SUMMARY**REPORT**

LONG-TERM BRIDGE PERFORMANCE PROGRAM DATA COLLECTION WORKSHOP

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FHWA Contact: Robert Zobel, HRDI-30; 202- 493-3024, robert.zobel@dot.gov.

This document is a summary report of the Long-Term Bridge Performance (LTBP) Program's data collection workshop held from February 25, 2021, through March 18, 2021.

OBJECTIVE

The purpose of this summary report is to describe the planning, objectives, conduct, and outcomes of the LTBP Program's data collection workshop, which was held from February 25, 2021, through March 18, 2021, and during which the assessment of the LTBP Program's current and future data collection needs was discussed.

INTRODUCTION

The performance of a bridge or a bridge component depends on multiple factors, many of which are closely linked. These factors include the original design parameters and specifications, such as bridge type, materials, geometries, and load capacities; initial quality of materials and quality of the as-built construction; varying conditions of climate, air quality, and soil properties; and corrosion and other deterioration processes. Other factors influencing performance include traffic volumes, counts and weights of truck loads and truck live load impacts, and damages caused by scour, seismic events, wind, and water or ice flow. A critical factor influencing performance is preventive maintenance, including the type, timing, and effectiveness of minor and major rehabilitation actions, and ultimately of replacement actions applied to the bridge.

Prior LTBP Program efforts identified 23 high-priority bridge performance topics from which the top 6 high-priority performance issues that the LTBP Program would address were determined. (See Brown 2014). The six high-priority performance issues identified with the help of stakeholder input were as follows:

Top Six High-Priority Performance Issues

1. Untreated (bare) concrete decks.
2. Treated (overlays) concrete decks.
3. Deck joints.
4. Superstructure bearings.
5. Steel coatings.
6. Embedded strands.

These six high-priority performance issues were used as the basis for identifying the field data to collect through LTBP Program efforts. Since the initiation of the LTBP Program, many advances have been made in data collection methods and automation. With this in mind, FHWA's LTBP Program managers determined that a reassessment of data collection needs was appropriate. So FHWA planned and conducted a data collection workshop to receive input from bridge community subject matter experts (SMEs) who would assist in assessing the LTBP Program's future data collection approach.

DATA COLLECTION WORKSHOP PLANNING AND CONDUCT

It was imperative during the planning stages of the workshop to develop the agenda and expected outcomes needed for obtaining the input of bridge community SMEs to help ensure proper focus and results. As such, the LTBP Program staff engaged the Bridge Expert Task Group (ETG) of the National Academies of Sciences and Engineering to provide input to FHWA for the planning and development of the workshop. LTBP Program staff held seven planning sessions with the Bridge ETG members to develop the workshop agenda and schedule and identify the working groups (WGs) of SMEs to address the six high-priority performance topics.

The primary objective of the workshop was to receive input from the bridge community SMEs to assist FHWA in assessing the LTBP Program's future data collection approach. The workshop was conducted in two phases. The first focused on data needs, and the second examined data collection methods, data granularity, and specific data quality assurance and quality control procedures for the identified data.

The six high-priority performance topics were pared down to five and were used as the basis for five WGs. (See inset). Deck Joints and Superstructure Bearings were combined into one group. Additionally, concrete bridge decks were recategorized based on location (hot or cold weather climate) rather than surface treatment (untreated or treated). The inset box shows the resulting five WGs. The roster of each individual WG consisted of representation from State highway departments, industry, academia, and FHWA. The chair and co-chair for each WG were members of the Bridge ETG (providing program continuity) and represented either academia or a State highway department.

Data Collection Workshop WGs		
WG1	Warm Weather Reinforced Concrete Bridge Decks	
	Chair:	George Conner (Alabama Department of Transportation [DOT])
	Co-Chair:	Soheil Nazarian (University of Texas El Paso)
WG2	Cold Weather Reinforced Concrete Bridge Decks	
	Chair:	Sarah Wilson (Illinois DOT)
	Co-Chair:	George Hearn (University of Colorado)
WG3	Bridge Deck Joints and Superstructure Bearings	
	Chair:	Zhengzheng (Jenny) Fu (Louisiana DOT)
	Co-Chair:	Anne-Marie McDonnell (Connecticut DOT)
WG4	Corrosion Protection for Structural Steel	
	Chair:	Tom Macioce (Pennsylvania DOT)
	Co-Chair:	Ann Rearick (Indiana DOT)
WG5	Pretensioned and Post-Tensioned Strands	
	Chair:	Alexander Bardow (Massachusetts DOT)
	Co-Chair:	John Popovics (University of Illinois at Urbana - Champaign

WORKSHOP SCHEDULE, FORMAT, AND GUIDANCE

Each phase of the workshop consisted of two plenary sessions (PSs) with individual WG meetings held in between PSs: an initial introductory session, followed by WG meetings, and a report-out session to review the work of the WGs. The first PS for each phase (PS1 and PS3) provided the background information and overall charge to the individual WGs. The WGs then deliberated prior to the following PSs (PS2 and PS4). During PS2 and PS4, the WGs presented their results to all attendees. The format and overall schedule for each phase are shown in table 1:

To provide structure and guidance to each of the WGs, excerpts from the Strategic Performance Matrices (unpublished), developed previously by LTBP, were provided to the WGs during the first PS to assist with their individual deliberations. These matrices posed a series of both practical and fundamental questions to be addressed through data collection for each topical area previously identified. A few of these excerpts are provided in table 2 for further clarification. The original matrices were developed for each of the six identified high-priority performance issues. However, for the purposes of this workshop, several of these topical areas have been combined for brevity and are shown in table 2, table 3, and table 4.

Table 1: LTBP data collection workshop schedule.

