Long-Term Bridge Performance (LTBP) Program Protocols, Version 1

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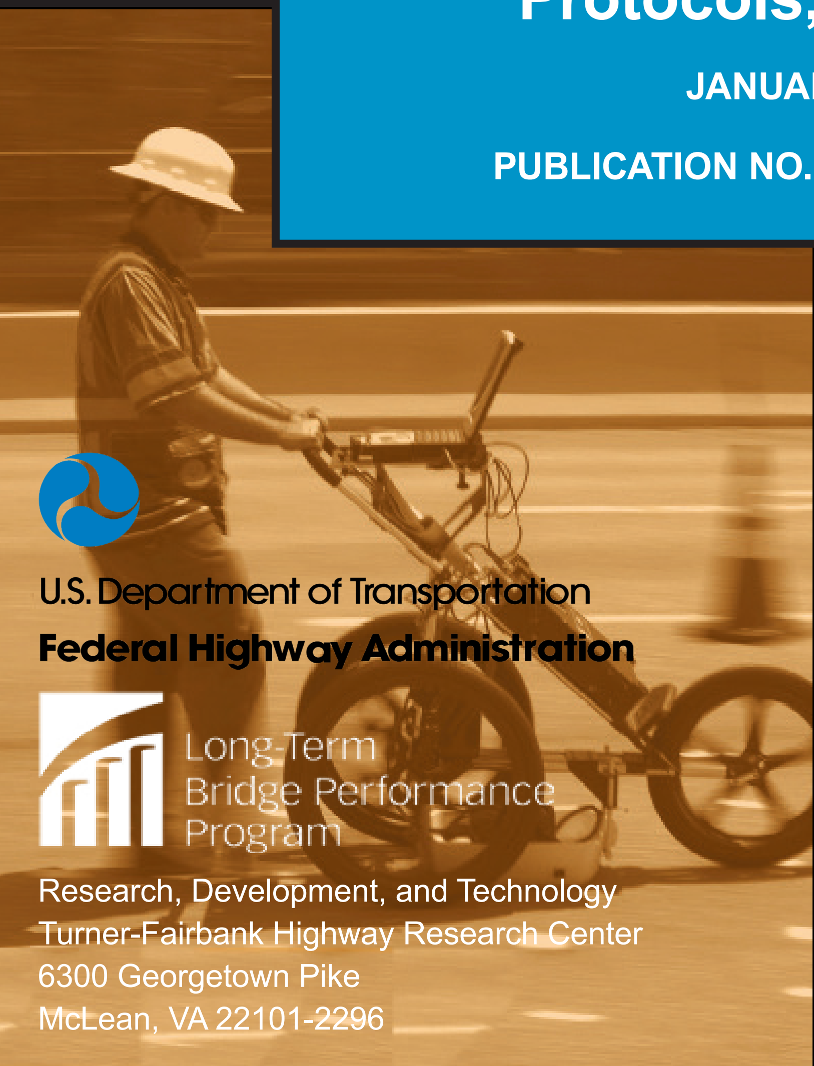

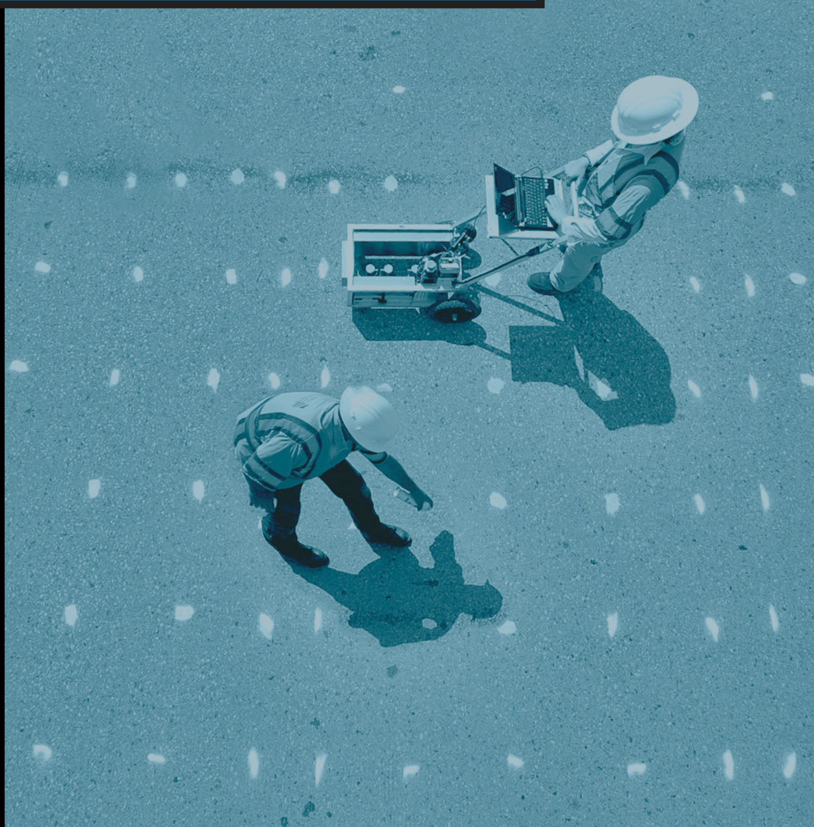

U.S. Department of Transportation

Federal Highway Administration

Long-Term Bridge Performance Program

Research, Development, and Technology
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FOREWORD

This study was conducted as part of the Federal Highway Administration's Long-Term Bridge Performance (LTBP) Program. The LTBP Program is a long-term research effort, authorized by the U.S. Congress under SAFETEA-LU, the "Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users," to collect high-quality bridge data from a representative sample of highway bridges nationwide that will help the bridge community to better understand bridge performance. The products from this program will be a suite of data-driven tools, including predictive and forecasting models that will enhance the ability of bridge owners to optimize their management of bridges.

In order to ensure that LTBP Program data are collected in a consistent manner over the duration of the program, data collection protocols are being developed for use by LTBP researchers. This report presents 51 protocols that will be used throughout the LTBP Program for data collection, mining of bridge legacy data, visual inspection, sampling and testing of concrete materials, and nondestructive evaluation of bridges, as well as data management and storage. Future versions will present additional protocols that will be implemented in the LTBP Program studies as well as any modifications deemed necessary to the 51 protocols herein. This report will be of interest to practitioners, researchers, and decision makers involved with the research, design, construction, inspection, maintenance, and management of bridges.

Jorge E. Pagán-Ortiz
Director, Office of Infrastructure
Research and Development

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16. Abstract

The Long-Term Bridge Performance (LTBP) Program is a long-term research effort to collect scientific performance data from a representative sample of bridges in the United States. Data will be collected for in-service bridges using a variety of techniques. These data will be supplemented with legacy data from design plans, design and construction specifications, as-built plans and construction records, inspection and maintenance records, weather records, and traffic data. To maintain consistency in the manner in which data are collected and stored, a set of protocols has been developed. These protocols provide guidance on what kinds of information to obtain from existing bridge records and how each field testing activity is to be conducted; how to identify and classify the defects and how to measure their extent; and how to document the location and severity of the defect in the bridge element being evaluated. The protocols also specify the accuracy to which defect measurements are to be recorded. This report presents protocols for the collection and mining of legacy data, site preparation, visual inspection, sampling and testing of materials, nondestructive evaluation, and data storage and management. Future versions of this report will include additional protocols covering other activities, data collection methods, and analysis and reporting protocols for the LTBP Program.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

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

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LIST OF ACRONYMS AND ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ABC	Accelerated bridge construction
ABET	Accreditation Board for Engineering and Technology
ASR	Alkali-silica reaction
ASTM	American Society of Testing and Materials
BIRM	Bridge Inspectors Reference Manual
BLOB	Binary large object
CIP	Cast-in-place
CSE	Copper sulfate electrode
DEF	Delayed ettringite formation
DMI	Distance measuring instrument
FHWA	Federal Highway Administration
HCP	Half-cell potential
HDR	High-dynamic range
IE	Impact echo
LPR	Linear polarization resistance
LTBP	Long-Term Bridge Performance
MPT	Maintenance and Protection of Traffic
NBIS	National Bridge Inspection Standards
NDE	Nondestructive evaluation
NICET	National Institute for Certification in Engineering Technologies
OSHA	Occupational Safety and Health Administration
PPE	Personal protection equipment
SSD	Saturated-surface-dry
TSA	Thaumasite sulfate attack
USW	Ultrasonic surface wave
UT	Ultrasonic testing
w/c	Water-cement (ratio)

Units of measure used in this report:

dB	Decibels
Hz	Hertz
kips	1,000 lb
kΩ/inch	Kilo-Ohm per inch
psi	Pounds per square inch
ksi	Kips per square inch
ns	Nanosecond
$\mu A/cm^2$	MicroAmps per centimeter square
mA	MilliAmp
mV	MilliVolt
pcf	Pounds per cubic ft
USD	U.S. dollar
V	Volt

CHAPTER 1. INTRODUCTION

The Long-Term Bridge Performance (LTBP) Program is a long-term research effort, during which a large amount of data on bridge condition and bridge performance will be collected for different groups of bridges across the United States. The activities of the LTBP Program will concentrate on the types of bridges most heavily represented in the U.S. bridge population. Although the population of U.S. bridges is diverse, there are a few common bridge types that predominate and are likely to do so in the future. For example, multigirder bridges of steel, concrete, or prestressed concrete represent the most common bridge types, and focusing on their performance enables the LTBP Program to make the largest impact in the near- and mid-terms.

The specific data to be collected will support experiments designed to study various issues related to bridge performance for these common bridge types. Depending on the specific experiment, data will be collected using a combination of document review, detailed visual inspection, sampling and testing of materials, nondestructive evaluation (NDE) testing, finite element modeling, structural testing, and long-term monitoring. These data collection efforts are designed to allow a series of guiding questions to be answered from existing documentation, if possible, and from field data collection efforts if necessary.

At the program level, guiding questions were developed via consultations with key program stakeholders who helped identify several high-priority bridge performance issues.(1) The LTBP Program aims to address these guiding questions. However, on a per-bridge level, additional, more specific, guiding questions will be developed prior to data collection considering what is learned during the previsit activities.

To maximize the quality and usefulness of the data, it is imperative that evaluations, data collection, testing, and reporting be implemented in a consistent manner regardless of where, when, and by whom they are conducted. To meet this need, the data collection processes, the units of measure, and the level of accuracy should be as consistent as possible. Therefore, a set of protocols that support the objectives of the LTBP Program have been developed. These protocols provide a set of step-by-step instructions governing all aspects of data collection, including planning, designing experiments, gathering bridge documentation from State transportation departments, extracting data, visual inspection, material testing, NDE testing, live load testing, instrumentation, logistics, safety, data reduction and processing, data interpretation, reporting results, data storage, archiving, and importing into the LTBP Program Bridge Portal.

The LTBP Program protocols are for research purposes and intended primarily for use within the LTBP Program. The protocols have the following attributes:

- Quantitative in nature and avoid vague statements that may permit multiple interpretations.
- Mandatory language without unnecessary commentary that may cause confusion.
- Integrated through a robust structure that permits cross-referencing to avoid repetition.
- Reference existing and proven standards without repeating content, which would likely result in conflicts over time as the existing standards are updated.

CHAPTER 2. ORGANIZATION AND DESIGNATIONS OF THE LTBP PROGRAM PROTOCOLS

The LTBP Program protocols are organized into a hierarchy based on the chronology of a data collection effort for a single bridge: before a field visit, during a field visit, and after a field visit. This simple chronology was selected to make finding the required protocols intuitive for end users. The first three levels of the proposed hierarchy are shown in figure 1.

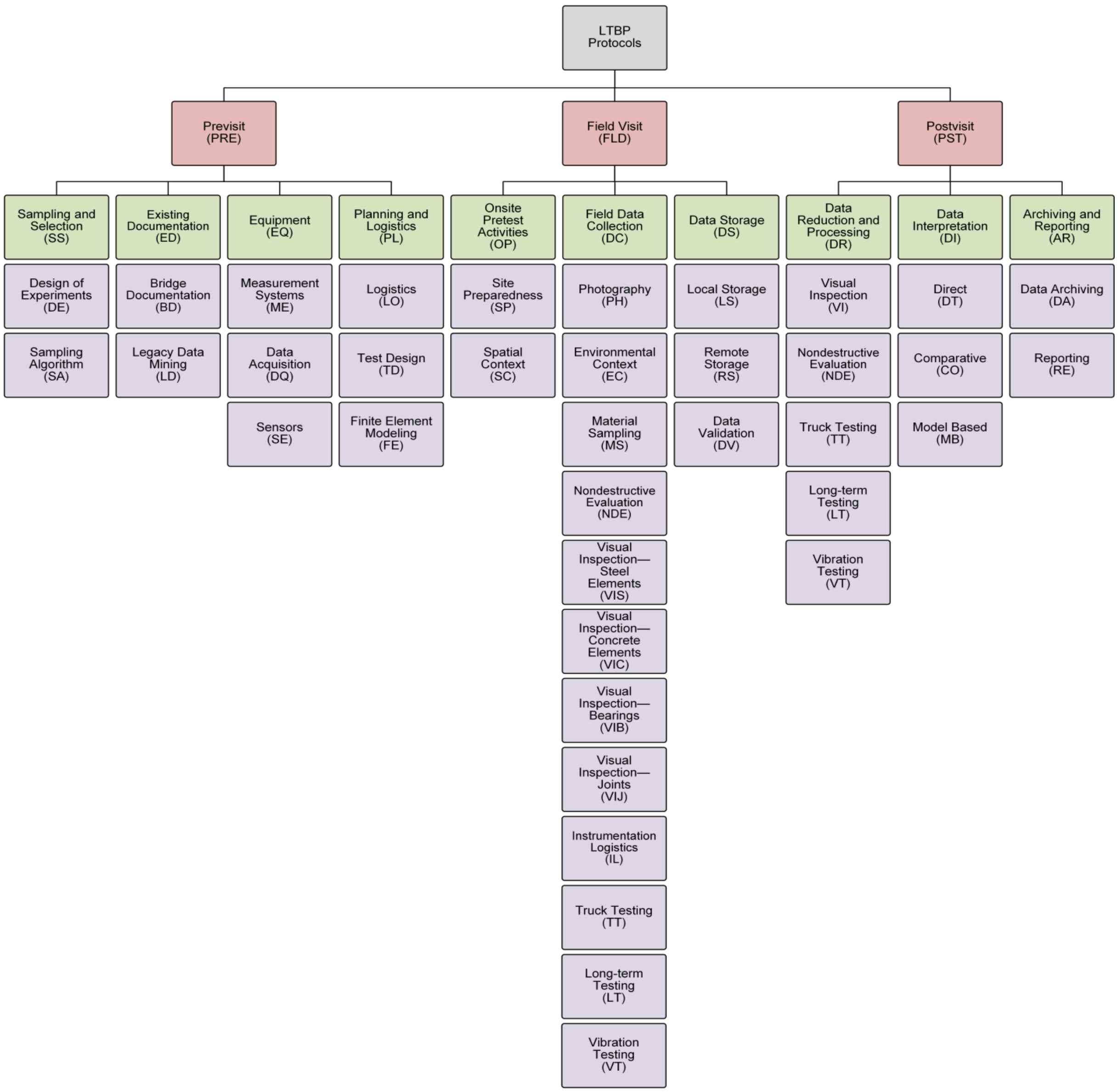

Figure 1. Illustration. LTBP Program Protocol Hierarchy.

The individual protocols that fall under each of the third-level groups are not shown for brevity. Following are brief descriptions of the primary and secondary levels and the kinds of protocols contained in the various groups.

This first version of the LTBP Protocols report includes some or all of the protocols intended for some of the groups shown in figure 1. Subsequent versions of the report will include protocols added, moved, or deleted to meet the needs of the LTBP Program.

PREVISIT PROTOCOLS (PRE)

The PRE protocols focus on preparations and actions that occur prior to collecting data at the bridge. This group includes protocols that provide guidance on bridge selection; obtaining existing bridge documentation from State departments of transportation and extracting the data; and preliminary planning and logistics for facilitating a safe and successful field data collection effort. The PRE protocols, such as those for traffic safety and personal safety equipment, are typical across multiple types of data collection. In other cases, information that varies between protocols, but is a common requirement, is collated in the previsit protocols. An example would be any personnel certification or experience requirements collected into a single protocol to facilitate updates in the future.

Sampling and Selection (SS)

The FHWA team is responsible for bridge selection and sampling, so these protocols are included as information resources for the persons responsible for data collection. This permits the team to understand the full process and ensures that, should the program expand and more bridges need to be selected, the knowledge is preserved, and the methods used for bridge selection can be repeated exactly.

Existing Documentation (ED)

The ED protocols address the information to be collected from bridge owners, dating back to the design and construction of the bridge, including data related to inspections, maintenance, and cost (when available). The ED protocol group also includes protocols detailing the execution of legacy data mining for specific performance issues—that is, identifying how the data can be used both before and after field testing to draw conclusions about a structure's performance and the factors that have influenced it. Field data collection will not occur for all bridges selected for participation in the LTBP Program, and data collection efforts will stop after legacy data mining is completed.

Equipment (EQ)

The EQ protocols cover equipment related to structural testing. Generally speaking, the EQ protocols include sensors and data acquisition systems, which are described in an overview protocol. There are specific protocols related to each type of structural testing, including truck testing, long-term monitoring, and vibration testing. The primary sensor types are described based on the measurement they are designed to collect, as opposed to specific sensor brands or types. The information in the EQ protocols is general in nature, and the information is not specific to brand or manufacturer.

Preliminary Planning and Logistics (PL)

The protocols in this group cover all aspects of preparation for a field data collection effort, from personnel safety to the processes for maintenance and protection of traffic and site-specific requirements. The PL protocols address equipment-related issues such as sensor calibration and maintenance requirements. For each data collection type, a general test planning protocol is included that covers test-specific requirements, general field requirements, and heuristic-based advice needed to achieve successful field data collection. Protocols providing guidance on developing and using representative models are also included.

FIELD VISIT PROTOCOLS (FLD)

The FLD protocols focus on the collection of research-quality data in a consistent manner to facilitate comparative analysis across structures and with time. While the protocols in this report address collecting both data and metadata for visual inspection, material testing, NDE testing, logistics and safety, and data storage, future versions of the LTBP Program's protocols report will cover live load testing, short- and long-term monitoring, weigh-in-motion techniques, instrumentation, and importing the data into the LTBP Bridge Portal.

Onsite Pretest Activities (OP)

This group of protocols provides guidance on segmenting, identifying, and labeling the various elements of a bridge so that the recorded findings of the field assessment and testing activities may be tied to specific elements and locations on the bridge. A convention for creating unique alphanumeric element identifiers for the various parts of the bridge is prescribed. In order to allow for the precise size and location of findings, a 2- by 2-ft grid with a defined origin is defined on the deck surface and local origins are described for the common elements of the bridge, such as girders, pier caps, and abutments.

Field Data Collection (DC)

The DC protocols make up the main portion of the protocols and cover data collection at the bridge. Methods of data collection included in this report are visual inspection, material sampling, and manual NDE testing. These protocols provide clear, step-by-step instructions for data collection, and comprehensive references for all standards cited in the protocols. The DC protocol group also includes protocols for documenting weather and traffic information during actual data collection, image capture (both still photography and videos), and names of the evaluators.

Data Storage (DS)

The DS protocols address the proper storage of raw data immediately after collection to ensure no repeat field efforts are required and that no data are lost. The critical timeframe covered by these data storage protocols spans between data collection and uploading to the LTBP Bridge Portal. The DS protocols also make provisions for loss of data by storing a second copy of the data at a remote location.

POSTVISIT PROTOCOLS (PST)

Protocols in the PST group focus on actions taken after the data are collected at the bridge and how the collected data are used to draw conclusions. These protocols include immediate data reduction, data validation, data interpretation, fusion and visualization of disparate of data, reporting data, and archiving integrated data into the LTBP Bridge Portal. PST protocols will be published in a later version of this report.

Data Reduction and Processing (DR)

Raw data, particularly quantitative data from structural testing or NDE, generally require error screening, postprocessing, and data reduction. Analogous protocols for material sampling and visual inspection are included as well. Consistency between data reduction and processing methods is critical to ensure comparisons of information from different modalities of data collection are reliable.

Data Interpretation (DI)

Data can be interpreted in many ways, including directly, comparatively, and through a model. The DI protocols identify the data interpretation methods and provide the steps to be taken to evaluate and interpret the data and metadata. The DI protocols also identify the relationships between data interpretation methods.

Archiving and Reporting (AR)

The AR group of protocols focuses on consistency in reporting results as well as formatting data and metadata for inclusion in the Bridge Portal. Future protocols will address archiving the data and metadata.

PROTOCOL NAMING CONVENTION

The following LTBP Program protocol naming convention was adopted to allow easy identification and future expansion:

XXX-YY-ZZ[Z]-###

where:

XXX = Stage of data collection (PRE, FLD, or PST).

YY = Subcategory under the stage describing the research activity or focus (e.g., ED = Existing Documentation).

ZZ[Z] = Identifier to distinguish further between data collection methods; note some protocols may have a third letter identifier.

= Number assigned sequentially from 001 to 999.

CHAPTER 3. HOW TO USE THE LTBP PROGRAM PROTOCOLS

The LTBP Program protocols are written to be implemented by various end users. The typical use case coincides with the simple chronology of the protocol hierarchy, beginning with the previsit activities; followed by the field assessment, testing, and data collection; and finally the postvisit data management. As an example, consider the following use case:

The person responsible for planning and logistics uses the PRE protocols to ensure that all requisite data from the bridge owner have been collected. From this data, the user extracts the critical physical attributes of the structure and conceptualizes what the onsite situation will be. If possible, the user will conduct a brief site visit to address any logistical concerns he or she may have based on documentation. Based on the site visit, the user will create a schedule for onsite data collection, encompassing the design of any structural testing, the intended distribution of material sampling locations, and the logistics required to conduct these investigative activities, as well as visual inspection and NDE in a timely, safe, and efficient fashion. These planning activities are some of the most important tasks in the LTBP Program, and without exception, are a task that requires clear, concise guidance from the protocols, as well as experienced, knowledgeable staff who can interpret and apply the protocols properly in many situations.

The field data collection effort is completed by as many users as required to amass the appropriate skillsets. The users perform various data collection tasks as described by the field data collection protocols. The person (or persons) responsible for data collection needs the required certifications described in the previsit protocols and a working knowledge of the types of data collection efforts they are leading. The protocols provide a uniform set of guidelines, decisions, and consistent references to other resources to guide the personnel performing data collection. These activities are overseen by the person who designed the data collection effort, who remains responsible for ensuring the protocols are enacted properly and the data are appropriately stored.

The final step of the process involves processing, interpreting, reporting, and archiving the collected data. Note that while the protocols will provide information and guidance in a clear and repeatable manner, this portion of the process has an element of creativity to it. To some extent, this is true for all phases of a data collection effort, which is why identifying appropriate personnel is critical.

CHAPTER 4. LTBP PROGRAM PROTOCOL CONTENT

PROTOCOL SECTIONS

Each of the LTBP Program protocols is organized into the following sections to provide information related to the data collection method being described:

Data Collected: Includes the bridge characteristic, condition, or defect about which data are to be collected, if applicable.

Onsite Equipment and Personnel Requirements: Lists equipment to be used in the data collection. The requirements also include references to safety and personnel qualification requirements.

Methodology: Describes how tests are to be conducted for the purposes of the LTBP Program, with references to the American Association of State Highway and Transportation Officials (AASHTO) and/or the American Society of Testing and Materials (ASTM) specifications, as appropriate. The methodology also gives a detailed description of how to take measurements of defects.

Data Collection Table: Guides what data and how the data have to be reported, with a key defining fields and colors. See Row Color Key for further details.

Criteria for Data Validation: Provides methods for determining if the data being collected are valid; this can vary based on the type of data being collected and the method of data collection.

Commentary/Background: Includes the following, as appropriate:

- A brief discussion of the purpose of the protocol.
- A brief description of the process leading to the condition being evaluated.
- The principle behind the data collection.
- Supplementary notes explaining the data collection process.
- Definitions of some terms or processes.
- Other general notes.

References: Refers to certain overarching protocols to keep data collection consistent and may also include references to external sources, such as AASHTO, ASTM, or FHWA standards.

Unless it is necessary for LTBP Program research purposes, the protocols for visual, hands-on evaluation of bridge elements are consistent with the bridge inspection guidance in the latest version of FHWA's Bridge Inspector Reference Manual (BIRM) dated 2012. Unless otherwise defined in the text of the protocols, the bridge terminology used in the LTBP Program protocols for visual inspection is consistent with the definitions in the glossary to BIRM 2012.

TYPICAL LTBP PROGRAM PROTOCOL DATA COLLECTION TABLE

Each LTBP Program protocol contains a table describing the manner in which data are to be collected. Table 1 illustrates the format of the LTBP Program data collection tables. Table 2 defines the types of information contained in each column and the colors of each row.

Table 1. Sample LTBP Program Protocol Data Collection Table.

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
1	State	Text			State Code; e.g., Virginia = VA	Green
2	NBI structure number	Text			Item 8, structure number; from NBI Coding Guide	Green
3	Structure name	Text			Descriptive name for the bridge; e.g., Route 15 SB over I–66	Green
4	Protocol name	Text			Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text			First name(s) Last name(s)	Green
7	Date data were collected	Text	Exact date		mm/dd/yyyy	Green
8	Location of defect: unique element identifier	Text			Record the unique element identifier of the element being evaluated for defects (for example, deck, abutment A, girder 2B, etc.)	Blue
9	Location of defect: element	Text			Describe the location of the defect on the bridge element (e.g., span number, lane number, shoulder, substructure unit, backwall of abutment, web of prestressed concrete girder, etc.)	Blue
10	Type of defect	Predefined list			Crack Spall Delaminations Other (specify in the comments)	Blue
11	Defect location 1	Number	1	in.	For example: *x*-coordinate of a point on the defect	Yellow
12	Defect location 2	Number	1	in.	For example: *y*-coordinate of a point on the defect	Yellow
13	Defect measurement 1	Number	0.5	in.	For example: length of the defect	Yellow
14	Defect measurement 1	Number	0.1	in.	For example: width of the defect	Yellow
15	Defect measurement 1	Number	0.1	in.	For example: depth of the defect	Yellow
16	Defect photos	BLOB			If defects are present, document typical defects with photos and/or sketches	Yellow
17	Comments	Text				Orange

Table 2. LTBP Program Protocol Data Collection Table Key.

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, predefined list, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data or list of items in a predefined list
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

In table 1, the green items serve to identify the bridge being evaluated, the protocol being followed, the person(s) conducting the tests and collecting the data, and the date of the evaluation (or data collection). The items shaded in blue provide information on the element of the bridge where the test is being performed and/or the distinct defect being measured and recorded. The items shaded in yellow are the data items being collected for each element/defect listed. During a typical assessment, on a bridge with multiples of the same element (such as a bridge with six girders), data items in yellow will be recorded in sequence and then the sequence repeated for each individual element or distinct defect until all elements have been evaluated under the relevant protocol. The orange row provides space for any relevant comments the researchers deem necessary to support the data being collected.

DATA IMPORT

While each research team investigating LTBP Program bridges may use different tools to collect the data (such as collecting the data manually or via computer), all teams must provide data for import to the LTBP Program Bridge Portal in an identical format.

CHAPTER 5. PROTOCOL DEVELOPMENT AND PUBLICATION PLAN

The LTBP protocols are intended to be living documents, growing as the program progresses. The framework hierarchy presented allows for this growth. The publication of the protocols will be in stages. Though the exact frequency of issuing additional versions is not yet established, the LTBP Program will issue periodic updates, which will include additional protocols and changes to previously published protocols. When possible, between major releases, additions and changes will be posted on the LTBP Web site.

The first publication covers the following subject areas (table 3):

- Bridge documentation.
- Legacy data mining.
- Planning and logistics.
- Onsite pretest activities.
- Spatial context.
- Photography.
- Material sampling.
- Nondestructive evaluation.
- Visual inspection.
- Data storage.

Table 3. Index of Version 1 LTBP Program Protocols.

Primary Group	Secondary Group	Tertiary Group	#	Protocol Name
PRE	**ED** (Existing Documentation)	**BD** (Bridge Documentation)	001	Plans and Specifications for Bridge Design and Construction
			002	Bridge Construction Records
			003	Bridge Design and Construction Cost Data
			004	Bridge Site Conditions
			005	Bridge Inspection Records
			006	Bridge Maintenance Records and Cost Data
			007	Calculations of Bridge Ratings
		LD (Legacy Data Mining)	001	Legacy Data Mining for Untreated Bridge Decks
	PL (Preliminary Planning and Logistics)	**LO** (Logistics)	001	Reference Bridge Testing
			002	Cluster Bridge Testing
			003	Traffic Control, Maintenance and Protection of Traffic (MPT), and Permits
			004	Personal Health and Safety Plan
			005	Personnel Qualifications
			006	Power and Network Requirements
			007	Communication and Coordination Plan

Primary Group	Secondary Group	Tertiary Group	#	Protocol Name
FLD	**OP** (Onsite Pretest Activities)	**SP** (Site Preparedness)	001	Site Preparation
		SC (Spatial Context)	001	Data Collection Grid and Coordinate System for Bridge Decks
			002	Structure Segmentation and Element Identification System
			003	Determination of Local Origins for Elements
	DC (Field Data Collection)	**PH** (Photography)	001	Photography Equipment Requirements
			002	Photographing for Documentation Purposes
			003	Image Naming
		MS (Material Sampling)	001	Wet Coring of Concrete Decks
			002	Compressive Strength and Static and Dynamic Elastic Moduli of Concrete Cores
			003	Resistance of Concrete to Chloride Ion Penetration (Permeability)
			004	Sampling and Testing for Chloride Profiles
		NDE (Nondestructive Evaluation)	001	Electrical Resistivity Testing
			002	Ground Penetrating Radar Testing for Bridge Decks
			003	Half-Cell Potential Testing
			004	Impact Echo Testing
			005	Linear Polarization Resistance Testing
			006	Dye Penetrant Testing
			007	Ultrasonic Surface Wave Testing—Concrete
			008	Ultrasonic Testing—Steel Fatigue Cracking
		VIS (Visual Inspection—Steel Elements)	001	Steel Superstructure Deterioration
			002	Steel Superstructure—Corrosion
			003	Steel Superstructure—Section Loss
			004	Steel Superstructure—Cracking, Deflection, Uplift, Distortion, Buckling, Rotation, and Impact Damage
		VIC (Visual Inspection—Concrete Bridge Elements)	001	Concrete Deterioration
			002	Concrete Substructure Condition Assessment
			003	Concrete Deck—Spalls and Delamination
			004	Concrete Superstructure and Substructure—Spalls and Delamination
			005	Concrete—Cracking
			006	Concrete—Abrasion
			007	Concrete—Sulfate Attack
		VIB (Visual Inspection—Bearings)	001	Elastomeric Bearings
			002	Rocker Bearings
		VIJ (Visual Inspection—Joints)	001	Drainage System on Bridge Decks and Approach Slabs
			002	Expansion Joints
	DS (Data Storage)	**LS** (Local Storage)	001	Data, Document, and Image Storage—Local
		RS (Remote Storage)	001	Data, Document, and Image Storage—Remote

Future versions of this report will cover the following topics, but may not be limited to these additions:

- Finite element modeling.
- Automated NDE.
- Instrumentation (sensors).
- Data acquisition systems.
- Structural testing.
- Structural monitoring.
- Data reduction, processing, and analysis.

SUMMARY

The bridges studied in the LTBP Program will undergo an initial round of evaluation, testing, and material characterization to establish baseline knowledge of the bridges' condition and behavior. Over time, these bridges will be reevaluated and retested, and the changes in values of the data collected will be used to document and analyze various aspects of the performance of bridges.

The overarching goal of the protocols is to ensure LTBP data are collected using scientifically sound methods that are applied uniformly regardless of when, where, or by whom the data are collected and then to ensure that the data collected are reduced and accessible within the LTBP Program Bridge Portal where it can be confidently used by LTBP Program researchers and others for years to come to better understand bridge performance. Given this, the protocols are more than a document that provides instructions for implementing various data collection techniques in a consistent manner. The LTBP Program protocols represent a comprehensive and continuous documentation of the entire LTBP Program, from selecting a structure, through onsite data collection, and ultimately answering the guiding questions associated with the top performance issues identified by the stakeholders.

This report includes the first version of the LTBP Program protocols for documentation of legacy data, onsite pretest activities, visual inspection, sampling and testing of concrete materials, nondestructive testing of bridge elements, and data storage. As the program proceeds, additional protocols will be developed to cover other activities necessary for data collection, management, processing, and analysis. Also, as the LTBP Program goes forward, experience may lead to improvements in the way the protocols are written and applied. Proper care will be taken to ensure that future changes in the protocols do not invalidate data collected using previous versions.

REFERENCES

1. FHWA, Long-Term Bridge Performance High Priority Bridge Performance Issues, Federal Highway Administration, Report No. FHWA-HRT-14-052, Washington, DC, 2014.

LTBP PROGRAM PROTOCOLS

PREVISIT PROTOCOLS (PRE)

EXISTING DOCUMENTATION (ED)

BRIDGE DOCUMENTATION (BD)

LEGACY DATA MINING (LD)

PRELIMINARY PLANNING AND LOGISTICS (PL)

LOGISTICS (LO)

BRIDGE DOCUMENTATION PROTOCOLS (BD)

PRE-ED-BD-001, Plans and Specifications for Bridge Design and Construction

PRE-ED-BD-002, Bridge Construction Records

PRE-ED-BD-003, Bridge Design and Construction Cost Data

PRE-ED-BD-004, Bridge Site Conditions

PRE-ED-BD-005, Bridge Inspection Records

PRE-ED-BD-006, Bridge Maintenance Records and Cost Data

PRE-ED-BD-007, Calculation of Bridge Ratings

Long-Term Bridge Performance Program

PLANS AND SPECIFICATIONS FOR BRIDGE DESIGN AND CONSTRUCTION

LTBP Protocol #: PRE-ED-BD-001

1. DATA COLLECTED

1.1 Bridge design and construction parameters and specifications.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 Computer.

2.1.2 Scanner.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Work with the appropriate branches and personnel from State departments of transportation to obtain all of the following, if available, for each bridge in the Long-Term Bridge Performance (LTBP) Program:

3.1.1 Original bridge design plans.

3.1.2 Shop drawings.

3.1.3 As-built plans.

3.1.4 Any State design specifications, current at the time of the design of the bridge, which applied to the bridge.

3.1.5 Any material and/or construction specifications, current at the time of construction, which applied to the bridge.

3.1.6 Special provisions.

3.1.7 Foundation design report.

3.1.8 Soils report.

3.1.9 American Association of State Highway and Transportation Officials (AASHTO) Bridge Design Specification governing at the time of design.

3.1.10 AASHTO Bridge Construction Specification governing at the time of construction.

3.2 If the bridge information exists only in paper form, scan that information into an electronic format so it can be stored in the LTBP Bridge Portal.

3.3 Extract the following types of data from the documents obtained in section 3.1. If appropriate, use the unique element identifiers (FLD-OP-SC-002, Structure Segmentation and Element Identification System) to identify the specific element(s) to which the data apply.

3.3.1 General structure details (data collection table items 8–33).

3.3.2 Approach slab details (data collection table items 34–40).

3.3.3 Approach span details (data collection table items 41–46).

3.3.4 Span details (data collection table items 47–54).

3.3.5 Deck drainage details (data collection table items 55–58).

3.3.6 Deck details (data collection table items 59–115).

3.3.7 General girder details (data collection table items 116–133).

3.3.8 Steel girder details (data collection table items 134–164).

3.3.9 Concrete girder details (data collection table items 165–200).

3.3.10 Pretensioned concrete girder details (data collection table items 201–213).

3.3.11 Posttensioned concrete girder details (data collection table items 214–232).

3.3.12 Bearing details (data collection table items 233–236).

3.3.13 Joint and railing details (data collection table items 237–243).

3.3.14 Abutment, pier, and wingwall concrete and reinforcement details (data collection table items 244–327).

3.3.15 Substructure footing concrete and reinforcement details (data collection table items 328–353).

3.3.16 Abutment, pier, and wingwall, foundation details (data collection table items 354–388).

3.4 Storing data, documents, and images:

3.4.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.4.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.5 Reporting: Transfer all metadata, data, documents, and images to Federal Highway Administration (FHWA), and/or upload all metadata, data, documents, and images into the LTBP Bridge Portal.

