (2019). “Effect of Ageing on the Microstructure of Reclaimed Asphalt Binder with Bio-based Rejuvenators.” *Road Materials and Pavement Design*, 1-12.
- Epps Martin, A., Kaseer, F., Arámbula-Mercado, E., Bajaj, A., Garcia Cucalon, L., Yin, F., Chowdhury, A., Epps, J., Glover, C., Hajj, E.Y., Morian, N., Sias Daniel, J., Oshone, M., Rahbar-Rastegar, R., Ogbo, C., and King, G. (2019). Evaluating the Effects of Recycling Agents on Asphalt Mixtures with High RAS and RAP Binder Ratios. Pre-publication draft of *NCHRP Research Report 927*. Transportation Research Board, Washington, D.C.

- Tang, S., Williams, R. C., and Cascione, A. (2017). "Reconsideration of the Fatigue Tests for Asphalt Mixtures and Binders Containing High Percentage RAP." *Pavement Eng.* 18(5), 443-449.
- Zaumanis, R., Mallick, R., and Frank, R. (2014). Evaluation of Rejuvenator's Effectiveness with Conventional Mix Testing for 100% Reclaimed Asphalt Pavement Mixtures. *Transportation Research Record: Journal of the Transportation Research Board*, 2370, 17–25.

Synthesis Topic 52-18
Practices for New Rock Slope Design and Rockfall Mitigation

NCHRP Staff: Jo Allen Gause

Design manuals for rock slope and rockfall mitigation have been in use by departments of transportation (DOTs) since the 1960s. Software tools have made complex data analyses faster and easier than in decades past. These manuals and software tools have proved invaluable to practitioners, helping them design rock slopes for highway modernization and the mitigation of rockfall hazards.

While there are no standard goals and objectives for rock slope design and rockfall mitigation, some DOTs have formally or informally adopted their own design goals and objectives. Examples of design goals DOTs have adopted, either on a project-specific or statewide basis, include:

- Acceptable percentages of rockfall debris that may exit the roadside ditch and reach travel lanes
- Improvement of the percentage of rockfall debris being caught in the roadside ditches
- General reductions in maintenance efforts or safety concerns
- Reductions in hazard "scoring," using evaluation systems such as the Rockfall Hazard Rating System

The objective of this synthesis is to document DOT practices for the design of new rock slopes and rockfall mitigation.

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

- Existence of formal design goals and objectives
- Connection between design goals with alternative project delivery, asset management, natural hazard resilience initiatives, highway system designation, or other risk management plans
- Factors that guide design (e.g., deterministic or probabilistic slope stability models, roadside ditch containment percentages, rockfall frequency, and other performance-based standards)
- Risk tolerance considerations
- Incorporation of aesthetic considerations in the design of new cut slopes
- Design practice for mitigation measures (e.g., flexible rockfall barriers, rock bolts and dowels, draped mesh, rockfall attenuators, and pinned mesh systems)
- Performance measures for rockfall mitigation

Information will be collected through literature review, a survey of 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):

- Andrew, R. D., Bartingale, R., and Hume, H. (January 2011). Context Sensitive Rock Slope Design Solutions. Federal Highway Administration, Central Federal Lands Highway Division. Report No. FHWA-CFL/TD-11-002.
- Brawner, C. O. (March 1994). *Manual of Practice on Rockfall Hazard Mitigation Methods.* Federal Highway Administration, National Highway Institute. Training Course No. 13219, Participant Workbook, Publication No. FHWA SA -93-085.
- Turner, K. A., and Schuster, R. L. (2012). *Rockfall Characterization and Control.* Transportation Research Board of the National Academies, Washington D.C.
- Wyllie, D. C., and Mah, C. W. (October 1998). *Rock Slopes Reference Manual.* Federal Highway Administration, National Highway Institute. Training Course in Geotechnical and Foundation Engineering, NHI Course No. 13235 - Module 5. Publication No. FHWA HI-99-007.
- Wyllie, D. C., and Mah, C. W. (2004). *Rock Slope Engineering. Civil and Mining, 4th Edition.* Spon Press, New York.
- Wyllie, D. C. (2018). *Rock Slope Engineering. Civil Applications, 5th Edition*, CRC Press, New York.

Synthesis Topic 52-19
Technological Capabilities of DOTs for Digital Project Management and Delivery

NCHRP Staff: Jo Allen Gause

Many believe the next sea change in efficiency and productivity for the highway industry will be the “digitalization” of project management and delivery, the ability to seamlessly use digital information across all project phases for visualization, automation, decision making, and management. FHWA has invested over $35 million to support this, in the form of components of the larger concept of Building Information Modeling (BIM) for Infrastructure. Examples of this investment include 3D modeling, e-Construction, automated Machine Guidance (AMG), UAS (drones), and BIM research. An FHWA 2019 Global Benchmarking study, which focused on BIM, revealed that digitalization within the highway industry is an international priority.

For many years, digital design, construction, and management methods as components of BIM have been improving delivery in the “vertical” building industry by creating efficiencies that lower costs, generate fewer field “clashes,” and increase the speed of construction. Recently, some of those technologies have made their way into civil infrastructure and transportation projects and have been steadily gaining traction with both departments of transportation (DOTs) and industry. For example, 3D models and e-Construction have gained significant momentum as the design and construction components of BIM, in which traditional paper and pdf documentation is replaced with digital information and tools to improve workflows and save time and money. Some DOTs have taken further steps to incorporate such digital technologies into their whole-enterprise business processes, moving toward the vision of BIM for life-cycle data management. Other DOTs have not strayed far from traditional techniques, waiting to see where digitalization makes sense and provides real benefits.

The objective of this synthesis is to document the use of advanced digital construction (ADC) management systems by DOTs in the delivery of highway projects, from planning to design to construction. ADC is not a term to replace BIM; rather ADC includes components of BIM such as e-Construction, 3D models, digital documentation, and geospatial tools that are working to leverage digital efficiencies.

This synthesis will document the preparedness and progress of DOTs to incorporate and integrate digital technologies into their infrastructure delivery and also document current practices in moving toward digitization of maintenance practices and transportation asset management.

Information will be collected through literature review, a survey of 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.