LTBP Data Collection Workshop—Phase 1		
PS1	Workshop Phase 1 Introduction and charge to WGs.	Wednesday, February 24, 2021 (1–3 p.m. EST)
WG Sessions (WG1 through WG5)	Five individual WGs (same as Phase 1). WG1—Warm Weather Reinforced Concrete Bridge Decks. WG2—Cold Weather Reinforced Concrete Bridge Decks. WG3—Bridge Deck Joints and Superstructure Bearings. WG4—Corrosion Protection for Structural Steel. WG5—Pretensioned and Post-tensioned Strands.	Meeting dates/times for sessions determined by individual WG Chairs. Thursday, February 24–Monday, March 1, 2021
PS2	Report out from individual WGs and discussions.	Tuesday, March 2, 2021
LTBP Data Collection Workshop—Phase 2		
PS3	Workshop Phase 2 Introduction and charge to individual WGs.	Monday, March 15, 2021 (1–3 p.m. EST)
WG Sessions (WG1 through WG5)	Five individual WGs (same as Phase 1).	Meeting dates/times for sessions will be determined by individual WG Chairs. Tuesday, March 16 through the morning of Thursday, March 18, 2021
PS4	Report out from individual WGs, discussions, and adjourn.	Thursday, March 18, 2021 (1–3 p.m. EST)

<table>
<tr><th colspan="6">Table 2: Strategic performance matrices for untreated and treated concrete decks, deck joints, and superstructure bearings</th></tr>
<tr><th colspan="6">Practical Questions
Goal: provide owners with data-driven actionable information</th></tr>
<tr><td>How should an untreated concrete deck (treated concrete deck, joints, or bearings) be inspected?</td><td>When should an untreated concrete deck (treated concrete deck, joints, or bearings) be inspected?</td><td colspan="2">How should an untreated concrete deck (treated concrete deck, joints, or bearings) be preserved or replaced?</td><td>When should an existing untreated concrete deck (treated concrete deck, joints, or bearings) be preserved or replaced?</td><td>How should an untreated concrete deck (treated concrete deck, joints, or bearings) be designed and constructed?</td></tr>
<tr><th colspan="6">Fundamental Questions
Goal: explain observed behavior to support the actions</th></tr>
<tr><td>How does live load influence performance?</td><td>How do environmental factors influence performance?</td><td colspan="2">How does the design of the untreated concrete deck (treated concrete deck, joints, or bearings) (e.g., cover) influence its performance?</td><td>How do structural characteristics (e.g., flexibility) of a bridge influence performance?</td><td>How do preservation activities influence performance?</td></tr>
<tr><th colspan="6">What Are the Key Causal Factors</th></tr>
<tr><td>ENVIRONMENT

Precipitation
Temperature
Proximity to the coast
Pollution
Age/deterioration</td><td>DECK DESIGN

Cover
Rebar type
Concrete mix
Proportioning
Reinforcing bars
Use of stay-in-place forms</td><td colspan="2">BRIDGE DESIGN

Span length
Girder stiffness
Girder spacing
Angle of skew
Bridge profile (bump at the end of the bridge)</td><td>LIVE LOAD

Frequency
Axle weights and axle spacing(s)
Speed</td><td>OWNER ACTIONS

Deicing
Level of preservation
Load permitting
Construction practices</td></tr>
<tr><th colspan="6">Potential Products</th></tr>
<tr><td rowspan="2">Best practices in nondestructive evaluation (NDE) and structural health monitoring (SHM) techniques for untreated concrete decks (treated concrete deck, joints, or bearings)</td><td rowspan="2">Data-driven, reliability-based inspection intervals and criteria for untreated concrete decks (treated concrete deck, joints, or bearings)</td><td colspan="4">1—Data-driven deterioration models for untreated concrete decks (treated concrete deck, joints, or bearings)</td></tr>
<tr><td colspan="2">2—Data-driven, lifecycle cost models for preservation and replacement practices for untreated concrete decks (treated concrete deck, joints, or bearings)</td><td colspan="2">2—Data-driven, lifecycle cost models for design and construction practices for untreated bridge decks (treated concrete deck, joints, or bearings)</td></tr>
</table>

Table 3: Strategic performance matrix for coatings for steel components.

<table>
<tr><th colspan="5">Practical Questions
Goal: provide owners with data-driven actionable information</th></tr>
<tr><td>How should coatings for steel components be inspected?</td><td>When should coatings for steel components be inspected?</td><td>How should coatings for steel components be preserved or replaced?</td><td>When should coatings for steel components be preserved or replaced?</td><td>How should new steel components be coated?</td></tr>
<tr><th colspan="5">Fundamental Questions
Goal: explain observed behavior to support the actions</th></tr>
<tr><td>How does environment influence performance?</td><td colspan="2">How does the selection and application of the coating influence performance?</td><td colspan="2">How do preservation activities influence performance?</td></tr>
<tr><th colspan="5">What Are the Key Causal Factors</th></tr>
<tr><td>ENVIRONMENT
Precipitation
Temperature
Proximity to the coast
Pollution
Age/deterioration</td><td colspan="2">COATING SELECTION
Type
Coats
Thicknesses
Surface prep</td><td colspan="2">OWNER ACTIONS
Deicing
Level of preservation
Load permitting
Construction practices</td></tr>
<tr><th colspan="5">Potential Products</th></tr>
<tr><td rowspan="2">Best practices in NDE and SHM techniques for coatings for steel components</td><td rowspan="2">Data-driven, reliability-based inspection intervals and criteria for coatings for steel components</td><td colspan="3">1—Data-driven deterioration models for coatings for steel components</td></tr>
<tr><td colspan="2">2—Data-driven, lifecycle cost models for preservation and replacement practices for coatings for steel components</td><td>2—Data-driven, lifecycle cost models for selection and application of coatings for steel</td></tr>
</table>

<table>
<tr><th colspan="6">Table 4: Strategic performance matrix for embedded or ducted strands.</th></tr>
<tr><th colspan="6">Practical Questions
Goal: provide owners with data-driven actionable information</th></tr>
<tr><td>How should embedded or ducted strands or tendons be inspected?</td><td>When should embedded or ducted strands or tendons be inspected?</td><td>How should embedded or ducted strands or tendons be preserved or replaced?</td><td colspan="2">When should embedded or ducted strands or tendons be preserved or replaced?</td><td>How should a new embedded or ducted strands or tendons be designed and constructed?</td></tr>
<tr><th colspan="6">Fundamental Questions
Goal: explain observed behavior to support the actions</th></tr>
<tr><td>How does environment influence performance?</td><td colspan="2">How does the design and construction of the strands or tendons influence performance?</td><td colspan="3">How do preservation activities influence performance?</td></tr>
<tr><th colspan="6">What Are the Key Causal Factors</th></tr>
<tr><td>Environment:
Precipitation
Temperature
Proximity to the coast
Pollution
Age/deterioration</td><td colspan="2">Strand or tendon design:
Type
Concrete Mix
Cover
Duct type
Anchorage type
Grout</td><td colspan="3">Owner actions:
Deicing
Level of preservation
Load permitting
Construction practices</td></tr>
<tr><th colspan="6">Potential Products</th></tr>
<tr><td rowspan="2">Best practices in NDE and SHM techniques for embedded or ducted strands or tendons</td><td rowspan="2">Data-driven, reliability-based inspection intervals and criteria for embedded or ducted strands or tendons</td><td colspan="4">1—Data-driven deterioration models for embedded or ducted strands or tendons</td></tr>
<tr><td colspan="2">2—Data-driven, lifecycle cost models for preservation and replacement practices for embedded or ducted strands or tendons</td><td colspan="2">2—Data-driven, lifecycle cost models for design and construction practices for pretensioned or post-tensioned bridges</td></tr>
</table>

The first phase of the workshop was held from February 25, 2021, to March 2, 2021, during which two PSs and individual WG meetings were held. The first PS was held on February 25, 2021, from 1–3 p.m. EST and provided attendees with background information about the LTBP Program, past data collection approaches used by LTBP, and the schedule, objectives, and expected outcomes for the first phase. Those outcomes, determined through the planning process, were as follows:

- Identification of the required data for your specific WG based on practical and fundamental questions.
- Identification of how the data is to be used for decision making and to answer the practical and fundamental questions from the strategic performance matrices.
- Prioritization of the data that is identified based on importance and best return on investment.