4. Data Collection Table

4.1 Table:

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
1	State	Text			State Code, e.g., Virginia = VA	Green
2	NBI structure number	Text			Item 8, structure number, from NBI Coding Guide	Green
3	Structure name	Text			Descriptive name for the bridge, e.g., Route 15 SB over I–66	Green
4	Protocol name	Text			Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text			First name(s) Last name(s)	Green
7	Date data collection completed	Text	Exact date		mm/dd/yyyy	Green
General Structure Details						Pink
8	Year design completed	Text	Exact year		yyyy	Green
9	Year construction started	Text	Exact year		yyyy	Green
10	Year construction finished	Text	Exact year		yyyy	Green
11	Year open to traffic	Text	Exact year		yyyy	Green
12	Year of bridge widening	Text	Exact year		yyyy; "0000" if none	Green
13	Year of deck replacement	Text	Exact year		yyyy; "0000" if none	Green
14	AASHTO bridge design spec for year designed	Text				Green
15	AASHTO bridge construction spec for year constructed	Text			yyyy; Year construction began	Green
16	Total length of bridge	Number	0.1	ft		Green
17	Total width of bridge	Number	0.1	ft		Green
18	Skew angle	Number	0.1	degree		Green
19	Degree of curvature	Number	0.1	degree		Green
20	Is bridge part of twin spans?	Predefined list			Yes or No	Green
21	Is bridge fracture critical?	Predefined list			Yes or No	Green
22	Number of spans	Number				Green
23	Type of foundation	Predefined list			Pile or drilled shaft foundation Spread footing Unknown foundation	Green
24	Original bridge design plans	BLOB				Green
25	Shop drawings	BLOB				Green
26	As-built plans	BLOB				Green
27	State design specifications	BLOB			In effect at the time of bridge design	Green
28	State materials specifications	BLOB			In effect at the time of bridge design and construction	Green
29	State construction specifications	BLOB			In effect at the time of bridge construction	Green

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
30	Special provisions for the design or construction of the bridge	BLOB				Green
31	Foundation design report	BLOB				Green
32	Soils report	BLOB				Green
33	Comments	Text				Orange
	Approach Slab Details					Pink
34	Abutment unique element identifier	Text			Provide data in rows 35–40 for slabs at abutments AA and AB	Blue
35	Span number at abutment	Text			Span 1 for abutment A; span N for abutment B	Yellow
36	Approach slab type, materials, and dimensions	Text				Yellow
37	Method of connection of approach slab to structure	Text				Yellow
38	Approach slab overlay, type	Text				Yellow
39	Does approach slab width match bridge width (lanes and shoulders)?	Predefined list			Yes or No	Yellow
40	Comments	Text				Orange
	Approach Span Details					Pink
41	Abutment unique element identifier	Text			Abutment A or abutment B	Blue
42	Total number of approach spans	Number			Total number of approach spans at abutment A or abutment B	Yellow
43	Span number	Text			e.g., span 1, span 2, etc.	Blue
44	Type of superstructure	Text			e.g., rolled steel beam, AASHTO prestressed beam, etc.	Yellow
45	Length of approach span	Number			Number and lengths of approach spans of the type noted	Yellow
46	Comments	Text				Orange
	Span Details					Pink
47	Span unique element identifier	Text			Provide data in rows 48–54 for each individual span	Blue
48	Span length	Number	0.1	ft		Yellow
49	Straight span	Predefined list			Yes or No	Yellow
50	Simple span	Predefined list			Yes or No	Yellow
51	Continuous span	Predefined list			Yes or No	Yellow
52	End span	Predefined list			Yes or No	Yellow
53	Fracture critical span	Predefined list			Yes or No	Yellow
54	Comments	Text				Orange

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
Deck Drainage Details						Pink
55	Span unique element identifier	Text			Provide data in rows 56–58 for each drain in each span	Blue
56	Deck drain (scupper) size—length, width	Number	0.1	ft	Length, width	Yellow
57	Deck drain (scupper) location (*x*,*y*)	Number	0.1	ft	Coordinates of drain center	Yellow
58	Comments	Text				Orange
Deck Details						Pink
59	Span unique element identifier	Text			Provide data from rows 60–114 for span 1 only; confirm in comments that data from all other spans are the same	Blue
60	Deck material	Predefined list			Concrete Timber Steel grid	Yellow
61	Wearing surface type	Text			If applicable	Yellow
62	Wearing surface, date of application	Text	Month and year		mm/yyyy, if applicable	Yellow
63	Wearing surface thickness	Number	0.25	in.	If applicable	Yellow
64	State deck concrete mix designation	Text			e.g., VAA4	Yellow
65	Concrete deck mix design type	Predefined list			Performance-based Amounts specified Hybrid	Yellow
66	Concrete deck—cement type	Predefined list			I, II, III, IV, or V	Yellow
67	Concrete deck—cement quantity	Number	1	lb/yd^3	Amount for the mix design	Yellow
68	Fly ash type	Predefined list			Type C or Type F	Yellow
69	Fly ash quantity	Number	1	lb/yd^3	Amount for the mix design	Yellow
70	Silica fume quantity	Number	1	lb/yd^3	Amount for the mix design	Yellow
71	Ground granulated blast furnace slag quantity	Number	1	lb/yd^3	Amount for the mix design	Yellow
72	Fine aggregate quantity	Number	1	lb/yd^3	Amount for the mix design	Yellow
73	Maximum size of coarse aggregate allowed by the State	Number	0.25	in.		Yellow
74	Coarse aggregate quantity	Number	1	lb/yd^3	Amount for the mix design	Yellow
75	Water quantity	Number	1	lb/yd^3	Amount for the mix design	Yellow
76	Air entrainment admixture quantity	Number	0.1	$fl\ oz/yd^3$	Amount for the mix design	Yellow
77	Water-reducing admixture quantity	Number	0.1	$fl\ oz/yd^3$	Amount for the mix design	Yellow
78	High-range water-reducing (Superplasticizer) admixture quantity	Number	0.1	$fl\ oz/yd^3$	Amount for the mix design	Yellow
79	Retarder admixture quantity	Number	0.1	$fl\ oz/yd^3$	Amount for the mix design	Yellow
80	Corrosion inhibitor admixture quantity	Number	0.1	$fl\ oz/yd^3$	Amount for the mix design	Yellow
81	Shrinkage reducing admixture quantity	Number	0.1	$fl\ oz/yd^3$	Amount for the mix design	Yellow
82	Specified deck water-cement	Number	0.01			Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
	(w/c) ratio					
83	Specified deck air content	Number	0.5	%		Yellow
84	Specified deck unit weight	Number	1	pcf		Yellow
85	Type of deck aggregate, sizes and gradation	Text				Yellow
86	Specified deck 28-day design strength	Number	50	psi		Yellow
87	Actual deck 28-day design strength (by cylinder breaks)	Number	50	psi		Yellow
88	Deck thickness	Number	0.25	in.		Yellow
89	Specified deck top clear cover	Number	0.25	in.		Yellow
90	Specified deck bottom clear cover	Number	0.25	in.		Yellow
91	Deck reinforcement spec	Text			e.g., ASTM A466	Yellow
92	Deck reinforcement grade	Text			e.g., grade 60	Yellow
93	Top reinforcement mat	Predefined list			Mild black steel Mild steel epoxy coated Stainless steel MMFX Galvanized Other (specify in comments)	Yellow
94	Bottom reinforcement mat	Predefined list			Mild black steel Mild steel epoxy coated Stainless steel MMFX Galvanized Other (specify in comments)	Yellow
95	Is top layer of top mat of reinforcement transverse or longitudinal?	Predefined list			Transverse or Longitudinal	Yellow
96	Top longitudinal bar size	Predefined list			#4, #5, #6, #7, #8, or #9	Yellow
97	Top longitudinal bar spacing	Number	0.25	in.		Yellow
98	Top transverse top bar size	Predefined list			#4, #5, #6, #7, #8, or #9	Yellow
99	Top transverse top bar spacing	Number	0.25	in.		Yellow
100	Bottom longitudinal bar size	Predefined list			#4, #5, #6, #7, #8, or #9	Yellow
101	Bottom longitudinal bar spacing	Number	0.25	in.		Yellow
102	Bottom transverse bar size	Predefined list			#4, #5, #6, #7, #8, or #9	Yellow
103	Bottom transverse bar spacing	Number	0.25	in.		Yellow
104	Truss bars used	Predefined list			Yes or No	Yellow
105	Truss bar size	Predefined list			#4, #5, #6, #7, #8, or #9	Yellow
106	Average truss bar spacing	Number	0.25	in.	Enter 0 if unused	Yellow
107	Direction of transverse reinforcement in middle of skewed bridge	Predefined list			Parallel to skew Perpendicular to girder	Yellow
108	Direction of transverse	Predefined			Parallel to skew	Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
	reinforcement near end of skewed bridge	list			Fanned with origin in acute corner Fanned with origin in obtuse corner	
109	Roadway slope type	Predefined list			Transverse single slope Transverse crowned	Yellow
110	Minimum transverse deck slope	Number	0.1	%		Yellow
111	Stay-in-place forms	Predefined list			Yes or No	Yellow
112	Type of stay-in-place forms	Text			e.g., timber, metal, precast concrete subdeck panel	Yellow
113	Coating on stay-in-place forms				e.g., galvanizing	Yellow
114	Composite deck	Predefined list			Yes or No	Yellow
115	Comments	Text				Orange
General Girder Details						Pink
116	Do all girders have the same general details?	Text			Yes. If yes, provide the data in rows 117–133 for one typical girder. No. If no, provide the data in rows 117–133 for one typical girder plus data for each girder with differing data.	Green
117	Girder unique element identifier(s)	Text				Blue
118	Type of shear studs	Text				Yellow
119	Shear stud spacing	Number	0.25	in.		Yellow
120	End diaphragm type	Predefined list			K or X frame Single channel, Box, or I-beam Solid cast concrete	Yellow
121	Intermediate diaphragm type	Predefined list			K or X frame Single channel, Box, or I-beam Solid cast concrete	Yellow
122	Girder material	Predefined list			Steel Reinforced concrete Prestressed concrete	Yellow
123	Average intermediate diaphragm spacing	Number	1	ft	“0” if none	Yellow
124	Girder type	Predefined list			Standard rolled beam (steel) AASHTO/PCI shape (prestressed concrete) Custom section Variable size section Curved Straight Other (specify in comments)	Yellow
125	Number of girders	Number				Yellow
126	Girder spacing	Number	0.1	ft	Distance between centerlines of the webs	Yellow
127	Maximum girder depth	Number	0.1	ft		Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
128	Maximum girder depth location	Number	0.1	ft		Yellow
129	Average deck haunch	Number	0.1	in.		Yellow
130	Design value for camber at mid-span	Number	0.1	in.	Beam weight and all dead load; check design plans or shop drawings	Yellow
131	Actual value for camber at midspan	Number	0.1	in.	Check as-built plans or construction notes	Yellow
132	Variable depth or prismatic girder	Predefined list			Variable depth or prismatic girder	Yellow
133	Comments	Text				Orange
Steel Girder Details						Pink
134	Do all steel girders have the same details?	Text			Yes. If yes, provide the data in rows 135–151 for one typical girder. No. If no, provide the data in rows 135–151 for one typical girder plus data for each girder with differing data.	Green
135	Girder unique element identifier(s)	Text				Blue
136	AASHTO/ASTM designation for steel in girder	Text			e.g., ASTM A36	Yellow
137	Steel yield strength	Number	1	ksi		Yellow
138	Steel composition	Text			Type and percentage of constituent materials/elements	Yellow
139	Steel toughness	Number	1	ft-lb	Charpy V-notch toughness, ASTM E23	Yellow
140	Steel girder type	Predefined list			Rolled section Rolled section with bottom cover plate Rolled section with top cover plate Rolled section with top and bottom cover plates Welded plate section Combination Other (specify in comments)	Yellow
141	Steel girder unit weight	Number	1	lb/lf		Yellow
142	Intermediate vertical stiffeners	Predefined list			Yes or No	Yellow
143	Longitudinal stiffeners	Predefined list			Yes or No	Yellow
144	Coating type/corrosion protection system	Predefined list			Weathering steel Coating overtop of weathering steel at girder ends Inorganic zinc primer Organic zinc primer Other (specify in comments)	Yellow
145	Coats of paint	Number	Exact number			Yellow
146	Thickness of primer	Number	1	mil		Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
147	Thickness of second coat	Number	1			Yellow
148	Thickness of third coat	Number	1			Yellow
149	Year coated	Text	Exact year		yyyy	Yellow
150	Color of topcoat	Text				Yellow
151	Comments	Text				Orange
Secondary Steel Member Details						Pink
152	End diaphragms	Text			Indicate substructure unit: abutment A, abutment B, or pier P_	Blue
153	Description of location of centerline of diaphragm	Text			For abutments: over centerline of abutment bearings; For continuous spans at pier P_: over centerline of pier bearings; for simple spans at pier P_: over centerline of pier bearings for span _	Yellow
154	Diaphragm member size	Text			e.g., "C15x33.9""	Yellow
155	Dimensions of vertical bearing stiffener/diaphragm to web connector	Number	0.0625	in.	Record length, width, and thickness	Yellow
156	Intermediate diaphragm(s)—description of location along girder				e.g., "spaced at 20', typical 4 bays"	Blue
157	Diaphragm member size	Text			e.g., "3 L4x3x3/8, 1 L5x5x3"	Yellow
158	Dimensions of vertical bearing stiffener/diaphragm to web connector	Number	0.0625	in.	Record length, width, and thickness	Yellow
159	Additional intermediate vertical stiffener(s)—description of location along girder location	Text			e.g., "spaced at 4', alternate on each side of web"	Blue
160	Dimensions of vertical stiffener	Number	0.0625	in.	Record length, width, and thickness	Yellow
161	Horizontal stiffener—description of position on girder	Text			e.g., "1' from top flange"	Blue
162	Dimensions of horizontal stiffener	Number	0.0625	in.	Record length, width, and thickness	Yellow
163	Fatigue details	Predefined list			None AASHTO Fatigue Category A AASHTO Fatigue Category B AASHTO Fatigue Category C AASHTO Fatigue Category D AASHTO Fatigue Category E AASHTO Fatigue Category F or above	Yellow
164	Comments	Text				Orange

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
Concrete Girder Details						Pink
165	Do all concrete girders have the same details?	Text			Yes. If yes, provide the data in rows 166–200 for one typical girder. No. If no, provide the data in rows 166–200 for one typical girder plus data for each girder with differing data.	Green
166	Girder unique element identifier(s)	Text				Blue
167	W/C ratio (spec)	Number	0.01			Yellow
168	Air content (spec)	Number	0.1	%		Yellow
169	Unit weight (spec)	Number	1	pcf		Yellow
170	Mix design	Predefined list			Performance-based Amounts specified Hybrid	Yellow
171	Cement type	Predefined list			I, II, III, IV, or V	Yellow
172	Cement quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
173	Fly ash type	Predefined list			Type C or Type F	Yellow
174	Fly ash quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
175	Silica fume quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
176	Ground granulated blast furnace slag quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
177	Fine aggregate quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
178	Maximum size of coarse aggregate allowed by the State	Number	0.25	in		Yellow
179	Coarse aggregate quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
180	Water quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
181	Air entrainment admixture quantity	Number	0.1	$fl\ oz/yd^3$	Amount for the mix design	Yellow
182	Water-reducing admixture quantity	Number	0.1	$fl\ oz/yd^3$	Amount for the mix design	Yellow
183	High-range water-reducing (superplasticizer) admixture quantity	Number	0.1	$fl\ oz/yd^3$	Amount for the mix design	Yellow
184	Retarder admixture quantity	Number	0.1	$fl\ oz/yd^3$	Amount for the mix design	Yellow
185	Corrosion inhibitor admixture quantity	Number	0.1	$fl\ oz/yd^3$	Amount for the mix design	Yellow
186	Shrinkage reducing admixture quantity	Number	0.1	$fl\ oz/yd^3$	Amount for the mix design	Yellow
187	Design compressive strength at detensioning/ tensioning	Number	50	psi		Yellow
188	Design compressive strength at 28 days	Number	50	psi		Yellow
189	Girder design strength (spec)	Number	50	psi		Yellow
190	Mild steel reinforcement—Spec	Text			e.g., ASTM A466	Yellow
191	Mild steel reinforcement—Grade	Text			e.g., grade 60	Yellow
192	Mild steel reinforcement—Yield strength	Number	50	psi		Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
193	Mild steel stirrups—Spec	Text			e.g., ASTM A466	Yellow
194	Mild steel stirrups—Grade	Text			e.g., grade 60	Yellow
195	Mild steel stirrups—Yield strength	Number	50	psi		Yellow
196	Prestressing steel reinforcement—Type	Text				Yellow
197	Prestressing steel reinforcement—Spec	Text			e.g., ASTM A705	Yellow
198	Prestressing steel reinforcement—Yield strength	Number	50	ksi		Yellow
199	Prestressing steel reinforcement—Ultimate strength	Number	50	ksi		Yellow
200	Comments	Text				Orange
Pretensioned Concrete Girder Details						Pink
201	Do all pretensioned concrete girders have the same details?	Text			Yes. If yes, provide the data in rows 202–213 for one typical girder. No. If no, provide the data in rows 202–213 for one typical girder plus data for each girder with differing data.	Green
202	Girder unique element identifier	Text				Blue
203	Number of strands per tendon	Number	1			Yellow
204	Strand pattern	Text				Yellow
205	Debonded strands	Text				Yellow
206	Length of debonding	Number	1	in.		Yellow
207	Location of tendons in cross-section	BLOB			Elevation and cross-sectional views	Yellow
208	Number of harped strands	Number	1			Yellow
209	Point of harp	Text				Yellow
210	Prestress force after losses	Number	1	kips		Yellow
211	Confinement reinforcement in bottom flange	Text				Yellow
212	Number of stirrups, location, and spacing	Text				Yellow
213	Comments	Text				Orange
Posttensioned Concrete Girder Details						Pink
214	Do all posttensioned concrete girders have the same details?	Text			Yes. If yes, provide the data in rows 215–232 for one typical girder. No. If no, provide the data in rows 215–232for one typical girder plus data for each girder with differing data.	Green
215	Girder unique element identifier	Text				Blue
216	Number of strands per tendon	Number				Yellow
217	Strand pattern	Predefined list			Straight or draped	Yellow
218	Number of external tendons	Number				Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
219	Number of internal tendons	Number				Yellow
220	Location of tendons in cross-section	BLOB			Elevation and cross-sectional views	Yellow
221	Prestress force after losses	Number	1	kips		Yellow
222	Confinement reinforcement in bottom flange	Text				Yellow
223	Number of stirrups, location, and spacing	Text				Yellow
224	Grout type	Text				Yellow
225	Grout manufacturer	Text				Yellow
226	Grout amount	Text				Yellow
227	Grout mix design	Text				Yellow
228	Grout constituent material types	Text				Yellow
229	Duct type	Text				Yellow
230	Duct manufacturer	Text				Yellow
231	General girder type	Predefined list			AASHTO standard type pretensioned concrete I-girder (1 through 6) Adjacent pretensioned concrete box girder Spread pretensioned concrete box girder Cast-in-place posttensioned concrete box girder AASHTO/PCI standard pretensioned concrete bulb-tee girder Pretensioned concrete decked bulb-tee girder (deck is precast onto the precast pretensioned girder) State standard section pretensioned concrete girder (example: Washington State bulb-tee, Florida bulb-tee, Texas U-Beam) Reinforced concrete voided slab Reinforced concrete solid slab Reinforced concrete T-beam Segmental concrete girder Concrete spliced girder Other or combination (specify in comments)	Yellow
232	Comments	Text				Orange
Bearing Details						Pink
233	Do all bearings have the same general details?	Text			Yes. If yes, provide the following data for one typical bearing. No. If no, provide the	Green

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
					following data for one typical bearing plus data for each bearing with differing data.	
234	Bearing unique element identifier	Text				Blue
235	Bearing type	Predefined list			Sliding plate: Lubricated steel Sliding plate: Lead between steel plates Sliding plate: Bronze bearing plates Sliding plate: Self-lubricating bronze bearings Sliding plate: Polytetrafluoroethylene on stainless steel plates Roller bearing Rocker bearing (no pin) Pinned rocker bearing Moveable elastomeric bearing w/ plain neoprene pad Moveable elastomeric bearing w/ laminated neoprene pad Moveable neoprene pot bearing Moveable spherical pot bearing Fixed neoprene pot bearing (no movement allowed) Moveable disc bearing Fixed disc bearing Isolation bearing Semi-integral abutment Integral abutment Other (specify in comments)	Yellow
236	Comments	Text				Orange
Joint and Railing Details						Pink
237	Do all joints have the same general details?	Text			Yes. If yes, provide the data in rows 238–243 for one typical joint. No. If no, provide the data in rows 238–243for one typical joint plus data for each joint with differing data.	Green
238	Joint unique element identifier	Text				Blue
239	Expansion joint type and material	Predefined list			Jointless Strip seal expansion joint Pourable joint seal Compression joint seal (neoprene in a honeycomb) Cellular seal (solid-cell	Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
					foam) Modular (hollow neoprene blocks connected with steel) Plan seal Sheet seal Asphaltic expansion joint Finger plate joint Sliding plate joint Open expansion joint Other (specify in comments)	
240	Barrier type	Text			e.g., standard Jersey shape, Texas shape for trucks	Yellow
241	Barrier material	Predefined list			Concrete Steel Other (specify in Comments)	Yellow
242	Deck-to-barrier connection	Predefined list			Reinforcement Grouted mechanical connection Through bolts Other (specify in comments) Unknown	Yellow
243	Comments	Text				Orange
Abutment walls—Concrete and Reinforcement Details						Pink
244	Clear cover	Number	0.25	in.		Yellow
245	Reinforcement specification	Text			e.g., ASTM A466	Yellow
246	Reinforcement grade	Text			e.g., 60	Yellow
247	Confinement reinforcement	Text			Type, alignment, spacing	Yellow
248	Substructure mix designs	Predefined list			Performance based Amounts specified Hybrid	Yellow
249	Cement type	Predefined list			I, II, III, IV, or V	Yellow
250	Cement quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
251	Fly ash type	Predefined list			Type C or Type F	Yellow
252	Fly ash quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
253	Silica fume quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
254	Ground granulated blast furnace slag quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
255	Fine aggregate quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
256	Maximum size of coarse aggregate allowed by the State	Number	0.25	in		Yellow
257	Coarse aggregate quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
258	Water quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
259	Air entrainment admixture quantity	Number	0.1	$fl\ oz/yd^3$	Amount for the mix design	Yellow
260	Water-reducing admixture quantity	Number	0.1	$fl\ oz/yd^3$	Amount for the mix design	Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
261	High-range water-reducing (superplasticizer) admixture quantity	Number	0.1	fl oz/yd^3	Amount for the mix design	Yellow
262	Retarder admixture quantity	Number	0.1	fl oz/yd^3	Amount for the mix design	Yellow
263	Corrosion inhibitor admixture quantity	Number	0.1	fl oz/yd^3	Amount for the mix design	Yellow
264	Shrinkage reducing admixture quantity	Number	0.1	fl oz/yd^3	Amount for the mix design	Yellow
265	W/C ratio (spec)	Number	0.01			Yellow
266	Air content (spec)	Number	0.1	%		Yellow
267	Unit weight (spec)	Number	1	pcf		Yellow
268	Admixtures used	Text				Yellow
269	Aggregate types and sizes	Text			Gradation	Yellow
270	(Design) 28-day concrete strength	Number	50	psi		Yellow
271	Comments	Text				Orange
Pier Columns and Pier Caps—Concrete and Reinforcement Details						Pink
272	Are the pier concrete and reinforcement details identical to the abutment walls?	Predefined list			Yes. If yes, note this in the comments in row 299, and do not fill in rows 272–298. No. If no, fill in the details in rows 272–298 for a typical pier.	Blue
273	Clear cover	Number	0.25	in.		Yellow
274	Reinforcement specification	Text			e.g., ASTM A466	Yellow
275	Reinforcement grade	Text			e.g., 60	Yellow
276	Confinement reinforcement	Text			Type, alignment, spacing	Yellow
277	Substructure mix designs	Predefined list			Performance based Amounts specified Hybrid	Yellow
278	Cement type	Predefined list			I, II, III, IV, or V	Yellow
279	Cement quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
280	Fly ash type	Predefined list			Type C or Type F	Yellow
281	Fly ash quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
282	Silica fume quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
283	Ground granulated blast furnace slag quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
284	Fine aggregate quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
285	Maximum size of coarse aggregate allowed by the State	Number	0.25	in		Yellow
286	Coarse aggregate quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
287	Air entrainment admixture quantity	Number	0.1	fl oz/yd^3	Amount for the mix design	Yellow
288	Water-reducing admixture quantity	Number	0.1	fl oz/yd^3	Amount for the mix design	Yellow
289	High-range water-reducing (superplasticizer) admixture quantity	Number	0.1	fl oz/yd^3	Amount for the mix design	Yellow
290	Retarder admixture quantity	Number	0.1	fl oz/yd^3	Amount for the mix design	Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
291	Corrosion inhibitor admixture quantity	Number	0.1	fl oz/yd^3	Amount for the mix design	Yellow
292	Shrinkage reducing admixture quantity	Number	0.1	fl oz/yd^3	Amount for the mix design	Yellow
293	W/C ratio (spec)	Number	0.01			Yellow
294	Air content (spec)	Number	0.1	%		Yellow
295	Unit weight (spec)	Number	1	pcf		Yellow
296	Admixtures used	Text				Yellow
297	Aggregate types and sizes	Text			Gradation	Yellow
298	(Design) 28-day concrete strength	Number	50	psi		Yellow
299	Comments	Text				Orange
Wingwalls—Concrete and Reinforcement Details						Pink
300	Are the wingwall concrete and reinforcement details identical to the abutment walls?	Predefined list			Yes. If yes, note this in the comments in row 327 and do not fill in rows 300–326. No. If no, fill in the details in rows 300–326 for a typical wingwall.	Blue
301	Clear cover	Number	0.25	in.		Yellow
302	Reinforcement specification	Text			e.g., ASTM A466	Yellow
303	Reinforcement grade	Text			e.g., 60	Yellow
304	Confinement reinforcement	Text			Type, alignment, spacing	Yellow
305	Substructure mix designs	Predefined list			Performance-based, Amounts specified, or Hybrid	Yellow
306	Cement type	Predefined list			I, II, III, IV, or V	Yellow
307	Cement quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
308	Fly ash type	Predefined list			Type C or Type F	Yellow
309	Fly ash quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
310	Silica fume quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
311	Ground granulated blast furnace slag quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
312	Fine aggregate quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
313	Maximum size of coarse aggregate allowed by the State	Number	0.25	in.		Yellow
314	Coarse aggregate quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
315	Air entrainment admixture quantity	Number	0.1	fl oz/yd^3	Amount for the mix design	Yellow
316	Water-reducing admixture quantity	Number	0.1	fl oz/yd^3	Amount for the mix design	Yellow
317	High-range water-reducing (superplasticizer) admixture quantity	Number	0.1	fl oz/yd^3	Amount for the mix design	Yellow
318	Retarder admixture quantity	Number	0.1	fl oz/yd^3	Amount for the mix design	Yellow
319	Corrosion inhibitor admixture quantity	Number	0.1	fl oz/yd^3	Amount for the mix design	Yellow
320	Shrinkage reducing admixture quantity	Number	0.1	fl oz/yd^3	Amount for the mix design	Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
321	W/C ratio (spec)	Number	0.01			Yellow
322	Air content (spec)	Number	0.1	%		Yellow
323	Unit weight (spec)	Number	1	pcf		Yellow
324	Admixtures used	Text				Yellow
325	Aggregate types and sizes	Text			Gradation	Yellow
326	(Design) 28-day concrete strength	Number	50	psi		Yellow
327	Comments	Text				Orange
Substructure Footings—Concrete and Reinforcement Details						Pink
328	Clear cover	Number	0.25	in.		Yellow
329	Reinforcement specification	Text			e.g., ASTM A466	Yellow
330	Substructure mix designs	Predefined list			Performance based Amounts specified Hybrid	Yellow
331	Cement type	Predefined list			I, II, III, IV, or V	Yellow
332	Cement quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
333	Fly ash type	Predefined list			Type C or Type F	Yellow
334	Fly ash quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
335	Silica fume quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
336	Ground granulated blast furnace slag quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
337	Fine aggregate quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
338	Maximum size of coarse aggregate allowed by the State	Number	0.25	in		Yellow
339	Coarse aggregate quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
340	Water quantity	Number	0.1	lb/yd^3	Amount for the mix design	Yellow
341	Air entrainment admixture quantity	Number	0.1	$fl\ oz/yd^3$	Amount for the mix design	Yellow
342	Water-reducing admixture quantity	Number	0.1	$fl\ oz/yd^3$	Amount for the mix design	Yellow
343	High-range water-reducing (superplasticizer) admixture quantity	Number	0.1	$fl\ oz/yd^3$	Amount for the mix design	Yellow
344	Retarder admixture quantity	Number	0.1	$fl\ oz/yd^3$	Amount for the mix design	Yellow
345	Corrosion inhibitor admixture quantity	Number	0.1	$fl\ oz/yd^3$	Amount for the mix design	Yellow
346	Shrinkage-reducing admixture quantity	Number	0.1	$fl\ oz/yd^3$	Amount for the mix design	Yellow
347	W/C ratio (spec)	Number	0.01			Yellow
348	Air content (spec)	Number	0.1	%		Yellow
349	Unit weight (spec)	Number	1	pcf		Yellow
350	Admixtures used	Text				Yellow
351	Aggregate types and sizes	Text			Gradation	Yellow
352	(Design) 28-day concrete strength	Number	50	psi		Yellow
353	Comments	Text				Orange
Abutment, Pier, Wingwall, and Foundation Details						Pink
354	Abutment unique element identifier	Text			e.g., abutment A	Blue

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
355	Precast abutment	Predefined list			Yes or No	Yellow
356	Abutment stem dimensions	Number	1	in.	Length, width, depth	Yellow
357	Abutment backwall dimensions	Number	1	in.	Length, width, depth	Yellow
358	Abutment footing dimensions	Number	1	in.	Length, width, depth	Yellow
359	Type of abutment foundation	Predefined list			Pile foundation Drilled shaft Spread footing Other Unknown foundation	Yellow
360	Type of pile/drilled shaft	Predefined list			Prestressed concrete pile Reinforced concrete pile Steel H-pile Steel cylindrical pile Timber pile Drilled shaft with self-consolidating concrete Drilled shaft with conventional concrete No piles/drilled shafts Unknown foundation	Yellow
361	Friction or bearing pile	Predefined list			Friction Bearing Combination friction/bearing pile No piles Unknown foundation	Yellow
362	Pile dimensions	Number	1	in.		Yellow
363	Number of straight pile rows/number of piles per row	Text				Yellow
364	Number of battered pile rows/number of piles per row	Text				Yellow
365	Comments	Text				Orange
366	Pier unique element identifier	Text			e.g., pier P1	Blue
367	Pier column shape	Predefined list			Solid wall Circular column Square column	Yellow
368	Pier column dimensions	Number	1	in.	Solid wall—length, height, thickness Circular column—height, diameter Square column—height, width	Yellow
369	Type of abutment foundation	Predefined list			Pile foundation Drilled shaft Spread footing Other Unknown foundation	Yellow
370	Pier footing dimensions	Number	1	in.	Length, width, depth	Yellow
371	Pier/pile cap dimensions	Number	1	in.	Length, width, depth	Yellow
372	Type of pile/drilled shaft	Predefined list			Prestressed concrete pile Reinforced concrete pile Steel H-pile Steel cylindrical pile Timber pile Drilled shaft with self-	Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
					consolidating concrete Drilled shaft with conventional concrete No piles/drilled shafts Unknown foundation	
373	Friction or bearing pile	Predefined list			Friction Bearing Combination friction/bearing pile No piles Unknown foundation	Yellow
374	Pile dimensions	Number	1	in.		Yellow
375	Number of straight pile rows/number of piles per row	Text				Yellow
376	Number of battered pile rows/number of piles per row	Text				Yellow
377	Number of piles					Yellow
378	Comments	Text				Orange
379	Wingwall unique element identifier	Text			e.g., Wingwall A Right	Blue
380	Wingwall dimensions					Yellow
381	Type of wingwall foundation	Predefined list			Pile foundation Drilled shaft Spread footing Other Unknown foundation	Yellow
382	Wingwall footing dimensions	Number	1	in.	Length, width, depth	Yellow
383	Type of pile/drilled shaft	Predefined list			Prestressed concrete pile Reinforced concrete pile Steel H-pile Steel cylindrical pile Timber pile Drilled shaft with self-consolidating concrete Drilled shaft with conventional concrete No piles/drilled shafts Unknown foundation	Yellow
384	Friction or bearing pile	Predefined list			Friction Bearing Combination friction/bearing pile No piles Unknown foundation	Yellow
385	Pile dimensions	Number	1	in.		Yellow
386	Number of straight pile rows/number of piles per row	Text				Yellow
387	Number of battered pile rows/number of piles per row	Text				Yellow
388	Comments	Text				Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. CRITERIA FOR DATA VALIDATION

5.1 Data extracted from bridge documents should be checked by second (independent) person.

5.2 Where feasible, data will be validated using standard error checking within the Bridge Portal.

6. COMMENTARY/BACKGROUND

6.1 This protocol provides guidance for collecting documents, images, information, and data about the design and construction of each bridge included in FHWA's LTBP Program. This includes documents, images, information, and data accessible either from the owner or other public information sources, without a visit to the bridge site. Specifically, this protocol focuses on obtaining plans, specifications, and other documents that help define the structural and material characteristics of the bridge at the time it was put into service, and extracting key data items from these documents.

6.2 This information is to be used to do the following:

6.2.1 Define the structural and material characteristics of the bridge at the time it was designed, constructed, and put into service.

6.2.2 Conduct legacy data mining (PRE-ED-LO-001, Legacy Data Mining for Untreated Bridge Deck).

6.3 When obtaining documents, such as State materials specifications in effect at the time the bridge was designed and constructed; foundation reports; soils report; etc., obtain a PDF version if possible.

6.4 For identifying the location of longitudinal and vertical stiffeners on the webs of steel girders:

6.4.1 Specify the element number of the girder to which the stiffener is attached, and indicate near face (NF), for the face of the web that is nearest to the local girder origin, or far face (FF), for the web face that is farthest from the local girder origin.

6.4.2 Measure and record the *x*-distance from the local girder origin to the nearest point on the stiffener.

6.5 Concrete design mix types are defined as follows:

6.5.1 Performance based: The owner specifies end results that must be met by the concrete, such as 28-day compressive strength and percent air entrainment. The construction contractor is responsible for designing a mix that produces the desired end results.

6.5.2 Amounts specified: The owner specifies the types and amounts of all ingredients that are used in the concrete mix.

6.5.3 Hybrid: The owner specifies the types and amounts of some ingredients that are used in the concrete mix and also specifies end results that must be met by the concrete, such as 28-day compressive strength.

7. REFERENCES

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-005, Personnel Qualifications.

7.1.2 FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks.

7.1.3 FLD-OP-SC-002, Structure Segmentation and Element Identification System.

7.1.4 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.5 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*:

7.2.1 FHWA-NHI-12-053, Bridge Inspector's Reference Manual, Federal Highway Administration, Washington, DC, 2012.

FHWA-PD-96-001, Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges, Federal Highway Administration, Washington, DC, 1995.

BRIDGE CONSTRUCTION RECORDS

LTBP Protocol #: PRE-ED-BD-002

1. DATA COLLECTED

1.1 Data and information related to the original construction of the structure, including details as well as material specifications and shop drawings.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 Computer.

2.1.2 Scanner.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Work with the bridge owner to identify and obtain construction records, shop drawings, State material specifications, and other details for the following:

3.1.1 Bridge as a whole (data collection table items 8–10).

3.1.2 Reinforced concrete and prestressed concrete girders (data collection table items 11–19).

3.1.3 Steel girders (data collection table items 20–27).

3.1.4 Deck (data collection table items 28–38).

3.1.5 Substructure: abutments, piers, wingwalls, and footings (data collection table items 39–89).

3.2 If the bridge information exists only in paper form, scan that information into an electronic format so it can be stored in the Long-Term Bridge Performance (LTBP) Bridge Portal.

3.3 Extract the following information from the documents from section 3.1:

3.3.1 Construction type.

3.3.2 Contract type.

3.3.3 Actual concrete strengths, curing times, and curing methods for reinforced concrete and prestressed concrete bridge members.

3.3.4 Coating and welding information for steel bridge members.

3.3.5 Pile driving information (if applicable).

3.4 Ambient temperatures and wind speeds during construction (if available).

3.5 Storing data, documents, and images:

3.5.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.5.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.6 Reporting: Transfer all metadata, data, documents, and images to Federal Highway Administration (FHWA), and/or upload all metadata, data, documents, and images into the LTBP Bridge Portal.

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4. DATA COLLECTION TABLE

4.1 Table:

#	FIELD NAME	DATA TYPE	ACCURACY	UNIT	FIELD DESCRIPTION	ROW COLOR
1	State	Text			State Code, e.g., Virginia = VA	Green
2	NBI structure number	Text			Item 8, structure number, from NBI Coding Guide	Green
3	Structure name	Text			Descriptive name for the bridge, e.g., Route 15 SB over I–66	Green
4	Protocol name	Text			Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text			First name(s) Last name(s)	Green
7	Date data collected	Text	Exact date		mm/dd/yyyy	Green
WHOLE BRIDGE						Pink
8	Type of construction	Predefined list	Text		Select all that apply: • Conventional construction. • Accelerated bridge construction (ABC) using bridge slide. • ABC using self-propelled modular transporters. • ABC using geosynthetic reinforced soil walls/abutments.	Yellow
9	Type of contract	Predefined list	Text		Select all that apply: • Design-bid-build. • Design-build. • Public-private partnership. • Construction manager/general contractor (CM/GC).	Yellow
10	Construction documents	BLOB			Upload all documents supplying information on construction of the bridge	Yellow
REINFORCED CONCRETE AND PRESTRESSED CONCRETE GIRDERS						Pink
11	State concrete specification used for girder concrete	Text			Name and year of State material specification used for the bridge	Yellow
12	Girder curing type	Predefined list			Ambient air Steam	Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
					High temperature Moist cure Unknown	
13	Girder curing time	Number	0.25	hours	Time from first curing application to end of curing	Yellow
14	Ambient air temperature at placement of girder concrete	Number	1	ºF		Yellow
15	Ambient wind speed at placement of girder concrete	Number	2	mph		Yellow
16	Actual girder concrete compressive strength at 28 days	Number	50	psi		Yellow
17	For pretensioned girders, actual concrete compressive strength at detensioning	Number	50	psi		Yellow
18	For pretensioned girders, age at detensioning	Number	1	hours		Yellow
19	Comments	Text				Orange
Steel Girders						Pink
20	Type of welding used	Predefined list			Shielded metal arc welding Submerged arc welding Flux core arc welding Gas metal arc welding Narrow gap improved electroslag welding Unknown welding No welding	Yellow
21	Location of welding	Predefined list			Shop Bridge site Unknown No welding	Yellow
22	Protective system used	Predefined list			Select all that apply: • One-coat paint/coating system. • Two-coat paint/coating system. • Three-coat paint/coating system. • Galvanized. • Weathering steel. • Unknown.	Yellow
23	Location of paint/coating system application	Predefined list			Select all that apply: • Shop. • Field. • No paint used. • Unknown.	Yellow
24	Type of primer	Predefined list			Organic zinc Inorganic zinc Other No primer used Unknown	Yellow
25	Type of paint/coating for second coat	Text				Yellow
26	Type of paint/coating for third coat	Text				Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
27	Comments	Text				Orange
			Specific Deck Information			Pink
28	Type of deck construction	List			Cast-in-place concrete Precast concrete partial-depth panels Precast concrete full-depth panels Pretopped girder with precast concrete deck	Yellow
29	Sequence of deck pours	BLOB			Upload document, diagram, or write the sequence used for cast-in-place concrete decks.	Yellow
30	State concrete specification used for deck	Text			Name and year of State material specification used for the bridge	Yellow
31	Deck curing type	Predefined list			Select all that apply: • Ambient air. • Steam. • High temperature. • Moist cure. • Curing compound. • Sprinkler with burlap. • Plastic sheets. • Wet burlap. • Unknown.	Yellow
32	Deck curing time	Number	3	hours	Time from first curing application to end of curing	Yellow
33	Ambient air temperature at placement of deck concrete	Number	1	ºF		Yellow
34	Ambient wind speed at placement of deck concrete	Number	2	mph		Yellow
35	Actual deck concrete compressive strength at 28 days	Number	50	psi		Yellow
36	Type of formwork used for deck	Predefined list			Removable plywood forms Stay-in-place wood forms Stay-in-place metal forms Prestressed concrete subdeck panels None	Yellow
37	Type of sealer applied at time of deck construction	Predefined list			None Silane Siloxane Other Unknown	Yellow
38	Comments	Text				Orange
			Abutments			Pink
39	Abutment unique element identifier	Text				Blue
40	Pile placement method	Predefined list			Driven pile Jetted pile Excavated drilled shaft No piles/drilled shafts Unknown foundation	Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
41	Pile driving data—maximum blow count	Number	1			Yellow
42	Pile driving data—minimum blow count	Number	1			Yellow
43	Pile driving data—average blow count	Number	1			Yellow
44	Pile driving data—maximum cutoff length	Number	1			Yellow
45	Pile driving data—minimum cutoff length	Number	1			Yellow
46	Pile driving data—average cutoff length	Number	1			Yellow
47	State concrete specification used for abutment	Text				Yellow
48	Abutment curing type	Predefined list			Name and year of State material specification used for the bridge	Yellow
49	Abutment curing time	Number	3	hours	Select all that apply: • Ambient air. • Steam. • High temperature. • Moist cure. • Curing compound. • Sprinkler with burlap. • Plastic sheets. • Wet burlap. • Unknown.	Yellow
50	Ambient air temperature at placement	Number	1	ºF		Yellow
51	Actual abutment concrete compressive strength at 28 days	Number	50	psi		Yellow
52	Comments	Text				Orange
			Piers			Pink
53	Pier unique element identifier	Text				Blue
54	Pile placement method	Predefined list			Driven pile Jetted pile Excavated drilled shaft No piles/drilled shafts Unknown foundation	Yellow
55	Pile driving data—maximum blow count	Number	1			Yellow
56	Pile driving data—minimum blow count	Number	1			Yellow
57	Pile driving data—average blow count	Number	1			Yellow
58	Pile driving data—maximum cutoff length	Number	1			Yellow
59	Pile driving data—minimum cutoff length	Number	1			Yellow
60	Pile driving data—average cutoff length	Number	1			Yellow
61	State concrete specification used for pier	Text			Name and year of State material specification used for the bridge.	Yellow
62	Pier curing type	Predefined list			Select all that apply:	Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
					• Ambient air. • Steam. • High temperature. • Moist cure. • Curing compound. • Sprinkler with burlap. • Plastic sheets. • Wet burlap. • Unknown.	
63	Pier curing time	Number	3	hours	Time from first curing application to end of curing.	Yellow
64	Ambient air temperature at placement	Number	1	ºF		Yellow
65	Actual pier concrete compressive strength at 28 days	Number	50	psi		Yellow
66	Comments	Text				Orange
Wingwalls						Pink
67	Wingwall unique element identifier					Blue
68	Pile placement method	Predefined list			Driven pile Jetted pile Excavated drilled shaft No piles/drilled shafts Unknown foundation	Yellow
69	Pile driving data—maximum blow count	Number	1			Yellow
70	Pile driving data—minimum blow count	Number	1			Yellow
71	Pile driving data—average blow count	Number	1			Yellow
72	Pile driving data—maximum cutoff length	Number	1			Yellow
73	Pile driving data—minimum cutoff length	Number	1			Yellow
74	Pile driving data—average cutoff length	Number	1			Yellow
75	State concrete specification used for wingwall	Text				Yellow
76	Wingwall curing type	Predefined list			Name and year of State material specification used for the bridge	Yellow
77	Wingwall curing time	Number	3	hours	Select all that apply: • Ambient air. • Steam. • High temperature. • Moist cure. • Curing compound. • Sprinkler with burlap. • Plastic sheets. • Wet burlap. • Unknown.	Yellow
78	Ambient air temperature at placement of wingwall	Number	1	ºF		Yellow
79	Ambient wind speed at placement of wingwall	Number	2	mph		Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
80	Actual wingwall concrete compressive strength at 28 days	Number	50	psi		Yellow
81	Comments	Text				Orange
	Footings					Pink
82	Footing unique element identifier					Blue
83	State concrete specification used for footing	Text				Yellow
84	Footing curing type	Predefined list			Name and year of State material specification used for the bridge.	Yellow
85	Footing curing time	Number	3	hours	Select all that apply: • Ambient air. • Steam. • High temperature. • Moist cure. • Curing compound. • Sprinkler with burlap. • Plastic sheets. • Wet burlap. • Unknown.	Yellow
86	Ambient air temperature at placement of abutment	Number	1	ºF		Yellow
87	Ambient wind speed at placement of footing	Number	2	mph		Yellow
88	Actual footing concrete compressive strength at 28 days	Number	50	psi		Yellow
89	Comments	Text				Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. Criteria for Data Validation

5.1 Data extracted from bridge documents should be checked by a second (independent) person.

5.2 Where feasible, data will be validated using standard error checking within the Bridge Portal.

6. COMMENTARY/BACKGROUND

6.1 This protocol provides guidance for collecting data that define the conditions under which the structure was built, details of the placement and curing of concrete elements, details of welding and coating systems for steel bridge members, and results of tests that were conducted on the materials during and immediately after construction.

6.2 A drilled shaft is a high load capacity foundation unit that consists of a cylindrical drilled hole, a steel reinforcement cage and cast-in-place concrete that takes the place of multiple driven or cast-in-place piles.

6.3 After placement and finishing, concrete hardens and develops its final properties through a process called hydration, which occurs when water and portland cement are mixed. In order for concrete to develop the desired properties, a satisfactory moisture content and temperature in the concrete is necessary. Curing is a general term for the method used to maintain that moisture content and temperature during hydration. Depending on the concrete member being cured, there may be more than one method of curing that can be used:

6.3.1 *Ambient air* – In this method, the temperature and level of humidity in the surrounding air maintain the proper curing conditions.

6.3.2 *High temperature* – This involves subjecting concrete to higher temperatures to accelerate the hydration process, resulting in faster development of strength. Concrete cannot be subjected to dry heat to accelerate the hydration process as the presence of moisture is also an essential requisite. Therefore, subjecting the concrete to higher temperature and maintaining the required wetness can be achieved by subjecting the concrete to steam curing.

6.3.3 *Moist cure* – This can be achieved with water by immersing the element, ponding water on the top of a horizontal or by spraying water on the surface of a horizontal or vertical surface.

6.3.4 *Curing compounds* – These are materials that are applied to the fresh concrete and which provide a membrane that retards or reduces evaporation of moisture from the concrete.

6.3.5 *Plastic sheets or impervious papers* – These are two materials that can be applied to seal in the moisture in the concrete while hydration proceeds. This type of curing generally does not require periodic additions of water.

6.3.6 *Wet burlap curing* – This maintains the proper moisture content by preventing evaporation of the water in the concrete. It also provides some cooling through evaporation of the water in the burlap, which is helpful in hot weather. Wet burlap curing is often augmented by sprinkling water on the burlap to maintain a continuous level of moisture in the burlap.

6.4 Coatings for protection of structural steel from corrosion are applied in two different settings:

6.4.1 *Shop-applied coatings* – Applied at the steel fabrication plant where surface preparation can be done in an enclosed environment and where temperature and humidity can be controlled, and the ergonomics of applying the coating can be optimized.

6.4.2 *Field-applied coatings* – Applied to the steel member, usually at the construction site; compared to shop-applied coatings, a lesser degree of control over the environment, temperature, humidity, and ergonomics is normal.