The second phase of the workshop was held from March 15–18, 2021, during which two PSs (PS3 and PS4) were held and individual WG meetings just as was done for Phase 1. The third PS was held on March 15, 2021, from 1–3 p.m. EST and provided attendees with a recap of the results from Phase 1 and the expected outcomes for the second phase. Those outcomes, as determined through the planning process, were as follows:

- Identification of the most efficient data collection methods for the data identified in Phase 1, including unmanned aerial systems (UAS) or drones, structural health monitoring, visual inspections, touchless technologies, and considerations of limited or no traffic control actions and data collections at traffic speeds.
- Identification of the data granularities required for decision making and for research purposes (e.g., deterioration modelling.)
- Identification of the quality assurance (QA) and quality control (QC) methods needed for all data types identified in Phase 1.
- Due to time constraints, data granularities and QA/QC methods were not addressed by all WGs.

INDIVIDUAL WG MEETINGS

Individual WGs met following the first and third PSs. The results of each of the WG meetings are summarized herein.

Summary of Outcomes for WG1—Warm Weather Reinforced Concrete Bridge Decks

The roster for WG1 is shown in table 5 along with the chair, co-chair, and FHWA staff that took part in the WG deliberations.

Chair: George Conner—Alabama DOT

Co-Chair: Soheil Nazarian—University of Texas at El Paso

FHWA Staff: Raj Ailaney, Hoda Azari

During Phase 1 of the workshop, the approach this WG employed was to use the excerpts from the LTBP Strategic Performance Matrices and rank the following items to guide their input: key causal factors; potential program products; and identified data. Although the WG was not charged with providing input/feedback on key causal factors or program products, the information provided by the WG is valuable to the LTBP Program and is reported below in table 6 and table 7.

Table 5: WG1 participants.

Name	Category	Affiliation
David Benton	State DOT	Arizona DOT
Michael Sprinkel	State DOT	Virginia DOT
Richard Walther	Industry	Wiss, Janney, Elstner Associates, Inc.
Shane Boone	Industry	Bridge Diagnostics, Inc.
Masato Matsumoto	Industry	NEXCO-West USA, Inc.
Necati Catbas	Academia	University of Central Florida
Nenad Gucunski	Academia	Rutgers, The State University of New Jersey

Table 6: Ranking of potential LTBP products (1– highest, 5– lowest).	
Potential LTBP Product	**Average Rating**
Best practices in NDE/SHM	2.1
Data-driven, reliability-based inspection intervals	2.0
Data-driven deterioration models	2.8
Data-driven, lifecycle cost models for preservation and replacement	3.0
Data-driven, lifecycle cost models for design and construction practices	4.6

Table 6 shows the WG's ranking of potential products and table 7 shows the WG's ranking of key causal factors.

The WG identified and prioritized the data to collect for warm weather bridge decks during Phase 1 of the workshop. During Phase 2, the WG revised and identified the various data and technologies accordingly. In addition to ranking the technologies in terms of importance, the WG also suggested that data collection on bridge decks be completed in two phases. During the first phase, scanning technologies would be implemented over the entire deck area with as dense a data collection grid as possible. Phase 2 would consist of a subset of bridges with more detailed inspection in select areas deemed anomalous during Phase 1 scanning. The WGs ranking of specific technologies or data is shown in table 8.

WG1 provided additional comments and input pertaining to data collection and data presentation methods. WG1 provided specific suggestions for both data collection and data presentation.

Table 7: Ranking of key causal factors (1–not important, 2–important, 3–critical).		
General Causal Factors	**Factor**	**Average Rating**
Environment	Precipitation	2.0
	Temperature	2.1
	Proximity to coast	2.2
	Pollution	1.0
	Age/deterioration	3.0
Deck Design	Cover	2.9
	Reinforcement type	2.3
	Concrete mix	2.6
	Proportioning of reinforcement	2.1
	Use of stay-in-place forms	1.7
Bridge Design	Span length	1.6
	Girder stiffness	2.1
	Girder spacing	2.3
	Angle of skew	2.0
	Bridge profile (bump at end)	2.1
Live Load	Frequency	2.6
	Axle weights and spacings	2.6
	Speed	1.4
Owner Actions	Deicing	3.0
	Level of preservation	2.9
	Load permitting	2.3
	Construction practices	2.6

Table 8: Ranking of data collection needs for warm weather reinforce concrete bridge decks.		
Phase of Assessment	**Technology or Data Type**	**Priority (5—highest 1—lowest)**
Phase 1	Construction data	3.4
	Air-coupled, high-speed, ground-penetrating radar (GPR)	3.1
	High-definition imaging	3.1
	Infrared thermography	2.7
Phase 2	Impact echo	2.1
	Ground-coupled GPR	2.6
	Ultrasonic surface waves (USW)	1.1
	Half-cell potential (HCP)	1.7
	Deck cores	1.2

Summary of Outcomes for WG2—Cold Weather Reinforced Concrete Bridge Decks

The roster for WG2 is shown in table 10 along with the chair, co-chair, and FHWA staff that took part in the WG deliberations.

Chair: Sarah Wilson—Illinois DOT

Co-Chair: George Hearn—University of Colorado Boulder

FHWA Staff: Derek Constable, Ping Lu

During Phase 1 of the workshop, WG2 first reviewed the data currently collected by the LTBP Program. The areas considered by the WG included: design construction data; data on owner actions; field inspection data; environmental data; and laboratory testing.

The WG noted that, although desirable, it is difficult to collect design and construction data for older bridges. Additional items were suggested to add to the data collection efforts as follows:

Table 9: Data collection and data presentation suggested practices.	
Data Collection	**Data Presentation**
Speed of data collection is critical, fast is best	Georeferenced color-coded defect maps with emphasis on location of defects
Automation in data collection is best	Overlay data on bridge or deck image
Potential to collect deck data from underneath	Statistical information about the classification and extent of defects

Temperature range during concrete placement; concrete curing specifications and time to open to traffic; year of deck replacement; concrete permeability; integral abutments or type of deck joints; proximity to permit routes leading to number of permit loads. The WG also suggested that LTBP includes new bridge deck construction (or rehabilitation) in the data collection efforts and to develop future strategies to specifically address the addition of new decks to the LTBP clusters, the number of new decks to add per year, the geographic distribution of new decks and the development of specific protocols pertaining to the frequency of data collection for new decks.

Owner actions related to deicing/anti-icing application rates, deck washing practices, and preservation practices were discussed. Although difficult to collect, the WG suggested collecting application rates for deicing or anti-icing chemicals. This could be indirectly derived from the deicing/anti-icing cost. The group also suggested collecting information pertaining to State policy on bridge and/or deck washing including the frequency and water pressure. A critical area discussed was obtaining maintenance history for LTBP bridges.

Table 10: WG2 participants.		
Name	**Category**	**Affiliation**
William Oliva	State DOT	Wisconsin DOT
Anthony Mizomuri	State DOT	Washington DOT
Greg Freeman	Industry	Kwik Bond Polymers
Amir Rezvani	Industry	Infratek Solutions Inc.
Sreenivas Alampalli	Industry	Consultant
Glenn Washer	Academia	University of Missouri
David Darwin	Academia	University of Kansas

Table 11: Ranking of data collection needs for cold weather reinforced concrete bridge decks.						
Data Type	**Prioritization Factor (A–E)**					**Average**
	A	**B**	**C**	**D**	**E**	
Environment						
Half-cell potential	2	2	4	4	2	2.8
Electrical resistivity	—	—	—	—	—	—
GPR-air coupled	3	3	2	2	3	2.6
GPR-ground coupled	2	4	3	2	3	2.8
Humidity sensor	2	3	2	2	2	2.2
Cover Depth						
GPR	2	2	2	1	3	2.0
R-meter	2	2	3	3	2	2.4
As-built plans	1	3	1	2	3	2.0
Chloride Contamination Profile						
Vacuum and hammer drill	2	2	2	2	2	2.0
Coring	2	2	3	3	2	2.4
Deicing Chemical Use						
State policy	2	2	2	2	1	1.8
State GPS road vehicles (records)	2	2	3	3	3	2.6
Concrete Permeability						
State specification	2	2	1	1	1	1.4
Core testing	1	2	3	4	2	2.4
Construction and Operational Data						
Temperature range during deck concrete placement	2	3	3	2	2	2.4
Live load information (routes for typical overweight permits)	2	2	3	2	3	2.4
Live load information (proximity to heavy industry)	2	2	2	2	2	2.0
Date(s) of deck concrete placement	3	3	4	2	2	2.8
Construction issues or deviations	3	2	4	3	2	2.8

— = No data.

Table 11: Ranking of data collection needs for cold weather reinforced concrete bridge decks.						
Data Type	Prioritization Factor (A–E)					Average
	A	B	C	D	E	
Maintenance Specifications and History						
Maintenance, preservation, rehabilitation, and replacement records	3	2	3	2	4	2.8
State policy	2	2	2	1	2	1.8
Bridge Deck Cracking						
Visual	1	1	3	2	2	1.8
High-resolution digital imaging	2	1	2	1	3	1.8
Bridge Deck Surface Defects (spall, scale, patch)						
Visual	1	1	2	2	2	1.6
High-resolution digital imaging	1	1	1	1	2	1.2
Bridge Deck Delamination						
Impact echo	1	2	3	2	3	2.2
Infrared (mobile or UAS mounted)	2	2	2	1	3	2.0
Infrared (time-lapse)	2	2	2	2	2	2.0
Chain drag	1	2	3	3	3	2.4
Mobile chain drag	2	2	3	2	2	2.2
Core	2	2	4	4	2	2.8
Deck Bottom Surface Defects						
High-resolution digital imaging	2	2	2	2	2	2.0
Infrared	2	2	2	1	3	2.0
Visual	2	1	2	2	2	1.8
Longitudinal and Transverse Profile						
Visual	2	3	1	2	2	2.0
Profile (transverse)	2	2	2	1	1	1.6
Profile (longitudinal)	2	2	2	1	1	1.6
Concrete Strength						
Core	1	2	3	2	1	1.8
USW	2	3	3	2	1	2.2

— = No data.

Additionally, it was suggested to collect information pertaining to State policy on deck sealing, crack sealing, overlays (standard thickness, materials, surface preparation, etc.), and other deck treatments in use by a State.

In terms of field inspection data, the WG discussed traditional methods such as chain dragging and various nondestructive test (NDT) methods and high-resolution imaging. Each of these technologies were prioritized by the WG and are reported herein. Environmental data needs and specific laboratory tests were also discussed and prioritized. Each data item was prioritized using five factors: use of existing technology; importance; ease of data collection or efficiency/ cost benefit; scalability or ability to be automated, and difficulty of data processing. The five factors were prioritized using a rating of 1 to 5 with 1 being lowest and 5 being highest for each factor.

Additionally, during Phase 2 of the workshop the WG reported information pertaining to data granularity, frequency of data collection, and potential QA/QC guidelines for those data types deemed appropriate by the WG.

Environment

For data collection of the deck environment both air-coupled and ground-coupled GPR were suggested. Data granularity suggested at least three antennas be used for air-coupled GPR, while for ground-coupled GPR a distance of less than 2 ft was suggested and the development of a protocol for calibrating GPR data. The frequency of data collection suggested for both air and ground-coupled GPR was a baseline followed by flexible and adaptive interval with an increase in frequency after initiation of deterioration. In terms of QA/QC guidelines, the following items were suggested for both air and ground-coupled GPR: develop a protocol for calibrating the images of rebar depth by R-meter; training and/or information to help differentiate between bad data and deck deterioration; reference the LTBP protocols, and collect data under similar weather conditions to provide best data comparison.

Chloride Contamination Profile

For determining the chloride contamination profile using a vacuum and hammer drill the WG suggested data collection along the shoulder of the deck where typically high contamination levels are found and locations in the vicinity of existing cracks with three locations crossing a crack and three locations next to the crack. The frequency suggested for chloride profile testing was a 6-yr interval until twice the corrosion threshold is reached and then discontinue the sampling.

Deicing Chemical Use

The WG suggested that State GPS road vehicle records should be used where available.

Bridge Deck Cracking

The WG suggested high-resolution digital imaging with a resolution that can differentiate crack size down to four thousandths of an inch, with images captured prior to any surface treatment and with an interval not exceeding 2 yr, and in accordance with LTBP protocols.