6.5 Developing the strength of concrete is a function of not only time but also that of temperature.

When concrete is subjected to higher temperatures, it accelerates the hydration process, resulting in faster development of strength. Concrete cannot be subjected to dry heat to accelerate the hydration process as the presence of moisture is also an essential requisite. Therefore, subjecting the concrete to a higher temperature and maintaining the required wetness can be achieved by subjecting the concrete to steam curing.

7. REFERENCES

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-005, Personnel Qualifications.

7.1.2 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.3 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*:

7.2.1 FHWA-NHI-12-053, Bridge Inspector's Reference Manual, Federal Highway Administration, Washington, DC, 2012.

7.2.2 State materials specifications for State and year that bridge was constructed.

BRIDGE DESIGN AND CONSTRUCTION COST DATA

LTBP Protocol #: PRE-ED-BD-003

1. DATA COLLECTED

1.1 Cost data related to the design and construction of the bridge.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 Computer.

2.1.2 Scanner.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Work with the bridge owner to identify and obtain cost data for the design and construction of the bridge.

3.2 If the bridge information exists only in paper form, scan that information into an electronic format so it can be stored in the Long-Term Bridge Performance (LTBP) Bridge Portal.

3.3 Extract the following cost information from bridge design and construction documents:

3.3.1 Bridge design cost, including costs by contract personnel and in-house staff (data collection table items 9–11).

3.3.2 Costs for the deck, including concrete materials, forming, finishing (including tining or grooving), and curing. Regarding reinforcing steel costs, the cost per pound is desired. This includes fastening clips, wires, separators, chairs, and other materials used in maintaining the reinforcement in place. The costs for deck sealers are applied during the initial construction of the bridge (data collection table items 12–29).

3.3.3 Costs for deck joints (data collection table items 30–38).

3.3.4 Cost of bearings (data collection table items 39–51).

3.3.5 Costs for concrete superstructure items – This includes girder fabrication, transportation, and erection costs, plus diaphragms, approach slabs, median barriers, and parapets (data collection table items 52–65).

3.3.6 Costs for steel superstructure items – This includes girder fabrication, transportation, and erection costs, plus connections, welding, stiffeners, and cross-frames. Costs for corrosion protection systems for steel superstructure members (shop applied or field applied) (data collection table items 66–81).

3.3.7 Costs of concrete substructure items (data collection table items 82–93).

3.3.8 Costs of steel foundation items (data collection table items 94–97).

3.3.9 Costs of timber foundation members (data collection table items 98–100).

3.3.10 Total bid price for construction of the bridge (data collection table items 101–102).

3.4 Storing data, documents, and images:

3.4.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.4.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.5 Reporting: Transfer all metadata, data, documents, and images to FHWA, and/or upload all metadata, data, documents, and images into the LTBP Bridge Portal.

4. Data Collection Table

4.1 Table:

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
1	State	Text			State Code; e.g., Virginia = VA	Green
2	NBI structure number	Text			Item 8, structure number; from NBI Coding Guide	Green
3	Structure name	Text			Descriptive name for the bridge; e.g., Route 15 SB over I–66	Green
4	Protocol name	Text			Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text			First name(s) Last name(s)	Green
7	Date data collected	Text	Exact date		mm/dd/yyyy	Green
8	Date of bid opening	Text	Exact date		mm/dd/yyyy	Green
	Bridge Design					Pink
9	Design by State staff	Number	1	USD		Yellow
10	Design by contract personnel	Number	1	USD		Yellow
11	Comments	Text				Orange
	Deck Items					Pink
12	Bridge deck grooving	Number	1	USD/yd^2	Cost of sawcut grooving	Yellow
13	Bridge deck tining	Number	1	USD/yd^2		Yellow
14	Cast-in-place concrete for bridge deck—Conventional concrete	Number	1	USD/yd^3		Yellow
15	Cast-in-place concrete for bridge deck—High-performance concrete	Number	1	USD/yd^3		Yellow
16	Cast-in-place concrete for bridge deck—Lightweight concrete	Number	1	USD/yd^3		Yellow
17	Reinforcing steel—Uncoated	Number	1	USD/lb		Yellow
18	Reinforcing steel—Epoxy coated	Number	1	USD/lb		Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
19	Reinforcing steel—Galvanized	Number	1	USD/lb		Yellow
20	Reinforcing steel—Stainless steel	Number	1	USD/lb		Yellow
21	Waterproofing	Number	1	USD/yd^2		Yellow
22	Welded wire fabric—Uncoated	Number	1	USD/lb		Yellow
23	Welded wire fabric—Epoxy coated	Number	1	USD/lb		Yellow
24	Depth of precast pretensioned concrete deck panel	Number	1	in.		Yellow
25	Precast pretensioned concrete deck panel	Number	1	USD/yd^2		Yellow
26	Grout for precast concrete deck panel	Number	1	USD/yd^3		Yellow
27	Bridge deck curing compound	Number	1	USD/gal		Yellow
28	Bridge deck sealer applied at time of construction	Number	1	USD/gal		Yellow
29	Comments	Text				Orange
Joints						Pink
30	Width of expansion joint	Number	1	in.		Yellow
31	Elastomeric expansion joint	Number	1	USD/ lin ft		Yellow
32	Preformed elastomeric joint sealer	Number	1	USD/ lin ft		Yellow
33	Steel reinforced elastomeric expansion joint	Number	1	USD/ lin ft		Yellow
34	Strip seal expansion joint	Number	1	USD/ lin ft		Yellow
35	Strip seal gland	Number	1	USD/ lin ft		Yellow
36	Asphaltic plug expansion joint	Number	1	USD/ lin ft		Yellow
37	Modular expansion joint system	Number	1	USD/ lin ft		Yellow
38	Comments	Text				Orange
Bearings						Pink
39	Sliding plate bearing	Number	1	USD		Yellow
40	Rocker bearing	Number	1	USD		Yellow
41	Roller bearing	Number	1	USD		Yellow
42	Rack and pinion (geared) bearing	Number	1	USD/ea.		Yellow
43	Pot bearing	Number	1	USD/ea.		Yellow
44	Spherical bearing	Number	1	USD/ea.		Yellow
45	Disc bearing	Number	1	USD/ea.		Yellow
46	Seismic isolation bearing	Number	1	USD/ea.		Yellow
47	Plain elastomeric (neoprene) bearing	Number	1	USD/ea.		Yellow
48	Laminated elastomeric (neoprene) bearing	Number	1	USD/ea.		Yellow
49	Elastomeric bearing	Number	1	USD/ea.		Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
	with polytetrafluoroethylene sliding surface					
50	Hardness of elastomeric (neoprene) bearing	Number	1	Durometers		Yellow
51	Comments	Text				Orange
	Concrete Superstructure Items					Pink
52	Concrete for approach slab	Number	1	USD/yd^3		Yellow
53	Concrete for median barrier	Number	1	USD/ lin ft		Yellow
54	Concrete for parapet	Number	1	USD/ lin ft		Yellow
55	Precast pretensioned concrete I-girder type	Predefined list			AASHTO Type I AASHTO Type II AASHTO Type III AASHTO Type IV AASHTO Type V AASHTO Type VI	Yellow
56	Precast pretensioned concrete I-girder type cost	Number	1	USD/ lin ft		Yellow
57	Bulb-tee pretensioned concrete girder type	Predefined list			AASHTO/PCI BT-54 AASHTO/PCI BT-63 AASHTO/PCI BT-72	Yellow
58	Bulb-tee pretensioned concrete girder	Number	1	USD/ lin ft		Yellow
59	Deck bulb-tee pretensioned concrete girder type	Number			AASHTO/PCI Deck BT-35 AASHTO/PCI Deck BT-53 AASHTO/PCI Deck BT-65	Yellow
60	Deck bulb-tee pretensioned concrete girder	Number	1	USD/ lin ft		Yellow
61	Precast pretensioned concrete box beam type	Predefined list			AASHTO Type BI-36 AASHTO Type BI-48 AASHTO Type BII-36 AASHTO Type BII-48 AASHTO Type BIII-36 AASHTO Type BIII-48 AASHTO Type BIV-36 AASHTO Type BIV-48	Yellow
62	Precast pretensioned concrete box beam cost	Number	1	USD/ lin ft		Yellow
63	Cast-in-place posttensioned concrete box girder	Number	1	USD/ lin ft		Yellow
64	Transportation and erection costs for precast concrete beams/girders	Number	1	USD/ lin ft		Yellow
65	Comments	Text			Dimensions of the cast-in-place posttensioned concrete box section	Orange

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
	Steel Superstructure Items					Pink
66	Fabrication of structural steel	Number	1	USD/lb		Yellow
67	Transportation and erection of structural steel beams/girders	Number	1	USD/lb		Yellow
68	Structural steel rolled beam grade	Predefined list			ASTM A709 Grade 36 ASTM A709 Grade 50 ASTM A709 Grade 50W	Yellow
69	Structural steel rolled beam—cost per linear foot	Number	1	USD/lin ft		Yellow
70	Structural steel plate girder grade	Predefined list			ASTM A709 Grade 36 ASTM A709 Grade 50 ASTM A709 Grade 50W ASTM A709 Grade HPS50W ASTM A709 Grade HPS70W	Yellow
71	Structural steel plate girder	Number	1	USD/ lin ft		Yellow
72	Surface preparation for coating structural steel	Number	1	USD/ lin ft		Yellow
73	Shop-applied primer	Number	1	USD/ lin ft	First coat in a three-coat paint/protective system.	Yellow
74	Shop-applied intermediate coat	Number	1	USD/ lin ft	Second coat in a three-coat paint/protective system.	Yellow
75	Shop-applied top coat	Number	1	USD/ lin ft	Third coat in a three-coat paint/protective system.	Yellow
76	Field-applied primer	Number	1	USD/ lin ft	First coat in a three-coat paint/protective system.	Yellow
77	Field-applied intermediate coat	Number	1	USD/ lin ft	Second coat in a three-coat paint/protective system.	Yellow
78	Field-applied top coat	Number	1	USD/ lin ft	Third coat in a three-coat paint/protective system.	Yellow
79	Galvanized coating	Number	1	USD/ lin ft		Yellow
80	Surface area of steel being coated that applies to the costs above.	Number	1	ft^2		Yellow
81	Comments	Text				Orange
	Concrete Substructure Items					Pink
82	Cast-in-place concrete for bridge abutments—Standard concrete	Number	1	USD/yd^3		Yellow
83	Cast-in-place concrete for bridge piers—Standard concrete	Number	1	USD/yd^3		Yellow
84	Cast-in-place concrete for bridge wingwall—Standard concrete	Number	1	USD/yd^3		Yellow
85	Cast-in-place concrete for bridge pier cap—Standard concrete	Number	1	USD/yd^3		Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
86	Diameter of precast reinforced concrete piles	Number	1	in.		Yellow
87	Precast reinforced concrete piles	Number	1	USD/ lin ft		Yellow
88	Diameter of precast prestressed (pretensioned) concrete piles	Number	1	in.		Yellow
89	Precast prestressed (pretensioned) concrete piles	Number	1	v		Yellow
90	Cast-in-place concrete for bridge footing—Standard concrete	Number	1	USD/yd^3		Yellow
91	Reinforcing Steel—Uncoated	Number	1	USD/lb		Yellow
92	Reinforcing Steel—Epoxy coated	Number	1	USD/lb		Yellow
93	Comments	Text				Orange
Steel Substructure Items						Pink
94	Steel sheet piling	Number	1	USD/ft^2		Yellow
95	Breadth of steel H-piles	Number	1	in.	Not the length in the ground	Yellow
96	Steel H-piles	Number	1	USD/ lin ft		Yellow
97	Comments	Text				Orange
Other Bridge Items						Pink
98	Untreated timber piles	Number	1	USD/ lin ft		Yellow
99	Treated timber piles	Number	1	USD/ lin ft		Yellow
100	Comments	Text				Orange
Total Bid for Bridge Construction (including fee)						Pink
101	Total construction of bridge	Number	1	USD		Yellow
102	Comments	Text				Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item.
Field Name	Data field name.
Data Type	Type of data, such as text, number, predefined list, binary large object (BLOB), or PDF file.
Accuracy	Accuracy to which the data are recorded.
Unit	Unit in which a measurement is taken and recorded.
Field Description	Commentary on the data.
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied.
Pink	Logical breakdown of data by elements or defect types (not always used).
Blue	Data identifying the element being evaluated or the type of defect being identified.
Yellow	LTBP data reported individually for each element or defect identified.
Orange	Comments on the data collection or data entered.

5. CRITERIA FOR DATA VALIDATION

5.1 Data extracted from bridge documents should be checked by a second (independent) person.

5.2 Where feasible, data will be validated using standard error checking within the Bridge Portal.

6. COMMENTARY/BACKGROUND

6.1 This protocol provides guidance for collecting data to document the costs of designing and constructing the bridge. These cost data are used in life-cycle cost analysis of bridges. Please note that other types of cost data are gathered in PRE-ED-BD-006, Bridge Maintenance Records and Cost Data.

6.2 States' cost data are typically in the form of unit costs, such as cost per square foot, cost per gallon, or cost per each item. Therefore, the LTBP Program will store unit cost data.

6.3 Bridge deck designers usually try to minimize water accumulation by establishing a cross slope with drainage channels and by deck surface texturing. Two methods of producing texturing are:

6.3.1 *Tining* – The deck is dragged transversely with a metal rake while the concrete is still plastic. Although this method can produce grooves deep enough for a high-friction surface, the grooves are not uniform and are limited in depth.

6.3.2 *Grooving* – A better method of getting maximum deck drainage is to saw grooves into the pavement transversely, or perpendicular to the direction of traffic, after the concrete has cured. Bridge deck grooving is achieved by diamond saw blades that are ganged, or arranged at spaced intervals, on a shaft. Grooving can begin after deck concrete has cured to the minimum required compressive strength. Grooving is usually done perpendicular to the centerline to within about 1 foot of the gutter, curb, or parapet lines.

7. REFERENCES

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-005, Personnel Qualifications.

7.1.2 PRE-ED-BD-006, Bridge Maintenance Records and Cost Data.

7.1.3 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.4 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*:

7.2.1 FHWA-NHI-12-053, Bridge Inspector's Reference Manual, Federal Highway Administration, Washington, DC, 2012.

BRIDGE SITE CONDITIONS

LTBP Protocol #: PRE-ED-BD-004

1. DATA COLLECTED

1.1 Data related to the typical environmental, anti-icing, and traffic conditions at the bridge site.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 Computer.

2.1.2 Scanner.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Work with the bridge owner to obtain values for average daily traffic (ADT), average daily truck traffic (ADTT), and amount and type of anti-icing agent, (data collection table items 8–15), beginning with the year construction of the bridge was completed and for each subsequent year that data are available.

3.2 Obtain marine environment, weather, and water flow data, beginning with the year construction of the bridge was completed and for each subsequent year that data are available:

3.2.1 Calculate the straight line distance from the centerline of the bridge to the nearest body of saltwater (miles) (data collection table item 16).

3.2.2 Obtain water flow data using publicly available Federal Emergency Management Agency (FEMA) flood maps and National Oceanic and Atmospheric Administration (NOAA) historic flood data (data collection table items 18–26).

3.3 If the bridge information exists only in paper form, scan that information into an electronic format so it can be stored in the LTBP Bridge Portal.

3.4 Storing data, documents, and images:

3.4.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.4.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.5 Reporting: Transfer all metadata, data, documents, and images to FHWA, and/or upload all metadata, data, documents, and images into the LTBP Bridge Portal.

4. DATA COLLECTION TABLE

4.1 Table:

#	FIELD NAME	DATA TYPE	ACCURACY	UNIT	FIELD DESCRIPTION	ROW COLOR
1	State	Text			State Code; e.g., Virginia = VA	Green
2	NBI structure number	Text			Item 8, structure number; from NBI Coding Guide	Green
3	Structure name	Text			Descriptive name for the bridge; e.g., Route 15 SB over I–66	Green
4	Protocol name	Text			Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text			First name(s) Last name(s)	Green
7	Date data were collected	Text	Exact date		mm/dd/yyyy	Green
	TRAFFIC DATA					Pink
8	Year ADT, ADTT, and WIM data were recorded	Text			yyyy	Blue
9	ADT	Number	100	Vehicles/day		Yellow
10	ADTT	Number	100	Vehicles/day		Yellow
11	Comments	Text			If WIM data is provided, provide the source of the WIM data	Orange
	ANTI-ICING PRACTICES AND MARINE ENVIRONMENT					Pink
12	Automated anti-icing system in use at bridge site	Predefined list			Yes or No	Yellow
13	Description of anti-icing system	Text			Manufacturer, model name and number	Yellow
14	Type of anti-icing agent	Text			Indicate "None" or specify name of the anti-icing agent	Yellow
15	Quantity of anti-icing agent per year applied to the bridge	Number	1	lbs	See section 6.2.	Yellow
16	Distance from bridge centerline to saltwater	Number	1	mi	Straight line distance to the nearest body of saltwater	Yellow
17	Comments	Text				Orange
	WATERWAY FLOW DATA (FOR BRIDGES CROSSING WATERWAYS)					Pink
18	FEMA flood plain designation	Text				Yellow
19	FEMA base flood elevation at the location of the bridge site	Number	1	ft		Yellow
20	100-year design flood velocity	Number	1	ft^3/sec		Yellow
21	Maximum known flow velocity	Number	1	ft^3/sec		Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
22	Historical flood events at the structure location	Text			Record how many 100-year-or-greater flood events have occurred at the bridge site and the years those events occurred. Also, record the crest height if known.	Yellow
23	Year recorded	Text	Year		yyyy	Blue
24	Average flow velocity	Number	1	ft^3/sec		Yellow
25	Peak flow velocity	Number	1	ft^3/sec		Yellow
26	Comments	Text				Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. Criteria for Data Validation

5.1 Where feasible, data will be validated using standard error checking within the Bridge Portal.

6. Commentary/Background

6.1 This protocol provides guidance for collecting data that help characterize the environmental, anti-icing, and traffic conditions at the bridge. This information is used to evaluate the relative impact of these factors on the performance of the bridge and subsequently account for these factors in the development of deterioration models.

6.2 Historic weather data on temperature, humidity, rainfall, snowfall, solar radiation, and wind speed will be collected under a protocol to be developed at a future date.

6.3 If the quantity of anti-icing agent per year applied to the bridge (data collection table item 16) is not available, then take the following steps:

6.3.1 Estimate the amount of anti-icing agent per year used over the route that the bridge carries.

6.3.2 Use the amount calculated in section 6.3.1, and prorate it for the length of the bridge.

7. References

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-005, Personnel Qualifications.

7.1.2 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.3 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*:

7.2.1 National Oceanic and Atmospheric Administration (NOAA): http://www.noaa.gov/

7.2.2 Modern Era-Retrospective Analysis for Research and Applications (MERRA): http://gmao.gsfc.nasa.gov/research/merra/intro.php

7.2.3 Federal Emergency Management Administration (FEMA): http://www.fema.gov/

1. DATA COLLECTED

1.1 Inspection information, metadata, data, documents, and images collected by the owner's inspection staff or owner's consultant inspection forces during the current and past biennial National Bridge Inspection Standards (NBIS) bridge inspections and any other inspections performed.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1.1 *Equipment:*

2.1.2 Computer.

2.1.3 Scanner.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Work with the bridge owner to obtain the required inspection information (data collection table items 9–13).

NOTE—All current and past National Bridge Inspection (NBI) data and all current and past AASHTO element level data will be obtained through separate processes.

3.2 If the bridge information exists only in paper form, scan that information into an electronic format so it can be stored in the LTBP Bridge Portal.

3.3 Storing data, documents, and images:

3.3.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.3.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.4 Reporting: Transfer all metadata, data, documents, and images to FHWA, and/or upload all metadata, data, documents, and images into the LTBP Bridge Portal.

4. DATA COLLECTION TABLE

4.1 Table:

#	FIELD NAME	DATA TYPE	ACCURACY	UNIT	FIELD DESCRIPTION	ROW COLOR
1	State	Text			State Code; e.g., Virginia = VA	Green
2	NBI structure number	Text			Item 8, structure number; from NBI Coding Guide	Green

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
3	Structure name	Text			Descriptive name for the bridge; e.g., Route 15 SB over I–66	Green
4	Protocol name	Text			Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text			First name(s) Last name(s)	Green
7	Date data was collected	Text	Exact date		mm/dd/yyyy	Green
8	Month and year of inspection	Text	Month and year		mm/yyyy, repeat for each year inspection information is collected	Blue
9	Copy of the periodic inspection report	BLOB			Electronic or scanned copy of full inspection report	Yellow
10	Inspection conducted by State personnel or a consultant	Predefined list			State inspector Consultant inspector	Yellow
11	Person(s) conducting inspection	Text			Name(s) and affiliations	Yellow
12	Copies of sketches, photographs, and other figures	BLOB			Electronic or scanned copy of each sketch, photograph or other figure not included in the inspection report	Yellow
13	Comments	Text				Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, predefined list, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. Criteria for Data Validation

5.1 None.

6. Commentary/Background

6.1 This protocol provides guidance for collecting records and data compiled by the owner during biennial NBIS inspections, as well as other periodic inspections.

The information in the owner's inspection files is an excellent resource for understanding the history of the bridge before beginning LTBP field data collection.

6.2 In accordance with the NBIS, every bridge (on public highways) must be inspected at least every 2 years. Inventory and inspection data collected during these inspections is reported to FHWA and stored in the NBI database. In addition to the required data for the NBI database, most State bridge owners keep detailed records of the inspection findings—details of deficiencies, photographs, and other information documenting the condition of the bridge and all of its elements.

6.3 During the biennial inspections, for bridges other than culverts, NBIS inspectors record NBI condition ratings for NBI items 58 (deck), 59 (superstructure), and 60 (substructure). These ratings are included in the inspection reports. These data will also be collected for all LTBP bridges under a separate process.

6.4 During the biennial inspections, depending on the owner's policies, inspectors may also estimate and record element level condition state data in accordance with reference 7.2.3 or 7.2.4 below. These data will be collected for all LTBP bridges under a separate process.

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7. REFERENCES

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-005, Personnel Qualifications.

7.1.2 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.3 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*:

7.2.1 FHWA, National Bridge Inspection Standards, 2009 Final Rule, Federal Register, Volume 74, Number 246, Pages 68377-68379, Washington, DC, 2009.

7.2.2 FHWA-NHI-12-053, Bridge Inspector's Reference Manual, Federal Highway Administration, Washington, DC, 2012.

7.2.3 AASHTO, AASHTO Guide for Commonly Recognized Structural Elements, 1st Edition with 2002 and 2010 Revisions, American Association of State Highway and Transportation Officials, Washington, DC, 2010.\

7.2.4 AASHTO, Manual for Bridge Element Inspection, 1st Edition with 2015 Interim Revisions, American Association of State Highway and Transportation Officials, Washington, DC, 2013.

BRIDGE MAINTENANCE RECORDS AND COST DATA

LTBP Protocol #: PRE-ED-BD-006

1. DATA COLLECTED

1.1 Information and data related to maintenance actions for the bridge and their costs.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 Computer.

2.1.2 Scanner.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Use the data collection grid (FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks) to locate maintenance actions on the deck.

3.2 Use the segmentation and numbering system (FLD-OP-SC-002, Structure Segmentation and Element Identification System) to locate and document maintenance actions by unique element identifier.

3.3 Use FLD-OP-SC-003, Determination of Local Origins for Elements, to establish a local origin on each element of the superstructure and substructure.

3.4 Work with the bridge owner to obtain information and cost data for each maintenance action for the bridge since 1960 or the year the bridge was opened to traffic, whichever is later (data collection table items 8–21). For treatments that involve several operations with different materials (e.g., patching deck, followed by sealing), report each action separately if possible.

3.4.1 If the bridge information exists only in paper form, scan that information into an electronic format so it can be stored in the LTBP Bridge Portal.

3.5 Storing data, documents, and images:

3.5.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.5.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.6 Reporting: Transfer all metadata, data, documents, and images to FHWA, and/or upload all metadata, data, documents, and images into the LTBP Bridge Portal.

4. DATA COLLECTION TABLE

4.1 Table:

#	FIELD NAME	DATA TYPE	ACCURACY	UNIT	FIELD DESCRIPTION	ROW COLOR
1	State	Text			State Code; e.g., Virginia = VA	Green
2	NBI structure number	Text			Item 8, structure number; from NBI Coding Guide	Green
3	Structure name	Text			Descriptive name for the bridge; e.g., Route 15 SB over I–66	Green
4	Protocol name	Text			Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text			First name(s) Last name(s)	Green
7	Date data were collected	Text	Exact date		mm/dd/yyyy	Green
8	Element type	Text			e.g.; abutment, pier, etc.	Blue
9	Unique element identifier	Text			If the entire element type is not impacted, list the unique element identifier(s) of elements impacted; P1C1 (column 1 of pier 1)	Blue
10	Year maintenance action completed	Text	Exact year		yyyy	Yellow
11	Type of maintenance action	Predefined list			Clean the deck Seal cracks Seal the full deck Patch deck Apply overlay to deck Remove debris from deck drainage system Paint girders and/or cross-frames Clean bearing Other (specify)	Yellow
12	Narrative and photographic description of element condition	Text				Yellow
13	Describe any preparation of element prior to maintenance action	Text			e.g., clean, blast clean, patch deck, remove existing paint,	Yellow
14	Materials and quantities used in the maintenance action	Text			Generic material types and brand names if known; quantities used if known	Yellow
15	Material specifications	Text			If available	Yellow
16	Quantity of maintenance action accomplished	Text	1	Varies	e.g., deck area sealed in square feet	Yellow
17	Cost of maintenance action	Number	1	USD		Yellow
18	Cost basis	Text			Specify cost basis; e.g., total cost, unit cost per square foot	Yellow
19	Maintenance of traffic (MOT) included in cost?	Predefined list			Yes or No	Yellow
20	Work done by State personnel or a contractor	Predefined list			State personnel Contractor	Yellow
21	Comments	Text				Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, predefined list, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. Criteria for Data Validation

5.1 None.

6. Commentary/Background

6.1 This protocol provides guidance for collecting data on the actions taken by the owner to maintain the bridge and its elements during the life of the bridge.

6.2 These data are used to do the following:

6.2.1 Document the actions that the owner took to maintain the elements of the bridge after the bridge was put into service.

6.2.2 Evaluate the causes of declining performance of the bridge and develop deterioration models.

6.2.3 Document the costs of maintaining the bridge and the elements of the bridge after the bridge was put into service.

7. References

7.1 *LTBP Protocols*:

7.1.1 FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks.

7.1.2 FLD-OP-SC-002, Structure Segmentation and Element Identification System.

7.1.3 FLD-OP-SC-003, Determination of Local Origins for Elements.

7.1.4 PRE-PL-LO-005, Personnel Qualifications.

7.1.5 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.6 FLD-DS-RS-001, Data, Document, Image Storage—Remote.

7.2 *External*: None.

CALCULATION OF BRIDGE RATINGS

LTBP Protocol #: PRE-ED-BD-007

1. DATA COLLECTED

1.1 Information and data related to load ratings of the bridge.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 Computer.

2.1.2 Scanner.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Work with the bridge owner to obtain bridge rating information for the year in which the bridge is first load rated and for each subsequent year ratings were calculated (data collection table items 8–18).

3.2 If the bridge information exists only in paper form, scan that information into an electronic format so it can be stored in the LTBP Bridge Portal.

3.3 Storing data, documents, and images:

3.3.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.3.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.4 Reporting: Transfer all metadata, data, documents, and images to Federal Highway Administration (FHWA), and/or upload all metadata, data, documents, and images into the LTBP Bridge Portal.

4. DATA COLLECTION TABLE

4.1 Table:

#	FIELD NAME	DATA TYPE	ACCURACY	UNIT	FIELD DESCRIPTION	ROW COLOR
1	State	Text	Text		State Code; e.g., Virginia = VA	Green
2	NBI structure number	Text	Text		Item 8, structure number; from NBI Coding Guide	Green
3	Structure name	Text	Text		Descriptive name for the bridge; e.g., Route 15 SB over I–66	Green
4	Protocol name	Text	Text		Title of the protocol	Green

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text	Text		First name(s) Last name(s)	Green
7	Date data were collected	Text	Exact date		mm/dd/yyyy	Green
8	Month and year of ratings	Text	Exact month and year		mm/yyyy; month and year that ratings were calculated	Blue
9	Rating calculated by consultant, State, or local	Predefined list			Consultant State agency Local agency	Yellow
10	Person(s) rating the bridge	Text			Name(s) and affiliations	Yellow
11	Method used to determine operating rating	Predefined list			Load factor rating Allowable stress rating Load and resistance factor rating Load testing No rating analysis performed	Yellow
12	Calculated operating rating	Numeric	0.1	T	1T = 2,000 lbs	Yellow
13	Method used to determine inventory rating	Predefined list			Load factor rating Allowable stress rating Load and resistance factor rating Load testing No rating analysis performed	Yellow
14	Calculated inventory rating	Numeric	0.1	T	1T = 2,000 lbs	Yellow
15	Rating vehicle used	Text				Yellow
16	Was the bridge posted, or continued to be posted, as a result of these ratings/load testing?	Predefined list			Yes No Continued Posting	Yellow
17	Posted load	Numeric	1	ton(s)	Posted load capacity, if any, due to these load ratings or load testing	Yellow
18	Comments	Text				Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, predefined list, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. CRITERIA FOR DATA VALIDATION

5.1 None.

6. COMMENTARY/BACKGROUND

6.1 This protocol provides guidance for collecting data on calculations performed by the bridge owner to determine the load rating of the bridge.

6.2 The operating rating is the maximum permissible live load to which a bridge may be subjected for the load configuration used in the rating.

6.3 The inventory rating is that load, including loads in multiple lanes that can safely use the bridge for an indefinite period of time.

6.4 See the AASHTO Manual for Bridge Evaluation, 2nd Edition (2010) for descriptions of the following:

6.4.1 The load factor rating method.

6.4.2 The allowable stress rating method.

6.4.3 The load and resistance factor rating method.

6.4.4 Load testing procedures.

6.4.5 Rating vehicle for load tests.

7. REFERENCES

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-005, Personnel Qualifications.

7.1.2 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.3 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*:

7.2.1 AASHTO, AASHTO Manual for Bridge Evaluation, 2nd Edition, Washington, DC, 2010.

7.2.2 FHWA-PD-96-001, Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation’s Bridges, Federal Highway Administration Office of Engineering, Washington, DC, 1995.

7.2.3 FHWA Memorandum, Bridge Load Ratings for the National Bridge Inventory, Federal Highway Administration Office of Infrastructure, Washington, DC, October 30, 2006.

LEGACY DATA MINING PROTOCOLS (LD)

PRE-ED-LD-001, Legacy Data Mining for Untreated Bridge Decks

LEGACY DATA MINING FOR UNTREATED BRIDGE DECKS

LTBP Protocol #: PRE-ED-LD-001

1. DATA COLLECTED

1.1 Analyzed quantitative data and other descriptive information gathered from the analysis of legacy data for the bridge.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*: Computer.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Calculate the following parameters from the data obtained from the Bridge Documentation Protocols (PRE-ED-BD-001, Plans and Specifications for Bridge Design and Construction; PRE-ED-BD-002, Bridge Construction Records):

3.1.1 Moment of inertia of noncomposite section.

3.1.2 Moment of inertia of composite section (if applicable).

3.1.3 Stiffness of superstructure.

3.1.4 Load distribution factor.

3.1.5 If data is available on the temperature, the relative humidity, and the wind speed at deck level at the time the deck was poured, use these data to estimate of the rate of evaporation.

3.2 Perform the following analyses using the National Bridge Inventory (NBI) Condition Ratings for the bridge, the data obtained from the Bridge Documentation Protocols (PRE-ED-BD-001, Plans and Specifications for Bridge Design and Construction; PRE-ED-BD-002, Bridge Construction Records; PRE-ED-BD-004, Bridge Site Conditions; PRE-ED-BD-005, Bridge Inspection Records) for the bridge, and the parameters calculated in section 3.1 above, to see if there is any correlation between them and the following:

3.2.1 Time to NBI ratings for decks:

3.2.1.1 Age when the deck first reached NBI rating 8.

NOTE—For States using the NBI translator to calculate NBI ratings, it will be necessary to estimate the age when the deck reaches a rating of 8.

3.2.1.2 Age when deck first reached NBI rating 7.

3.2.1.3 Age when deck first reached NBI rating 6.

3.2.1.4 Age when deck first reached NBI rating 5.

3.2.1.5 Age when deck first reached NBI rating 4.

3.2.1.6 Age when deck first reached NBI rating 3.

3.2.2 Time between NBI ratings for decks:

3.2.2.1 NBI rating 8 to NBI rating 7.

3.2.2.2 NBI rating 7 to NBI rating 6.

3.2.2.3 NBI rating 6 to NBI rating 5.

3.2.2.4 NBI rating 5 to NBI rating 4.

3.2.2.5 NBI rating 4 to NBI rating 3.

3.3 If possible, determine any correlation between the NBI rating of the deck and the following:

3.3.1 Crack density of deck.

3.3.2 Age and the following deck types:

3.3.2.1 Monolithic cast-in-place.

3.3.2.2 Precast subdeck panels with concrete topping.

3.3.2.3 Precast full-depth deck panels.

3.3.3 Moment of inertia of composite section.

3.3.4 Age, girder type, and girder material.

3.3.5 Age and permeability of deck.

3.3.6 Age and water-to-cement (w/c) materials ratio of deck.

3.3.7 Age and presence of the following supplementary cementitious materials in deck:

3.3.7.1 Fly ash.

3.3.7.2 Silica fume.

3.3.7.3 Slag.

3.3.7.4 Metakaolin.

3.3.8 Cement content.

3.3.9 Type of cement:

3.3.9.1 Type I.

3.3.9.2 Type II.

3.3.9.3 Type III.

3.3.9.4 Type IV (if applicable).

3.3.9.5 Type V (if applicable).

3.3.10 Water content with and without use of a superplasticizer.

3.3.11 Volume of paste per cubic yard (cement content plus water content).

3.3.12 Coarse aggregate type.

3.3.13 Percentage of air entrainment:

3.3.13.1 Specified.

3.3.13.2 Actual.

3.3.14 Concrete compressive strength at the following ages:

3.3.14.1 1 day

3.3.14.2 28 days

3.3.15 Size and spacing of reinforcing bars in top mat.

3.3.16 Size and spacing of reinforcing bars in bottom mat.

3.3.17 Grade and the following types of reinforcing bars in top mat:

3.3.17.1 Black bars.

3.3.17.2 Epoxy-coated bars.

3.3.17.3 Stainless steel bars.

3.3.17.4 Stainless-clad bars.

3.3.17.5 Grade 40 yield strength bars.

3.3.17.6 Grade 60 yield strength bars.

3.3.18 Grade and the following types of reinforcing bars in bottom mat:

3.3.18.1 Black bars.

3.3.18.2 Epoxy coated bars.

3.3.18.3 Stainless steel bars.

3.3.18.4 Stainless-clad bars.

3.3.18.5 Grade 40 yield strength bars.

3.3.18.6 Grade 60 yield strength bars.

3.3.19 The following weather factors at time of deck construction:

3.3.19.1 Season when constructed.

3.3.19.2 Mean ambient temperature.

3.3.19.3 Wind speed.

3.3.19.4 Estimate of evaporation rate.

3.3.20 The following age groups and changes in materials specifications (and cement changes, including fineness of cement):

3.3.20.1 1970–1975.

3.3.20.2 1975–1980.

3.3.20.3 1980–1985.

3.3.20.4 1985–1990.

3.3.20.5 1990–1995.

3.3.20.6 1995–2000.

3.3.20.7 2000–2005.

3.3.20.8 2005–2010.

3.3.21 Deck placement technique used by the contractor, such as the following:

3.3.21.1 Bucket.

3.3.21.2 Pumping.

3.3.22 Deck finishing technique used by the contractor, such as the following:

3.3.22.1 Manual with hand-held vibrators.

3.3.22.2 Roller screeds.

3.3.22.3 Vibrating screeds.

3.3.22.4 Tining.

3.3.22.5 Sawcut grooving.

3.3.23 Slump, including:

3.3.23.1 Specified slump.
3.3.23.2 Actual measured slump.

3.3.24 The curing method used by the contractor, including:
3.3.24.1 Sprinkler and burlap.
3.3.24.2 Fogging.
3.3.24.3 Curing compound.
3.3.24.4 Wet burlap.
3.3.24.5 Plastic sheets.

3.3.25 Length of curing period.

3.3.26 Time of initiation of wet curing.

3.3.27 Age and clear cover of top mat of reinforcement in deck.

3.3.28 Girder spacing.

3.3.29 Girder type, material, and spacing.

3.3.30 Girder end condition:
3.3.30.1 Fixed.
3.3.30.2 Allows translation only.
3.3.30.3 Allows rotation only.

3.3.31 Integral or semi-integral abutments.

3.3.32 Superstructure stiffness.

3.3.33 Span length.

3.3.34 Average daily truck traffic.

3.3.35 Amount and type of anti-icing agent applied to the deck at each of the following intervals:
3.3.35.1 Week.
3.3.35.2 Month.
3.3.35.3 Winter season.

3.3.36 Slope of deck surface:
3.3.36.1 Longitudinal slope.
3.3.36.2 Cross slope.

3.3.37 Number and spacing of deck joints (if any).

3.3.38 The type of deck joints.

3.3.39 The condition of deck joints, including water tightness.

3.3.40 Number of scuppers.

3.3.41 Condition of scuppers.

3.3.42 Locations of scuppers.

3.3.43 The frequency of the following maintenance/preservation activities:
3.3.43.1 Bridge washing.
3.3.43.2 Cleaning joints.
3.3.43.3 Cleaning scuppers.

3.4 Write a summary report describing the analyses and findings from sections 3.1, 3.2, and 3.3, and upload it into the LTBP Bridge Portal.

3.5 Storing data, documents, and images:

3.5.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.5.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.6 Reporting: Transfer all metadata, data, documents, and images to FHWA, and/or upload all metadata, data, documents, and images into the LTBP Bridge Portal.

4. DATA COLLECTION TABLE

4.1 Table:

#	FIELD NAME	DATA TYPE	ACCURACY	UNIT	FIELD DESCRIPTION	ROW COLOR
1	Protocol name	Text			Title of the protocol	Green
2	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
3	Contractor or agency performing the legacy data mining	Text			Name of contractor, university, State agency, or Federal agency performing the legacy data mining.	Green
4	Personnel performing legacy data mining	Text			First name(s) Last name(s)	Green
5	Title of legacy data mining report	Text			e.g., Legacy Data Mining Report for Untreated Bridge Decks—LTBP Mid-Atlantic Cluster	Green
6	Date legacy data mining completed	Text	Exact date		mm/dd/yyyy	Green
7	Clusters and/or corridors covered by the legacy data mining report	Text			e.g., LTBP Mid-Atlantic Cluster	Yellow
8	Legacy data mining report	BLOB			Microsoft® Word file	Yellow
9	Comments	Text				Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, predefined list, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. CRITERIA FOR DATA VALIDATION

5.1 None.

6. COMMENTARY/BACKGROUND

6.1 This protocol provides guidance on using legacy data for an LTBP bridge to evaluate performance of an untreated bridge deck using structural characteristics, material properties, construction practices, and its condition over time as expressed by the NBI rating.

6.2 Legacy data includes data from NBI inspections and from documents obtained from the bridge owner about the bridge characteristics, bridge construction practices, the material properties of the bridge and the bridge deck, as well as the condition of the bridge deck.

6.3 Data about bridges available and accessible without a site visit to the bridge are used to evaluate deterioration trends and answer key performance questions on a large set of bridges. These data are collected using the Bridge Documentation protocols.

7. REFERENCES

7.1 *LTBP Protocols*:

7.1.1 PRE-ED-BD-001, Plans and Specifications for Bridge Design and Construction.

7.1.2 PRE-ED-BD-002, Bridge Construction Records.

7.1.3 PRE-ED-BD-003, Bridge Design and Construction Cost Data.

7.1.4 PRE-ED-BD-004, Bridge Site Conditions.

7.1.5 PRE-ED-BD-005, Bridge Inspection Records.

7.1.6 PRE-ED-BD-006, Bridge Maintenance Records and Cost Data.

7.1.7 PRE-ED-BD-007, Calculation of Bridge Ratings.

7.1.8 PRE-PL-LO-005, Personnel Qualifications.

7.1.9 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.10 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*: None.

Logistics Protocols (LO)

PRE-PL-LO-001, Reference Bridge Testing

PRE-PL-LO-002, Cluster Bridge Testing

PRE-PL-LO-003, Traffic Control, Maintenance and Protection of Traffic (MPT), and Permits

PRE-PL-LO-004, Personal Health and Safety Plan

PRE-PL-LO-005, Personnel Qualifications

PRE-PL-LO-006, Power and Network Requirements

PRE-PL-LO-007, Communication and Coordination Plan

Long-Term Bridge Performance Program

REFERENCE BRIDGE TESTING

LTBP Protocol #: PRE-PL-LO-001

1. DATA COLLECTED

1.1 None. This protocol provides a list of all the standard tests to be conducted on bridges designated as reference bridges.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*: None.

2.2 *Personnel*: None.

3. METHODOLOGY

3.1 Conduct the following visual inspection tests and procedures on reference bridges, unless otherwise directed by Federal Highway Administration (FHWA):

3.1.1 FLD-DC-VIS-001, Steel Superstructure Deterioration.

3.1.2 FLD-DC-VIS-002, Steel Superstructure—Corrosion.

3.1.3 FLD-DC-VIS-003, Steel Superstructure—Section Loss.

3.1.4 FLD-DC-VIS-004, Steel Superstructure—Cracking, Deflection, Uplift, Distortion, Buckling, Rotation, and Impact Damage.