Bridge Deck Surface Defects (Spall, Scale, Patch)

The WG suggested high-resolution digital imaging using a square-fit image at least every 4 yr and in accordance with LTBP protocols.

Bridge Deck Delamination

For bridge deck delamination, several methods were reported, and the WG's suggestions are as follows:

- Impact echo—Use of a 6-inch data grid or smaller; collect baseline data followed by a flexible and adaptive data collection interval that is based on infrared data; and decrease the testing interval once deterioration is detected.
- Infrared (mobile or UAS mounted)—Collect baseline data and repeat at least every four years. Infrared can be combined with mobile chain drag.
- Infrared (time-lapse)—Can use instead of impact echo when an asphalt overlay is present.
- Mobile chain drag—Collect baseline data and repeat at least every four years. Mobile chain drag can be combined with infrared methods.
- Concrete coring—Collect samples to use only for calibration of various NDT methods.

Deck Bottom Surface Defects

The WG suggested the use of high-resolution digital imaging using a square fit image at least every 4 yr and in accordance with LTBP protocols. Additionally, infrared can also be considered with a baseline and at least every 4 yr.

Concrete Strength

Use concrete cores, when permissible, to determine concrete strength in-situ for decks without mix specification, mix design, or cylinder breaks, otherwise only for forensics when necessary.

Summary of Outcomes for WG3—Bridge Deck Joints and Superstructure Bearings

The roster for WG3 is shown in table 12 along with the chair, co-chair, and FHWA staff that took part in the WG deliberations.

Chair: Zhengzheng (Jenny) Fu—Louisiana DOT

Co-Chair: Anne-Marie McDonnell—Connecticut DOT

FHWA Staff: Jerry Shen, Frank Jalinoos

During Phase 1, WG3 focused on the following questions:

- What are the performance issues for joints and bearings?
- How has the performance of joints and bearings been inspected and documented in the past?
- What kind of data has been collected for joints and bearings by bridge owners or others, and are additional data needed?
- How has existing data been used in decision making?

The ensuing discussions led to specific suggestions for LTBP data collection and for American Association of State Highway and Transportation Officials (AASHTO). The suggestions for AASHTO were to: standardize definitions for small and large movement joints; expand the element list for joints and bearings; define additional defects and clarify existing defects for data collection efficiency.

During Phase 2, WG3 clarified the results from Phase 1 and reported a multilevel approach for data collection for both joints and bearings.

The first-level approach to data collection suggested by the WG was to utilize data that has already either been collected through the National Bridge Elements (NBE) (Office of Bridges and Structures 2015–2020) or to suggest new or expanded element lists to be included within AASHTO's *Manual for Bridge Element Inspection* (MBEI) (AASHTO 2011) in the future to augment what is already being collected at the element level for both joints and bearings. Both the first and second levels of data collection as suggested by the WG are detailed in table 13.

Table 12: WG3 participants.

Name	Category	Affiliation
Edward Lutgen	DOT	Minnesota DOT
Ralph Dornsife	DOT	Washington DOT
Christopher Keegan	DOT	Washington DOT
Steven Austin	DOT	Texas DOT
David Hiscox	DOT	Connecticut DOT
Biniam Aregawi	DOT	Texas DOT
Deborah Steiger	Industry	Watson Bowman Acme
Marc Stafford	Industry	R.J. Watson Inc.
Jill Walsh	Academia	St. Martin's University
John Stanton	Academia	University of Washington

Table 13: Ranking of data collection needs for deck joints and superstructure bearings.

Priority Level	Data Type	Obtain From	Frequency	Issue/Comment
Assessment Level 1—Joints and Bearings				
1	National Bridge Inventory Database: NBE/MBEI condition states (CS1-CS4)	FHWA	As submitted	Use for deterioration models.
Assessment Level 2—Joints				
2	Inspection report and agency defined elements	Request from bridge owners	As available	Develop new protocols for additional joints and bearings as needed
	Joint opening at various temperatures	Field measurements	Every 2 yr	Strip seal gland pinched or extended, decreased service life
	Seal leak, flushing			
	Concrete condition, delamination, corrosion	Field measurement, NDE, lab testing (cores)	Not reported	All joints, concrete headers that exhibit deterioration from deicing chemicals
	Visual	Field measurement	Annual	Assess compression joint adhesion issues
	Surface profile of joint	Field measurement	Annual	Conduct a visual inspection
Assessment Level 2—Bearings				
2	Visual NDE SHM	Field measurements	Annual As needed Continuous	Elastomeric bearing pad walk out
	Movement, rotation, and temperature (bridge and ambient), section loss	Field measurements	Visual (2 yr) NDE (as needed) SHM (continuous)	Corrosion of steel components of movable bearings
	Roller/rocker nest break out or lock up			
	Section loss	Field measurements	Visual (2 yr) NDE (as needed)	Corrosion of disk bearings
	Crack detection and measurement	Field measurement	NDE (as needed)	Pin-hanger fatigue/ fracture
	Seal damage detection	Field measurement	Visual (2 yr) NDE SHM	Pot bearing seal damage

Summary of Outcomes for WG4—Corrosion Protection for Structural Steel

The roster for WG4 is shown in table 14 along with the chair, co-chair, and FHWA staff that took part in the WG deliberations.

Chair: Tom Macioce—Pennsylvania DOT

Co-Chair: Anne Rearick—Indiana DOT

FHWA Staff: Larry O'Donnell, Justin Ocel

Table 14: WG4 participants.

Name	Category	Affiliation
Michael Todsen	DOT	Iowa DOT
Dave Kuniega	DOT	Pennsylvania DOT
Chris Garrell	Industry	National Steel Bridge Alliance
Robert Kogler	Industry	Rampart LLC
Charles Brown	Industry	Greenman-Pedersen, Inc.
Jennifer McConnel	Academia	University of Delaware
Sudhir Palle	Academia	University of Kentucky

During Phase 1, WG4 focused on the following key questions or topics: What data should be collected for steel bridge coatings? What is the vision for how these data will be used? Prioritize the data that was identified.

As a starting point, the WG reviewed existing LTBP data collection protocols and then split the data into two categories, inventory data and field data, related to the LTBP protocol categories of "PRE" and "FLD," respectively. The suggested data items, their priority (1 being the lowest and 5 the highest), and comments from the group are shown in table 15.

Table 15: "Inventory" or "PRE" data identification and prioritization for assessing corrosion protection for structural steel.

Inventory Data Element	How would it be used? Why do we want it?	Priority
Date of coating application.	The age of a coating is fundamental to determining deterio-ration curves. Date, and not year, is important in case the maintenance coating could have been affected by climate on the date of application.	4.9
Climate data • Snow fall. • Freezing days. • Rain fall. • Humidity. • Mean temperature. • Time of wetness.	Climate data both directly and indirectly link to corrosion system performance. For instance, ultraviolet exposure leads to direct deterioration of topcoats. However, below-freezing temperatures and snowfall trigger deicing operation, which can also link to coating system performance. Data can come from National Oceanic and Atmospheric Administration and National Aeronautics and Space Administration's Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2) (National Aeronautics and Space Administration, n.d.).	4.9
Were coatings applied in the shop or field?	Coatings applied in the shop are likely in optimal conditions whereas field-applied coatings are subject to local weather conditions.	4.9
Type of surface preparation.	Surface preparation is fundamental to performance. If the system doesn't stick, then there is bare, exposed steel. This data item could help to address the question of the Society for Protective Coatings (SSPC) Standard Surface Prepara-tion 6 (SP 6) versus SP 10 (SSPC 2007).	4.7

Table 15: "Inventory" or "PRE" data identification and prioritization for assessing corrosion protection for structural steel.		
Initial coating, or a maintenance coating? Maintenance coating could be an overcoat or a full blast and repaint.	Maintenance coatings are generally perceived to perform worse than the initial coatings, and full blast outperforms overcoating. Asking this question will provide needed con-text.	4.6
Type of corrosion protection system: 1-coat, 2-coat, 3-coat, hot-dip galvanized, thermal spray, duplex, unpainted weathering steel.	Each corrosion protection system may deteriorate at differ-ent rates and therefore knowing the type of system is critical information.	4.4
• Coating material type organic zinc, inorganic zinc, epoxy, urethane, fluoropolymer etc. for liquid applied. • Alloy type for thermal spray coating.	This is critical data because all materials will perform differently. There are assumed service lives based on the type of materials used. Historical data could prove or disprove such assumptions.	4.4
National Bridge Elements #515 "Steel Protective Coatings" (Office of Bridges and Structures 2015-2020).	For bridges with element-level data, do the four condition states of Element #515 provide the fidelity we need? This will help guide field activities and inspections. LTBPP also needs to gather the defect data as well.	4.1
Specified thickness of third coat.	Thickness is tied to barrier protection and it may have a relationship to performance.	3.9
Specified thickness of primer/first coat.	Thickness is tied to barrier protection and it may have a relationship to performance.	3.9
Specified thickness of second coat.	Thickness is tied to barrier protection and it may have a relationship to performance.	3.9
Base metal grade.	Knowledge of base metal grade may help to address the various types of unpainted weathering steel that exist and if a performance difference exists. This would also provide more detailed information on whether coating weathering steel yields a performance gain. It would also be beneficial to know if there is substantial usage of low-grade stainless-steel bridges.	3.7
Type of Joint	**How would it be used? Why do we want it?**	**Priority**
Bridge surface drainage characteristics: • Joints. • Scuppers. • Parapet slit drains/ open rail. • Deck overhang.	Keeping the steel dry is fundamental to performance. Knowledge of the bridge surface drainage system may help to address the potential for localized areas of deterioration.	3.7
How was quality enforced? • 100 percent oversight. • Third party at defined hold points. • Final inspection only	The performance of a corrosion protection system is directly correlated with workmanship. Workmanship increases along with inspection. Therefore, an understanding of the level of inspection performed will indirectly indicate the level of workmanship.	3.6
Was a warranty specified? If so, what were the terms?	Warranties are an indirect measure of workmanship when inspection may be minimized. Therefore, knowledge of a specified warranty will indirectly indicate the level of workmanship.	3.1
If applicable, were individual coats striped?	Coating thickness can be reduced at corners/edges from surface tension stress. Stripe coats help build thickness on corners/edges and this practice may lead to enhanced performance.	3.1

Table 16: "Field" or "FLD" data identification and prioritization for assessing corrosion protection for structural steel.		
Field Data Element	**How would it be used? Why do we want it?**	**Priority**
Photos	Standard photos from the same location will help identify changing trends from one inspection cycle to the next. Artificial Intelligence and image recognition could aid to remove subjectivity from visual inspection photos to help calculate percent delamination and rusting. May need more robust photographic documentation protocol to ensure consistent white and color balance.	5.0
Percent rusting per element	This data item represents total failure of the coating system and the beginning of structural capacity deterioration. Note: Unpainted Weathering Steel needs rewording away from "rusting."	4.9
Percent coating delamination	This data item represents partial failure of the coating system. Coating delamination could lead to accelerated deterioration of intermediate and primer coats. This would be a helpful measure for duplex systems, but it is not applicable to unpainted weathering steel.	4.9
Underfeatures (roadway features beneath the bridge) • Road, rail, or waterway. • Underclearance. • Average Daily Traffic/Average Daily Truck Traffic of underfeature.	Underfeatures and their proximity can lead to performance issues, particularly if the underfeature is a high-volume road with application of deicing chemicals. The intent is to record actual conditions in the field of underfeatures and their clearances.	4.7
Measure/monitor deicing chemical application rates	An indirect measure of chloride exposure to the bridge, but easier to correlate to bridge owner records for deicing chemical procurement and application rates. Note: Iowa DOT uses GPS tracking of the salt trucks and real-time application rates. Airports do this too.	4.7
Are maintenance actions like washing, clearing scuppers, joint cleaning regularly performed?	Knowledge of maintenance actions and policies may lead to a better understanding of how these actions can potentially influence performance.	4.4
Bridge joint condition	Bridge deck joint condition can provide context to other data.	4.3
Actual coating thickness • Hot-dip galvanized. • Thermal spray. • Liquid applied.	Knowledge of coating thickness is most important for cathodic coatings (i.e., hot-dip galvanized and thermal spray coatings). Coating thickness measurements can aid in determining deterioration rates prior to steel exposure. Note: Unpainted weathering steel requires measuring the remaining base metal thickness.	4.3
Rust particle size distribution (tape test)	This data item is only applicable to unpainted weathering steel and is used to judge the patina effectiveness in a simple and indirect way. The tape test assesses how much and of what size particles come off the surface with a piece of tape.	4.0
Surface chloride measurements	Amount of chloride on the steel surface affects the deterioration rate of all systems. Note: For unpainted weathering steel this is soluble chloride.	3.9
Real traffic monitoring for under features (average daily traffic, annual average daily traffic, and average daily truck traffic)	The accuracy of the data reported in the National Bridge Inventory can be questionable and more accurate data is needed.	3.9
System cost	From the owner's perspective, system cost would be helpful data to know to make programming or specification decisions.	3.7
Gloss	This data item measures the change in gloss from a prior inspection. Topcoat transition from gloss to dull is indicative of breakdown of topcoat from deterioration.	3.6