3.1.5 FLD-DC-VIC-001, Concrete Deterioration.

3.1.6 FLD-DC-VIC-002, Concrete Substructure Condition Assessment.

3.1.7 FLD-DC-VIC-003, Concrete Deck—Spalls and Delamination.

3.1.8 FLD-DC-VIC-004, Concrete Superstructure and Substructure—Spalls and Delamination.

3.1.9 FLD-DC-VIC-005, Concrete—Cracking.

3.1.10 FLD-DC-VIC-006, Concrete—Abrasion.

3.1.11 FLD-DC-VIC-007, Concrete—Sulfate Attack.

3.1.12 FLD-DC-VIB-001, Elastomeric Bearings.

3.1.13 FLD-DC-VIB-002, Rocker Bearings.

3.1.14 FLD-DC-VIJ-001, Drainage System on Bridge Decks and Approach Slabs.

3.1.15 FLD-DC-VIJ-002, Expansion Joints.

3.2 Conduct the following manual and/or automated, nondestructive evaluation (NDE) tests on reference bridges, unless otherwise directed by FHWA:

3.2.1 FLD-DC-NDE-001, Electrical Resistivity Testing.

3.2.2 FLD-DC-NDE-002, Ground Penetrating Radar Testing for Bridge Decks.

3.2.3 FLD-DC-NDE-003, Half-Cell Potential Testing.

3.2.4 FLD-DC-NDE-004, Impact Echo Testing.

3.2.5 FLD-DC-NDE-007, Ultrasonic Surface Wave Testing—Concrete.

3.3 FLD-DC-MS-001, Wet Coring of Concrete Decks. Obtain concrete cores from one span of the bridge deck in the following numbers and locations, unless otherwise directed by FHWA:

3.3.1 The results of the visual inspection of the deck and NDE testing (if available) should be considered in the location of cores. Cores should be taken from sound concrete that is determined to be free of cracks, delaminations, and spalls.

3.3.2 Obtain one 4-inch diameter core in each lane and in each shoulder on the untreated bridge decks of reference bridges.

3.3.3 Obtain one 2.5-inch core in each lane and in each shoulder on the untreated bridge decks of reference bridges.

3.3.4 Transverse location of cores should be:

3.3.4.1 Shoulders – between 2 and 4 ft from the face of the curb or parapet or from the edge of the deck if there is no curb or parapet.

3.3.4.2 Travel lanes – between the wheel paths.

3.3.5 The location of cores should be spaced longitudinally in order to cover different sections of the span selected for coring.

3.4 Conduct the following material and physical sampling procedures and tests on the cores obtained under section 3.3:

3.4.1 FLD-DC-MS-002, Compressive Strength and Static and Dynamic Elastic Moduli of Concrete Cores.

3.4.2 FLD-DC-MS-003, Resistance of Concrete to Chloride Ion Penetration (Permeability).

3.4.3 FLD-DC-MS-004, Sampling and Testing for Chloride Profiles.

3.5 Reference bridges will typically be instrumented for live load testing and long-term monitoring. Protocols governing these types of testing will be developed.

3.6 Conduct other/optional tests, where applicable and as specified by the owner agency and/or FHWA.

4. DATA COLLECTION TABLE

4.1 None.

5. CRITERIA FOR DATA VALIDATION

5.1 None.

6. COMMENTARY/BACKGROUND

6.1 This protocol provides guidance for developing a plan for evaluating and testing reference bridges.

6.2 A "reference bridge" is the bridge within each cluster that is representative of the cluster as a whole. It will undergo periodic evaluation and testing using a detailed visual inspection protocol supplemented with material testing and advanced evaluation methods utilizing NDE tools. Collecting additional concrete cores after the initial round of material testing should be governed by the following:

6.2.1 Unless otherwise directed by FHWA, no cores will be taken for the purposes of testing strength, modulus of elasticity, or permeability. These properties of mature concrete are not expected to vary significantly with age.

6.2.2 Unless otherwise directed by FHWA, obtaining cores and sampling for chloride profile testing is to be repeated every 5 years.

6.3 Additional tests may be added for a particular reference bridge. Given that each bridge is different, a specific test plan may be developed for a specific reference bridge.

7. REFERENCES

7.1 *LTBP Protocols*:

7.1.1 FLD-DC-VIS-001, Steel Superstructure Deterioration.

7.1.2 FLD-DC-VIS-002, Steel Superstructure—Corrosion.

7.1.3 FLD-DC-VIS-003, Steel Superstructure—Section Loss.

7.1.4 FLD-DC-VIS-004, Steel Superstructure—Cracking, Deflection, Uplift, Distortion, Buckling, Rotation, and Impact Damage.

7.1.5 FLD-DC-VIC-001, Concrete Deterioration.

7.1.6 FLD-DC-VIC-002, Concrete Substructure Condition Assessment.

7.1.7 FLD-DC-VIC-003, Concrete Deck—Spalls and Delamination.

7.1.8 FLD-DC-VIC-004, Concrete Superstructure and Substructure—Spalls and Delamination.

7.1.9 FLD-DC-VIC-005, Concrete—Cracking.

7.1.10 FLD-DC-VIC-006, Concrete—Abrasion.

7.1.11 FLD-DC-VIC-007, Concrete—Sulfate Attack.

7.1.12 FLD-DC-VIB-001, Elastomeric Bearings.

7.1.13 FLD-DC-VIB-002, Rocker Bearings.

7.1.14 FLD-DC-VIJ-001, Drainage System on Bridge Decks and Approach Slabs.

7.1.15 FLD-DC-VIJ-002, Expansion Joints.

7.1.16 FLD-DC-NDE-001, Electrical Resistivity Testing.

7.1.17 FLD-DC-NDE-002, Ground Penetrating Radar Testing for Bridge Decks.

7.1.18 FLD-DC-NDE-003, Half-Cell Potential Testing.

7.1.19 FLD-DC-NDE-004, Impact Echo Testing.

7.1.20 FLD-DC-NDE-007, Ultrasonic Surface Wave Testing—Concrete.

7.1.21 FLD-DC-MS-001, Wet Coring of Concrete Decks.

7.1.22 FLD-DC-MS-002, Compressive Strength and Static and Dynamic Elastic Moduli of Concrete Cores.

7.1.23 FLD-DC-MS-003, Resistance of Concrete to Chloride Ion Penetration (Permeability).

7.1.24 FLD-DC-MS-004, Sampling and Testing for Chloride Profiles.

7.2 *External*: None.

CLUSTER BRIDGE TESTING

LTBP Protocol #: PRE-PL-LO-002

1. DATA COLLECTED

1.1 None. This protocol provides a list of all the standard tests to be conducted on bridges designated as cluster bridges.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*: None.

2.2 *Personnel*: None.

3. METHODOLOGY

3.1 Conduct the following visual inspection tests and procedures on cluster bridges, unless otherwise directed by Federal Highway Administration (FHWA):

3.1.1 FLD-DC-VIS-001, Steel Superstructure Deterioration.

3.1.2 FLD-DC-VIS-002, Steel Superstructure—Corrosion.

3.1.3 FLD-DC-VIS-003, Steel Superstructure—Section Loss.

3.1.4 FLD-DC-VIS-004, Steel Superstructure—Cracking, Deflection, Uplift, Distortion, Buckling, Rotation, and Impact Damage.

3.1.5 FLD-DC-VIC-001, Concrete Deterioration.

3.1.6 FLD-DC-VIC-002, Concrete Substructure Condition Assessment.

3.1.7 FLD-DC-VIC-003, Concrete Deck—Spalls and Delamination.

3.1.8 FLD-DC-VIC-004, Concrete Superstructure and Substructure—Spalls and Delamination.

3.1.9 FLD-DC-VIC-005, Concrete—Cracking.

3.1.10 FLD-DC-VIC-006, Concrete—Abrasion.

3.1.11 FLD-DC-VIC-007, Concrete—Sulfate Attack.

3.1.12 FLD-DC-VIB-001, Elastomeric Bearings.

3.1.13 FLD-DC-VIB-002, Rocker Bearings.

3.1.14 FLD-DC-VIJ-001, Drainage System on Bridge Decks and Approach Slabs.

3.1.15 FLD-DC-VIJ-002, Expansion Joints.

3.2 Conduct the following manual and/or automated nondestructive evaluation (NDE) tests on cluster bridges, unless otherwise directed by FHWA:

3.2.1 FLD-DC-NDE-001, Electrical Resistivity Testing.

3.2.2 FLD-DC-NDE-002, Ground Penetrating Radar Testing for Bridge Decks.

3.2.3 FLD-DC-NDE-004, Impact Echo Testing.

3.3 FLD-DC-MS-001, Wet Coring of Concrete Decks. Obtain one 2.5-inch diameter core in each lane and in each shoulder on the untreated bridge decks of cluster bridges from one span of the bridge deck in the following locations, unless otherwise directed by FHWA:

3.3.1 The results of the deck visual inspection and NDE testing (if available) should be considered in the location of cores. Cores should be taken from sound concrete that is determined to be free of cracks, delaminations, and spalls.

3.3.2 Transverse location of cores should be:

3.3.2.1 Shoulders – between 2 and 4 feet from the face of the curb or parapet or from the edge of the deck if there is no curb or parapet.

3.3.2.2 Travel lanes – between the wheel paths.

3.3.3 The location of cores should be spaced longitudinally in order to cover different sections of the span selected for coring.

3.4 Conduct the material and physical sampling procedures and tests in FLD-DC-MS-003, Resistance of Concrete to Chloride Ion Penetration (Permeability), on the cores obtained under section 3.3.

3.5 Cluster bridges will not typically be instrumented or monitored during the term of the LTBP Program.

3.6 Conduct other/optional tests, where applicable and as specified by the owner agency and/or FHWA.

4. DATA COLLECTION TABLE

4.1 None.

5. CRITERIA FOR DATA VALIDATION

5.1 None.

6. COMMENTARY/BACKGROUND

6.1 This protocol provides guidance for developing a plan for evaluating and testing cluster bridges.

6.1.1 A "cluster bridge" is a bridge that is one of a designated subset of the bridges within a specific type that meet a predefined set of NBI data (e.g., age range, design load, simple/continuous span type, maximum span length, etc.). The designated subset of bridges may be entirely within the boundaries of a certain State or may be situated along a multi-State corridor. Unless otherwise directed by FHWA, cores will be taken for the purpose of permeability testing only during the initial round of material testing. Permeability of the mature concrete is not expected to vary significantly with age.

6.2 Additional tests may be added for a particular cluster bridge. Given that each bridge is different, a specific test plan may be developed for a specific cluster bridge.

7. REFERENCES

7.1 *LTBP Protocols*:

7.1.1 FLD-DC-VIS-001, Steel Superstructure Deterioration.

7.1.2 FLD-DC-VIS-002, Steel Superstructure—Corrosion.

7.1.3 FLD-DC-VIS-003, Steel Superstructure—Section Loss.

7.1.4 FLD-DC-VIS-004, Steel Superstructure—Cracking, Deflection, Uplift, Distortion, Buckling, Rotation, and Impact Damage.

7.1.5 FLD-DC-VIC-001, Concrete Deterioration.

7.1.6 FLD-DC-VIC-002, Concrete Substructure Condition Assessment.

7.1.7 FLD-DC-VIC-003, Concrete Deck—Spalls and Delamination.

7.1.8 FLD-DC-VIC-004, Concrete Superstructure and Substructure—Spalls and Delamination.

7.1.9 FLD-DC-VIC-005, Concrete—Cracking.

7.1.10 FLD-DC-VIC-006, Concrete—Abrasion.

7.1.11 FLD-DC-VIC-007, Concrete—Sulfate Attack.

7.1.12 FLD-DC-VIB-001, Elastomeric Bearings.

7.1.13 FLD-DC-VIB-002, Rocker Bearings.

7.1.14 FLD-DC-VIJ-001, Drainage System on Bridge Decks and Approach Slabs.

7.1.15 FLD-DC-VIJ-002, Expansion Joints.

7.1.16 FLD-DC-NDE-001, Electrical Resistivity Testing.

7.1.17 FLD-DC-NDE-002, Ground Penetrating Radar Testing for Bridge Decks.

7.1.18 FLD-DC-NDE-004, Impact Echo Testing.

7.1.19 FLD-DC-MS-001, Wet Coring of Concrete Decks.

7.1.20 FLD-DC-MS-003, Resistance of Concrete to Chloride Ion Penetration (Permeability).

7.2 *External*: None.

TRAFFIC CONTROL, MAINTENANCE AND PROTECTION OF TRAFFIC (MPT), AND PERMITS

LTBP Protocol #: PRE-PL-LO-003

1. DATA COLLECTED

1.1 A traffic control and maintenance and protection of traffic (MPT) plan approved by a State department of transportation and any State-issued access permits for onsite bridge data collection for the Long-Term Bridge Performance (LTBP) Program.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*: None.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Establish contact with responsible parties within bridge owner organization and Federal Highway Administration (FHWA):

3.1.1 The primary contact with the bridge owner is the LTBP State Coordinator. This person facilitates the LTBP project and associated operations within their State. The State Coordinator determines the appropriate personnel for coordinating the field effort (PRE-PL-LO-007, Communication and Coordination Plan).

3.1.2 The primary local contact within FHWA is the FHWA Division Bridge Engineer for the State where the bridge is located.

3.1.3 With the LTBP State Coordinator's assistance, contact the traffic control coordinator within the district or region where the bridge is located.

3.2 Work with FHWA LTBP staff and/or other LTBP contractors to obtain the bridge plans and latest inspection report for the bridge being evaluated. The bridge file developed by LTBP with the bridge owner provides the base material required to develop the traffic control plan (PRE-ED-BD-001, Plans and Specifications for Bridge Design and Construction).

3.3 Responsibility:

3.3.1 Determine who is responsible for traffic control in four aspects:

3.3.1.1 Design of MPT plan.

3.3.1.2 Financial responsibility for MPT plan.

3.3.1.3 Approval of MPT plan.

3.3.1.4 Implementation of MPT plan.

3.3.2 If the bridge owner is responsible for all traffic control responsibilities, then do the following:

3.3.2.1 Obtain a copy of the approved MPT plan for the bridge, and make sure all LTBP contractor personnel understand the plan, the timeframe LTBP contractor personnel are allowed on the bridge, and any areas of safety concern.

3.3.2.2 Apply for and obtain any State-required access permits for LTBP contractor personnel to evaluate the bridge.

3.3.2.3 Develop a Personal Health and Safety Plan for the bridge, following PRE-PL-LO-004, Personal Health and Safety Plan, and any State-specific requirements and guidelines.

3.3.2.4 Procure and/or supply any safety equipment required by the Personal Health and Safety Plan to all onsite LTBP contractor personnel.

3.3.3 If the LTBP contractor is responsible for all traffic control responsibilities, then do the following:

3.3.3.1 If the State has any preapproved contractors to perform maintenance of traffic, identify one of those contractors to perform the steps that follow. If not, then perform the steps that follow alone.

3.3.3.2 The field coordinator designs an MPT plan that follows the latest version of the Manual on Uniform Traffic Control Devices (MUTCD) and any State-specific requirements and guidelines. Submit it to the bridge owner for approval. If the bridge owner provides comments and/or rejects the MPT plan, then revise and resubmit the MPT, continuing the revisions and resubmissions process until the MPT plan is approved.

3.3.3.3 Review the MPT plan with all LTBP contractor onsite personnel so they understand the plan, the window of time LTBP contractor personnel are allowed on the bridge, and any areas of safety concern.

3.3.3.4 Apply for and obtain any State-required access permits for LTBP contractor personnel to evaluate the bridge.

3.3.3.5 Develop a Personal Health and Safety Plan for the bridge, following PRE-PL-LO-004, Personal Health and Safety Plan, and any State-specific requirements and guidelines.

3.3.3.6 Procure and/or supply any safety equipment required by the Personal Health and Safety Plan to all onsite LTBP contractor personnel.

3.4 Clearly establish communication requirements for traffic control as part of the entire field communication plan (PRE-PL-LO-007, Communication and Coordination Plan), including a list of emergency contacts. These requirements includes establishing and maintaining communication with local law enforcement and emergency responders throughout traffic interruption.

3.5 Ensuring all requirements are met before field work:

3.5.1 Any permits that are required onsite should be available but protected from exposure or damage.

3.5.2 Ensure all required personnel or organizations have been notified of the impending traffic interruption and field work according to the communication plan.

3.5.3 Check the traffic control to verify that the plan has been implemented as designed and that onsite staff are safe while in the closure area.

3.6 Maintaining records:

3.6.1 Maintain records, including the MPT plan, permits, photo documentation, and logs of any issues or accidents that may arise during the field work.

3.6.2 Take photographs using FLD-DC-PH-002, Photographing for Documentation Purposes, and create a photo log.

3.7 Storing data, documents, and images:

3.7.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.7.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.8 Reporting: Transfer all metadata, data, documents, and images to FHWA, and/or upload all metadata, data, documents, and images into the LTBP Bridge Portal.

4. Data Collection Table

4.1 Table:

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
1	State	Text	Text		State Code; e.g., Virginia = VA	Green
2	NBI structure number	Text	Text		Item 8, structure number; from NBI Coding Guide	Green
3	Structure name	Text	Text		Descriptive name for the bridge; e.g., Route 15 SB over I–66	Green
4	Protocol name	Text	Text		Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text	Text		First name(s) Last name(s)	Green
7	Date data was collected	Text	Exact date		mm/dd/yyyy	Green
8	Approved MPT plan	BLOB	NA		Attachment	Blue
9	Permit	BLOB	NA		Approved State-issued access permit for evaluation of the bridge	Yellow
10	Other Permit	BLOB	NA		Second approved State-issued permit for evaluation of the bridge (if applicable)	Yellow
11	Comments					Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. Criteria for Data Validation

5.1 None.

6. COMMENTARY/BACKGROUND

6.1 This protocol provides guidance for establishing a safe, efficient traffic control and MPT plan for any onsite data collection for the LTBP Program.

6.2 Ideally, the bridge owner will provide traffic control during field work at bridges, but if that is not possible, an MPT plan must be developed. The LTBP Program is a nationwide program, and requirements vary significantly from State to State.

6.3 Each State has specific and often different requirements for traffic control procedures included in its design standards and State traffic control device manual. These requirements may include permitting requirements, lead times, communication chains, inclusion of State or local law enforcement, or many other logistical specifics. Establish requirements via the traffic control coordinator. Requirements for State-specific traffic control above and beyond the FHWA MUTCD are provided on the FHWA MUTCD Web site.

7. REFERENCES

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-005, Personnel Qualifications.

7.1.3 PRE-PL-LO-007, Communication and Coordination Plan.

7.1.4 PRE-ED-BD-001, Plans and Specifications for Bridge Design and Construction.

7.1.5 FLD-DC-PH-002, Photographing for Documentation Purposes.

7.1.6 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.7 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*:

7.2.1 FHWA, Manual on Uniform Traffic Control Devices for Streets and Highways, 2009 Edition with Revisions 1 and 2 Incorporated, Federal Highway Administration, Washington, DC, 2012.

7.2.2 State-specific requirements and/or guidelines for maintenance and protection of traffic: http://mutcd.fhwa.dot.gov/.

PERSONAL HEALTH AND SAFETY PLAN

LTBP Protocol #: PRE-PL-LO-004

1. DATA COLLECTED

1.1 None. This protocol provides guidance for developing a personal health and safety plan for onsite protection of staff.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*: None.

2.2 *Personnel*: None.

3. METHODOLOGY

3.1 Develop a bridge-specific personal health and safety plan that follows both Occupational Safety and Health Administration and bridge owner requirements and contains the following components as a minimum.

3.2 Emergency contact information and call chain: List of people to contact and the order in which to contact them in case of an emergency or unexpected changes to the operational plan. (PRE-PL-LO-007 Communication and Coordination Plan).

3.3 Site specific hazards and concerns: Any site concerns particular to the bridge, such as water, poison ivy, proximity to heavy traffic, or potential animal threats.

3.4 Work zone safety: Develop a work zone safety plan according to PRE-PL-LO-003, Traffic Control, Maintenance and Protection of Traffic (MPT), and Permits; the current version of Manual on Uniform Traffic Control Devices (MUTCD); and any State transportation department guidance.

3.5 General personal protection equipment (PPE) requirements: Standard list of minimum personal protection equipment that each onsite staff person should have on their person while on the bridge site. This includes but is not limited to the following:

3.5.1 Safety glasses.

3.5.2 Hardhat.

3.5.3 Class 3 safety vest.

3.5.4 Gloves.

3.5.5 Long pants.

3.5.6 Closed toe shoes/steel toe boots.

3.5.7 Ear plugs.

3.6 Other required onsite safety equipment: Minimum safety equipment at the site level; for example, a first aid kit.

3.7 Task specific safety equipment: Any equipment that is specific to the site or a particular task. This includes but is not limited to the following:

3.7.1 Fall protection (harness).

3.7.2 Face shield (grinding).

3.7.3 Dust mask (grinding).

3.7.4 Personal flotation devices (if working on, over, or near water).

3.8 General well-being equipment and recommendations: Instructions for keeping the team healthy and functional onsite. This includes but is not limited to the following:

3.8.1 Sunscreen.

3.8.2 Access to a restroom.

3.8.3 Drinking water and food.

3.9 Onsite personnel daily signin sheet: A daily log of who was onsite and when during each day. The log is signed during the morning safety meeting at the start of the work day.

3.10 Distribute the safety plan to the entire onsite team prior to commencement of field activities.

4. Data Collection Table

4.1 None.

5. Criteria for Data Validation

5.1 None.

6. Commentary/Background

6.1 Provides guidance on developing a plan for health and safety on a bridge. This plan covers personal safety, including PPE, work zone safety, and first aid preparation.

6.2 Additional guidance can be found in the Federal Highway Administration (FHWA) Work Zone Operations Best Practices Guidebook.

7. References

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-003, Traffic Control, Maintenance and Protection of Traffic (MPT), and Permits.

7.1.2 PRE-PL-LO-007, Communication and Coordination Plan.

7.2 *External*:

7.2.1 FWHA-HOP-13-012, Work Zone Operations Best Practices Guidebook, Federal Highway Administration, Washington, DC, 2013.

7.2.2 FHWA, Manual on Uniform Traffic Control Devices for Streets and Highways, 2009 Edition with Revisions 1 and 2 Incorporated, Federal Highway Administration, Washington, DC, 2012.

7.2.3 Occupational Safety and Health Administration Web site, https://www.osha.gov/.

Long-Term Bridge Performance Program

PERSONNEL QUALIFICATIONS

LTBP Protocol #: PRE-PL-LO-005

1. DATA COLLECTED

1.1 None. This protocol provides a list of qualifications for personnel for field work and postvisit data usage.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*: None.

2.2 *Personnel*: None.

3. METHODOLOGY

3.1 Table 1 lists the general qualifications for all personnel working onsite at any bridge as part of the Long-Term Bridge Performance (LTBP) Program. Additional, more stringent requirements are provided for personnel acting as assessment technique team leaders and for other staff members.

Table 1. Personnel Qualifications.

POSITION	REQUIREMENTS
ALL ONSITE STAFF INCLUDING TEAM LEADERS	LTBP protocol training for relevant data collection tasks (specific to type of data collection to be performed)
	Occupational Safety and Health Administration 10-hour Road Construction Safety Certification
	Fall Protection Training (for access trucks, etc.)
VISUAL INSPECTION TEAM LEADER	National Bridge Inspection Standards (NBIS) Team leaders must be one of the following (adopted from Metrics for the Oversight of the National Bridge Inspection Program) • Professional engineer. • Five years of bridge inspection experience. • National Institute for Certification in Engineering Technologies (NICET) Level III or IV Bridge Safety Inspector Certification. • Bachelor's degree in engineering from the Accreditation Board for Engineering and Technology (ABET)-accredited college or university; a passing score on the Fundamentals of Engineering Exam; and 2 years of bridge inspection experience. • Associate's degree in engineering from an ABET-accredited college or university and 4 years of bridge inspection experience. In addition, team leaders must have the following training: • Successful completion of Federal Highway Administration (FHWA)-approved comprehensive bridge inspection training. • Completion of periodic bridge inspection refresher training according to NBIS.

POSITION	REQUIREMENTS
NDE TEAM LEADER	RABIT™ bridge deck inspection tool training (operators)
MATERIAL SAMPLING	American Concrete Institute, Concrete Laboratory Testing Technician—Level 1
	American Concrete Institute, Concrete Field Testing Technician—Grade 1

3.2 Submit a list of staff qualifications to FHWA prior to commencing field work.

4. DATA COLLECTION TABLE

4.1 None.

5. CRITERIA FOR DATA VALIDATION

5.1 None.

6. COMMENTARY/BACKGROUND

6.1 NICET is a division of the National Society for Professional Engineers with a mission promoting excellence in engineering technologies through certification and related services. Within this mission, NICET provides four levels of Bridge Safety Inspection Certification.

6.2 ABET is the entity that ensures quality of engineering and related science and technology education programs. If an institution is accredited by ABET, one can be confident that certain quality standards in education are met.

7. REFERENCES

7.1 *LTBP Protocols*: All.

7.2 *External*:

7.2.1 FHWA, National Bridge Inspection Standards, 2009 Final Rule, Federal Register, Volume 74, Number 246, Pages 68377–68379, Washington, DC, 2009.

7.2.2 FHWA-HIBS-30-NBIPOT, Metrics for the Oversight of the National Bridge Inspection Program, Federal Highway Administration, Washington, DC, 2013.

POWER AND NETWORK REQUIREMENTS

LTBP Protocol #: PRE-PL-LO-006

1. DATA COLLECTED

1.1 None. This protocol provides guidance for developing a plan of action for obtaining power and network access at a given bridge site for truck testing, vibration testing, long-term monitoring, local data storage, remote data storage, and/or lighting for night fieldwork.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

2.1.2 Generator (at least 2 kW, but small and lightweight is preferred). (See section 6.3 for power requirements.)

2.1.3 Gas container.

2.1.4 Motor oil.

2.1.5 Funnel.

2.1.6 Wireless modem with paid subscription to an Internet service provider and static IP address.

2.1.7 WiFi hotspot.

2.1.8 Extension cords.

2.1.9 Network cable.

2.1.10 Ethernet connectors, spare Ethernet cable, and crimpers.

2.2 *Personnel*: None.

3. METHODOLOGY

3.1 Develop a plan for power and network access. The plan should address the following:

3.1.1 Types of equipment used at the bridge.

3.1.2 Nearest electrical power source to the bridge. Use independent power when available onsite. An independent power source is required for long-term monitoring. (See section 6.3 for power requirements.)

3.1.3 Need for a generator and required attributes for a generator. A generator can serve as a short-term power source. It is not recommended for semipermanent installations (more than 30 days).

3.1.4 Loss of power and battery backups for key equipment.

3.1.5 Cell phone signal strength at the bridge and active service agreement.

3.1.6 Need for a wireless hotspot. Cellular modem (3G or LTE) or a WiFi hotspot can provide short-term network connectivity and connectivity in remote locations.

It is not recommended for semipermanent installations (more than 30 days). (See section 6.4 for external network requirements.)

3.1.7 Spare parts for key pieces of equipment.

3.2 Table 1provides the requirements for power and the network for the assessment methods used on a bridge in the LTBP Program.

Table 1. Power and Network Requirements by Technique.

Assessment Method	Power	Network
Visual Inspection	None	None
Nondestructive Testing	None	None
Material Sampling	None	None
Truck Testing	Generator	None
Vibration Testing	Generator	None
Long-Term Monitoring	Independent	Hardwire, wireless modem, or combination
Remote Data Storage	Generator	Wireless modem

4. Data Collection Table

4.1 None.

5. Criteria for Data Validation

5.1 None.

6. Commentary/Background

6.1 This protocol describes the elements needed in a plan for power and access at a bridge site.

6.2 The primary function of external network access on a bridge is to ensure the local and remote storage and backup of collected data (FLD-DS-RS-001, Data, Document, and Image Storage—Remote).

6.3 Power requirements:

6.3.1 Generators:

6.3.1.1 For most applications, a portable gasoline generator is needed to provide power.

6.3.1.2 Even if testing is limited to an application where power may not be required, having a generator available is useful.

6.3.1.3 The generator must be able to provide at least 2,000 W with 2 or more 30-amp circuits and supply 120 V of power.

6.3.1.4 Extension cords, a gas can, funnel, and motor oil are required for use with the generator.

6.3.1.5 Operate and maintain the generator according to manufacturer specifications, including safety requirements and proper ventilation.

6.3.1.6 Keep tools and sensitive equipment on separate circuits within the generator.

6.3.1.7 Assign one onsite staff person to maintain the fuel level in the generator throughout the testing.

6.3.1.8 Loss of power during a test can result in the loss of valuable data, which could cause delays.

6.3.2 Independent power sources:

6.3.2.1 If an independent power source is not available in advance, then it must be brought to the bridge site. Providing an independent power source to a bridge requires coordination between the State, the local power company, and the project team. Solar panels and backup batteries may be used as a stopgap solution or when it is impossible to route power to the bridge. This stopgap solution is not desirable as it requires more maintenance and is subject to vandalism.

6.3.2.2 Fiber optic systems can be located at remote locations and connected to the bridge via fiber without detrimental effects on signal or power.

6.4 External network requirements:

6.4.1 A cellular modem with an active service plan is adequate for short-term applications.

6.4.2 A wireless hotspot is adequate when WiFi-ready equipment is used.

7. References

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.3 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*: None.

COMMUNICATION AND COORDINATION PLAN

LTBP Protocol #: PRE-PL-LO-007

1. DATA COLLECTED

1.1 None. This protocol provides guidance for establishing a communication and coordination plan prior to any field assessment.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*: Computer.

2.2 *Personnel*: None.

3. METHODOLOGY

3.1 Develop a communication and coordination plan to provide contact information for each bridge to be evaluated, prior to any field assessment.

3.2 The plan should include the following:

3.2.1 The following contact information for all onsite personnel:

3.2.1.1 Full name.

3.2.1.2 Email address.

3.2.1.3 Office phone (if relevant).

3.2.1.4 Cell phone.

3.2.2 The following contact information for the State department of transportation, local Federal Highway Administration (FHWA) division office, local and/or State police department, FHWA Long-Term Bridge Performance (LTBP) Program contacts, emergency contacts, and other personnel:

3.2.2.1 Name of department or agency.

3.2.2.2 Name of contact person.

3.2.2.3 Office phone—General.

3.2.2.4 Office phone—Direct line.

3.2.2.5 Cell phone (optional).

3.2.3 Contact information for the following unexpected scenarios:

3.2.3.1 Medical emergency.

3.2.3.2 Vehicular incident.

3.2.3.3 Inclement weather.

3.2.3.4 Need for a change to the data collection plan.

3.2.3.5 Communication with traveling public.

3.2.3.6 Unexpected media visits.

3.2.4 The specifics about when the bridge owner, State or local police, the local FHWA office, and FHWA LTBP Program contacts will need to be contacted.

3.3 Ensure that onsite staff has access to the communication and coordination plan while onsite.

4. DATA COLLECTION TABLE

4.1 None.

5. CRITERIA FOR DATA VALIDATION

5.1 None.

6. COMMENTARY/BACKGROUND

6.1 This protocol provides guidance on establishing a communication plan to be distributed to all onsite personnel.

6.2 The communication plan provides a comprehensive list of the external parties that need to be contacted prior to and during any field work and visits to the bridge site.

7. REFERENCES

7.1 *LTBP Protocols*: None.

7.2 *External*: None.

Field Visit Protocols (FLD)

Onsite Pretest Activities (OP)

Site Preparedness (SP)

Spatial Context (SC)

Field Data Collection (DC)

Photography (PH)

Material Sampling (MS)

Nondestructive Evaluation (NDE)

Visual Inspection—Steel Elements (VIS)

Visual Inspection—Concrete Elements (VIC)

Visual Inspection—Bearings (VIB)

Visual Inspection—Joints (VIJ)

Data Storage (DS)

Local Storage (LS)

Remote Storage (RS)

SITE PREPAREDNESS PROTOCOLS (SP)

FLD-OP-SP-001, Site Preparation

SITE PREPARATION

LTBP Protocol #: FLD-OP-SP-001

1. DATA COLLECTED

1.1 None. This protocol provides guidance for site preparation to facilitate onsite data collection activities.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

2.1.2 Pencil, sketch pad, and clipboard.

2.1.3 Hand water sprayer.

2.1.4 Brooms.

2.1.5 Water-soluble paint for marking areas where travel should not occur (if necessary).

2.2 *Personnel*:

2.2.1 PRE-PL-LO-005, Personnel Qualifications

3. METHODOLOGY

3.1 Site visit: A site visit to the bridge should precede any visual inspection, nondestructive evaluation (NDE), and/or material sampling data collection. A site visit includes the following:

3.1.1 Verifying bridge structure number, girder type, and wearing surface (untreated or treated deck).

3.1.2 Identifying access requirements.

3.1.3 Identifying equipment needed for field data collection.

3.1.4 Identifying staging areas for contractor equipment, parking, and live load trucks for testing.

3.1.5 Determining site-specific concerns to address.

3.1.6 Cleaning the top of the bridge and preparing the structure for data collection.

3.1.7 Identifying areas for instrumentation (if applicable).

3.1.8 Marking areas for sensors and data acquisition equipment with water-soluble paint.

3.1.9 Marking any location where equipment cannot travel.

3.2 Cleaning:

3.2.1 Certain NDE techniques require the deck to be clear of any large debris and accumulations of dirt and sediment. Underside access requires that any large undergrowth be eliminated if possible.

3.2.2 Request, through appropriate channels, that the bridge owner provide deck cleaning and underbrush trimming before the test.

If prior trimming or cleaning is not possible, obtain approval from the bridge owner to clean the bridge deck the night before testing (inclusive of traffic control), or leave time for cleaning during data collection.

3.3 Prewetting: Due to the use of water-soluble paint marking the grid on the deck, only prewet the deck with a hand sprayer immediately in front of the resistivity test.

4. Data Collection Table

4.1 None.

5. Criteria for Data Validation

5.1 None.

6. Commentary/Background

6.1 This protocol provides guidance on the details of a site visit to the bridge before any data collection begins.

6.2 Staging areas are areas either on, adjacent, below, or otherwise nearby the bridge designated for specific purposes. For a full field data collection effort, staging areas accommodate visual inspection, NDE, and material sampling.

6.3 Identify and clear parking areas with local law enforcement per PRE-PL-LO-007, Communication and Coordination Plan. Include parking for personnel transportation, access equipment, and equipment transportation in the plan. The parking area provides easy access via vehicle to both the underside and topside of the bridge and allows for safe travel on foot to the bridge. Parking areas must not infringe upon private property or local businesses without permission from the owner.

7. References

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-007, Communication and Coordination Plan.

7.2 *External*: None.

SPATIAL CONTEXT PROTOCOLS (SC)

FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks

FLD-OP-SC-002, Structure Segmentation and Element Identification System

FLD-OP-SC-003, Determination of Local Origins for Elements

DATA COLLECTION GRID AND COORDINATE SYSTEM FOR BRIDGE DECKS

LTBP Protocol #: FLD-OP-SC-001

1. DATA COLLECTED

1.1 Physical layout of a grid for data collection on a bridge deck.

1.2 Location and description of the origin for a rectangular coordinate system.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

2.1.2 Temporary (water-soluble) paint.

2.1.3 Measuring wheel.

2.1.3 Tape measure.

2.1.4 6-ft folding rule.

2.1.5 Hand compass or other device for measuring angles.

2.1.6 Jig or similar tool for marking the grid nodes.

2.1.7 Temporary marker.

2.1.8 Digital camera.

2.1.9 Pencil, sketch pad, and clipboard.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Measure and record the bridge skew angle.

3.2 Establish the origin of the rectangular coordinate system at the end of the bridge with the lowest mileage point on the linear referencing system of the route that is carried on the bridge. For bridges on highways that to do not have a linear referencing system, the origin will be located at the most southerly point on the northbound side of a north-south local road or the most westerly point on the eastbound side of an east-west local road.

3.2.1 Mark the origin for the coordinate system for bridge decks with water-soluble paint.

3.2.2 The *x*-axis runs parallel to the centerline of the bridge. The positive direction is determined by the route's linear referencing system. The *y*-axis runs across the width of the deck. The convention used is shown in figures 1 through 5, which shows the general location of the origin for different combinations of bridge and traffic patterns. In the case of skewed bridges, the rectangular coordinate system is retained, and the skew angle measured and noted with respect to the *y*-axis.

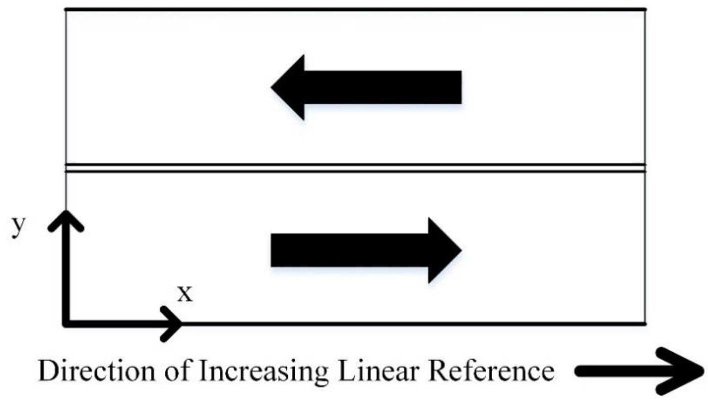

Figure 1. Illustration. Local coordinate origin for non-skewed bridge with two-way traffic.

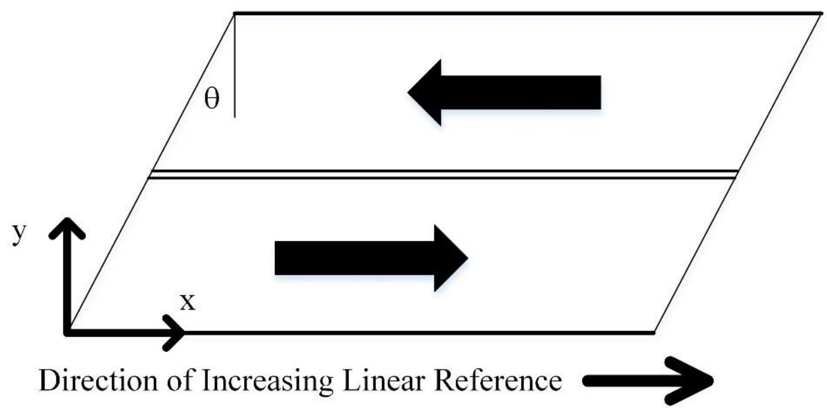

Figure 2. Illustration. Local coordinate origin for skewed bridge with two-way traffic—right-hand skew angle.

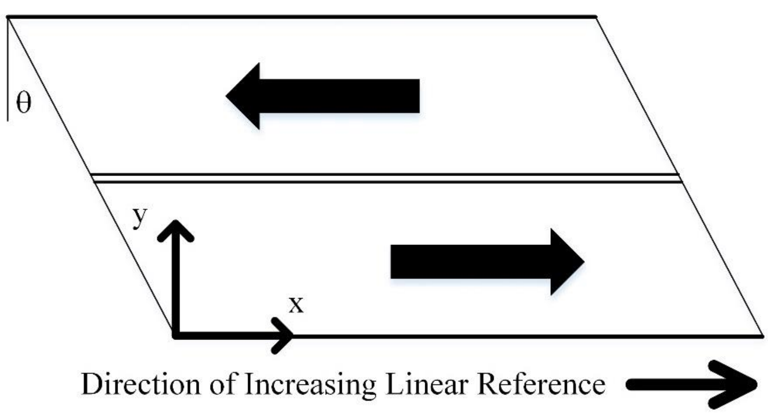

Figure 3. Illustration. Local coordinate origin for skewed bridge with two-way traffic—left-hand skew angle.

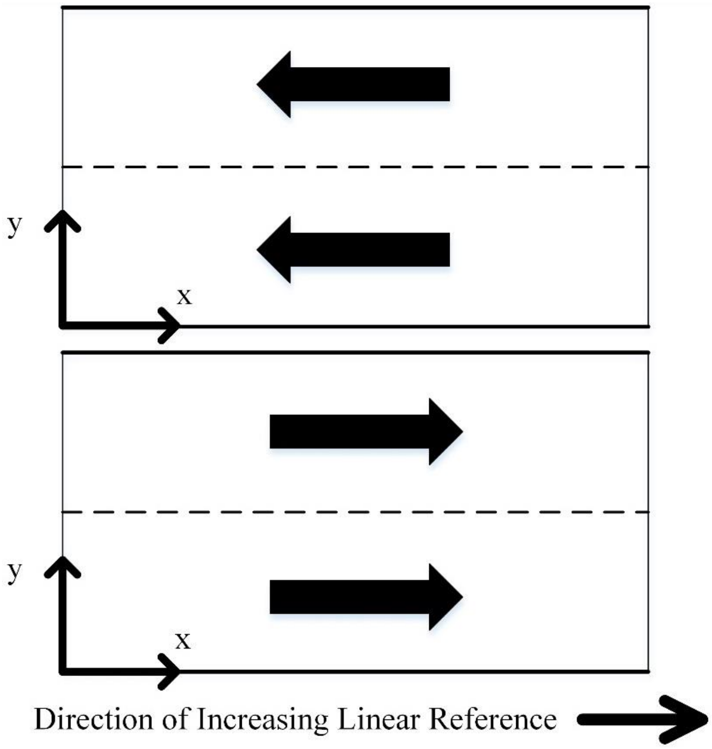

Figure 4. Illustration. Local coordinate origin for non-skewed twin bridges with one-way traffic.

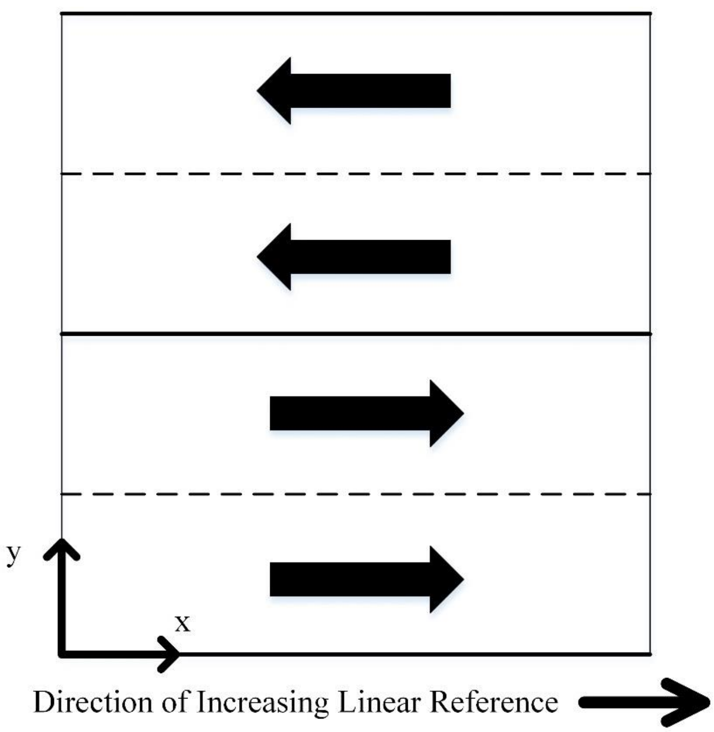

Figure 5. Illustration. Local coordinate origin for non-skewed single bridge with two-way traffic and a median barrier.