Table 16: "Field" or "FLD" data identification and prioritization for assessing corrosion protection for structural steel.		
Corrosivity monitoring	This datum would directly measure corrosion rates of various metals in different parts of a bridge, and far field. This would capture the amplification of corrosion in the microenvironment of the bridge (e.g., over travel lanes, over median, in between girders, on girder fascias) relative to its macroenvironment. These monitoring tests may be American Society of Testing and Materials (ASTM) G92-20 (Standard Practice for Characterization of Atmospheric Test Sites) (ASTM International 2020) or ASTM G116-99(2020)e1 (Standard Practice for Conducting Wire-on-Bolt Test for Atmospheric Galvanic Corrosion) (ASTM International 1999) type of tests.	3.6
X-ray diffraction (XRD) of rust	This data item is only applicable to unpainted weathering steel. Proportion of rust species (goethite, akageneite, lepidocrocite) determine if patina is working or not. Collecting samples would help determine threshold values of chloride and humidity.	3.4
Far-field chloride measurements	Determines atmospheric chloride near the bridge that can be subtracted from surface chloride measurements.	3.4
Color	The purpose is to measure the change in color from the previous inspection. Color change is indicative of topcoat deterioration.	3.1
Adhesion	Adhesion is an indirect indicator of workmanship deficiencies with surface preparation and coating application. Not applicable to unpainted weathering steel.	3.1
Coated witness coupons	Mounting exposure panels on certain parts of the bridge will directly measure deterioration rate for that location and component. Most importantly, workmanship is tightly controlled, and coating properties from time zero are known. These witness coupons would be similar to the National Transportation Product Evaluation Program (AASHTO, n.d.) atmospheric tests, though mounted to a bridge over travel lanes, over medians, and in vertical/horizontal positions.	3.0

During Phase 2 the WG used the data items identified above and addressed the objectives accordingly. The results of their deliberations are reported in table 17.

Table 17: Suggested data collection, data granularity, and quality assurance/quality control for corrosion protection of structural steel assessment.	
Photographic Documentation	• Potentially couple with thermography (to get coating thickness). • Check at a frequency of every 2 yr. • Consider a potential quality control issue with images that would require establishing color, white balance, and lighting requirements. • Examine how images could serve as a benchmark to see when changes occur to trigger hands on inspection of color retention, gloss, maybe thickness. • Concurrently assess percent rusting and percent delamination
Underfeatures	• Underclearance should be measured. Light detecting and ranging (LiDAR) would be most effective because no maintenance of traffic would be required to collect data. Manual measurements would be required for features that are not roads. • Measurements should be made to the nearest 3 inches. • Check at a frequency of every 10 yr. • Type of route and speed limit need to be obtained.
Deicing	• Focus effort on the owners that have salt truck tracking of location and application rates. • Determine if adjustment in frequency is needed to smooth out data over 5-yr periods. • Track the type of chloride (solid vs. liquid) and sodium chloride/calcium chloride/magnesium chloride (NaCl/CaCl2/MgCl2).
Rust Particle Size	• Six samples at each of the following locations: o Over roadway. o Away from roadway. o Girder flange and girder web.

Table 17: Suggested data collection, data granularity, and quality assurance/quality control for corrosion protection of structural steel assessment.	
Performance of Maintenance Actions	• Can potentially be obtained through direct inquiry to States. • Frequency—could be collected annually for just the bridges of interest. • Need to document the procedures (e.g., temperature and pressure of water for washing). • In terms of quality assurance and quality control all that could be done is to field verify identified maintenance actions.
Bridge Joint Condition	• Rely on WG3 for how to collect the data. • Check at a frequency of every 2 yr. • Defer to WG3 for quality assurance and quality control. • Most interested if the joint is leaking or not as if affects coating performance.
Coating Thickness	• Would need to develop a viable thermographic technique to see if it could be performed with UAS. • Mostly applicable to just thermal spray coatings and hot-dip galvanized coatings. • Check at a frequency of every 5 yr. • Total thickness of liquid applied coating probably not of interest, beyond initial reading. If possible, assessment of liquid-applied topcoats erosion may have value. • For point measurement, use SSPC Paint Application (PA) 2 (SSPC 2018) for number of readings and averaging, consider future scanning dry film thickness measurement. • Near open joints, over traffic, and a lower stressed area. Do fascia and first interior girder, on girder flange and girder web. • Focus on areas no larger than 1 ft2 that can be located easily in subsequent inspection cycles so thickness is assessed in the same area.
Element # 515	• This data item would require assessing Element #515 condition states AND defects. • Check at a frequency of every 2 yr. • Would ensure assessment of fascia girder and first interior girder at a minimum. Expand to whole bridge depending on time/cost. • Back check to state national Bridge Element #515 for quality assurance/quality control purposes.
Surface Chloride	• Don't consider pursuing. • As an alternative, consider the silver strip method instead.
Real Traffic Monitoring	• Can be obtained from other sources. • Query from the FHWA Performance Monitoring System (HPMS) (Office of Highway Policy Information, n.d.) or directly from States. • Check every year. • Try to attain average annual daily traffic and average annual daily truck traffic (annual averages, not daily measurements). • If traffic is low volume (local road, minor collector), LTBP may have to monitor independently. • Query annually, or consistent with HPMS updates.
Corrosivity Monitoring	• Could be combined with surface chloride measurements. • Over roadways, under joints, and a benign area of the bridge. • Check every 1, 2, 4, 8, and 16 yr. • Categorize with "far-field chloride measurements" and "coated witness panels."
Gloss	• Captured with photographic documentation. • Only measure on the facia girders.
XRD of Rust	• For unpainted weathering steel. • Four samples in current work seems to provide the needed fidelity. • Over roadways, under joints, and a benign area of the bridge. • Frequency—every 2 yr.
Coated Witness Panels	• This type of witness panel monitoring is categorized with corrosivity monitoring. • Would be very challenging to pick the systems because there are so many options.

The WG also provided additional noteworthy input as a result of their deliberations. It was noted that there were commonalities among all the WGs. For example, all WGs are likely to be affected by traffic volume, climate data, deicing chemical usage, but for WG4 it is critical to obtain traffic data and deicing chemical use on the underfeatures. Additionally, climate data would have to be extended to also include higher temperature metrics, humidity, and UV exposure. The WG suggested that LTBP PRE and FLD protocols be amended for girder-level data collection as there is typically a different corrosion protection scheme for facia and interior girders that the current protocols do not capture. The WG also suggested that bridges subject to deicing and marine environments should be prioritized for inclusion in LTBP data collection efforts. Other less-severe environments would also be important for comparison.

Summary of Outcomes for WG5—Pretensioned and Post-Tensioned Strands

The roster for WG5 is shown in table 18 along with the chair, co-chair, and FHWA staff that took part in the WG deliberations.

Chair: Alexander Bardow—Massachusetts DOT

Co-Chair: John Popovics—University of Illinois at Urbana-Champaign

FHWA Staff: Reggie Holt, Shri Bhide

Table 18: WG5 participants.

Name	Category	Affiliation
Bijan Khaleghi	DOT	Washington DOT
Sam Fallaha	DOT	Florida DOT
Anthony Mizomuri	DOT	Washington DOT
David Whitmore	Industry	Vector Corrosion Technologies
William Nickas	Industry	Precast/Prestressed Concrete Institute
Ozzie Bayrak	Academia	University of Texas at Austin

During Phase 1, the Pretensioned and Post-Tensioned Strands WG met to identify appropriate performance data for both pretensioned and post-tensioned strands. The identified data was categorized as to what data is common to both pretensioned and post-tensioned bridges, and what is specific to each. Following the data identification during Phase 1, the WG spent much of the time during Phase 2 discussing specifics pertaining to the collection of such data and the results are reported in this report.

Table 19: Data identification and prioritization for pretensioned and post-tensioned strand assessment

Concrete Crack and Spall Count	Data collected as part of routine inspection (biennial) condition surveys. Currently visual but use of high-resolution photos/videos (enabling future machine learning algorithms to be applied) and crack comparators are encouraged across entire structure. With these data it is important for inspector/engineer to understand and document the significance of the location of the damage; whether cracks are active or stable; the underlying cause/source of the damage; and the resulting underlying load paths in the structure.
Chloride Ingress/ Content in Concrete	Data (for research purposes) collected as part of regular (biennial) condition surveys using standard minimally invasive sampling for chemical tests. Data (for operational purposes) collected less frequently (5–10 yr, based on owner's judgement). Test data collected at only few representative locations in the structure, and especially near bridge/deck joints and marine exposure regions. The best chloride analysis methods (water soluble vs. acid soluble, absolute content vs. chloride-hydroxide ratio, etc.) are still up for debate at this time, so all raw chemical data should be collected.
Section Loss of Strand	Direct measurement of strand/tendon cross-sectional loss should be carried out whenever that strand/tendon is made directly accessible, for example because of spalling of concrete or excavation/access at select locations for other reasons. Where possible, regular continued monitoring should be carried out at those locations to establish accumulated damage over time. Frequency should be established based on severity of conditions, such as annually or biennially.

Table 19: Data identification and prioritization for pretensioned and post-tensioned strand assessment	
Corrosion Half-Cell Potential	Data (for research purposes) collected as part of regular (biennial) condition surveys using standard minimally invasive sampling for chemical tests. Data (for operational purposes) collected less frequently (5–10 yr, based on owner's judgement). Tests should be collected only from a few representative strands in the structure, and especially near bridge/deck joints and marine exposure regions. The same strands should be tested in subsequent evaluations to establish baseline behavior and trends.
Internal Moisture in Tendon Ducts	Tests require a small, minimally invasive drill hole into duct, and an air sample extracted to get RH and moisture level of air; duct is then sealed. The test is appropriate for both internal and external ducts and all duct materials. These data should start being collected regularly, starting at birth and/or then regularly thereafter at low frequency (10 yr). Test collected only from one or a few representative ducts in the structure (for in-service bridges, testing should focus on representative ducts in problematic areas) at one single representative location for each duct.
Duct Grouting Condition	Nondestructive test (shear wave tomography" impact-echo, ultrasonic pulse velocity, or combinations of these methods) data should start being collected regularly on a reasonable subsample of ducts, either at birth or one time in the structure's life. Data should be collected only from a few representative/critical ducts in the structure (for in-service bridges, testing should focus on representative ducts in problematic areas) with data collected along the entire duct length at test location intervals of 0.5 ft to 2 ft.w

In addition to the above suggestions for data collection needs, WG5 provided suggestions on topics that could be addressed within research needs statements that would be beneficial to LTBP efforts with respect to this WG. These suggested research topics are summarized as follows in no specific order of priority:

- Develop a means of "inspectability" (e.g., access ports) that can be incorporated into the design of pretensioned and post-tensioned structures, following recommendations in the document Designing and Detailing Post-Tensioned Bridges to Accommodate Nondestructive Evaluation (Office of Bridges and Structures 2018).
- Develop a means to determine strand/tendon section loss in hidden locations using NDT.
- Develop a means to determine stress or strain condition in strands in situ using NDT (some emerging monitoring technology, e.g. fiber optic, already exists).
- Characterize chloride content in concrete using NDT.
- Develop of completely noninvasive means to collect corrosion data from structures (some emerging technology already exists).

SUMMARY

The LTBP Data Collection Workshop was conducted to receive input from bridge community SMEs to assist FHWA in assessing the LTBP Program's future data collection approach. Each of the five WGs, which consisted of SMEs from State highway departments, industry, academia, and FHWA, provided input during their deliberations as described in this report. A great deal of information was gleaned from the five WGs. Commonalities for certain data were found between various WGs such as climate data, joint condition data (WG3 and WG4), and others as reported. Analysis of the input received from each of the five WGs, in addition to lessons learned from past LTBP data collection efforts, resulted in developing two overall data collection strategies.

The first strategy identified can be termed as a "desk audit" type of data collection. The collection of design and construction data, for instance, would fall into this category. Obtaining the documentation (bridge plans and specifications) from which design and construction data is extracted can be accomplished in an office environment and through various forms of communication. The second strategy identified involves collection of physical and visual data from bridges in the field. Typical examples of field data include various nondestructive and destructive techniques, visual assessment of physical elements, and other physical measurements.

Data collection requires extensive resources and a strategy to collect data to study the long-term performance of bridges. Such a strategy should not consist of gathering all desired data at any cost. It is imperative to determine the value of any data and how that data can be used when developing the LTBP's future data collection approach. The LTBP Program is currently working on executing two studies to assess the overall value of already-collected data, namely data collected through an ongoing accelerated testing experiment and data available through earlier LTBP data collection efforts, to help guide the path forward.

Note that a substantial amount of information was identified that may not fall within the breadth and scope of what the LTBP Program is able to support. However, other entities such as AASHTO, State highway agencies, bridge preservation partnerships, and others may find the information useful in their respective data collection efforts and while pursuing research targeted at understanding and improving the performance of bridges.

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