3.3 In accordance with the right-hand rule, the positive *z*-axis protrudes from the bridge deck towards the sky.

3.4 The rectangular coordinate system for the bridge deck is established with an origin ($x = 0$, $y = 0$, $z = 0$) matching the intersection of either of the following (figure 6):

3.4.1 The innermost face of a solid bridge parapet or raised curb and the transverse edge of the top of the deck.

3.4.2 The outer edge of the bridge deck (beyond an open metal railing) and the transverse edge of the top of the deck.

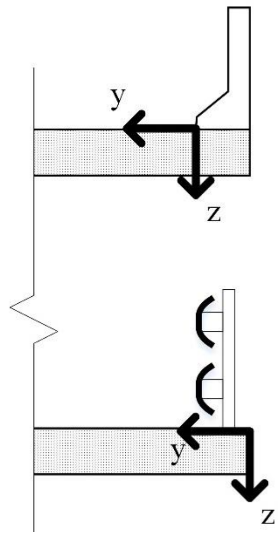

Figure 6. Illustration. Location of the deck local origin on bridges with different types of safety barriers.

3.5 The coordinates of the grid nodes and other points on a deck surface are numeric, corresponding to the distance (measured in feet) from the origin. That is, a point described as (2.25, 6.5, 0.0) is a location on the top surface of the deck 2.25 ft longitudinally and 6.5 ft transversely from the origin.

NOTE—For the sake of simplicity, all points on the top surface of the deck are considered as having a *z* coordinate of 0.0.

3.6 Create a 2- by 2-ft data collection grid.

3.6.1 For all bridges, skewed or not skewed, set the first grid point using a 2-ft offset along the *y*-axis from the coordinate system origin.

3.6.2 Mark the 2- by 2-ft grid on the rest of the top surface of the bridge deck using temporary, water-soluble paint (figure 7).

3.6.3 A jig, or similar apparatus, can be used to standardize the process and quickly mark the grid (figure 7).

3.6.3.1 Use the rolling wheel to mark nodes spaced 10 ft apart across the deck in both the longitudinal and transverse directions. These markings help properly line up the jig and prevent the propagation and accumulation of error as the jig is moved across the bridge.

3.6.3.2 Align the jig with the coordinate system origin, and mark the 2- by 2-ft nodes with temporary paint.

3.6.3.3 Move the jig forward, realign it with the end of the marked grid, and mark the nodes.

3.6.3.4 Repeat the process to extend the grid across the bridge and to the end of the approach slab.

Figure 7. Photo. Layout of the data collection grid with jig.

3.6.4 A grid similar to the one in figure 8 is replicated on the bridge at the start of each data collection cycle. The origin of the grid should always match the origin established at the time of the first data collection cycle.

3.7 Take photos of the coordinate system origin and the grid laid out on the deck using FLD-DC-PH-002, Photographing for Documentation Purposes, and create a photo log.

3.8 Storing data, documents, and images:

3.8.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.8.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.9 Reporting: Transfer all metadata, data, documents, and images to FHWA, and/or upload all metadata, data, documents, and images into the Long-Term Bridge Performance (LTBP) Bridge Portal.

4. DATA COLLECTION TABLE

4.1 Table:

#	FIELD NAME	DATA TYPE	ACCURACY	UNIT	FIELD DESCRIPTION	ROW COLOR
1	State	Text			State Code; e.g., Virginia = VA	Green
2	NBI structure number	Text			Item 8, structure number; from NBI Coding Guide	Green
3	Structure name	Text			Descriptive name for the bridge; e.g., Route 15 SB over I–66	Green

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
4	Protocol name	Text			Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text			First name(s) Last name(s)	Green
7	Date grid created	Text	Exact date	Date	mm/dd/yyyy	Green
8	Description of the location of the grid origin				Description of the origin of the coordinate system; e.g., on the top surface of the deck at the junction of the top transverse edge of the deck and the interior face of the raised curb or the parapet	Green
9	Bridge skew angle with respect to *y*-axis	Number	1	Degrees and minutes	If applicable	Yellow
10	Photo of bridge deck with coordinate system origin marked with temporary marker	BLOB				Yellow
11	Photo of bridge deck with grid painted on it	BLOB				Yellow
12	Comments	Text				Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, predefined list, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. Criteria for Data Validation

5.1 Compare measured skew angle to the value obtained using PRE-ED-BD-001, Plans and Specifications for Bridge Design and Construction.

5.2 Verify origin is properly located; spot check painted nodes with tape measure to verify 2- by 2-ft spacing.

5.3 Tolerances for grid location: actual x and y coordinates of each painted node must be within 1 inch (0.083 feet) of the theoretical coordinate system values.

6. COMMENTARY/BACKGROUND

6.1 This protocol describes how a rectangular coordinate system is established at each bridge and a 2- by 2-ft data collection grid is laid out on the top of the deck before data collection begins. The coordinate system provides a fixed reference for locating the position of defects observed on the top surface of the deck or overlay (if any) and the approach slabs; it also provides a fixed reference for locating sampling or testing points where NDE tests will be conducted, cores will be obtained, etc. A common coordinate system allows data from all testing methods to be easily tied to a location on the bridge and facilitates data fusion and analysis, allowing data from different tests to be layered and directly compared.

6.2 The linear referencing system is a system that allows location of any point or feature on a highway with respect to a known point. On a highway, the linear referencing system is often shown using mile post numbers, which generally increase from south to north or west to east. The zero mileage point of the route's linear referencing system is at the southernmost or the westernmost point of the route within the State lines.

6.3 The locations of defects as well as sampling and testing points on other elements of the bridge, including the underside of the deck, girders, etc., are identified and documented using the element identification system described in FLD-OP-SC-002, Structure Segmentation and Element Identification System, and the local element origins established using FLD-OP-SC-003, Determination of Local Origins for Elements.

7. REFERENCES

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-005, Personnel Qualifications.

7.1.3 PRE-ED-BD-001, Plans and Specifications for Bridge Design and Construction.

7.1.4 FLD-OP-SC-002, Structure Segmentation and Element Identification System.

7.1.5 FLD-OP-SC-003, Determination of Local Origins for Elements.

7.1.6 FLD-DC-PH-002, Photographing for Documentation Purposes.

7.1.7 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.8 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*: None.

STRUCTURE SEGMENTATION AND ELEMENT IDENTIFICATION SYSTEM

LTBP Protocol #: FLD-OP-SC-002

1. DATA COLLECTED

1.1 None. This protocol provides a system for creating a unique identifier for each bridge element other than the deck.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*: PRE-PL-LO-004, Personal Health and Safety Plan.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Assign a unique identifier to each element of the bridge superstructure and the substructure using the system described below. The unique identifier is a combination of alphanumeric characters, with the number and sequence of characters depending on the type of element being identified. Figure 1 shows an example of the unique identifiers for a two-span continuous bridge with five lines of girders in each span and diaphragms between the girders at the one-quarter points and over the pier.

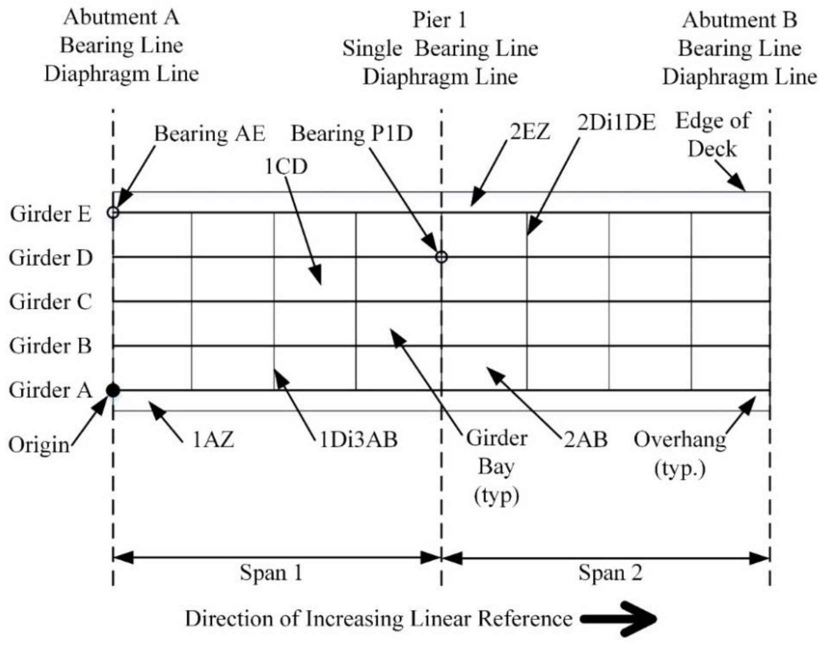

Figure 1. Illustration. Element identification system—girder example.

3.2 Spans: The span number is the first character of the identifiers for the elements that comprise the superstructure. Spans are numbered sequentially, proceeding from the coordinate system origin along the *x*-axis in the positive direction. The span nearest to the deck origin is span 1; the next span proceeding along the *x*-axis is span 2; and so on until span N, where N is the total number of spans in the bridge.

3.3 Girders: The identifier for girders takes the form of "1A," where:

3.3.1 The first character is the span number.

3.3.2 The second character is a letter, identifying the girder line. "A" is the girder line closest to the deck origin; "B" is the next closest, etc.

3.4 Diaphragms: Diaphragms are labeled along each diaphragm line, starting with the diaphragm line closest to deck origin. The identifier for diaphragms takes the form of "1Di1AB," where:

3.4.1 The first character is the span number.

3.4.2 The next component of the identifier is "Di" plus an integer, identifying the diaphragm line number. Di1 is the diaphragm line closest to the deck origin; DiN is the diaphragm line in the span farthest from the deck origin.

3.4.3 When the superstructure is continuous over a pier and there is only one diaphragm line at the pier, that diaphragm is identified as the N^{th} diaphragm in the span with the lower number.

3.4.4 The last two characters are letters, identifying the two girders to which the diaphragm is connected.

3.5 Secondary members: Secondary members are identified and labeled on a case-by-case basis. For example, if there is wind bracing between girder A and B along the length of the span, it is identified using a four-component label in the form of "1AB-WB," where:

3.5.1 The first character is the span number.

3.5.2 The second and third characters are letters, identifying the two girders to which the secondary member is connected.

3.5.3 The last component of the identifier, preceded by a dash, signifies the type of secondary member. For example, a wind brace (WB) between girders A and B in span 1 is identified as 1AB-WB.

3.6 Girder bays: The identifier for locating defects or instrumentation on the underside of the deck between girders takes the form of "1AB," where:

3.6.1 The first character is the span number.

3.6.2 The second and third characters are letters, identifying the two girders that are the sides of the bays.

3.7 Overhangs: The identifier for locating defects or instrumentation occurring on deck overhangs outside of the exterior girders takes the form of "1AZ," where:

3.7.1 The first character is an integer and identifies the span number.

3.7.2 The second character is a letter, identifying the exterior girder closest to the overhang.

3.7.3 The third character is always the letter "Z," indicating the defect or instrumentation is on an overhang. The letter Z has been chosen to denote overhangs because most girder bridges will not have more than 25 girder lines.

3.8 Abutments: The abutment nearest to the deck origin is abutment A; the other abutment is abutment B. The deck origin is used to set the orientation of the wingwalls. For abutments, the right wingwall is closest to the deck origin, while the left wingwall is farthest from the deck origin.

3.9 Piers/pier caps: Piers are numbered sequentially, proceeding from the deck origin along the *x*-axis in the positive direction. The pier nearest to the deck origin is pier 1; the next pier proceeding along the *x*-axis is pier 2; and so on until pier N, where N is the total number of piers in the bridge.

3.10 Pier columns/piles: The identifier for pier columns/piles takes the form of “P1C1,” where:

3.10.1 The first two characters are the identifier for the pier.

3.10.2 The last two characters are the letter “C” and the column number.

3.10.3 The pier column nearest the deck origin is pier column 1. The first pier column located closest to the deck origin is identified as “P1C1.” In the case where piles are visible or there are multiple rows of pier columns/piles, identification starts at the column/pier nearest the deck origin and proceeds along the *y*-axis until the end of the row. Identification continues to be numbered in this manner for each row of columns/piles.

3.11 Joints: Joints are identified by their respective abutment or pier.

3.11.1 The joint at abutment A is joint A, and the joint at abutment B is joint B.

3.11.2 The joint at pier 1 is joint P1; the joint at the next pier proceeding along the *x*-axis is joint P2, and so on until joint PN, where N is the number of piers in the bridge.

3.12 Bearings: Bearings are identified by a letter, identifying their location on an abutment or pier along the *y*-axis.

3.12.1 The identifier for bearings at abutments takes the form of “bearing AA,” where:

3.12.1.1 The first character is a letter, identifying the abutment.

3.12.1.2 The second character is a letter, identifying its location along the *y*-axis. The bearing at abutment A nearest to the deck origin is bearing AA; the next bearing proceeding along the *y*-axis is bearing AB, and so on. The bearing at abutment B nearest to the *x*-axis is bearing BA; the next bearing proceeding along the *y*-axis is bearing BB, and so on.

3.12.2 The identifier for bearings at piers takes the form of “bearing P1A[1],” where the first two characters identify the pier number, and the last one or two characters identify its location along the *y*-axis.

3.12.2.1 When two adjacent spans are continuous for dead load, the pier has one bearing line, as shown in the example in figure 1. The bearing nearest the *x*-axis at pier 1 is bearing P1A; the next bearing proceeding along the *y*-axis is bearing P1B; and so on until bearing P1N, where N is the total number of bearings on the pier.

3.12.2.2 When two adjacent spans are simply supported, the pier has two bearing lines. When a pier has two bearing lines, the bearing numbers at pier 1 have an additional labeling component consisting of the integer 1 or 2 at the end of the bearing number. The bearings in the first bearing line (the one closest to the deck origin) are bearings P1A1 through P1N1; the bearings in the second bearing line at pier 1 are bearings P1A2 through P1N2.

3.13 The following describes the segmentation of the two-span continuous bridge shown in figure 1 using the system described above. Items marked with an asterisk (*) are not assigned a unique element identifier.

- Span 1
  - Deck
    - Railings*
    - Curb*
    - Overlay*
    - Top of deck*
    - Bottom of deck*
    - Bays 1AB 1BC 1CD 1DE
    - Overhangs
      - Overhang 1AZ
      - Overhang 1EZ
  - Superstructure
    - Girder 1A
    - Girder 1B
    - Girder 1C
    - Girder 1D
    - Girder 1E
    - Diaphragms
      - End diaphragms 1Di1AB, 1Di1BC, 1Di1CD, 1Di1DE
      - Intermediate diaphragms 1Di2AB, 1Di2BC, 1Di2CD, 1Di2DE
      - Intermediate diaphragms 1Di3AB, 1Di3BC, 1Di3CD, 1Di3DE
      - Intermediate diaphragms 1Di4AB, 1Di4BC, 1Di4CD, 1Di4DE
      - End diaphragms 1Di5AB, 1Di5BC, 1Di5CD, 1Di5DE
    - Secondary Members – None
  - Abutment A
    - Left wingwall
    - Right wingwall
    - Joint A
    - Bearings
      - Bearing AA
      - Bearing AB
      - Bearing AC
      - Bearing AD
      - Bearing AE
    - Bridge pedestal/seat*
    - Backwall*
    - Stem*
    - Footings*
    - Piles
  - Pier 1 (repeat for total number of piers)
    - Joint P1
    - Pier cap
    - Bearings
      - Bearing P1A
      - Bearing P1B
      - Bearing P1C

        - Bearing P1D
        - Bearing P1E
      - Pier columns
        - Pier Column P1C1
        - Pier Column P1C2
        - Pier Column P1C3
        - Pier Column P1C4
      - Footings*
      - Piles
- Span 2
  - Deck
    - Railings*
    - Curb*
    - Overlay*
    - Top of deck*
    - Bottom of deck*
    - Bays 2AB 2BC 2CD 2DE
    - Overhangs
      - Overhang 2AZ
      - Overhang 2EZ
  - Superstructure
    - Girder 2A
    - Girder 2B
    - Girder 2C
    - Girder 2D
    - Girder 2E
    - Diaphragms
      - Intermediate diaphragms 2Di1AB, 2Di1BC, 2Di1CD, 2Di1DE
      - Intermediate diaphragms 2Di2AB, 2Di2BC, 2Di2CD, 2Di2DE
      - Intermediate diaphragms 2Di3AB, 2Di3BC, 2Di3CD, 2Di3DE
      - End diaphragms 2Di4AB, 2Di4BC, 2Di4CD, 2Di4DE
    - Secondary Members – None
  - Abutment B
    - Left wingwall
    - Right wingwall
    - Joint B
    - Bearings
      - Bearing BA
      - Bearing BB
      - Bearing BC
      - Bearing BD
      - Bearing BE
    - Bridge pedestal/seat*
    - Backwall*
    - Stem*
    - Footings*
    - Piles

4. DATA COLLECTION TABLE

4.1 None.

5. CRITERIA FOR DATA VALIDATION

5.1 None.

6. COMMENTARY/BACKGROUND

6.1 It is not practical to use the rectangular coordinate system on the top of the deck (FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks) as a basis for locating, measuring, and documenting defects or placing instrumentation on other elements of the bridge, including abutments, wingwalls, pier columns, pier caps, joints, bearings, girders, diaphragms, secondary superstructure elements, girder bays, and deck overhangs. For these elements, it is more practical to have an identification system that creates a unique identifier for each individual element. The identification system assigns each individual element a unique identifier consisting of a specific combination of whole numbers and letters.

6.2 The origin of the rectangular coordinate system for the top of the deck is the starting point for numbering and lettering of elements. Refer to FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks, for a description of the coordinate system and for the location of the coordinate system origin.

6.3 Web stiffeners, both vertical and longitudinal, are not assigned a unique element identifier; they are considered part of the steel girder element.

7. REFERENCES

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-005, Personnel Qualifications.

7.1.3 FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks.

7.2 *External*: None.

DETERMINATION OF LOCAL ORIGINS FOR ELEMENTS

LTBP Protocol #: FLD-OP-SC-003

1. DATA COLLECTED

1.1 This protocol provides guidance for locating local origins for data collection on bridge elements other than the deck, deck overlay, or approach slabs.

1.2 Descriptions, sketches, and/or photographs of the local element origins.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

2.1.2 Temporary marker.

2.1.3 Digital camera.

2.1.4 Pen, sketch pad, and clipboard.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Identify the origin of the rectangular local coordinate system and the data collection grid for the deck (FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks).

3.2 Segment the bridge, the superstructure, and substructure into individual elements such as girders, abutments, bearings, etc. Identify each element with a unique element identifier (FLD-OP-SC-002, Structure Segmentation and Element Identification System).

3.3 Identify a local origin on each individual element to be evaluated; use this point for locating defects on the element. There are three directions of the triaxial coordinate system that originate at each element local origin:

3.3.1 X – Longitudinal along the bridge.

3.3.2 Y – Transverse to the direction of travel.

3.3.3 Z – Vertical.

3.4 Establish the local element origins as follows:

3.4.1 Girders: Establish the local origin for girders at the end of the girder nearest to the deck origin in the “X” direction, as shown in figures 1 through 4.

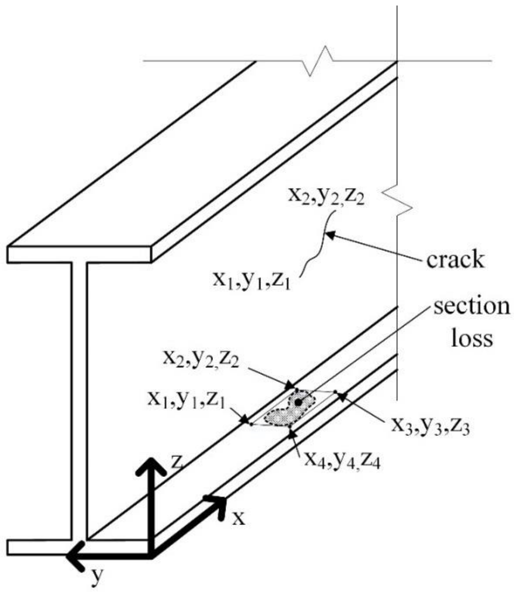

Figure 1. Illustration. Location of local element origin and defect coordinates on steel I-beam—isometric view.

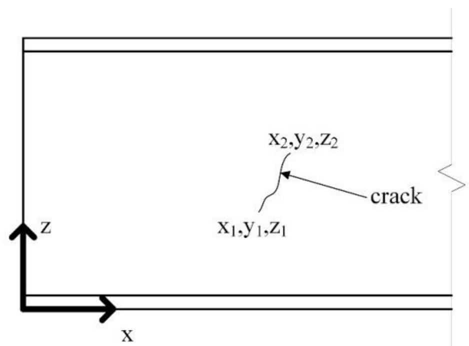

Figure 2. Illustration. Location of local element origin and defect coordinates on steel I-beam—elevation view.

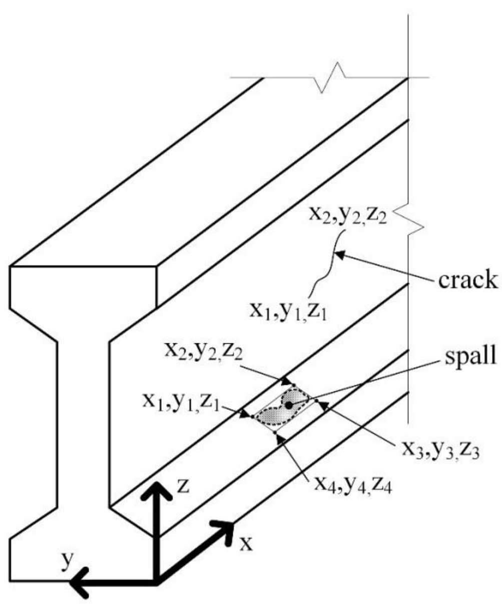

Figure 3. Illustration. Location of local element origin and defect coordinates on concrete I-beam—isometric view.

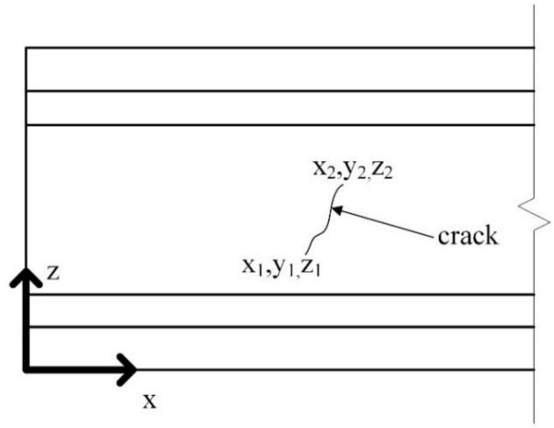

Figure 4. Illustration. Location of local element origin and defect coordinates on concrete I-beam—elevation view.

3.4.2 Diaphragms: Establish the local origin for the diaphragms at the point nearest to the deck origin in the "Y" direction and at the lowest point possible on the diaphragm in the "Z" direction. When locating defects on the diaphragm, ignore the effects of skew on the *x*-coordinate.

3.4.3 Secondary members: Establish the local origin for all secondary members following the same scheme as the diaphragms. If the members are in plane with the deck, then the *y*- and *x*-coordinates of the local origin will be closest to the deck origin as possible.

3.4.4 Girder bays: Establish the local origin for girder bays (stay-in-place forms, or exposed deck undersides) at a point on the underside of the forms or the exposed deck nearest to the deck origin in the "X" and "Y" directions.

3.4.5 Overhangs: Establish the local origin for overhangs at a point on the underside of the nearest to the deck origin in the "X" and "Y" directions.

3.4.6 Abutments: Establish the local origin for abutment A on the top of the abutment cap at the point closest to the deck origin in the "X" and "Y" directions (figure 5). Establish the local origin for abutment B on the top of the abutment cap at the point farthest from the deck origin in the "X" and "Y" directions.

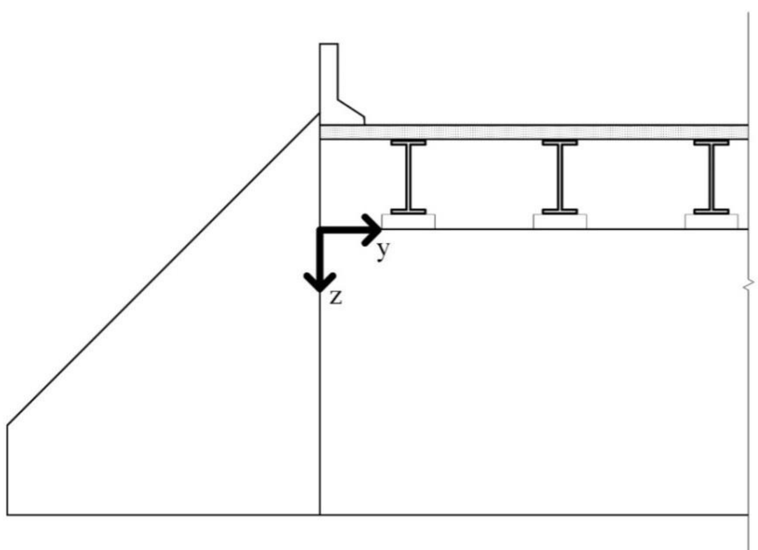

Figure 5. Illustration. Location of local element origin on abutment stem.

3.4.7 Pier caps: Establish the local origin for pier caps at the bottom corner closest to the deck origin in the “X” and “Y” directions. Locate defects by using the two directions that are in the plane of each face of the pier cap or pier. For example, defects on the top of the pier cap will be located in global “X” and “Y” directions, with the “Z” coordinate value remaining constant regardless of skew or super elevations. Figures 6 through 9 illustrate the location of the origin on typical pier elements.

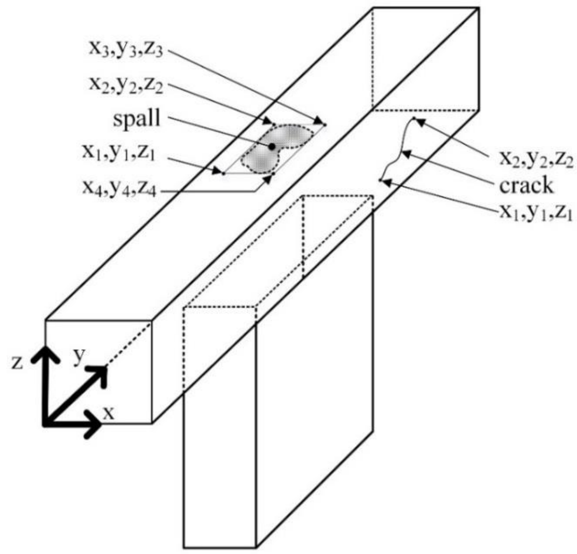

Figure 6. Illustration. Location of local element origin and defect coordinates on pier cap with square end—isometric view.

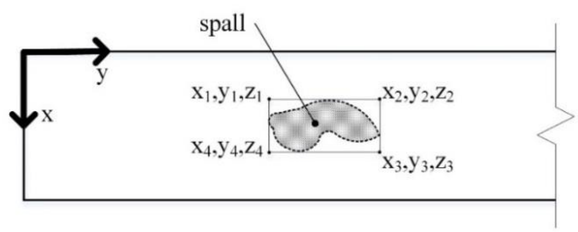

Figure 7. Illustration. Location of local element origin and defect coordinates on pier cap with square end—plan view.

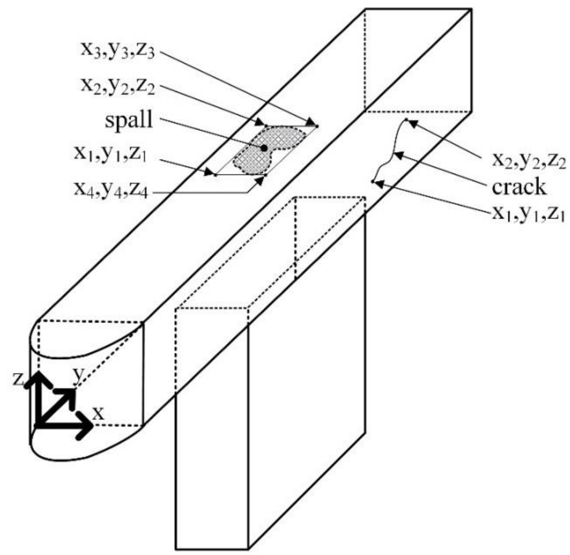

Figure 8. Illustration. Location of local element origin and defect coordinates on pier cap with rounded end—isometric view.

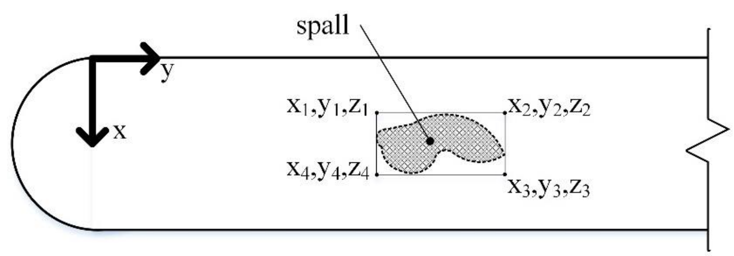

Figure 9. Illustration. Location of local element origin and defect coordinates on pier cap with rounded end—plan view.

3.4.8 Rectangular pier columns: Establish the local origin for rectangular pier columns at the top corner of the exposed length of the column closest to the deck origin in all three directions (figure 10).

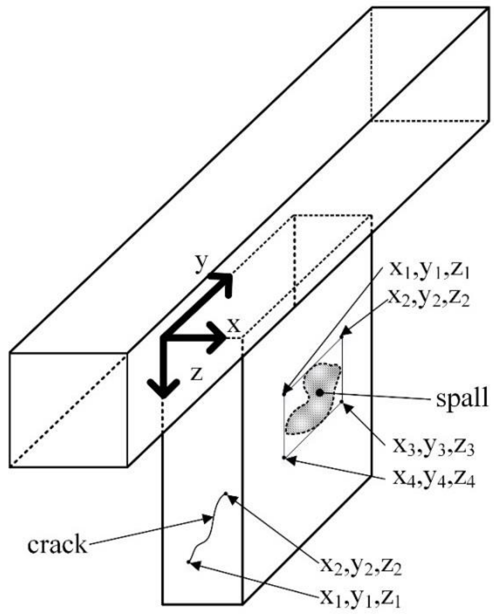

Figure 10. Illustration. Location of local element origin and defect coordinates on square pier column.

3.4.9 Round pier columns: Establish the local element origin for round columns at the top of the exposed length of the column at the intersection of the circumference of the column and a tangential line parallel to the transverse direction of the cap. The local origin is defined as (0,0) for two dimensions: "z," vertical on the column face; and "c," around the circumference of the column (figure 11).

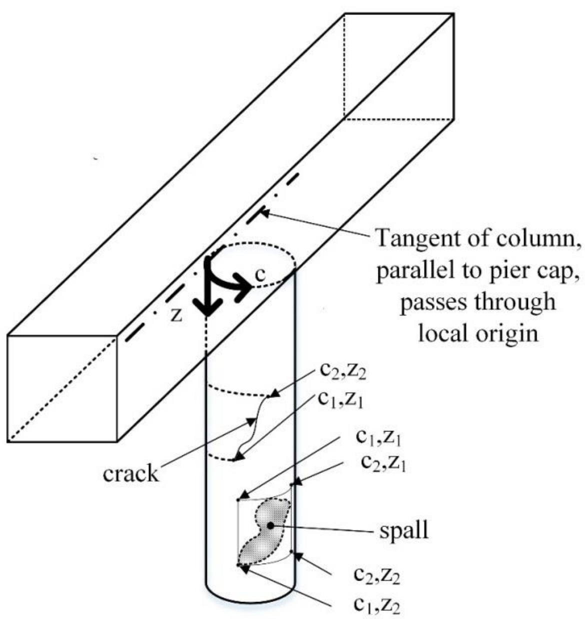

Figure 11. Illustration. Location of local element origin and defect coordinates on round pier column.

3.4.10 Treat piles visible above ground the same as columns.

3.4.11 Joints: Locate the local origin for joints at the end of the joint closest to the deck origin in the "Y" direction.

3.4.12 Bearings: Bearings are not described via coordinates and thus do not need a local element origin.

3.4.13 Use a temporary marker to mark typical local origins for each type of element. Take photos of each type of local origin using FLD-DC-PH-002, Photographing for Documentation Purposes, and create a photo log.

3.5 Use sketches as needed to document locations of local origins and to supplement the photographs.

3.6 Storing data, documents, and images:

3.6.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.6.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.7 Reporting: Transfer all metadata, data, documents, and images to FHWA, and/or upload all metadata, data, documents, and images into the Long-Term Bridge Performance (LTBP) Bridge Portal.

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4. Data Collection Table

4.1 Table:

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
1	State	Text			State Code; e.g., Virginia = VA	Green
2	NBI structure number	Text			Item 8, structure number; from NBI Coding Guide	Green
3	Structure name	Text			Descriptive name for the bridge; e.g., Route 15 SB over I–66	Green
4	Protocol name	Text			Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text			First name(s) Last name(s)	Green
7	Date element local origins established	Text	Exact date		mm/dd/yyyy	Green
8	Element number	Text			e.g., P1 (pier 1)	Blue
9	Portion of the element where local origin is being established	Text			e.g., the concrete pier cap of pier P1	Blue
10	Description of local origin	Text			e.g., bottom corner of the pier cap nearest to the local origin on the deck in the "X" and "Y" directions	Yellow
11	Photo	BLOB			Picture of local element origin identified on the element	Yellow
12	Sketch	BLOB			Sketch of the element with local element origin and relevant axis marked	Yellow
13	Comments	Text				Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, predefined list, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. Criteria for Data Validation

5.1 None.

6. Commentary/Background

6.1 For the elements identified in FLD-OP-SC-002, Structure Segmentation and Element Identification System, it is most efficient for each individual element to have a local origin from which measurements to the location of defects can be made. This protocol provides guidance on locating that origin and using the local origin to measure the location of defects.

6.2 The local origin on each individual element has the local coordinates x = 0, y = 0, and z = 0.

6.3 If the theoretical location of the local origin is missing due to loss of section at the local origin's point on the element, use straight edges to estimate its location for measurement to nearby defects.

6.4 Many elements will have one or more sets of parallel surfaces to be evaluated. For example:

6.4.1 A pier cap has top and bottom surfaces, two surfaces at opposite ends of the cap as well as the two opposite sides of the cap.

6.4.2 A steel I-girder has the two opposing surfaces of the web as well as the bottom surface of the top flange and the top and bottom surfaces of the bottom flange.

6.4.3 A concrete I-girder has the two opposing surfaces of the web as well as the bottom surface of the beam and the sloped faces of the beam flanges.

6.5 For each surface of each element being evaluated, the points that describe the location of the defect will have two coordinates with variable values; the third coordinate will have a constant value that does not account for the effects of skew and/or superelevation. For example:

6.5.1 For a defect on the end face of the square end pier cap, the *y*-coordinate will be either 0 for the end of the cap nearest the local origin or a value equal to the length of the pier cap for the end of the cap farthest from the local origin.

6.5.2 For a defect on the long face of the cap, the *x*-coordinate will be either 0 for the face of the cap nearest the local origin or a value equal to the width of the pier cap for the face of the cap farthest from the local origin.

6.5.3 For a defect on the top surface of the cap, the *z*-coordinate will always be a value equal to the depth of the pier cap; for a defect on the underside of the cap, the *z*-coordinate will always be 0.

6.6 The location of a linear defect (e.g., an individual crack) on an element is documented by determining the coordinates of the beginning and ending points of the defect on the element. The relevant coordinates—*x*, *y*, and/or *z*—are dependent on the type of element, the surface on which the defect is located, and the type of defect being documented. For example:

6.6.1 If the defect being documented is a crack located on the face of the web of a girder, the crack location is defined by the x and z coordinates of the beginning and end of the crack, plus a constant value for y. In this example, the orientation of the crack would be the angle between a straight line from the beginning to the end of the crack and the *x*-axis.

6.6.2 If the defect being documented is impact damage on the bottom flange of a steel girder, the location of the impact damage is defined by the *x*-coordinates of the beginning and end of the affected length of the flange.

6.7 The location of an area defect (such as an irregular spall) is documented by determining the coordinates of the four corners of a rectangle bordering the largest dimensions of the defect on the element.

6.8 The location of defects on the surface of a round pier column differs from the location of defects on elements or parts of elements that have flat surfaces, such as rectangular pier columns. Unlike the rectangular column, it is not practical to project an *x*-axis and a *y*-axis on the face of the column because it is a continuous arc. Therefore, vertical measurements of defect locations are made along the *z*-axis, and horizontal measurements, "c," are made on the circumference of the round column. For example:

6.8.1 To locate a linear defect (such as a crack) on the face of a round column, measure and record the *z*-coordinates and the circumferential measurement, "c," at the beginning and end of a crack.

6.8.2 To locate an irregular defect (such as a spall) on the face of a round column, measure and record the *z*-coordinates and the circumferential measurement, "c," of the four corners of a rectangle bordering the largest dimensions of the defect on the column.

7. References

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-005, Personnel Qualifications.

7.1.3 FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks.

7.1.4 FLD-OP-SC-002, Structure Segmentation and Element Identification System.

7.1.5 FLD-DC-PH-002, Photographing for Documentation Purposes.

7.1.6 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.7 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*: None.

PHOTOGRAPHY PROTOCOLS (PH)

FLD-DC-PH-001, Photography Equipment Requirements

FLD-DC-PH-002, Photographing for Documentation Purposes

FLD-DC-PH-003, Image Naming

PHOTOGRAPHY EQUIPMENT REQUIREMENTS

LTBP Protocol #: FLD-DC-PH-001

1. DATA COLLECTED

1.1 None. This protocol provides the specifications for photography equipment for onsite documentation and data collection.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 Digital camera or smartphone with built-in camera, as described below.

2.1.2 Tripod (optional).

2.2 *Personnel*: None.

3. METHODOLOGY

3.1 The equipment used must meet the following specifications, at a minimum:

3.1.1 Resolution: 8 megapixels.

3.1.2 Sensitivity for digital cameras: ISO 100 to ISO 1600 (minimum range).

3.1.3 Flash: built in.

3.1.4 Storage: 4 GB, internal or external.

3.1.5 Timestamping: Required.

3.1.6 Geotagging: Desired.

3.1.7 Video: Capable.

4. DATA COLLECTION TABLE

4.1 None.

5. CRITERIA FOR DATA VALIDATION

5.1 The assessment team leader will verify the appropriateness of the team's photo documentation equipment.

6. COMMENTARY/BACKGROUND

6.1 This protocol provides guidance on the important characteristics of a camera for field documentation. Use only digital photography for field documentation.

6.2 Camera Types. There are several families of camera that meet these qualifications.

6.2.1 "Point and shoot:"

6.2.1.1 Benefits:

- Compact.
- Affordable.
- Easy to operate.
- Expandable memory cards.
- Replaceable batteries.
- Can be dustproof and waterproof, making them versatile for field applications.

6.2.1.2 Drawbacks:

- Small, digital screen as opposed to a viewfinder for framing shots, resulting in focus and framing issues.
- Lack of geotagging.
- Poor performance in low light.
- Pixilation when zooming (digital zoom).
- A tendency for photographers to overestimate the quality of their images.

6.2.2 Digital Single Lens Reflex (DSLR) cameras:

6.2.2.1 Benefits:

- Interchangeable lenses, expanding the camera's capabilities.
- Viewfinder for framing shots, resulting in more high-quality images on the first shot.
- Users can control the camera settings in challenging imaging scenarios even with powerful automatic exposure tools.
- Expandable memory cards.
- Replaceable batteries.

6.2.2.2 Drawbacks:

- Price.
- Size.
- Steep learning curve for operation.

6.2.3 Smartphone cameras:

6.2.3.1 Benefits:

- Geotagging.
- Automatic cloud backup.
- Video and still image capabilities.
- Panoramic capabilities.
- High dynamic range (HDR) capabilities.
- Image quality on par with point and shoot cameras.

6.2.3.2 Drawbacks:

- Price.
- Susceptibility to damage.
- Pixilation when zooming.
- Poor performance in low light, depending on smartphone model.

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7. REFERENCES

7.1 *LTBP Protocols*: None.

7.2 *External*: None.

PHOTOGRAPHING FOR DOCUMENTATION PURPOSES

LTBP Protocol #: FLD-DC-PH-002

1. DATA COLLECTED

1.1 None. This is an instructional protocol to provide specifications for photography for onsite documentation and data collection.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

2.1.2 Digital camera (FLD-DC-PH-001, Photography Equipment Requirements).

2.1.3 Tripod (optional).

2.1.4 Markers (optional).

2.2 Personnel: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Plan and gather photographic documentation following these guidelines:

3.1.1 All personnel in any photographs must be wearing proper safety equipment.

3.1.2 Take photographs using the highest resolution possible.

3.1.3 Document the bridge structure (elevation view and plan view, if possible).

3.1.4 Document any defects found for each bridge element.

3.1.5 Document the surrounding site (waterway or highway underneath the structure).

3.1.6 Document data collection efforts.

3.2 To maximize the value of photos for the Long-Term Bridge Performance (LTBP) Program, use a multiscale approach to photography:

3.2.1 Large scale:

3.2.1.1 Work from a large-to-small or a general-to-specific scale.

3.2.1.2 Approach the bridge in an organized manner, capturing all critical subjects.

3.2.1.3 Provide global context by capturing traffic signs, lights, lanes, pedestrian travel routes, etc.

3.2.1.4 Take images in cardinal directions for later reference.

3.2.1.5 Provide panoramic shots of the entire scene.

3.2.1.6 Provide point-of-view shots of interest, including overall shots, pedestrian views, driver views, and underside shots.

3.2.2 Midrange scale:

3.2.2.1 The midrange scale provides relative context between specific bridge components and the structure as a whole. Components or features could be deteriorations or structural elements.

3.2.2.2 Pay careful attention to the background of the image to avoid distracting backgrounds.

3.2.3 Closeup scale:

3.2.3.1 These images are used to provide intimate details of features or deteriorations.

3.2.3.2 For closeup photos, carefully focus the image. Closeup focus requires a stable camera and adequate lighting.

3.2.3.3 Fill the viewfinder with the subject.

3.2.3.4 Closeup detail makes any sort of context impossible. Therefore, add external context such as scales, arrows, comments, direction of traffic, cardinal direction indicators, and numbers marking each feature.

3.3 Creating a photo log*:* Create and maintain a photo log throughout the day.

3.3.1 The log should include the following information:

3.3.1.1 State and bridge number.

3.3.1.2 Bridge element (FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks; FLD-OP-SC-002, Structure Segmentation and Element Identification System).

3.3.1.3 Date.

3.3.1.4 Image number.

3.3.1.5 Comment or description.

3.3.2 Include the State, bridge number, and date in the photo log file name.

3.4 Immediately review images, if possible, to verify the quality of the image.

3.5 Store the photo log and the raw image files according to FLD-DC-PH-003, Image Naming.

4. DATA COLLECTION TABLE

4.1 None.

5. CRITERIA FOR DATA VALIDATION

5.1 None.

6. COMMENTARY/BACKGROUND

6.1 Photography has an important role in documenting field data collection efforts. This protocol provides guidance on photography as part of the LTBP Program field data collection effort.

6.2 Several photography techniques are valuable for LTBP Program documentation photography.

6.2.1 Depth of field:

6.2.1.1 Depth of field is the amount or area of focus of an object.

6.2.1.2 Depth of field typically decreases with longer focal length lens, larger aperture sizes, and smaller camera-to-subject distances.

6.2.1.3 Small depth of field can make it difficult to ensure the subject matter is entirely in focus.

6.2.1.4 Blurring the background of an image and highlighting the subject in focus may be a beneficial technique.

6.2.2 Exposure:

6.2.2.1 Most modern cameras determine how much light to allow in (known as metering) based on an average of the entire scene captured in the viewfinder or image extents. This can result in overexposed or underexposed images. This requires practice and careful checking of images.

6.2.2.2 Exposure settings can be manually configured or the camera metering can be modified based on the situation.

6.2.3 Bracketing:

6.2.3.1 Bracketing limits the effects of exposure issues by capturing the same image three times at different exposure levels.

6.2.3.2 Bracketing is a feature of many modern cameras and can be used to provide backup images.

6.2.4 Daytime flash. Using a flash during the day may seem counterintuitive to many, but it can be used to put light into shadowed areas, and to add balance to an exposure.

7. References

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-005, Personnel Qualifications.

7.1.3 FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks.

7.1.4 FLD-OP-SC-002, Structure Segmentation and Element Identification System.

7.1.5 FLD-DC-PH-001, Photography Equipment Requirements.

7.1.6 FLD-DC-PH-003, Image Naming.

7.2 *External*: None.

IMAGE NAMING

LTBP Protocol #: FLD-DC-PH-003

1. DATA COLLECTED

1.1 None. This protocol provides guidance and specifications for manually organizing and naming images, as well as developing a final photo log, as part of data collection on a Long-Term Bridge Performance (LTBP) Program bridge.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 Digital camera.

2.1.2 Computer.

2.2 Personnel: None.

3. METHODOLOGY

3.1 Managing image files and the photo log from onsite data collection is the responsibility of the team member taking the photos.

3.2 Organizing and storing images:

3.2.1 In the absence of an automated (software-based) inspection with an image collection system, set up the following folder structure in advance of the site visit to allow for verification and easy duplication.

3.2.2 Establish a folder for the bridge on an onsite laptop. Label the folder "XX-#####," where XX is the two-letter State identifier, and ##### refers to the NBI structure number.

3.2.3 Within the bridge folder, create daily folders for each day onsite, labeled, "YYYY-MM-DD."

3.2.4 Within each daily folder, create the following subfolders:

3.2.4.1 An assessment technique folder for each assessment performed, labeled according to the tertiary two- or three-letter abbreviation used in the protocol naming scheme (e.g., NDE, VIC).

3.2.4.2 General folders, labeled "Overall," "Site," "Traffic," and "Other."

3.2.4.3 A folder labeled "Raw."

3.3 Raw images: Store all pictures taken in the "Raw" folder.

3.4 Curated images:

3.4.1 Curated images are those images selected and/or edited for inclusion in the curated photo log. These images are selected based on quality and value (e.g., not blurry, the best of a set of duplicates, etc.). The curated photo log will contain only images to be imported into the LTBP Bridge Portal.

3.4.2 Only curated images are stored in the general and assessment technique folders. Store them in the following manner:

3.4.2.1 Copy (do not cut, delete, or move) images to be included in the curated photo log from the daily "Raw" folder to the appropriate daily general or assessment technique folder.

3.4.2.2 Rename the curated images from whatever the camera labels them (e.g., IMG_0001.jpg) to the format "###.jpg," where ### is the number of the photo, continuous across all days onsite. Photo numbering should not restart each new day.

3.5 Creating a photo log for curated images:

3.5.1 Create a curated photo log for the curated photos. The curated photo log references the curated image numbers and provides a cursory description of image content as outlined in the onsite photo log (FLD-DC-PH-002, Photographing for Document Purposes).

3.5.2 Include the following in the image description, where applicable:

3.5.2.1 Element name (e.g., Girder, Bearing, Deck).

3.5.2.2 Element designation (per FLD-OP-SC-002, Structure Segmentation and Element Identification System).

3.5.2.3 Span number (e.g., span 2).

3.6 By setting up the folders this way, the metadata for the image is contained in the file path. When imported into the LTBP Bridge Portal, the file path will be included as metadata, and the description in the curated photo log will be text-searchable captions.

4. DATA COLLECTION TABLE

4.1 None.

5. CRITERIA FOR DATA VALIDATION

5.1 None.

6. COMMENTARY/BACKGROUND

6.1 This protocol provides guidance on naming digital image files.

6.2 As an example of the procedure previously listed, consider the hypothetical file path: C:/Pictures/PA-123456/2015-07-01/ND/007.jpg.

6.2.1 From the file path, the following can be determined:

6.2.1.1 Photo taken at Bridge PA-123456.

6.2.1.2 Photo captured on July 1, 2015.

6.2.1.3 Photo contents are part of nondestructive testing.

6.2.1.4 It is the seventh image on the curated photo log.

6.2.2 The corresponding photo log entry may be "007 – Image of technician collecting GPR data from the deck on span 2 – facing east." From this description, the element (including designation where applicable), the general location, and an understanding of the image contents can be obtained.

7. REFERENCES

7.1 *LTBP Protocols*:

7.1.1 FLD-DC-PH-001, Photography Equipment Requirements.

7.1.2 FLD-DC-PH-002, Photographing for Documentation Purposes.

7.1.3 FLD-OP-SC-002, Structure Segmentation and Element Identification System.

MATERIAL SAMPLING PROTOCOLS (MS)

FLD-DC-MS-001, Wet Coring of Concrete Decks

FLD-DC-MS-002, Compressive Strength and Static and Dynamic Elastic Moduli of Concrete Cores

FLD-DC-MS-003, Resistance of Concrete to Chloride Ion Penetration (Permeability)

FLD-DC-MS-004, Sampling and Testing for Chloride Profiles

WET CORING OF CONCRETE DECKS

LTBP Protocol #: FLD-DC-MS-001

1. DATA COLLECTED

1.1 Concrete heterogeneity and consolidation.

1.2 Reinforcing steel depth, size, and condition.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

2.1.2 Concrete pachometer (cover meter).

2.1.3 Permanent marker.

2.1.4 Temporary chalk marker.

2.1.5 Water-cooled core drilling machine (portable or vehicle based) for nominal 4-inch diameter core.

NOTE—Electricity may not be available at the bridge.

2.1.6 Water (for cooling).

2.1.7 Diamond-impregnated coring bit(s) of appropriate diameter.

2.1.8 Wrapping materials.

2.1.9 Approved patching materials.

2.1.10 Hammer.

2.1.11 Chisel or flathead screwdriver.

2.1.12 Core extraction tool.

2.1.13 Three-point caliper.

2.1.14 Digital camera.

2.1.15 Pencil, sketch pad, and clipboard.

2.1.16 Tape measure.

2.1.17 6-ft folding rule.

2.1.18 Push broom or hand broom.

2.1.19 Ground penetrating radar (GPR); if necessary.

2.2 Personnel: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Select equipment for coring that meets the requirements of section 2.1 of this protocol.

3.2 Site cleaning and preparation:

3.2.1 Clean debris from the deck area(s) using the push broom or hand broom.

3.2.2 Follow PRE-OP-SP-001, Site Preparation.

3.3 Unique core identifier:

3.3.1 Create a unique identifier for each core. The identifier has three components: the two-letter State code; the NBI structure number; and a sequential number. For example: VA-0102030-1 is the first core on a bridge in the Commonwealth of Virginia having an NBI number of 0102030.

3.3.2 The sequential number component of the unique core identifier is determined as follows: core number VA-0102030-1 is the core nearest to the deck origin in the *x* direction; core number VA-0102030-2 is the next closest core to the deck origin in the *x* direction; core number VA-0102030-N is the core farthest from the deck origin in the *x* direction.

3.4 Determining locations and sizes of cores:

3.4.1 For locations, number, and sizes of cores for reference bridges, follow PRE-PL-LO-001, Reference Bridge Testing.

3.4.2 For locations, number, and sizes of cores for cluster bridges, follow PRE-PL-LO-002, Cluster Bridge Testing.

3.4.3 Consult as-built plans for reinforcing steel (rebar) locations to avoid cores with rebar in them.

3.4.4 Use the concrete pachometer (cover meter) to confirm the location of the reinforcement and avoid cores with rebar in it. Indicate longitudinal and transverse (or skewed) reinforcement in the vicinity of the core location. Record the depth of reinforcement detected. If the pachometer cannot confirm the reinforcing bar locations, use GPR (if available) to confirm the locations.

3.4.5 Use the results of visual inspection and NDE testing of the deck (if available) to identify possible locations of cores in sound concrete that is determined to be free of cracks, delaminations, and spalls.

3.4.6 Use the temporary chalk marker to mark the location of the core on the deck.

3.4.7 Measure the *x*-coordinates and *y*-coordinates of the core location using the grid from section 3.3 of this protocol, and record these values in the data collection table.

3.4.8 Use a permanent marker to clearly mark the top of the core so that physical orientation in relation to the deck is known.

3.4.9 Mark the location of each core and the respective unique core identifier on a sketch of the bridge deck.

3.5 Obtaining the core(s):

3.5.1 Determine the ideal core length (depth)—this is at least two times the core diameter. Refer to sections 7.1 and 7.1.1 of AASHTO T 24-07 (2011), Standard Method of Test for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete, for further guidance on permissible core lengths.

3.5.2 Mark the intended core length (depth) on the coring bit with a permanent marker. Most concrete cores will not break off evenly at the bottom of the cored depth, so add an inch of penetration to the desired core length, if possible.

3.5.3 Obtain the core(s) following AASHTO T 24-07 (2011).

3.6 Extracting samples:

3.6.1 When the desired depth is reached, stop coring.

3.6.2 When coring at a location where delaminations exist, the top portion of the concrete core comes loose in the core barrel once delamination depth is reached. Stop coring immediately, remove the loose top section, retain the loose concrete, and then continue coring.

3.6.3 Insert a screwdriver, chisel, or other suitable lever instrument into the annular space of the core, and gently tap with a hammer. Repeat tapping along different sectors of the core until the bond at the bottom of the core is broken.

3.6.4 Use the core extraction tool to grab the core and pull it out of the hole.

3.6.5 Using the permanent marker, mark the core with unique labeling. Identify this unique label on the sketch of coring locations.

3.7 Determine and record the core's diameter and length following AASHTO T 24-07 (2011). Record any necessary correction factors from section 7.1.1 of AASHTO T 24-07 (2011).

3.8 Using the three-point caliper, determine (in the data collection table) the length of the core(s) following AASHTO T 148-07 (2011), Standard Method of Test for Measuring Length of Drilled Concrete Cores.

3.9 Storing samples:

3.9.1 Within 1 hour of extracting the core, wrap the specimen in four layers: 4-mil polyethylene sheet or similar, aluminum foil, 4-mil polyethylene sheet, and duct tape.

3.9.2 Clearly label the external wrapping with the unique identifier.

3.9.3 Before wrapping the specimen, note important characteristics, such as maximum aggregate size, presence and location of reinforcing steel in the specimen, cracking, and voids.

3.9.4 To preserve the "as-is" condition of the concrete and prevent net moisture gain or loss, allow the cores to air dry only long enough for visible water (from coring) on the core perimeter to evaporate.

3.10 Repairing sample locations:

3.10.1 Before leaving the site, repair each location where physical sampling resulted in a hole in the concrete element. Coordinate with and obtain approval from the bridge owner/agency concerning the material used in the repair and the method of repair.

3.10.2 Repairs to overlays or membranes should be compatible with the base material and approved by the owner.

3.10.3 Allow deck repair materials time to reach adequate strength before reopening deck to traffic.

3.11 Documenting cores: Take photographs of core locations before testing, after locating reinforcement, and after coring is completed, using FLD-DC-PH-002, Photographing for Documentation Purposes, and create a photo log.

3.12 Storing data, documents, and images:

3.12.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.12.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.13 Reporting: Transfer all metadata, data, documents, and images to Federal Highway Administration (FHWA), and/or upload all metadata, data, documents, and images into the Long-Term Bridge Performance (LTBP) Bridge Portal.

4. Data Collection Table

4.1 Table:

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
1	State	Text			State Code; e.g., Virginia = VA	Green
2	NBI structure number	Text			Item 8, structure number; from NBI Coding Guide	Green
3	Structure name	Text			Descriptive name for the bridge; e.g., Route 15 SB over I–66	Green
4	Protocol name	Text			Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text			First name(s) Last name(s)	Green
7	Date data was collected	Text	Exact date		mm/dd/yyyy	Green
8	Coring equipment name	Text				Green
9	Coring equipment manufacturer	Text				Green
10	Coring equipment model name and number	Text			If available	Green
11	Equipment comments	Text				Orange
12	Span number	Text				Blue
13	Location of core (*x*-, *y*-coordinates)	Number	1	in.		Blue
14	Test location description	Text			Descriptive location of core on the bridge (e.g., slow (right) lane, fast lane (left lane), right or left shoulder, etc.)	Blue
15	Ambient temperature during testing – High	Number	1	ºF		Blue
16	Ambient temperature during testing – Low	Number	1	ºF		Blue
17	Unique core identifier	Text				Blue
18	Core length measurement	Number	0.05	in.	See AASHTO T 148-07 (2011)	Yellow
19	Core diameter	Number	0.1	in.		Yellow
20	Correction factor used	Number	0.1		Obtain correction factor from Section 7.1.1 of AASHTO T 24 – 07 (2011)	Yellow
21	Overlay depth	Number	0.1	in.		Yellow
22	Depth to reinforcement	Number	0.1	in.		Yellow
23	Weather during sampling	Text			e.g., cloudy, sunny, etc.	Yellow
24	Core photos	BLOB			Document core condition with photos	Yellow

#	FIELD NAME	DATA TYPE	ACCURACY	UNIT	FIELD DESCRIPTION	ROW COLOR
25	Comments	Text				Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. CRITERIA FOR DATA VALIDATION

5.1 Where feasible, data will be validated using standard error checking within the Bridge Portal.

6. COMMENTARY/BACKGROUND

6.1 The purpose of this protocol is to obtain physical samples of concrete materials for subsequent laboratory evaluation and testing.

6.2 Physical sampling of the concrete material is often required to evaluate the condition of reinforced concrete bridge decks and other conventionally reinforced concrete elements. Laboratory assessment and testing determines the fundamental physical properties of the material, evaluates construction quality, and identifies evidence of deleterious reactions that may inhibit performance.

6.3 Coring is often the most convenient method of physical sampling. The cores and the exposed substrate are visually evaluated, and the cores are transported to the laboratory for closer visual evaluation as well as physical and chemical testing. The number, location, size, and depth of cores to be sampled are determined as part of a comprehensive evaluation plan for a given structure or element.

6.4 Conventional pachometers will not detect stainless steel or other nonferromagnetic elements. In such cases, it may be necessary to use GPR or another method to locate such features.

6.5 Pachometer and GPR are used to locate top mat or nearest-to-surface reinforcement easily, but it is difficult to identify the lower mat reinforcement location. Take cores to a shallower depth to avoid encountering lower mat if avoiding reinforcement is critical.
Alternatively, probe locations adjacent to the intended core to positively identify reinforcement and bracket the core location. However, this method is time- and labor-intensive and increases intrusion into the structure.

6.6 In some cases where reinforcement is taken within the core, particularly where epoxy coating inhibits the bond of concrete to reinforcement, the core may break at the plane of reinforcement rather than at the bottom of the core during extraction of the core. If breakage occurs at the plane of the reinforcement, remove the loose top section and retain, then proceed coring to the desired depth. This situation may be unavoidable.

6.7 If interference between tests is avoided and tests are performed on appropriate sections of the core, extracted cores can serve for multiple observations and tests. Time between field sampling and laboratory testing may influence the outcome of certain tests and should be considered in advance.

6.8 Typical materials for repairing core locations are rapid set cementitious repair materials, although gel-type polymer mortars may be used. Consult the State department of transportation for a list of materials on its approved materials list.

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7. REFERENCES

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-001, Reference Bridge Testing.

7.1.2 PRE-PL-LO-002, Cluster Bridge Testing.

7.1.3 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.4 PRE-PL-LO-005, Personnel Qualifications.

7.1.5 FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks.

7.1.6 FLD-DC-PH-002, Photographing for Documentation Purposes.

7.1.7 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.8 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*:

7.2.1 AASHTO T 24-07 (2011), Standard Method of Test for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete, American Association of State Highway and Transportation Officials, Washington, DC, 2011.

7.2.2 AASHTO T 148-07 (2011), Standard Method of Test for Measuring Length of Drilled Concrete Cores, American Association of State Highway and Transportation Officials, Washington, DC, 2011.

7.2.3 FHWA-NHI-12-053, Bridge Inspector’s Reference Manual, Federal Highway Administration, Washington, DC, 2012.

COMPRESSIVE STRENGTH AND STATIC AND DYNAMIC ELASTIC MODULI OF CONCRETE CORES

LTBP Protocol #: FLD-DC-MS-002

1. DATA COLLECTED

1.1 Compressive strength and static and dynamic elastic moduli of concrete cores.

2. EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

2.1.2 Test specimens.

2.1.3 Compression testing machine meeting the requirements of AASHTO T 22-10 (2011).

2.1.4 Testing apparatus for determining dynamic modulus of elasticity, conforming to the requirements of ASTM C215-14.

2.1.5 Compressometer for determining the static modulus of elasticity, conforming to the requirements of ASTM C469/C469M-14.

2.1.6 Digital camera.

2.2 Personnel: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Test preparation:

3.1.1 A minimum 5-day waiting period between encapsulation of the cores and unwrapping for testing of the cores is recommended to minimize moisture gradients.

3.1.2 Use a 4-inch diameter core that has been properly obtained and prepared for storage using FLD-DC-MS-001, Wet Coring of Concrete Decks. Record the unique core identifier, and note any damage to the wrapping.

3.1.3 Unwrap the core, removing all four layers of wrapping. Compare sample number and other descriptive information on the wrapping with the similar data on the unwrapped core.

3.1.4 Weigh the uncut sample immediately, and record the result.

3.1.5 Photograph the sample (top, bottom, and sides at four quadrants), and create a photo log following FLD-DC-PH-002, Photographing for Documentation Purposes.

3.2 Core testing:

3.2.1 Conduct dynamic modulus test of the core, and calculate the dynamic Young's modulus of elasticity, all in accordance with ASTM C215, and record the following:

3.2.1.1 Unique core identifier.

3.2.1.2 Diameter.

3.2.1.3 Length.

3.2.1.4 Mass.

3.2.1.5 Description of any defects, including the presence of reinforcement.

3.2.1.6 Mode of vibration.

3.2.1.7 Corresponding resonant frequency.

3.2.1.8 Dynamic Young's modulus of elasticity.

3.2.1.9 Correction factor.

3.2.2 Using the same core, conduct test for static modulus of elasticity of the core, and calculate the static modulus of elasticity, all in accordance with ASTM C469, and record the following:

3.2.2.1 Curing and environmental histories of the core.

3.2.2.2 Age of the core.

3.2.2.3 Unit weight of the concrete.

3.2.2.4 Stress–strain curves.

3.2.2.5 Static modulus of elasticity (chord modulus of elasticity).

3.2.3 Using the same core, conduct compressive strength test of core in accordance with AASHTO T 22-10 (2011), and record the following:

3.2.3.1 Maximum load.

3.2.3.2 Compressive strength.

3.2.3.3 Type of fracture.

3.3 Storing data, documents, and images:

3.3.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.3.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.4 Reporting: Transfer all metadata, data, documents, and images to Federal Highway Administration (FHWA), and/or upload all metadata, data, documents, and images into the Long-Term Bridge Performance (LTBP) Bridge Portal.

4. DATA COLLECTION TABLE

4.1 Table:

#	FIELD NAME	DATA TYPE	ACCURACY	UNIT	FIELD DESCRIPTION	ROW COLOR
1	State	Text			State Code; e.g., Virginia = VA	Green
2	NBI structure number	Text			Item 8, structure number; from NBI Coding Guide	Green
3	Structure name	Text			Descriptive name for the	Green

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
					bridge; e.g., Route 15 SB over I–66	
4	Protocol name	Text			Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing testing activities	Text			First name(s) Last name(s)	Green
7	Date testing was performed	Text	Exact date		mm/dd/yyyy	Green
8	Sampling site	Text			Location of core extraction on the bridge (e.g., span number, lane number, right or left shoulder, etc.)	Blue
9	Unique core identifier	Text				Blue
Dynamic Modulus of Elasticity						Pink
10	Equipment name	Text				Green
11	Equipment manufacturer	Text				Green
12	Equipment model name and number	Text			If available	Green
13	Equipment comments	Text				Orange
14	Core length	Number	0.1	in.		Yellow
15	Core diameter	Number	0.1	in.		Yellow
16	Overlay depth	Number	0.1	in.		Yellow
17	Description of any defects, including the presence of reinforcement	Text				Yellow
18	Mass	Number	0.5	kg		Yellow
19	Mode of vibration	Text				Yellow
20	Resonant frequency	Number	10	Hz		Yellow
21	Dynamic modulus	Number	0.05×10^6	psi		Yellow
22	Correction factor	Number	0.01		Range: 1.00 to 6.34	Yellow
23	Comments	Text				Orange
Static Modulus of Elasticity						Pink
24	Equipment name	Text				Green
25	Equipment manufacturer	Text				Green
26	Equipment model name and number	Text			If available	Green
27	Equipment comments	Text				Orange
28	Curing and environmental history of the core	Text				Yellow
29	Age of the core					Yellow
30	Unit weight of the core					Yellow
31	Stress-strain curves	BLOB				Yellow
32	Static modulus of elasticity		0.05×10^6	psi		Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
33	Comments	Text				Orange
	Compressive Strength					Pink
34	Equipment name	Text				Green
35	Equipment manufacturer	Text				Green
36	Equipment model name & number	Text			If available	Green
37	Equipment comments	Text				Orange
38	Maximum load	Number	1	lbs		Yellow
39	Compressive strength	Number	10	psi		Yellow
40	Type of fracture	Text				Yellow
41	Comments	Text	Unlimited			Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. Criteria for Data Validation

5.1 Precision, bias, and repeatability of the individual tests outlined herein are addressed in the respective AASHTO and ASTM standards that govern the laboratory tests being conducted.

6. Commentary/Background

6.1 The purpose of this protocol is to obtain physical parameters useful for structural evaluation of the concrete bridge members by lab testing of the concrete cores taken by wet coring (FLD-DC-MS-001, Wet Coring of Concrete Decks) of reinforced concrete decks.

6.2 If the concrete core contains distinguishing features about the quality or condition of the material, conduct a visual condition assessment and record details about paste, aggregate type and distribution, defects, deleterious reactions, and embedded items.

6.3 For static elastic modulus testing, if the outside diameters of the samples are not 4 inches (102 mm), or the lengths are insufficient to fit the elastic modulus jig, adhere two concrete strain gages of no less than three times the nominal aggregate size to diametrically opposite faces.

7. REFERENCES

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-005, Personnel Qualifications.

7.1.3 FLD-DC-MS-001, Wet Coring of Concrete Decks.

7.1.4 FLD-DC-PH-002, Photographing for Documentation Purposes.

7.1.5 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.6 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*:

7.2.1 AASHTO T 22-10 (2011), Standard Method of Test for Compressive Strengths of Cylindrical Concrete Specimens, American Association of State Highway and Transportation Officials, Washington, DC, 2011.

7.2.2 ASTM C215-14, Standard Test Method for Fundamental Transverse, Longitudinal, and Torsional Resonant Frequencies of Concrete Specimens, ASTM International, West Conshohocken, PA, 2014.

7.2.3 ASTM C469/C469M-14, Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression, ASTM International, West Conshohocken, PA, 2014.

RESISTANCE OF CONCRETE TO CHLORIDE ION PENETRATION (PERMEABILITY)

LTBP Protocol #: FLD-DC-MS-003

1. DATA COLLECTED

1.1 Electrical conductance of the concrete, an indication of resistance of the concrete to chloride ion penetration.

2. EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

2.1.2 Test specimens.

2.1.3 Applied voltage cell as specified in ASTM C1202-12.

2.1.4 Apparatus specified in Section 6 of ASTM C1202-12.

2.1.5 Digital camera.

2.2 Personnel: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Test preparation:

3.1.1 Use a 2.5-inch diameter core that has been properly obtained, prepared, and stored using FLD-DC-MS-001, Wet Coring of Concrete Decks.

3.1.2 Record the unique core identifier, and note any damage to the wrapping.

3.1.3 Unwrap the core, removing all four layers of wrapping. Compare the sample number and other descriptive information on the wrapping with the similar data on the unwrapped core.

3.1.4 Weigh and record the weight of the core as-received, uncut sample.

3.1.5 Photograph the sample (top, bottom, and sides at four quadrants), and create a photo log, following FLD-DC-PH-002, Photographing for Documentation Purposes.

3.2 Core sampling:

3.2.1 For each core, if conducting both the permeability test and the chloride profile test, use the top 3 inches of the core for the chloride profile and the remainder of the core for the permeability test.

3.2.2 For each core, if conducting only the permeability test, use the top 2 inches of the core for the permeability test.

3.3 Laboratory testing:

3.3.1 Conduct the test to measure the electrical conductance of the concrete and determine the total charge passed over the test period, in accordance with ASTM C1202-12, and record the following:

3.3.1.1 Unique core identifier.

3.3.1.2 Location of the core on the bridge.

3.3.1.3 Location of the test specimen for this test within the core.

3.3.1.4 Description of the test specimen, including location and thickness of reinforcing steel, overlays, and/or surface treatments.

3.3.1.5 Curing history of the specimen itself immediately prior to the test—moist curing, extended moist curing, or accelerated moist curing (as per section 8 of ASTM C1202-12).

3.3.1.6 Any special surface preparation of the test specimen.

3.3.1.7 Plot of current versus time.

3.3.1.8 The total charge passed during the test period, in coulombs (ampere-seconds).

3.4 Storing data, documents, and images:

3.4.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.4.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.5 Reporting: Transfer all metadata, data, documents, and images to Federal Highway Administration (FHWA), and/or upload all metadata, data, documents, and images into the Long-Term Bridge Performance (LTBP) Bridge Portal.

4. DATA COLLECTION TABLE

4.1 Table:

#	FIELD NAME	DATA TYPE	ACCURACY	UNIT	FIELD DESCRIPTION	ROW COLOR
1	State	Text	Text		State Code, e.g., Virginia = VA	Green
2	NBI structure number	Text	Text		Item 8, Structure Number from NBI Coding Guide	Green
3	Structure name	Text	Text		Descriptive name for the bridge, e.g., Route 15 SB over I–66	Green
4	Protocol name	Text	Text		Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing testing activities	Text	Text		First name(s) Last name(s)	Green
7	Date testing was performed	Text	Exact date		mm/dd/yyyy	Green
8	Equipment name	Text	Text			Green
9	Equipment manufacturer	Text	Text			Green
10	Equipment model name and number	Text	Text		If available	Green

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
11	Equipment comments	Text	Unlimited			Orange
12	Unique core identifier	Text				Blue
13	Weight of uncut sample	Number	0.1	pounds		Yellow
14	Sampling site	Text			Location of core extraction on the bridge (e.g., span number, lane number, right or left shoulder, etc.)	Yellow
15	Location of the test specimen within the core	Text			For example: top 2 inches of the core, 2 inches to 4 inches from the top of the core, bottom 2 inches of the core, etc.	Yellow
16	Description of the test specimen	Text			Presence, location, and thickness of any reinforcing steel, overlay, or surface treatment	Yellow
17	Curing history of the test specimen	Text			Moist Curing/Extended Moist Curing/Accelerated Moist Curing [Note: As per section 8 of ASTM C1202-12]	Yellow
18	Any special surface preparation of the test specimen	Text				Yellow
19	Plot of current versus time	BLOB				Yellow
20	Total charge passed	Number	1	C		Yellow
21	Comments	Text				Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. Criteria for Data Validation

5.1 Precision, bias, and repeatability of the individual tests outlined herein are addressed in ASTM C1202-12.

6. COMMENTARY/BACKGROUND

6.1 The purpose of this protocol is to assess the quality of the concrete regarding the permeability and resistance to chloride ion penetration by lab testing of the concrete cores taken by wet coring (FLD-DC-MS-001, Wet Coring of Concrete Decks) from the bridge.

6.2 If the concrete sample (core) contains distinguishing features about the quality or condition of the material, conduct and record a visual condition assessment (include details about paste, aggregate type and distribution, defects, deleterious reactions). Take additional photographs as appropriate to record these features.

7. REFERENCES

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-005, Personnel Qualifications.

7.1.3 FLD-DC-MS-001, Wet Coring of Concrete Decks.

7.1.4 FLD-DC-PH-002, Photographing for Documentation Purposes.

7.1.5 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.6 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*:

7.2.1 ASTM C1202-12, Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration, ASTM International, West Conshohocken, PA, 2012.

SAMPLING AND TESTING FOR CHLORIDE PROFILES

LTBP PROTOCOL #: FLD-DC-MS-004

1. DATA COLLECTED

1.1 Testing of concrete cores to estimate the permeability to chloride ingress and the density and voids characteristics of the concrete.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

2.1.2 Sampling plan with sample locations marked.

2.1.3 Test specimens.

2.1.4 Apparatus specified in AASHTO T 260-97 (2011).

2.1.5 Tape measure.

2.1.6 Digital camera.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Test preparation:

3.1.1 Use a 2.5-inch diameter core that has been properly obtained, prepared, and stored using FLD-DC-MS-001, Wet Coring of Concrete Decks.

3.1.2 Record the unique core identifier, and note any damage to the wrapping.

3.1.3 Unwrap the core, removing all four layers of wrapping. Compare sample number and other descriptive information on the wrapping with the similar data on the unwrapped core.

3.1.4 Weigh and record the weight of the core as-received uncut sample.

3.1.5 Photograph the sample (top, bottom, and sides at four quadrants), and create a photo log following FLD-DC-PH-002, Photographing for Documentation Purposes.

3.2 Core sampling: For each core, if conducting both the permeability test and the chloride profile test, use the top 3 inches of the core for the chloride profile and the remainder of the core for the permeability test.

3.3 Laboratory testing:

3.3.1 To minimize the potential for cross-contamination of titrated samples, specimens should be tested in order of anticipated increasing chloride concentration, typically taken from deepest depth increment to shallowest increment. Conduct titration of all specimens from a given sample location in one group, and calculate and analyze results (as outlined below) before proceeding with titration of specimens from the next sample location.

3.3.2 To determine the profile of chloride concentrations as a function of depth at each sample location, determine the diffused chloride contents for depth increments as shown in table 1. The surface chloride value is the chloride content determined for the 0.25–0.75-inch depth range for concrete bridge decks.

Table 1. Chloride Profile Depth Increments.

Increment #	Base unit (U.S. Customary)		Metric Equivalent (S.I.)	
	Nominal Depth (in.)	Depth Range (in.)	Nominal Depth (mm)	Depth Range (mm)
1	0.5*	0.25–0.75	13	6–19
2	1.0	0.75–1.25	25	19–32
3	1.5	1.25–1.75	38	32–44
4	2.0	1.75–2.25	51	44–57
5	2.5	2.25–2.75	64	57–70
6	3.0	2.75–3.25	76	70–83

* Concentration at this depth is to be used as driving chloride concentration, C_o, for diffusion calculations.

3.3.3 Determine and record the chloride concentration of the powdered sample from each depth increment following AASHTO T 260-97 (2011), Sampling and Testing for Chloride Ion in Concrete and Concrete Raw Materials, procedure A.

3.4 Retain for reference, but do not report, detailed titration records, to include all of the following: the identification and amount of sample, the calibration standards of titrant, the endpoint values of required blank samples, the detailed log of incremental titrant addition and resulting reference voltage readings, and the calculation of endpoint values using the second derivative analysis for each powdered concrete sample. Such information can be captured and stored by automated titration systems and should be archived.

3.5 Take photographs to document the core features using FLD-DC-PH-002, Photographing for Documentation Purposes, and create a photo log.

3.6 Storing data, documents, and images:

3.6.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.6.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.7 Reporting: Transfer all metadata, data, documents, and images to Federal Highway Administration (FHWA), and/or upload all metadata, data, documents, and images into the Long-Term Bridge Performance (LTBP) Bridge Portal.

4. Data Collection Table

4.1 Table:

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
1	State	Text			State Code (e.g., Virginia = VA)	Green
2	NBI structure number	Text			Item 8, structure number; from NBI Coding Guide	Green
3	Structure name (e.g., Route 15 SB over I–66)	Text			Descriptive name for the bridge (e.g., Route 15 SB over I–66)	Green
4	Protocol name	Text			Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text			First name(s) Last name(s)	Green
7	Date data collected	Text	Exact date		mm/dd/yyyy	Green
8	Test site	Text			Location of data collection on the bridge (e.g., span number, lane number, right or left shoulder, substructure unit, etc.)	Green
9	Equipment name	Text				Green
10	Equipment manufacturer	Text				Green
11	Equipment model name and number	Text			Include model number if available	Green
12	Equipment comments	Text				Orange
Core Information						Pink
13	Unique core identifier	Text				Blue
14	Sample location on structure (*x*-coordinate)	Number	1	in.	Transverse distance from grid origin	Yellow
15	Sample location on structure (*y*-coordinate)	Number	1	in.	Longitudinal distance from grid origin	Yellow
16	Core length	Number	0.1	in.		Yellow
17	Core diameter	Number	0.1	in.		Yellow
18	Presence of reinforcement	Predefined list			Yes No	Yellow
19	Overlay depth	Number	0.1	in.		Yellow
20	Weight of core	Number	0.1	lb.		Yellow
21	Reinforcement depth	Number	0.05	in.		Yellow
Chloride Concentration Results						Pink
22	Nominal depth of 0.5 in.	Number	0.05	%	Chloride concentration expressed as percent chloride per concrete mass	Yellow
23	Nominal depth of 1.0 in.	Number	0.05	%	Chloride concentration	Yellow
24	Nominal depth of 1.5 in.	Number	0.05	%	Chloride concentration	Yellow
25	Nominal depth of 2.0 in.	Number	0.05	%	Chloride concentration	Yellow
26	Nominal depth of 2.5 in.	Number	0.05	%	Chloride concentration	Yellow
27	Nominal depth of 3.0 in.	Number	0.05	%	Chloride concentration	Yellow
28	Comments	Text	Unlimited			Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. CRITERIA FOR DATA VALIDATION

5.1 Precision, bias, and repeatability of the individual tests outlined herein are addressed in the respective ASTM standards that govern the laboratory tests being conducted.

6. COMMENTARY/BACKGROUND

6.1 The purpose of this protocol is to describe the laboratory test methods to determine the indication of permeability to chloride ingress and density and voids characteristics.

6.2 Corrosion of the reinforcement due to chloride ingress is a primary cause of damage to reinforced concrete structures. Sources of chloride in concrete include internal chloride, which refers to chloride added to the concrete at the time of mixing (calcium chloride accelerators for rapid hardening concrete, salt contaminated aggregates, sea water, or other saline contaminated water) and external chloride, which refers to chloride ingress into the concrete from the environment (typically deicer salt and marine salt).

6.3 Ions, such as chloride, penetrate into the concrete by various processes, most notably diffusion, eventually reaching the reinforcing steel where chloride accumulates to sufficient concentration to induce corrosion. At such concentrations, chloride destroys the naturally occurring protective film on the reinforcing steel that forms in the highly alkaline environment of concrete. This depassivation leads to severe corrosion when sufficient oxygen and moisture are present at the steel–concrete interface.

6.4 Corrosion of mild steel produces oxide products that consume more volume than the original reactants, which causes expansive pressures and subsequent cracking of the surrounding concrete. Therefore, chloride attack could be very critical for the concrete structure.

6.5 Identification of chloride attack may be conducted via a combination of visual characterization of the environment and the concrete element condition, as well as chemical and electrochemical testing of the environment and reinforced concrete materials.

7. REFERENCES

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-005, Personnel Qualifications.

7.1.3 FLD-DC-MS-001, Wet Coring of Concrete Decks.

7.1.4 FLD-DC-PH-002, Photographing for Documentation Purposes.

7.1.5 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.6 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*:

7.2.1 AASHTO T 260-97 (2011), Sampling and Testing for Chloride Ion in Concrete and Concrete Raw Materials, American Association of State Highway and Transportation Officials, Washington, DC, 2011.

NONDESTRUCTIVE EVALUATION PROTOCOLS (NDE)

FLD-DC-NDE-001, Electrical Resistivity Testing

FLD-DC-NDE-002, Ground Penetrating Radar Testing for Bridge Decks

FLD-DC-NDE-003, Half-Cell Potential Testing

FLD-DC-NDE-004, Impact Echo Testing

FLD-DC-NDE-005, Linear Polarization Resistance Testing

FLD-DC-NDE-006, Dye Penetrant Testing

FLD-DC-NDE-007, Ultrasonic Surface Wave Testing—Concrete

FLD-DC-NDE-008, Ultrasonic Testing—Steel Fatigue Cracking

Long-Term Bridge Performance Program

ELECTRICAL RESISTIVITY TESTING

LTBP Protocol #: FLD-DC-NDE-001

1. DATA COLLECTED

1.1 Indication of a concrete member's ability to support corrosion based on electrical resistivity (ER) testing.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment:*

2.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

2.1.2 Four-point Wenner Probe with 50 mm probe spacing, 40 Hz Frequency, and 1 percent to 5 percent resolution.

2.1.3 Electrical resistivity probe (a machined jig with either wooden dowels or foam contacts wetted with surfactant solution), configured to permit sufficient vertical movement of contact points to conform to irregular surfaces; some instruments may provide units of resistivity directly based on preset probe spacing.

2.1.4 Digital camera.

2.2 *Personnel:* PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Use the global rectangular grid (FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks) to locate test points on the deck.

3.2 Test preparation:

3.2.1 Determine if there are any electrical conduits in the structure producing an electromagnetic field that may affect the measurement stability.

3.2.2 Mark the position of the cable in the resistivity map as a sign of possible interference in its proximity.

3.2.3 Prewet the bridge deck (FLD-OP-SP-001, Site Preparation) until it is in a saturated-surface-dry (SSD) condition. The electrodes require ionic coupling to the concrete to measure resistivity, and uniformly prewetting the deck provides this water evenly, thereby removing variability induced by irregular weather and rainfall patterns. Supplemental wetting is necessary immediately before measuring, particularly when the weather is hot, windy, and/or the relative humidity is low. For both prewetting and supplemental wetting, it is important that no surface water or visible film is present during measurements.

3.3 Measurements:

3.3.1 Place the four wetted probe points of the Wenner array in contact with the concrete surface, and apply current (if required by the particular instrument) between the two outer electrodes.

To ensure a minimal effect of the reinforcing steel, the probe spacing of the Wenner probe must be less than the depth of the concrete cover over the reinforcing steel. Where practical, avoid placing probe points on individual, exposed aggregate particles that may inordinately influence the reading.

3.3.2 Apply consistent and even pressure to the probe points, because variable contact pressure will influence the readings.

3.3.3 Read and record the indicated resistance or resistivity.

3.3.4 Monitor each point for at least 3 seconds before recording to ensure the reading is stable (not increasing). If readings are not stable, it may indicate inadequate moisture or interference by an external electrical source. To remedy this situation, remove the probe from the test point, rewet the probe, and then retake the measurement. If that does not work, pour more water on the deck surface, and repeat the test at the test point when it reaches an saturated-surface-dry (SSD) state.

3.3.5 For comparison with other complementary nondestructive evaluation (NDE) test data at selected point locations, take additional detailed measurements. To ensure repeatability of the localized measurements, repeat the readings five times at each location. For each measurement, remove the probe from the test point, rewet it, and place it again on the test point. Take extra care to ensure the proper contact between probes and deck surface.

3.4 Traffic in the lanes outside of the work zone is permissible during data collection and does not affect data quality.

3.5 Storing data, documents, and images:

3.5.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.5.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.6 Reporting: Transfer all metadata, data, documents, and images to Federal Highway Administration (FHWA), and/or upload all metadata, data, documents, and images into the Long-Term Bridge Performance (LTBP) Bridge Portal.

4. DATA COLLECTION TABLE

4.1 Table:

#	FIELD NAME	DATA TYPE	ACCURACY	UNIT	FIELD DESCRIPTION	ROW COLOR
1	State	Text			State Code; e.g., Virginia = VA	Green
2	NBI structure number	Text			Item 8, structure number; from NBI Coding Guide	Green
3	Structure name	Text			Descriptive name for the bridge; e.g., Route 15 SB over I–66	Green
4	Protocol name	Text			Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May	Green

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
					2015	
6	Personnel performing data collection activities	Text			First name(s) Last name(s)	Green
7	Date data was collected	Text	Exact date		mm/dd/yyyy	Green
8	Ambient air temperature	Number	1	ºF	Range: -50 to 150	Green
9	Deck surface temperature	Number	1	ºF	Range: -50 to 150	Green
10	Equipment name	Text				Green
11	Equipment manufacturer	Text				Green
12	Equipment model name and number	Text			If available	Green
13	Comments (equipment)	Text	Unlimited			Orange
14	Test site	Text			Describe the location of data collection on the bridge (e.g., span number, lane number, right or left shoulder, substructure unit, etc.)	Blue
15	Location of test site (*x*-coordinate)	Number	1	ft	Longitudinal distance from the local grid origin	Blue
16	Location of test site (*y*-coordinate)	Number	1	ft	Transverse distance from the local grid origin	Blue
17	Electrical resistivity reading	Number	1	$k\Omega/m^3$	Range: 0 to 200	Yellow
18	Comments	Text				Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. Criteria for Data Validation

5.1 Verification and comparison should be made with results obtained from the same concrete member using other NDE methods, including acoustic methods, chemical/potential methods, and electromagnetic methods.

5.2 If half-cell potential results are available, compare results from the current test to the half-cell potential results.

6. COMMENTARY/BACKGROUND

6.1 The purpose of this protocol is to provide a standard procedure for determining electrical resistivity of the concrete in a reinforced concrete member. ER is one measure of a concrete member's ability to protect reinforcing steel from corrosion. Low ER is indicative of an environment that will support corrosion but does not indicate that corrosion is ongoing.

6.2 Applied on a broad scale, ER provides spatial variability of resistivity for the tested concrete member; applied at finite locations, it can be compared to corrosion measures, such as half-cell, linear polarization, and chloride profiles.

6.3 Electrical resistivity surveys are used to map corrosion activity in tandem with another corrosion technique, like half-cell potential (FLD-DC-NDE-003, Half-Cell Potential Testing). Concrete with a high ER has a greater resistance to the corrosion current passing between anodic and cathodic areas of the reinforcing steel. In contrast, damaged and cracked areas with increased porosity create preferential paths for fluid and ion flow and have low resistivity. There is a relationship between electrical resistivity and corrosion rate for steel in concrete. Resistivity of less than 1.97 kΩ/inch supports very rapid corrosion of steel, whereas resistivity greater than 7.88 kΩ/inch supports very low corrosion rate.

6.4 A common device to measure electrical resistivity is the Wenner array. The Wenner array uses four probes arranged linearly with equal spacing. Current is applied between the outer electrodes and the resulting potential is measured between the two inner electrodes. The resistivity is calculated as $\rho=2\pi aV/I$, where "a" is the probe spacing, "V" is the voltage, and "I" is the current.

6.5 Any steel located in the concrete being measured can affect electrical resistivity. To decrease the effect, measure the resistivity on a set grid over the whole deck so that any influence from steel is statistically removed due to sampling.

6.6 Overlays can affect the ability to take ER measurements. If the overlay is highly resistive, like epoxy or asphalt, ER measurements will be extremely high and will only be an indication of the overlay's resistivity. These measurements will give no indication of the concrete member's environment regarding corrosion. If the overlay is a concrete overlay that has similar electrical properties to the concrete substrate, resistivity measurements can be conducted without any issue. However, during interpretation of the results, it is important to know that the resistivity values measured will be a combination of the overlay and the concrete below.

7. REFERENCES

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-005, Personnel Qualifications.

7.1.3 FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks.

7.1.4 FLD-DC-NDE-003, Half-Cell Potential Testing.

7.1.5 FLD-DC-PH-002, Photographing for Documentation Purposes.

7.1.6 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.7 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*: None.

GROUND PENETRATING RADAR TESTING FOR BRIDGE DECKS

LTBP Protocol #: FLD-DC-NDE-002

1. DATA COLLECTED

1.1 Characterization of broad scale concrete deterioration based on ground penetrating radar (GPR) signal attenuation.

1.2 Estimate of broad scale concrete cover (rebar depth) or deck thickness, overlay thickness, etc.

1.3 Localized mapping or locating of rebars, posttensioning, conduits, etc.; verification of reinforcement layout shown on drawings and plans.

1.4 Detection and localization of voids, rock pockets, or honeycombs.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

2.1.2 Ground-coupled GPR instruments, consisting of portable, single channel digital data acquisition systems with a dynamic range of 60 dB or greater and 16-bit data acquisition or greater. GPR scanning (1.0 to 2.5GHz) must occur with a minimum spatial sampling of 60 scans per foot using a distance measuring instrument (DMI). Systems must maintain a stable, steady-state signal and must collect at least 512 samples per scan at scan rates of 120 scans per second or greater. GPR Ground penetrating radar systems must be able to store at least 2 GB of data on a hard drive or flash drive and be capable of rapidly transferring data via Universal Serial Bus (USB), ethernet, or other backup media to a computer for storage, processing, and interpretation.

NOTE—Though multichannel GPR arrays, dual-polarization antennas (sensors), air-coupled (horn) antenna GPR systems, etc., can be used for bridge deck condition assessment, most systems in use are single-channel, ground-coupled GPR instruments. This protocol applies only to ground-coupled systems used in the Long-Term Bridge Performance (LTBP) Program because of accuracy, portability, and ease of use.

2.1.3 Vehicle or cart; speed is dependent on the system used, the scan rate and signal quality, and the spatial sampling along the GPR profile line (path). Normally, walking speed with a cart is sufficient for high-resolution data using 1.0 to 2.5 GHz ground-coupled antennas. For other systems, refer to the manufacturer’s operations manual.

2.1.4 Digital camera.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Use the GPR equipment's manufacturer procedures with the following protocol steps to ensure proper equipment settings and data collection procedures.

3.2 Use the grid described in FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks, to provide lines along which to collect GPR data.

3.3 Collect GPR data along lines perpendicular to the orientation of the upper rebar mat.

3.4 Record the GPR signal (A-scan), including the entire surface reflection (combination of surface reflection and internal, direct coupling) and the "flat-line" (no amplitude/noise only) data immediately above the surface reflection. This ensures that all data from the deck are captured.

3.5 Conduct a preliminary scan of at least three 50-ft lines on the bridge deck surface with the A-scan visible at all times in order to set up the GPR signal properly. Doing this ensures that the GPR signal does not "clip" (saturate measurement window width) during data collection and storage. The preliminary scan will find locations of strong signal reflection from the top rebar mat. Then, set the gain for the GPR signal waveform at the location with the strongest rebar reflection so that the resulting signal does not exceed two-thirds to three-quarters of the measurement window width.

3.6 Keep the gain constant while scanning the entire bridge deck. Avoid automatic gain settings except during initial GPR calibration and for fine tuning after the system is first turned on.

3.7 Most bridge decks can be scanned using the same settings, except for signal gain and position, which are often site specific. When returning to any bridge for successive, periodic tests, use the same system settings, such as gains, filters, samples/scan, scan rate, spatial scan density. The following minimum settings for GPR data collection are applicable for most reinforced concrete bridge decks and other reinforced concrete structures:

3.7.1 512 samples per scan.

3.7.2 12 ns signal duration.

3.7.3 16-bit data.

3.7.4 Appropriate vertical filter settings for the antenna frequency used.

3.8 Correct position of the signal guarantees appropriate sampling of the entire deck without cutting out the upper surface or amplifying noise and misinterpreting it as data. To set the signal gain and position, the following procedures must be performed:

3.8.1 Since the GPR records waveforms of 10 to 20 ns, representing the entire bridge deck thickness, the signal must be positioned after the waveform is recorded on oscilloscopes.

3.8.2 Locate the first arrival (transmit–receive pulse).

3.8.3 Place the antenna on the ground, and identify the surface reflection. The surface reflection is a merger of the transmit–receive reflection generated internally within the antenna and the reflection of the GPR waveform from the surface of the deck.

3.8.4 Move surface reflection at the beginning of the sample window of interest.

The sample window (10 to 20 ns, two-way travel time) is used to measure GPR reflection energy throughout the GPR survey. Reflections from internal, embedded elements, such as rebars, conduits, cables, deck bottom, overlays, etc., are captured, stored, then ultimately analyzed and interpreted prior to mapping results.

3.9 Traffic in the lanes outside of the work zone is permissible during GPR data collection and does not affect data quality. Take extra safety precautions and coordinate with the traffic control crew when GPR lines are oriented across traffic lanes, even if only the closed lane(s) are accessed by the GPR operator. In such a field operation, the front end of the equipment/cart must temporarily penetrate beyond the lane closure (while no traffic is oncoming). This ensures that a complete dataset is obtained when the partial GPR lines are "stitched together" during processing.

3.10 Storing data, documents, and images:

3.10.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.10.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.11 Reporting: Transfer all metadata, data, documents, and images to Federal Highway Administration (FHWA), and/or upload all metadata, data, documents, and images into the LTBP Bridge Portal.

4. DATA COLLECTION TABLE

4.1 Table:

#	FIELD NAME	DATA TYPE	ACCURACY	UNIT	FIELD DESCRIPTION	ROW COLOR
1	State	Text	Text		State Code, e.g., Virginia = VA	Green
2	NBI structure number	Text	Text		Item 8, Structure Number from NBI Coding Guide	Green
3	Structure name	Text	Text		Descriptive name for the bridge, e.g., Route 15 SB over I–66	Green
4	Protocol name	Text	Text		Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text	Text		First name(s) Last name(s)	Green
7	Date data was collected	Text	Exact date		mm/dd/yyyy	Green
8	Ambient air temperature	Number	1	ºF	Numeric means negative and positive integers, range: -50 to 150	Green
9	Deck surface temperature	Number	1	ºF	Numeric means negative and positive integers, range: -50 to 150	Green
10	Equipment name	Text	Text			Green
11	Equipment manufacturer	Text	Text			Green
12	Equipment model name and number	Text	Text		If available	Green
13	Data acquisition system model	Text				Green
14	Comments (equipment)	Text	Unlimited			Orange
15	Testing site	Text			Location and date of the test on the bridge (e.g., shoulder	Blue

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
					and lane 1)	
16	Pulse length	Number		ns		Blue
17	Center frequency	Number		MHz		Blue
18	Bandwidth	Number		MHz		Blue
19	Stress S1	Number				Blue
20	Stress S2	Number				Blue
21	Longitudinal strain, Ɛ2	Number				Blue
22	Transverse strain, Ɛt1	Number				Blue
23	Transverse strain, Ɛt2	Number				Blue
24	Antenna model	Text				Blue
25	Gain	Number				Blue
26	Range	Number				Blue
27	Longitudinal rebar	Yes/No				Blue
28	Pulse repetition rate	Number				Blue
29	Samples/scan	Number				Blue
30	Scans/second	Number				Blue
31	Scans/unit	Number				Blue
32	Vertical filters	Text				Blue
33	Horizontal filters	Text				Blue
34	Line location	Number	1	ft	Transversal distance from origin Range: 0 to 300	Yellow
35	Data collection direction	Predefined list			Transversal Longitudinal	Yellow
36	Data	BLOB				Yellow
37	ASCII file	CLOB			DZT or DT file	Yellow
38	Comments	Text	Unlimited			Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. Criteria for Data Validation

5.1 Verification and comparison should be made with results obtained using other NDE methods, including acoustic methods and chemical/potential methods, as well as with ground truth data.

6. COMMENTARY/BACKGROUND

6.1 The purpose of this protocol is to provide a standard procedure for using GPR to detect and characterize deterioration in bridge decks. GPR can also serve additional purposes, including the following:

6.1.1 Characterizing presence, pattern, depth, and density (layout) of structural steel reinforcement in the deck.

6.1.2 Estimating deck thickness.

6.1.3 Identifying anomalies or locating construction elements such as posttensioning conduits.

6.2 The principle of GPR is the reflection of electromagnetic waves from interfaces of two materials that differ in relative dielectric permittivity. Different reflectors within or on the boundary of a bridge deck, such as overlays, upper and lower reinforcement mats, deck bottom, etc., are identified in the time domain by viewing what is commonly referred to as a B-scan (line scan). The image is a recognizable representation of the cross-section of the deck proved by the moving GPR antenna. The vertical scale (two-way travel time) can be associated with a physical depth, and the horizontal scale (distance) is controlled by a distance measuring instrument (DMI) that fixes the scan density (scans per meter or scans per ft). Typical bridge deck surveys use antennae ranging in frequency between 1.0 GHz to 2.5 GHz, with those in the 1.5 GHz range most common. Testing equipment consists of a digital data acquisition unit that controls signal stability, filtering and scan rate; cabling; a DMI; and ground-coupled sensors in the frequency range specified. The equipment usually includes a deployment system (pushed or hand-towed cart, vehicle, etc.).

6.3 For the LTBP Program, GPR testing is done using ground-coupled, high-frequency instruments to ensure the most accurate results. GPR scan density for the LTBP Program is 60 scans per foot. This high spatial density aids not only during processing and interpretation but also in activities where raw data must be interpreted and used in the field; for example, to validate and update core locations.

7. REFERENCES

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-005, Personnel Qualifications.

7.1.3 FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks.

7.1.4 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.5 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*: None.

HALF-CELL POTENTIAL TESTING

LTBP Protocol #: FLD-DC-NDE-003

1. DATA COLLECTED

1.1 Potential for electrochemical corrosion of steel reinforcement in concrete.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

2.1.2 Concrete pachometer (cover meter).

2.1.3 Permanent marker.

2.1.4 Temporary chalk marker.

2.1.5 Power source.

2.1.6 Hammer drill.

2.1.7 Depth measuring instrument or drill stop with precision to one-quarter inch or less.

2.1.8 Stainless steel screw of appropriate length and diameter.

2.1.9 Drill bit of appropriate diameter for the stainless steel screw.

2.1.10 Concrete patching compound.

2.1.11 Half-cell electrode; copper–copper sulfate (Cu–$CuSO_4$) [units mV copper sulfate electrode (CSE)], silver–silver chloride (Ag–$AgCl_2$) [units mV AgCl], or other.

2.1.12 High-impedance portable voltmeter.

2.1.13 Low-resistance lead wire with electrical clamps or plugs.

2.1.14 Open-celled sponges.

2.1.15 Surfactant (soap) solution.

2.1.16 Cu–$CuSO_4$ CSE reference electrode.

2.1.17 Ag–$AgCl_2$ reference electrode.

2.1.18 Digital camera.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 For concrete decks, identify the location and position of the test points using the local rectangular coordinate system (FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks). For other concrete elements, identify the location and position of the test points using the structure segmentation and element numbering system (FLD-OP-SC-002, Structure Segmentation and Element Identification System).

3.2 Test Preparation:

3.2.1 The half-cell potential test requires a direct connection to the reinforcing steel.

3.2.1.1 Select a location in the shoulder area and use the pachometer (cover meter) to identify the location and measure the depth to the upper mat of reinforcing steel. Record the depth of the reinforcement detected. Mark the intersection of the longitudinal and transverse steel of the upper mat with the temporary chalk marker.

3.2.1.2 Using the hammer drill, remove concrete down to the level of the upper mat of the reinforcing steel.

3.2.1.3 Drill a pilot hole into the reinforcing bar and screw in the stainless steel screw.

3.2.2 Ensure the bridge deck is in a saturated-surface-dry condition (PRE-OP-SP-001, Site Preparation).

3.2.3 Apply water to the testing points immediately before surveying.

3.3 Measurements:

3.3.1 Connect the positive terminal of the high-impedance portable voltmeter to the stainless steel screw using the low-resistance lead wire with electrical clamps.

3.3.2 Place the half-cell in contact with a wetted sponge on the concrete surface, then read and record (automatically if so equipped) the indicated potential.

3.3.3 Apply consistent pressure to the half-cell as variability in contact pressure may influence the readings.

3.3.4 Do not place the half-cell on individual exposed aggregate particles or other obstructions (e.g., asphalt or coating splotches) that may inordinately influence the reading.

3.3.5 Monitor each point for at least 3 seconds before recording to ensure the reading is stable (not increasing). A variation of no more than +/- 5 mV per minute is necessary. If readings are not stable, this may indicate inadequate moisture or interference by an external electrical source, which should be evaluated and rectified before proceeding.

3.3.6 In reinforced concrete, half-cell potential values for mild steel reinforcement commonly range from +50 to -600 mV CSE. Zinc and zinc coatings, as found on galvanized steel or in galvanic anodes for corrosion protection, will indicate more negative potentials in many cases. Regions where lack of oxygen restricts the cathode reaction to support corrosion may also produce unusually negative half-cell potential values. For valid interpretation, convert values for half-cell types other than $Cu–CuSO_4$.

3.3.7 If using a rolling wheel half-cell, the half-cell potential wheel must be rolled back and forth at least 3 inches to find the smallest negative number around each point (this generally corresponds to the location closest to the steel reinforcement).

3.3.8 For comparison to other complementary test data at selected point locations, take additional detailed measurements. Take extra care to ensure proper probe contact and avoid exposed aggregate particles or other obstacles that may influence current flow. Select locations based on other survey data, including broad scale half-cell and resistivity mapping, as well as visual damage survey (for example, at locations showing delaminations, spalls, and repairs). Site restoration: When the half-cell potential testing is complete, fill in the hole flush with the surface of the surrounding area of the deck with a suitable concrete patching compound (approved by the bridge owner).

3.4 Storing data, documents, and images:

3.4.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.4.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.5 Reporting: Transfer all metadata, data, documents, and images to Federal Highway Administration (FHWA), and/or upload all metadata, data, documents, and images into the Long-Term Bridge Performance (LTBP) Bridge Portal.

4. DATA COLLECTION TABLE

4.1 Table:

#	FIELD NAME	DATA TYPE	ACCURACY	UNIT	FIELD DESCRIPTION	ROW COLOR
1	State	Text			State Code; e.g., Virginia = VA	Green
2	NBI structure number	Text			Item 8, structure number; from NBI Coding Guide	Green
3	Structure name	Text			Descriptive name for the bridge; e.g., Route 15 SB over I–66	Green
4	Protocol name	Text			Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text			First name(s) Last name(s)	Green
7	Date data were collected	Text	Exact date		mm/dd/yyyy	Green
8	Ambient air temperature	Number	1	ºF	Range: -50 to 150	Green
9	Deck surface temperature	Number	1	ºF	Range: -50 to 150	Green
10	Equipment name	Text				Green
11	Equipment manufacturer	Text				Green
12	Equipment model name and number	Text			If available	Green
13	Comments (equipment)	Text				Orange
14	Location of electrical connection to the reinforcing steel	Text			Descriptive location of the connection screw on the bridge (e.g., left shoulder 30 feet from joint 1 and 3 feet from the edge of the lane.)	Green
15	Location of connection screw (*x*-coordinate)	Number	1	ft	Longitudinal distance from the local grid origin	Green
16	Location of connection screw (*y*-coordinate)	Number	1	ft	Transverse distance from the local grid origin	Green
17	Test site	Text			Descriptive location of the test on the bridge (e.g., shoulder and lane 1)	Blue
18	Location of test site (*x*-coordinate)	Number	1	ft	Longitudinal distance from the local grid origin	Blue
19	Location of test site (*y*-coordinate)	Number	1	ft	Transverse distance from the local grid origin	Blue
20	Half-cell potential (HCP) reading	Number	1	mV	Range: -999 to 99	Yellow
21	Comments	Text				Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. CRITERIA FOR DATA VALIDATION

5.1 Verification and comparison should be made with results obtained from other NDE methods including chemical/potential methods, acoustic methods, and electromagnetic methods.

6. COMMENTARY/BACKGROUND

6.1 The purpose of this protocol is to provide a standard procedure for using half-cell potential measurements to assess the probability of active steel corrosion in a reinforced concrete member.

6.2 Traffic in the lanes outside of the work zone is permissible during data collection.

6.3 The stainless steel screw should be of a length that when firmly connected to the reinforcing bar, the head of the screw protrudes about 0.5 inches above the top of the core hole. Thus, after the core hole is patched, the stainless steel screw will be available for future half-cell potential testing and a positive connection to the screw will be possible.

6.4 The half-cell potential test measures the electrical potential between the embedded steel reinforcement in the concrete and a reference electrode, typically a copper electrode in a copper sulfate solution, electrically coupled to the concrete surface. The electrical potential is measured as a voltage using a high-impedance voltmeter. The reference electrode is connected to the negative terminal of the voltmeter and a direct connection to the steel reinforcement is connected to the positive terminal. The reference electrode is typically coupled to the concrete surface using a porous ceramic plug and an open-celled sponge wetted with surfactant solution. Measurements are taken at point locations by moving the electrode from one point to another on a grid on the concrete.

6.5 Regions with a significantly lower negative potential compared to surrounding areas indicate a 90 percent probability of corrosion. ASTM C876 gives guidelines for evaluating active corrosion probability in concrete structures containing uncoated mild steel reinforcement.

6.6 HCP measurements do not give quantitative information about the rate of corrosion. The potential is influenced by cover depth, permeability and moisture content of concrete, and, therefore, a combination of HCP and resistivity measurements may help interpret the collected data. Coatings on concrete (isolating layers, asphalt, and paint) or reinforcement may influence or nullify HCP measurements.

7. REFERENCES

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-005, Personnel Qualifications.

7.1.3 FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks.

7.1.4 FLD-OP-SC-002, Structure Segmentation and Element Identification System.

7.1.5 PRE-OP-SP-001, Site Preparation.

7.1.6 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.7 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*:

7.2.1 ASTM C876-09, Standard Test Method for Corrosion Potentials of Uncoated Reinforcing Steel in Concrete, ASTM International, West Conshohocken, PA, 2009.

IMPACT ECHO TESTING

LTBP Protocol #: FLD-DC-NDE-004

1. DATA COLLECTED

1.1 Evidence of concrete delamination and other defects such as overlay debonding.

1.2 Detection of anomalies such as material variation, flaws, and vertical cracks.

1.3 Condition evaluation of grouted ducts.

1.4 Actual deck slab thickness.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

2.1.2 Impact echo (IE) equipment/device; either of the following are acceptable:

2.1.2.1 Cart-mounted and semiautomated to control data collection line length and spatial location on deck, spacing between individual test measurements, triggering impact/source deployment, ease of use, etc.

2.1.2.2 Hand deployed and triggered manually at each test point location.

2.1.3 Data acquisition controller and software capable of sampling and recording at a minimum rate of 50 kHz.

2.1.4 Data controller/storage device: laptop or data logger.

2.1.5 Data conditioning and analysis software capable of filtering, clipping, segmenting, and discarding noise and waveforms unrelated to the IE data.

2.1.6 Impact source capable of generating and a receiver capable of recording signals, with an acceptable signal to noise ratio that exists in a range of at least 2 to 25 kHz.

2.1.7 Digital camera.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Use the local rectangular grid (FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks) to locate test points on the deck.

3.2 Test Preparation: Clear any debris from the deck surface.

3.3 Measurements:

3.3.1 Collect data along any test line, as long as the location of every IE reading is properly recorded.

3.3.2 Place the impact device and sensor in direct contact with the sampled concrete surface.

3.3.3 Avoid hitting or resting on exposed aggregate, edges, or depressions within surface voids. Otherwise, erroneous signals may be generated, collected, and stored.

3.3.4 Conduct IE testing on concrete decks with hot-mix asphalt or similar overlays with the overlay surface temperatures lower than 50 °F. Results depend on the temperature at the time of testing and should be corrected based on a reference temperature.

3.3.5 During field operations, take care that the collected data in the time and frequency domains are consistent with expected signals from the structure being surveyed. For instance, it is expected that a frequency corresponding to the deck thickness dominates the frequency response of an intact portion of a deck. Other dominant frequency responses include very low resonant frequencies consistent with flexural oscillations, corresponding to shallow delaminations—those which should be audible during hammer sounding or the chain drag test. Also, there should be high-frequency resonant responses from deeper, less extensive delaminations or from incipient delaminations, either of which fully or partially blocks incident waveforms from reaching the bottom of the deck. Equipment must guarantee visualization of time histories for each collected signal, as well as frequency response and/or B-scan display obtained from a continuous set of measurements along a test line.

NOTE—There should be no chain drag, hammer sounding, coring, impact or hammer drilling, or similar operations producing high-frequency vibration (such as operation of an electric generator) in the proximity (within 100 ft) of the IE equipment. Operation of such equipment may produce frequency responses within the range of interest, which decrease the signal-to-noise ratio and makes it either difficult or impossible to collect and interpret data.

3.4 Traffic in the lanes outside of the work zone is permissible during the data collection.

3.5 Final forms for collected data include time histories and frequency response of measured raw data at all *x* and *y* test locations from gridded deck. Processed data consists of condition grading based on resonant frequency response of IE data (grades 1 to 4), also on *x*-*y* coordinate system.

3.6 Storing data, documents, and images:

3.6.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.6.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.7 Reporting: Transfer all metadata, data, documents, and images to Federal Highway Administration (FHWA), and/or upload all metadata, data, documents, and images into the Long-Term Bridge Performance (LTBP) Bridge Portal.

4. DATA COLLECTION TABLE

4.1 Table:

#	FIELD NAME	DATA TYPE	ACCURACY	UNIT	FIELD DESCRIPTION	ROW COLOR
1	State	Text			State Code; e.g., Virginia = VA	Green
2	NBI structure number	Text			Item 8, structure number; from NBI Coding Guide	Green

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
3	Structure name	Text			Descriptive name for the bridge; e.g., Route 15 SB over I–66	Green
4	Protocol name	Text			Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text			First name(s) Last name(s)	Green
7	Date data were collected	Text	Exact date		mm/dd/yyyy	Green
8	Ambient air temperature	Number	1	°F	Range: -50 to 150	Green
9	Deck surface temperature	Number	1	°F	Range: -50 to 150	Green
10	Equipment name	Text				Green
11	Equipment manufacturer	Text				Green
12	Equipment model name and number	Text			If available	Green
13	Comments (equipment)	Text				Orange
14	Overlay material	Text				Green
15	Overlay thickness	Number	0.5	in.		Green
16	Bridge deck thickness	Number	0.5	in.		Green
17	Source type	Text				Green
18	Sensor type	Text				Green
19	Source sensor spacing	Number	0.1	in.		Green
20	Pulse period	Number	0.1	µs		Green
21	Pulse length	Number	1	µs		Green
22	Sampling rate	Number	1			Green
23	Samples per scan	Number	1			Green
24	Number of pretrigger samples	Number	1			Green
25	Span	Text				Blue
26	Test site	Text			Descriptive location of the test on the bridge (e.g., shoulder and lane 1)	Blue
27	Location of test site (*x*-coordinate)	Number	1	ft	Longitudinal distance from the local grid origin	Blue
28	Location of test site (*y*-coordinate)	Number	1	ft	Transverse distance from the local grid origin	Blue
29	Voltage array	Array of numbers	0.000000001	V	Voltage array (time history) data for the point The number of elements are the same as samples per scan (item 23) and can be different numbers for each element Range: -1 to +1	Yellow
30	Comments	Text				Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
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Green	Data items only entered once for each protocol for each day the protocol is applied
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Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. Criteria for Data Validation

5.1 Verification and comparison should be made with results obtained from other NDE methods, including sounding methods, such as chain drag (FLD-DC-VIC-003, Chain Drag); acoustic methods; electromagnetic methods; as well as with ground truth data.

6. Commentary/Background

6.1 The purpose of this protocol is to provide a standard procedure for using IE testing to estimate deck thickness and detect and characterize the presence of delamination in bridge decks or other reinforced concrete elements. IE can serve additional purposes, such as for material evaluation, vertical crack characterization, detection of anomalies, concrete overlay debonding, etc.

6.2 IE is based on the reflection of elastic (compressive) waves from interfaces of two materials that have significant contrast in acoustic impedances. Different reflectors, such as the surface of the deck bottom delaminations, deck bottom, cavities, ducts, etc., are delineated with different dominant frequency peaks in the recorded response spectrum. The frequency range of interest in the testing of bridge decks and concrete elements is between 2 and 25 kHz. The testing equipment consists of an impact source and a receiver (displacement or velocity transducer, or accelerometer).

6.3 The test is also described in ASTM C1383-04 (2010), "Standard Test Method for Measuring the P-Wave Speed and the Thickness of Concrete Plates Using the Impact-Echo Method."

7. References

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-005, Personnel Qualifications.

7.1.3 FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks.

7.1.4 FLD-DC-VIC-003, Chain Drag.

7.1.5 FLD-DC-PH-002, Photographing for Documentation Purposes.

7.1.6 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.7 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*:

7.2.1 ASTM C 1383-04(2010), Standard Test Method for Measuring the P-Wave Speed and the Thickness of Concrete Plates Using the Impact-Echo Method, ASTM International, West Conshohocken, PA, 2010.

LINEAR POLARIZATION RESISTANCE TESTING

LTBP Protocol #: FLD-DC-NDE-005

1. DATA COLLECTED

1.1 Rate of corrosion of reinforcement in concrete.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS:

2.1 *Equipment*:

2.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

2.1.2 Linear polarization resistance (LPR) measurement system (manual or computer-operated potentiostat), including reference (half-cell) and counter electrode in portable probe configuration.

2.1.3 Low-resistance electrical leads with connectors.

2.1.4 Surfactant solution.

2.1.5 Digital camera.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Test preparation:

3.1.1 LPR testing is conducted at identified point locations, and the data can be used to correlate with indications of the presence and rate of corrosion from other test methods, such as resistivity and chloride profiles. Select locations based on other survey data, including half-cell and resistivity mapping, as well as visual damage survey (delaminations, spalls, and repairs).

3.1.2 Use the local rectangular grid (FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks) to locate and document test points on the deck.

3.1.3 Ensure the bridge deck is in a saturated-surface-dry condition (PRE-OP-SP-001, Site Preparation).

3.2 Establishing electrical continuity:

3.2.1 Provide positive electrical contact to the steel reinforcement to ensure electrical continuity between the electrical contact (tap) point and the reinforcement in the concrete surveyed section. This can be accomplished by providing multiple contact points at geometrically distributed points along the element being investigated.

3.2.2 Depending upon reinforcement distribution, electrical continuity may not be expected over joints between spans, precast or cast-in-place (CIP) segments, and between structural components not cast monolithically. Carefully review structural and as-built drawings to determine the number and location of contact points to service the surveyed section.

3.2.3 Using a high-impedance multimeter, measure the electrical resistance between the distributed points.

3.2.4 Note that nonmetallic coatings, such as epoxy on concrete surfaces or reinforcement, asphalt, or polymer membranes may be electrical insulators and should be evaluated before proceeding with LPR measurements. Some organic coatings have been noted to uptake moisture over several years of service and may no longer preclude the flow of current, permitting measurements to be taken. However, interpretation may not be straightforward, since the area of bar polarized may be called into question. Results of tests on coated reinforcement should be taken in context with other measurements.

3.2.5 If direct resistance between distributed contact points (after subtracting the lead-wire resistance) is only a few ohms and stable, then adequate conductivity should exist for LPR measurements.

3.3 Placing the probe:

3.3.1 Placing the half-cell/counter electrode assembly (probe) in contact with the concrete surface immediately over a reinforcing steel bar to which electrical continuity has been established. Avoid placing the probe on nonconductive obstructions (e.g., asphalt or coating splotches) that may influence the reading.

3.3.2 Prior to executing a polarization test, if possible, observe the open circuit potential with the test instrument to ensure that readings are stable. The test should not be run if open circuit potential values drift more than 5 mV/min.

3.3.2.1 If potential moves steadily in one direction, consider whether the concrete is adequately saturated or if there is an external source of electrical current that is affecting the reinforcement.

3.3.2.2 If potential values jump erratically, this generally indicates an incomplete circuit; items to check include electrical connections, seating of the probe and reference cells, and electrical continuity of reinforcement between tap site and test location.

3.3.2.3 Values of open circuit potential should be similar to those observed in measurement of half-cell potential at the same location, though the magnitude of reading may differ if a different type of reference electrode is used (for example copper–copper sulfate ($Cu–CuSO_4$) versus silver–silver chloride (Ag-AgCl)).

3.4 Manual testing: For the manual three-electrode polarization resistance (3LP) system, collect readings, and polarize the reinforcement through hand-driven operations:

3.4.1 Monitor the electrical potential until stable. Stability corresponds to variations smaller than +/-5 mV per minute. Once stable potential is established and recorded, the system is ready to report relative potential versus the open-circuit potential (OCP).

NOTE—If readings are not stable, it may indicate an incomplete electrochemical circuit due to loose connections, inadequate moisture content, or interference by an external electrical source. Check connections, eliminate extraneous sources of electrical fields, and establish adequate moisture content.

3.4.2 Zero the meter by engaging the offset switch and turning the knob until potential value reads 0 mV.

3.4.3 Apply electrical current to polarize the reinforcement at a slow, steady rate in increments until the offset potential reaches +4, +8, and +12 mV from OCP. Record the current required to achieve the offset at the precise moment each noted increment is reached. The complete polarization procedure should take no longer than 2 minutes.

3.4.4 Once complete, remove the current by rapidly turning the current knob back to zero and allow the reinforcement to depolarize. Continue to monitor the potential.

3.4.5 Within 3 minutes, the potential should return to the original OCP (or “0” if offset is still engaged). If it does not, retake the measurement because the associated “drift” in OCP will influence the estimated corrosion rate. A period of 10 minutes must elapse before repeating the readings to ensure adequate depolarization.

3.5 Automated testing: Some field instruments and laboratory potentiostats can be programmed to perform the polarization process automatically:

3.5.1 If possible, program the system to monitor and collect the OCP by recording potential at 1-second intervals for at least 1 minute before and after the test.

3.5.2 Program automated systems to conduct a potentiostatic linear polarization resistance procedure, which induces a current from the counter electrode that causes the electrical potential of the reinforcement to shift from the OCP (i.e., polarize) by at least +12 mV and no more than +20 mV, at a rate of 10 mV per minute.

3.5.3 Some devices are equipped with a “guard ring” electrode that induces a separate current into an electrode that surrounds and attempts to contain the primary counter electrode current into a specified polarization area. Such instruments are known to give significantly different corrosion rate values than the methods outlined above and are believed to underestimate the actual corrosion rate. Therefore, if used for the purposes of this program, such test devices must be operated with the guard ring electrode disabled.

3.6 Storing data, documents, and images:

3.6.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.6.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.7 Reporting: Transfer all metadata, data, documents, and images to Federal Highway Administration (FHWA), and/or upload all metadata, data, documents, and images into the Long-Term Bridge Performance (LTBP) Bridge Portal.

4. DATA COLLECTION TABLE

4.1 Table:

#	FIELD NAME	DATA TYPE	ACCURACY	UNIT	FIELD DESCRIPTION	ROW COLOR
1	State	Text			State Code, e.g., Virginia = VA	Green
2	NBI structure number	Text			Item 8, structure number, from NBI Coding Guide	Green
3	Structure name	Text			Descriptive name for the bridge, e.g., Route 15 SB over I–66	Green
4	Protocol name	Text			Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text			First name(s) Last name(s)	Green

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
7	Date data were collected	Text	Exact date		mm/dd/yyyy	Green
8	Ambient air temperature	Number	1	°F	Numeric means negative and positive integers, range: -50 to 150	Green
9	Deck surface temperature	Number	1	°F	Numeric means negative and positive integers, range: -50 to 150	Green
10	Equipment name	Text				Green
11	Equipment manufacturer	Text				Green
12	Equipment model name and number	Text			If available	Green
13	Comments (equipment)	Text	Unlimited			Orange
14	Reinforcement locating equipment name	Text				Green
15	Reinforcement locating equipment manufacturer	Text				Green
16	Comments (reinforcement locating equipment)	Text	Unlimited			Orange
17	Test site	Text			Location of the test on the bridge (e.g., shoulder and lane 1)	Blue
18	Location of test site (*x*-coordinate)	Number	1	ft	Longitudinal distance from the local grid origin	Blue
19	Location of test site (*y*-coordinate)	Number	1	ft	Transverse distance from the local grid origin	Blue
20	OCP (before test)	Number	1	mV		Yellow
21	Applied current readings	Number	0.0001	mA		Yellow
22	Corresponding potential	Number	1	mV		Yellow
23	Length of probe	Number	0.1	in.		Yellow
24	Reinforcement size	List			#3, #4, #5, #6, #7, #8, #9	Yellow
25	Range of polarization (offset) vs. OCP	Number	1	mV		Yellow
26	Scan rate	Number	0.1	mV/sec		Yellow
27	Depolarization OCP	Number	1	mV		Yellow
28	Polarized bar surface	Number	0.01	$in.^2$		Yellow
29	Corrosion current density (i_{corr})	Number	0.01	mA/ft^2		Yellow
30	OCP (after test)	Number	1	mV		Yellow
31	Metal loss	Number	0.000001	in./yr		Yellow
32	Comments	Text	Unlimited			Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. Criteria for Data Validation

5.1 Linear polarization resistance at any given location should correlate to measurements taken with the simpler half-cell potential test protocol (FLD-DC-NDE-003, Half-Cell Potential Testing). Corrosion rates can be calculated as corrosion current density, as total current is applied over the length and surface area of a reinforcement bar immediately below the probe, and translated into estimated metal loss using Faraday's Law. Measurements of 0.1 $\mu A/cm^2$ or less indicate negligible corrosion rate, whereas measurements greater than 5 $\mu A/cm^2$ indicate very rapid corrosion.

6. Commentary/Background

6.1 The purpose of this protocol is to provide a standard procedure for using linear polarization resistance measurements for evaluating the instantaneous corrosion rate, as compared to other methods on which metal loss is measured over a finite period of time.

6.2 The LPR technique is rapid and relatively nonintrusive; it requires only localized damage to the concrete cover to enable an electrical connection to be made to the reinforcing steel. Monitoring the relationship between electrochemical potential and the current generated between electrically charged electrodes allows the estimation of the corrosion rate. The data provide the instantaneous corrosion rate of the steel reinforcement at the test location, giving more detailed information than a simple half-cell potential (HCP) measurement.

6.3 Reinforcement corrosion is mainly due to chloride ingress, causing depassivation and leading to corrosion when oxygen and moisture are present in the steel-concrete interface. Acid attack and carbonation could also provoke corrosion.

6.4 This technique is used for estimating corrosion rates and is sensitive to very low corrosion rates; a rate of less than 0.1 millionths of an inch per year (mpy) can be detected.

6.5 Periodic monitoring allows onset of corrosion and subsequent rate of corrosion to be evaluated.

7. References

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-005, Personnel Qualifications.

7.1.3 PRE-OP-SP-001, Site Preparation.

7.1.4 FLD-DC-NDE-003, Half-Cell Potential Testing.

7.1.5 FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks.

7.1.6 FLD-DC-PH-002, Photographing for Documentation Purposes.

7.1.7 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.8 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*: None.

DYE PENETRANT TESTING

LTBP Protocol #: FLD-DC-NDE-006

1. DATA COLLECTED

1.1 Crack detail in steel bridge members.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

2.1.2 Liquid penetrant examination set.

2.1.3 Tape measure.

2.1.4 Temporary marker.

2.1.5 Digital camera.

2.1.6 Pencil, sketch, and clipboard.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Establishing a local origin:

3.1.1 Use the segmentation and numbering system (FLD-OP-SC-002, Structure Segmentation and Element Identification System) so defects can be located and noted by a unique element identifier.

3.1.1.1 Use FLD-OP-SC-003, Determination of Local Origins for Elements, to establish a local origin on each individual element. Establish the two relevant coordinate axes for each face of each element being evaluated.

3.2 Testing:

3.2.1 Perform the dye penetrant in accordance with ASTM E165-02.

3.2.1.1 Clean the surface with appropriate cleaner.

3.2.1.2 Apply the penetrant, and let it dwell.

3.2.1.3 Remove the excess penetrant from the surface.

3.2.1.4 Apply developer.

3.2.2 Observe and measure crack extent.

3.3 Documenting cracks:

3.3.1 Location:

3.3.1.1 Document the unique element identifier of the superstructure element on which the crack is located.

3.3.1.2 Follow FLD-OP-SC-003, Determination of Local Origins for Elements, to establish a local origin on each element; identify the relevant coordinate axis (such as *x*, *z* for a girder web), and document the beginning and ending points of the crack using the *y*, *z* coordinates.

3.3.1.3 Describe the location of the crack, e.g., adjacent to the connection of diaphragm 1DiAB to girder 1A.

3.3.2 Size and orientation:

3.3.2.1 Record the length of the crack (from one end to the other in a straight line) in decimal inches using the tape measure, measuring wheel, and/or laser measuring device.

3.3.2.2 Measure the maximum crack width (opening) with the crack comparison card (crack gage).

3.3.2.3 Record the orientation of the crack (degrees) using a plump bob, or compass (or other angle-measuring device).

3.3.3 Take photographs (FLD-DC-PH-002, Photographing for Documentation Purposes) and/or draw sketches illustrating the location and size of the crack.

3.4 Storing data, documents, and images:

3.4.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.4.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.5 Reporting: Transfer all metadata, data, documents, and images to Federal Highway Administration (FHWA), and/or upload all metadata, data, documents, and images into the Long-Term Bridge Performance (LTBP) Bridge Portal.

4. DATA COLLECTION TABLE

4.1 Table:

#	FIELD NAME	DATA TYPE	ACCURACY	UNIT	FIELD DESCRIPTION	ROW COLOR
1	State	Text			State Code; e.g., Virginia = VA	Green
2	NBI structure number	Text			Item 8, structure number; from NBI Coding Guide	Green
3	Structure name	Text			Descriptive name for the bridge; e.g., Route 15 SB over I–66	Green
4	Protocol name	Text			Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text			First name(s) Last name(s)	Green
7	Date data were collected	Text	Exact date		mm/dd/yyyy	Green
8	Ambient air temperature	Number	1	ºF	Range: -50 to 150	Green
9	Deck surface temperature	Number	1	ºF	Range: -50 to 150	Green

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
10	Location of crack: element type and unique identifier	Text			Example: Girder 1A; evaluate and record data for each crack identified in the individual element	Blue
11	Test site	Text			Descriptive location of the crack on the bridge (e.g., adjacent to the connection of diaphragm 1Di1AB to girder A)	Yellow
12	Pair of axis used to locate crack on deck or element	Text			(*x*, *y*), (*x*, *z*), or (*y*, *z*)	Yellow
13	Coordinates of the beginning of the crack	Number	0.125	In.	Example on web (*x*, *z*)	Yellow
14	Coordinates of the end of the crack	Number	0.005	In.	Example on web (*x*, *z*)	Yellow
15	Crack length	Number	0.1	In.		Yellow
16	Crack width	Number	0.01	In.		Yellow
17	Presence of rust at crack	List			Yes or No	Yellow
18	Crack photo	BLOB			Take one or more photos of each crack identified	Yellow
19	Comments	Text				Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. Criteria for Data Validation

5.1 Comparison should be made with crack data and photos from previous inspections as well as with crack data and photos from FLD-DC-NDE-008, Ultrasonic Testing—Steel Fatigue Cracking, if available.

6. Commentary/Background

6.1 The purpose of this protocol is to provide a standard procedure for using dye penetrant examination of materials for detecting discontinuities that are open to the surface, such as cracks, seams, laps, cold shuts, laminations, through leaks, or lack of fusion.

6.2 Dye penetrant testing is applicable to in-process, final, and maintenance examination. It can be effectively used in the examination of nonporous, metallic materials, both ferrous and nonferrous.

6.3 Solvent-removable, visible dye liquid penetrant examination is generally the preferred method for field use where surface examinations are required. It has the advantage of easy portability and simplicity, and it does not require electricity, black lights and dark rooms, or a water source.

6.4 The minimum requirements for conducting liquid penetrant examination are specified in ASTM E1417-05e1. The nature of the cleaner, the penetrant, and the developer are specified in ASTM E165-02.

7. REFERENCES

7.1 *LTBP Protocols*:

7.1.1 FLD-OP-SC-002, Structure Segmentation and Element Identification System.

7.1.2 FLD-OP-SC-003, Determination of Local Origins for Elements.

7.1.3 FLD-DC-NDE-008, Ultrasonic Testing—Steel Fatigue Cracking.

7.1.4 FLD-DC-PH-002, Photographing for Documentation Purposes.

7.1.5 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.6 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*:

7.2.1 ASTM E1417-05e1, Standard Practice for Liquid Penetrant Testing, ASTM International, West Conshohocken, PA, 2005.

7.2.2 ASTM E165-02, Standard Practice for Liquid Penetrant Examination, ASTM International, West Conshohocken, PA, 2002.

ULTRASONIC SURFACE WAVE TESTING—CONCRETE

LTBP Protocol #: FLD-DC-NDE-007

1. DATA COLLECTED

1.1 Elastic modulus variation of concrete throughout tested deck area.

1.2 Indications of concrete degradation.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

2.1.2 Ultrasonic surface wave (USW) equipment/device with impact source and sensors (cart mounted or hand deployed and triggered manually at each test point location); capable of generating and accurately recording signals in a range of at least 5 to 30 kHz positioned inline.

2.1.3 Data acquisition system, capable of sampling and recording at a minimum rate of 60 kHz.

2.1.4 Data conditioning and analysis software, capable of filtering, clipping, segmenting, and isolating frequency response data; hand deployed and triggered manually at each test point location.

2.1.5 Laptop or data logger.

2.1.6 Hammer.

2.1.7 Small diameter punch.

2.1.8 Digital camera.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Use the global rectangular grid (FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks) to locate test points on the deck.

3.2 Test preparation:

3.2.1 Ensure the deck surface is clear of any debris.

3.2.2 Measure the thickness of the asphalt overlay, if any, by driving a small diameter punch through the overlay until it reaches the concrete deck and record the embedded length of the punch.

3.3 Testing:

3.3.1 Collect data along any test line, as long as the location of every USW reading is properly recorded.

3.3.2 Place the impact source and sensors in direct contact with the sampled concrete surface.

3.3.3 Avoid hitting or resting on exposed aggregate, edges or depressions within surface voids, vugs, or surface tining. Otherwise, erroneous signals may be generated, collected, and stored.

3.3.4 During field operations, note that displayed dispersion curves (modulus vs. depth), calculated modulus, and other data are consistent with expected results based on the design strength of the concrete, overall visible deck condition, and feedback from other nondestructive evaluation (NDE) or concrete condition assessment data. For instance, the variation of modulus with depth is relatively constant in an intact area of a bridge deck. There would be a drop in modulus in the presence of defect within the bridge deck.

NOTE—There should be no chain drag, hammer sounding, coring, impact or hammer drilling, an electric generator, or similar operations producing high-frequency vibration in the proximity (within 100 ft) of the USW equipment. Operation of such equipment may produce frequency responses within the range of interest, which decrease the signal/noise ratio and make it either impossible or more difficult to isolate and interpret collected data.

3.4 Traffic in the lanes outside of the work zone is permissible during the data collection.

3.5 Final forms for collected data include time histories and frequency response of measured raw data at all *x* and *y* test locations from gridded deck. Processed data consist of condition grading based on resonant frequency response of impact-echo data (grades 1 to 4), also on an *x*-*y* coordinate system.

3.6 Storing data, documents, and images:

3.6.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.6.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.7 Reporting: Transfer all metadata, data, documents, and images to Federal Highway Administration (FHWA), and/or upload all metadata, data, documents, and images into the Long-Term Bridge Performance (LTBP) Bridge Portal.

4. DATA COLLECTION TABLE

4.1 Table:

#	FIELD NAME	DATA TYPE	ACCURACY	UNIT	FIELD DESCRIPTION	ROW COLOR
1	State	Text			State Code; e.g., Virginia = VA	Green
2	NBI structure number	Text			Item 8, structure number; from NBI Coding Guide	Green
3	Structure name	Text			Descriptive name for the bridge; e.g., Route 15 SB over I–66	Green
4	Protocol name	Text			Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text			First name(s) Last name(s)	Green
7	Date data were collected	Text	Exact date		mm/dd/yyyy	Green
8	Ambient air temperature	Number	1	°F	Range: -50 to 150	Green

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
9	Deck surface temperature	Number	1	°F	Range: -50 to 150	Green
10	Equipment name	Text				Green
11	Equipment manufacturer	Text				Green
12	Equipment model name and number	Text			If available	Green
13	Comments (equipment)	Text	Unlimited			Orange
14	Overlay material	Text				Green
15	Overlay thickness	Number	0.5	in.		Green
16	Bridge deck thickness	Number	0.5	in.	Range: 0 to 10	Green
17	Source type	Text			Range: 0 to 60	Green
18	Sensor type	Text				Green
19	Source sensor spacing	Number	0.1	in.	Range: 0.1 to 20	Green
20	Sensor 1 Sensor 2 spacing	Number	0.1	in.	Range: 0.1 to 20	Green
21	Pulse period	Number	0.1			Green
22	Pulse length	Number	1			Green
23	Sampling rate	Number	1			Green
24	Samples per scan	Number	1		Range: 0 to 16,400	Green
25	Number of pretrigger samples	Number	1			Green
26	Span number	Text			Span 1, Span 2, Span N (if testing on deck surface)	Blue
27	Test site	Text			Describe the location of the test on the bridge (e.g., shoulder and lane 1)	Blue
28	Location of test site (*x*-coordinate)	Number	1	ft	Transverse distance from the grid origin	Blue
29	Location of test site (*y*-coordinate)	Number	1	ft	Longitudinal distance from the grid origin	Blue
30	Hammer voltage array	Array of numbers	0.000000001	V	Voltage array (time history) data for the test point; the number of elements are the same as samples per scan (item 24) and can be different numbers for each element Range: -1 to +1	Yellow
31	Sensor 1 voltage array	Array of numbers	0.000000001	V		Yellow
32	Sensor 2 voltage array	Array of numbers	0.000000001	V		Yellow
33	Comments	Text				Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
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Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. CRITERIA FOR DATA VALIDATION

5.1 Verification and comparison should be made with results obtained from other NDE methods, including sounding methods, such as chain drag (FLD-DC-VIC-003, Concrete Deck—Spalls and Delamination), acoustic methods, electromagnetic methods, as well as with ground truth data.

6. COMMENTARY/BACKGROUND

6.1 The purpose of this protocol is to provide a standard procedure for using USW testing to measure the elastic modulus of concrete. Significant changes in the modulus between two periodical measurements are an indication of concrete degradation. Changes in the modulus among several periodic measurements can be used to map the condition degradation rate of a structure over time.

6.2 USW testing is the measurement of the velocity of surface waves in concrete of a bridge deck or other reinforced concrete members. The measured velocity of surface waves is linked to the elastic modulus. The frequency range of interest in testing of bridge decks and other concrete members is between 5 and 30 kHz. The testing equipment consists of an impact source and two receivers, positioned along a line, so that velocity of the surface wave can be determined with the distance between two sensors (displacement or velocity transducers, or accelerometers) and the travel time of the surface wave as it propagates away from the near receiver to the far receiver. The spacing of sensors on the instruments used for USW measurement specifies the penetration depth of surface waves. The rule of thumb is that the sensors' spacing should be half the member's thickness to measure the variation of surface wave velocity over the full depth of the concrete member.

7. REFERENCES

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-005, Personnel Qualifications.

7.1.3 FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks.

7.1.4 FLD-DC-VIC-003, Concrete Deck—Spalls and Delamination.

7.1.5 FLD-DC-PH-002, Photographing for Documentation Purposes.

7.1.6 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.7 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*:

7.2.1 S2-R06A-RR-1, Nondestructive Testing to Identify Concrete Bridge Deterioration, Transportation Research Board, Washington, DC, 2013.

ULTRASONIC TESTING—STEEL FATIGUE CRACKING

LTBP Protocol #: FLD-DC-NDE-008

1. DATA COLLECTED

1.1 Location and measurements of cracks and discontinuities.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS:

2.1 *Equipment*:

2.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

2.1.2 Ultrasonic testing (UT) system.

2.1.3 Wire brush or hand broom.

2.1.4 Tape measure.

2.1.5 Temporary marker.

2.1.6 Digital camera.

2.1.7 Pencil, sketch pad, and clipboard.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Establishing a local origin:

3.1.1 Use the segmentation and numbering system (FLD-OP-SC-002, Structure Segmentation and Element Identification System) so defects can be located and noted by a unique element identifier.

3.1.1.1 Use FLD-OP-SC-003, Determination of Local Origins for Elements, to establish a local origin on each individual element. Establish the two relevant coordinate axes for each face of each element being evaluated.

3.2 Test preparation:

3.2.1 Use a wire brush to clean the surface of the bridge element in the area where cracking is suspected and flaw detection and measurement is desired.

3.2.2 Calibrate the system according to the manufacturer's instructions.

3.3 Testing:

3.3.1 Run the procedure as described in the instruction manual of the ultrasonic testing system to do the following:

3.3.1.1 Configure the transducer wavelength/frequency in order to detect voids (generally, a void must be larger than half the wavelength to be detected).

3.3.1.2 Create and propagate waves in the material, using couplant and wedges when necessary.

3.3.1.3 Determine the thickness of the material.

3.3.1.4 Record reflected waves seeking reflection from defects; convert waveforms into a frequency spectrum if necessary.

3.3.1.5 Determine the distance to any defect identified.

3.3.1.6 When a flaw is detected, scan the area, and estimate the length of the crack from beginning point to ending point with the ultrasonic testing system and the tape measure. Collect these values and note the location in the segment.

3.3.1.7 Mark the beginning and ending points of the crack.

3.4 Documenting cracks:

3.4.1 Location:

3.4.1.1 Document the unique element identifier of the superstructure element on which the crack is located.

3.4.1.2 Follow FLD-OP-SC-003, Determination of Local Origins for Elements, to establish a local origin on each element; identify the relevant coordinate axis (such as *x*, *z* for a girder web), and document the beginning and ending points of the crack using the *y*, *z* coordinates.

3.4.1.3 Describe the location of the crack, e.g., adjacent to the connection of diaphragm 1Di1AB to girder 1A.

3.4.2 Size and orientation:

3.4.2.1 Record the length of the crack (from one end to the other in a straight line) in decimal inches using the tape measure, measuring wheel, and/or laser measuring device.

3.4.2.2 Measure the maximum crack width (opening) with the crack comparison card (crack gage).

3.4.2.3 Record the orientation of the crack (degrees) using a plump bob, compass, or other angle-measuring device.

3.4.3 Take photographs (FLD-DC-PH-002, Photographing for Documentation Purposes) and/or draw sketches that illustrate the location and size of the crack.

3.5 Storing data, documents, and images:

3.5.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.5.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.6 Reporting: Transfer all metadata, data, documents, and images to Federal Highway Administration (FHWA), and/or upload all metadata, data, documents, and images into the Long-Term Bridge Performance (LTBP) Bridge Portal.

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4. DATA COLLECTION TABLE

4.1 Table:

#	FIELD NAME	DATA TYPE	ACCURACY	UNIT	FIELD DESCRIPTION	ROW COLOR
1	State	Text	Text		State Code, e.g., Virginia = VA	Green
2	NBI structure number	Text	Text		Item 8, Structure Number from NBI Coding Guide	Green

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
3	Structure name	Text	Text		Descriptive name for the bridge, e.g., Route 15 SB over I–66	Green
4	Protocol name	Text	Text		Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text	Text		First name(s) Last name(s)	Green
7	Date data were collected	Text	Exact date		mm/dd/yyyy	Green
8	Ambient air temperature	Number	1	ºF	Numeric means negative and positive integers, range: -50 to 150	Green
9	Deck surface temperature	Number	1	ºF	Numeric means negative and positive integers, range: -50 to 150	Green
10	Equipment name	Text	Text			Green
11	Equipment manufacturer	Text	Text			Green
12	Equipment model name and number	Text	Text		If available	Green
13	Comments (equipment)	Text	Unlimited			Orange
14	Bridge deck thickness	Number	0.5	in.	Range: 0 to 10	Green
15	Pulse period	Number	0.1			Green
16	Pulse length	Number	1			Green
17	Pulse voltage	Number	0.1			Green
18	Sampling rate	Number	1			Green
19	Samples per scan	Number	1			Green
20	Location of crack: element type and unique identifier	Text			Example: Girder 1A; evaluate and record data for each crack identified in the individual element	Blue
21	Test site	Text			Descriptive location of the crack on the bridge (e.g., adjacent to the connection of diaphragm 1DiAB to girder A)	Yellow
22	Voltage array	Array of numbers	0.000000001	Volts	Voltage array (time history) data for the point; the number of elements are the same as samples per scan (item 19) and can be different numbers for each element Range: -1 to +1	Yellow
23	Thickness of member	Number	0.1	in.		Yellow

24	Pair of axis used to locate crack on deck or element	Text			(*x*, *y*), (*x*, *z*), or (*y*, *z*)	Yellow
25	Coordinates of the beginning of the crack	Number	0.125	in.	Example on web (*x*, *z*)	Yellow
26	Coordinates of the end of the crack	Number	0.005	in.	Example on web (*x*, *z*)	Yellow
28	Crack length	Number	0.1	in.		Yellow
29	Crack width	Number	0.01	in.		Yellow
30	Presence of rust at crack	List			Yes or No	Yellow
31	Crack photo	BLOB			Take one or more photos of each crack identified	Yellow
32	Comments	Text	Unlimited			Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. CRITERIA FOR DATA VALIDATION

5.1 Comparison should be made with crack data and photos from previous inspections as well as with crack data and photos from FLD-DC-NDE-006, Dye Penetrant Testing, if available.

6. COMMENTARY/BACKGROUND

6.1 The purpose of this protocol is to provide a standard procedure for using ultrasonic testing to locate and measure cracks or discontinuities in steel members.

6.2 Ultrasonic testing uses high-frequency sound energy used for flaw detection and evaluation. A UT system uses a transducer that generates high-frequency ultrasonic energy. The sound energy is introduced and propagates through the materials in the form of waves. When there is a discontinuity (such as a void) in the wave path, part of the energy is reflected back from the flaw surface. The reflected wave signal is transformed into an electrical signal by the transducer and is displayed on a screen. Signal travel time can be related to the distance that the signal traveled. From the signal, information about the void location and size can be determined.

6.3 Only single-sided access is needed when the pulse-echo technique is used. However, there are some limitations to UT: the surface must be accessible to transmit ultrasound, skill and training is more extensive than with other NDE methods, and it requires a coupling medium to promote the transfer of sound energy into the test specimen.

7. REFERENCES

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-005, Personnel Qualifications.

7.1.3 FLD-OP-SC-002, Structure Segmentation and Element Identification System.

7.1.4 FLD-OP-SC-003, Determination of Local Origins for Elements.

7.1.5 FLD-DC-NDE-006, Dye Penetrant Testing.

7.1.6 FLD-DC-PH-002, Photographing for Documentation Purposes.

7.1.7 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.8 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*: None.

VISUAL INSPECTION—STEEL ELEMENTS PROTOCOLS (VIS)

STEEL SUPERSTRUCTURE DETERIORATION

LTBP Protocol #: FLD-DC-VIS-001

1. DATA COLLECTED

1.1 None. This is an instructional protocol for visual inspection of a bridge or span with a steel superstructure.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*: None.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Use the segmentation and numbering system for the superstructure (FLD-OP-SC-002, Structure Segmentation and Element Identification System) so defects can be located and noted by the unique element identifier.

3.2 Use FLD-OP-SC-003, Determination of Local Origins for Elements, to establish a local origin on each individual element.

3.3 Evaluating and recording characteristics of the superstructure:

3.3.1 FLD-DC-VIS-002, Steel Superstructure—Corrosion, for each instance of paint deterioration or peeling, visible corrosion, or pitting.

3.3.2 FLD-DC-VIS-003, Steel Superstructure—Section Loss, for each instance of loss of section.

3.3.3 FLD-DC-VIS-004, Steel Superstructure—Cracking, Deflection, Uplift, Distortion, Buckling, Rotation, and Impact Damage, for each instance of cracking, deflections, uplift, distortion, rotations, and buckling, as well as any damages from strikes by vehicles, vessels, or floating debris.

3.4 Evaluating bearings:

3.4.1 FLD-DC-VIB-001, Elastomeric Bearings.

3.4.2 FLD-DC-VIB-002, Rocker Bearings.

3.5 Documenting defects:

3.5.1 Take photographs of defects using FLD-DC-PH-002, Photographing for Documentation Purposes, and create a photo log.

3.5.2 Use sketches as needed to document typical defects and supplement the photographs.

3.6 Storing data, documents, and images:

3.6.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.6.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.7 Reporting: Transfer all metadata, data, documents, and images to Federal Highway Administration (FHWA), and/or upload all metadata, data, documents, and images into the Long-Term Bridge Performance (LTBP) Bridge Portal.

4. DATA COLLECTION TABLE

4.1 None.

5. CRITERIA FOR DATA VALIDATION

5.1 None.

6. COMMENTARY/BACKGROUND

6.1 This protocol provides guidance for planning the detailed visual inspection of a bridge superstructure that consists of steel members. Use the listed protocols to guide data collection and recording.

6.2 A bridge superstructure is the portion of a bridge structure that receives and supports traffic loads (distributed by the bridge deck) and, in turn, transfers these loads to the bridge substructure via the bridge bearings. A steel superstructure can consist of girders (rolled beams, rolled beams with a cover plate, or plate girders), floor beams and stringers (concrete encased, rolled, and welded or bolted plates), cross-frames, diaphragms, and vertical and/or horizontal stiffeners.

6.3 Truss structures may have built-up sections for top and bottom chords, vertical and diagonal members, lateral and sway frame bracings, and gusset plates.

6.4 The bearings are considered elements of the superstructure.

7. REFERENCES

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-005, Personnel Qualifications.

7.1.3 FLD-OP-SC-002, Structure Segmentation and Element Identification System.

7.1.4 FLD-OP-SC-003, Determination of Local Origins for Elements.

7.1.5 FLD-DC-VIB-001, Elastomeric Bearings.

7.1.6 FLD-DC-VIB-002, Rocker Bearings.

7.1.7 FLD-DC-VIS-002, Steel Superstructure—Corrosion.

7.1.8 FLD-DC-VIS-003, Steel Superstructure—Section Loss.

7.1.9 FLD-DC-VIS-004, Steel Superstructure—Cracking, Deflection, Uplift, Distortion, Buckling, Rotation, and Impact Damage.

7.1.10 FLD-DC-PH-002, Photographing for Documentation Purposes.

7.1.11 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.12 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*:

7.2.1 FHWA-NHI-12-053, Bridge Inspector's Reference Manual, Federal Highway Administration, Washington, DC, 2012.

Long-Term Bridge Performance Program

STEEL SUPERSTRUCTURE—CORROSION

LTBP Protocol #: FLD-DC-VIS-002

1. DATA COLLECTED

1.1 Description and location of corrosion on a steel superstructure.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

2.1.2 Ladder, access platform, snooper, bucket truck, man lift, and/or high-reach equipment (if necessary).

2.1.3 Tape measure.

2.1.4 6-ft folding rule.

2.1.5 Scraper.

2.1.6 Wire brush or hand broom.

2.1.7 Sounding hammer.

2.1.8 Lever pit gage.

2.1.9 Slide caliper.

2.1.10 Laser measuring device (optional).

2.1.11 Temporary marker.

2.1.12 Digital camera.

2.1.13 Pencil, sketch pad, and clipboard.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Use the segmentation and numbering system for the superstructure (FLD-OP-SC-002, Structure Segmentation and Element Identification System) so defects can be located and noted by the unique element identifier.

3.2 Use FLD-OP-SC-003, Determination of Local Origins for Elements, to establish a local origin on each element to be used to locate defects.

3.3 Cleaning:

3.3.1 Use the scraper and wire brush to clean loose, deteriorated protective coating and surface corrosion, if any are present.

3.3.2 If after cleaning, section loss to the steel is evident, follow FLD-DC-VIS-003, Steel Superstructure—Section Loss, to record measurements and characteristics of the section loss.

3.4 Measuring, recording, and evaluating characteristics of corrosive activity:

3.4.1 Mark the limits of each area with deteriorated coatings on the element with a temporary marker, and mark the corners of a rectangle that encompasses the maximum length and maximum width of the corroded area.

3.4.1.1 Using the element local origin as point (0,0,0), determine and record the coordinates of the four corners of the rectangle.

3.4.1.2 Measure the maximum length and width of the area with deteriorated coatings.

3.4.2 Mark the limits of each corroded area on the element with a temporary marker, and mark the corners of a rectangle that encompasses the maximum length and maximum width of the corroded area.

3.4.2.1 Using the element local origin as point (0,0,0), determine and record the coordinates of the four corners of the rectangle.

3.4.2.2 Measure the maximum length and width of the corrosion.

3.4.3 Determine the extent (depth) and severity of any pitting using a lever pit gage.

3.5 Documenting defects:

3.5.1 Take photographs of defects using FLD-DC-PH-002, Photographing for Documentation Purposes, and create a photo log.

3.5.2 Use sketches as needed to document section loss and cracking and supplement the photographs.

3.6 Storing data, documents, and images:

3.6.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.6.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.7 Reporting: Transfer all metadata, data, documents, and images to Federal Highway Administration (FHWA), and/or upload all metadata, data, documents, and images into the Long-Term Bridge Performance (LTBP) Bridge Portal.

4. DATA COLLECTION TABLE

4.1 Table:

#	FIELD NAME	DATA TYPE	ACCURACY	UNIT	FIELD DESCRIPTION	ROW COLOR
1	State	Text			State Code; e.g., Virginia = VA	Green
2	NBI structure number	Text			Item 8, structure number; from NBI Coding Guide	Green
3	Structure name	Text			Descriptive name for the bridge; e.g., Route 15 SB over I–66	Green
4	Protocol name	Text			Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was	Green

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
					published; e.g., May 2015	
6	Personnel performing data collection activities	Text			First name(s) Last name(s)	Green
7	Date data were collected	Text	Exact date		mm/dd/yyyy	Green
For Coating Deterioration						Pink
8	Location of deteriorated coating: element type and unique identifier	Text			Example: Girder, 1A; evaluate and record data for areas of deteriorated coating on each individual element	Blue
9	Location of defect on the element	Text			Example: bottom flange of girder 1A	Blue
10	Type of defect	Text			Chalking Cracking Loss of adhesion Peeling Other (specify)	Yellow
11	Location of corner 1	Number	1	in.	(x,y,z) coordinates of the four corners of a rectangle encompassing the deteriorated area	Yellow
12	Location of corner 2	Number	1	in.		Yellow
13	Location of corner 3	Number	1	in.		Yellow
14	Location of corner 4	Number	1	in.		Yellow
15	Maximum length of deteriorated coating area	Number	1	in.	Measured parallel to the x-axis	Yellow
16	Maximum width of deteriorated coating area	Number	1	in.	Measured parallel to the z-axis	Yellow
17	Defect photos and sketches	BLOB	BLOB		Document typical areas of deteriorated coating with photos and/or sketches	Yellow
18	Comments	Text				Orange
For Corrosion						Pink
19	Location of corroded area: element type and unique identifier	Text			Example: Girder, 1A; evaluate and record data for corroded areas on each individual element	Blue
20	Location of defect on the element	Text			Example: web of girder 1A	Blue
21	Location of corroded area on member – corner 1	Number	1	in.	(x,y) coordinates of the four corners of a rectangle encompassing the deteriorated area	Yellow
22	Location of corner 2	Number	1	in.		Yellow
23	Location of corner 3	Number	1	in.		Yellow
24	Location of corner 4	Number	1	in.		Yellow
25	Maximum length of corroded area	Number	1	in.	Measured parallel to the x-axis	Yellow
26	Maximum width of corroded area	Number	1	in.	Measured parallel to the z-axis	Yellow
27	Depth of pitting	Number	0.01	in.		Yellow
28	Defect photos and sketches	BLOB			Document typical corroded areas with photos and/or sketches	Yellow
29	Comments	Text				Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. CRITERIA FOR DATA VALIDATION

5.1 Compare measurements with measurements from previous inspections of the same structure to make sure values make sense.

5.2 Compare measurements with photo documentation to make sure results shown in photos are consistent with items measured.

5.3 If an element's condition is improved when compared to the condition documented in a previous inspection, check with the State department of transportation to determine if any maintenance, repair, and/or bridge preservation actions have occurred. If so, document these maintenance, repair, and/or bridge preservation actions using the appropriate protocols.

6. COMMENTARY/BACKGROUND

6.1 This protocol provides guidance on identifying corroded areas on steel superstructure elements and documenting their extent and location on the element. Guidance is also provided for measuring the extent and depth of any pitting of the steel is present.

6.2 Steel superstructures, such as trusses (deck, through, and pony), multigirder beams, girder/floor beam/stringer systems, box girders, etc., that are not built of weathering steel and are not protected by galvanizing or metallizing are usually protected by one or more coats of paint to guard against oxidation (rusting) of the steel.

6.3 The most common types of defects in bridge coatings include chalking, cracking, loss of adhesion, and peeling. Data collection involves identifying areas where coating defects are evident and documenting the location and size of the affected areas.

6.4 The main cause of steel corrosion in coated bridges is the lack and/or breakdown of the protective coating. Once this occurs, the exposure to corrosive agents (water, salts, and chemicals) begins a disintegration process on the surface metal. Corrosion grows from a few, small starting points, and then expands as steel molecules that are directly in contact with the corroded area also corrode; eventually, small, medium, and large contiguous areas of corrosion are evident. Data collection involves identifying areas where corrosion is evident and documenting the location and size of the affected areas.

7. REFERENCES

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-005, Personnel Qualifications.

7.1.3 FLD-OP-SC-002, Structure Segmentation and Element Identification System.

7.1.4 FLD-OP-SC-003, Determination of Local Origins for Elements.

7.1.5 FLD-DC-VIS-003, Steel Superstructure—Section Loss.

7.1.6 FLD-DC-PH-002, Photographing for Documentation Purposes.

7.1.7 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.8 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*:

7.2.1 FHWA-NHI-12-053, Bridge Inspector's Reference Manual, Federal Highway Administration, Washington, DC, 2012.

STEEL SUPERSTRUCTURE—SECTION LOSS

LTBP Protocol #: FLD-DC-VIS-003

1. DATA COLLECTED

1.1 Description and location of steel section loss on a steel superstructure.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

2.1.2 Ladder, access platform, snooper, bucket truck, man lift, and/or high-reach equipment (if necessary).

2.1.3 Sounding hammer.

2.1.4 Tape measure.

2.1.5 6-ft folding rule.

2.1.6 Scraper.

2.1.7 Crack comparison card.

2.1.8 Wire brush or hand broom.

2.1.9 Slide calipers.

2.1.10 Web calipers.

2.1.11 Straight edge or ruler.

2.1.12 Ultrasonic thickness gage.

2.1.13 Digital camera.

2.1.14 Temporary marker.

2.1.15 Laser measuring device (optional).

2.1.16 Pencil, sketch pad, and clipboard.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Use the segmentation and numbering system for the superstructure (FLD-OP-SC-002, Structure Segmentation and Element Identification System) so defects can be located and noted by the unique element identifier.

3.2 Use FLD-OP-SC-003, Determination of Local Origins for Elements, to establish a local origin on each element.

3.3 Cleaning:

3.3.1 Use a scraper and/or a hammer to remove exfoliated steel at suspect areas until the base metal is uncovered.

3.3.2 With a wire brush, clear away loose metal and other debris, if necessary, to allow accurate measurements and photographs.

3.4 Measuring, recording, and evaluating characteristics of section loss:

3.4.1 After removing all loose material from the surface, mark the limits of the section loss. Measure the remaining thicknesses of the reduced section with slide calipers or ultrasonic thickness gage. Measure the initial thickness of the element cross section, and calculate the percentage of section remaining.

3.4.1.1 Measure flange thickness with slide calipers.

3.4.1.2 Measure web thicknesses with web calipers if feasible. If is not feasible, use an ultrasonic thickness gage on the web; as a last alternative, estimate the loss of thickness using a straight edge and ruler.

3.4.2 Sample areas of section loss to determine the maximum value of loss (minimum remaining section). To do this, use calipers, or ultrasonic thickness gage. The as-built construction plans can be used to obtain the original thickness of the member at a location where there is no loss of section.

3.4.3 Mark the limits of each area of section loss on the element with a temporary marker and also mark the corners of a rectangle that encompasses the maximum length and maximum width of the area of section loss.

3.4.3.1 Using the element local origin as point (0,0,0), determine and record the coordinates of the four corners of the rectangle.

3.4.3.2 Measure the length and width of each area of section loss with a tape measure.

3.5 Documenting defects:

3.5.1 Take photographs of defects using FLD-DC-PH-002, Photographing for Documentation Purposes, and create a photo log.

3.5.2 Use sketches as needed to document section loss and supplement the photographs.

3.6 Storing data, documents, and images:

3.6.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.6.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.7 Reporting: Transfer all metadata, data, documents, and images to Federal Highway Administration (FHWA), and/or upload all metadata, data, documents, and images into the Long-Term Bridge Performance (LTBP) Bridge Portal.

4. DATA COLLECTION TABLE

4.1 Table:

#	FIELD NAME	DATA TYPE	ACCURACY	UNIT	FIELD DESCRIPTION	ROW COLOR
1	State	Text			State Code; e.g., Virginia = VA	Green
2	NBI structure number	Text			Item 8, structure number; from NBI Coding Guide	Green
3	Structure name	Text			Descriptive name for the bridge; e.g., Route 15 SB over I–66	Green
4	Protocol name	Text			Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text			First name(s) Last name(s)	Green
8	Date data were collected	Text	Exact date		mm/dd/yyyy	Green
9	Location of section loss: element type and unique identifier	Text			Example: Girder, 1A; evaluate and record data for areas with section loss on each individual element	Blue
10	Location of defect on the element	Text			Example: web of girder 1A	Blue
11	Location of corner 1	Number	1	in.	(*x*,*y*,*z*) coordinates of the four corners of a rectangle encompassing the deteriorated area	Yellow
12	Location of corner 2	Number	1	in.		Yellow
13	Location of corner 3	Number	1	in.		Yellow
14	Location of corner 4	Number	1	in.		Yellow
15	Maximum length of section loss	Number	1	in.		Yellow
16	Maximum width of section loss	Number	1	in.		Yellow
17	Minimum remaining thickness	Number	0.0625	in.		Yellow
18	Original thickness	Number	0.0625	in.		Yellow
19	Defect photos	BLOB			If defects are present, document typical defects with photos and/or sketches	Yellow
20	Comments	Text				Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. Criteria for Data Validation

5.1 Compare measurements with measurements from previous inspections of the same structure to make sure values make sense.

5.2 Compare measurements with photo documentation to make sure results shown in photos are consistent with items measured.

5.3 If an element's condition is improved when compared to the condition documented in a previous inspection, check with the State department of transportation to determine if any maintenance, repair, and/or bridge preservation actions have occurred. If so, document these maintenance, repair, and/or bridge preservation actions using appropriate protocols.

6. Commentary/Background

6.1 This protocol describes the evaluation of steel with section loss, oxidation, or rusting.

6.2 After a period of exposure to water, salts, and chemical agents, load and/or other factors, advanced deterioration of steel may result in material section loss that can ultimately lead to a perforated section.

6.3 Data collection involves exposing the areas where section loss has occurred, removing all loose materials, and then determining the thickness of the steel and the amount of the original section still remaining and documenting the location and size of the affected areas.

7. References

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-005, Personnel Qualifications.

7.1.3 FLD-OP-SC-002, Structure Segmentation and Element Identification System.

7.1.4 FLD-OP-SC-003, Determination of Local Origins for Elements.

7.1.5 FLD-DC-PH-002, Photographing for Documentation Purposes.

7.1.6 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.7 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*:

7.2.1 FHWA-NHI-12-053, Bridge Inspector's Reference Manual, Federal Highway Administration, Washington, DC, 2012.

STEEL SUPERSTRUCTURE— CRACKING, DEFLECTION, UPLIFT, DISTORTION, BUCKLING, ROTATION, AND IMPACT DAMAGE

LTBP Protocol #: FLD-DC-VIS-004

1. DATA COLLECTED

1.1 Description and location of each instance of cracking, deflection, distortion, rotation, and buckling, as well as any damage from strikes by vehicles, ships, or floating debris.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

2.1.2 Ladder, access platform, snooper, bucket truck, man lift, and/or high-reach equipment.

2.1.3 Tape measure.

2.1.4 6-ft folding rule.

2.1.5 Slide caliper.

2.1.6 Crack comparison cards.

2.1.7 Sounding hammer.

2.1.8 Wire brush or hand broom.

2.1.9 Hand scraper (for paint and rust remover).

2.1.10 Plumb bob.

2.1.11 Hand compass or other angle measuring device.

2.1.12 Level.

2.1.13 Laser measuring device (optional).

2.1.14 Temporary marker.

2.1.15 Digital camera.

2.1.16 Pencil, sketch pad, and clipboard.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Use the segmentation and numbering system for the superstructure (FLD-OP-SC-002, Structure Segmentation and Element Identification System) to locate and document defects according to the unique element identifier.

3.2 Use FLD-OP-SC-003, Determination of Local Origins for Elements, to establish a local origin on each individual element. Establish the two relevant coordinate axes for each face of each element being evaluated.

3.3 Cleaning:

3.3.1 Use the hammer, scraper, and/or wire brush to clean loose, deteriorated protective coating and loose surface corrosion, if any are present.

3.4 After cleaning, if areas of section loss in the steel are evident, follow FLD-DC-VIC-003, Steel Superstructure—Section Loss, for the elements where section loss is noted.

3.5 For each element of the steel superstructure, identify and document each instance of the following defects:

3.5.1 Cracks:

3.5.1.1 Mark the ends of each crack on the superstructure element with a temporary marker, and photograph the crack.

3.5.1.2 Record the type and unique element identifier of the superstructure element where the crack is located.

3.5.1.3 Record the location of the beginning and the end of each crack by measuring the coordinates from the local grid origin.

3.5.1.4 Measure the length of the crack in a straight line from one end of the crack to the other using the tape measure, folding rule, measuring wheel, or laser measuring device.

3.5.1.5 Measure the orientation of the crack (degrees) using a plumb bob, compass, or other angle-measuring device.

3.5.1.6 Measure the crack width (opening) with the crack comparator (crack gage) at the maximum width.

3.5.1.7 Measure or estimate the depth of the crack at the deepest point.

3.5.1.8 Document any rust present in the crack using FLD-DC-VIC-002, Steel Superstructure—Corrosion.

3.5.2 Deflections, uplifts, distortions, or buckling:

3.5.2.1 Record the type and unique element identifier of the superstructure element where the deflection, uplift, distortion, or buckling is located. If possible, photograph the defect.

3.5.2.2 Document the location of the deflection, uplift, distortion, or buckling by determining the coordinates of the beginning and the end of the affected portion of the element.

3.5.2.3 Measure the amount of deflection, uplift, distortion, or buckling using a tape measure, folding rule, or laser measuring device.

3.5.3 Rotation:

3.5.3.1 Record the type and unique element identifier of the superstructure element where the rotation is located. If possible, photograph the rotation.

3.5.3.2 Document the location of the rotation by determining the coordinates of the beginning and the end of the affected portion of the element.

3.5.3.3 Measure the amount of rotation (degrees) using a plumb bob, compass, angle-measuring device, or laser measuring device.

3.5.4 Impact damage:

3.5.4.1 Record the type and unique element identifier of the superstructure element where the impact damage is located and photograph the damage.

3.5.4.2 Mark the extent (length, width, depth) of the impact damage with a temporary marker, and photograph the damage.

3.5.4.3 Measure the extent (length, width, and/or depth) of the impact damage.

3.5.4.4 Document the location of the impact damage by determining and recording the coordinates of the beginning and the end of the affected portion of the element.

3.6 Documenting defects:

3.6.1 Take photographs to document the defects using FLD-DC-PH-002, Photographing for Documentation Purposes, and create a photo log.

3.6.2 Use sketches to document defects and supplement the photographs.

3.7 Storing data, documents, and images:

3.7.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.7.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.8 Reporting: Transfer all metadata, data, documents, and images to Federal Highway Administration (FHWA), and/or upload all metadata, data, documents, and images into the Long-Term Bridge Performance (LTBP) Bridge Portal.

4. DATA COLLECTION TABLE

4.1 Table:

#	FIELD NAME	DATA TYPE	ACCURACY	UNIT	FIELD DESCRIPTION	ROW COLOR
1	State	Text			State Code, e.g., Virginia = VA	Green
2	NBI structure number	Text			Item 8, structure number, from NBI Coding Guide	Green
3	Structure name	Text			Descriptive name for the bridge, e.g., Route 15 SB over I–66	Green
4	Protocol name	Text			Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text			First name(s) last name(s)	Green
7	Date data were collected	Text	Exact date		mm/dd/yyyy	Green
FOR INDIVIDUAL CRACKS ON A STEEL ELEMENT						Pink
8	Location of crack: element type and number	Text			Example: Girder, 1A; evaluate and record data for cracks in each individual element	Blue

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
9	Location of crack on the element	Text			Examples: in the top flange; in the weld at the third longitudinal stiffener from the bottom	Yellow
10	Location of the start of the crack	Number	1	in.	(*x*,*y*,*z*) coordinates of the ends of the crack	Yellow
11	Location of the end of the crack	Number	1	in.		Yellow
12	Crack length	Number	0.125	in.	Measured in a straight line from the beginning to the end of the crack	Yellow
13	Axes used to determine crack orientation	Text			Example: *x* and *y*	Yellow
14	Crack orientation	Number	1	Degrees	Based on the angle between the line of the crack and the axis of the local coordinate system for the element	Yellow
15	Maximum crack width	Number	0.125	in.		Yellow
16	Maximum crack depth	Number	0.125	in.		Yellow
17	Presence of rust at crack	List			Yes or No	Yellow
18	Comments	Text				Orange
For Deflection, Uplift, Distortion, or Buckling on a Steel Element						Pink
19	Location of defect: element type and number	Text			Evaluate and record data for deflection, uplift, distortion, or buckling in each individual element	Blue
20	Type of defect	Text			Deflection Uplift Distortion Buckling	Yellow
21	Amount of deflection, uplift, distortion, or buckling	Number	0.125	in.		Yellow
22	Comments	Text				Orange
For Rotation on a Steel Element						Pink
23	Location of the rotation: element type and number	Text			Example: Girder, 1A; evaluate and record data for cracks in each individual element	Blue
24	Location on element of rotation	Text				Yellow
25	Amount of rotation	Number	1	Degrees		Yellow
26	Comments	Text				Orange
For Impact Damage on a Steel Element						Pink
27	Location of impact damage: element type and number	Text			Example: Girder, 1A; evaluate and record data for cracks in each individual element	Blue
28	Location of the beginning of the impact damage: *x*-coordinate	Number	1	in.	Measured from the element local origin to the beginning of the impact damage	Yellow
29	Location of the end of the impact damage: *x*-coordinate	Number	1	in.	Measured from the element local origin to the end of the impact damage	Yellow
30	Length of impact damage	Number	1	in.		Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
31	Width of impact damage	Number	1	in.		Yellow
32	Depth of impact damage	Number	1	in.		Yellow
33	Defect photos and sketches	BLOB			Document all defects with photos and/or sketches	Yellow
34	Comments	Text				Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. Criteria for Data Validation

5.1 Compare measurements with measurements from previous inspections of the same structure to make sure that values make sense.

5.2 Compare measurements with photo documentation to make sure results shown in photos are consistent with items measured.

5.3 If an element's condition is improved when compared to the condition documented in a previous inspection, check with the State department of transportation to determine if any maintenance, repair, and/or bridge preservation actions have occurred. If so, document these maintenance, repair, and/or bridge preservation actions using appropriate protocols.

6. Commentary/Background

6.1 This protocol provides guidance for identifying different types of defects on steel elements and documenting the location and extent of the defect.

6.2 A steel superstructure can consist of girders (rolled beams, rolled beams with a cover plate, or plate girders), floor beams and stringers (concrete encased, rolled beams, or rolled beams with welded or bolted plates), cross-frames, diaphragms, and vertical and/or horizontal stiffeners.

6.3 Truss structures may have built-up sections for top and bottom chords, vertical and diagonal elements/members, lateral and sway frame bracings, and gusset plates.

6.4 Impact damage can result from strikes by vehicles, ships, trains, or debris.

7. REFERENCES

7.1 *LTBP Protocols:*

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-005, Personnel Qualifications.

7.1.3 FLD-OP-SC-002, Structure Segmentation and Element Identification System.

7.1.4 FLD-OP-SC-003, Determination of Local Origins for Elements.

7.1.5 FLD-DC-VIS-002, Steel Superstructure—Corrosion.

7.1.6 FLD-DC-PH-002, Photographing for Documentation Purposes.

7.1.7 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.8 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*:

7.2.1 FHWA-NHI-12-053, Bridge Inspector's Reference Manual, Federal Highway Administration, Washington, DC, 2012.

VISUAL INSPECTION—CONCRETE ELEMENTS PROTOCOLS (VIC)

FLD-DC-VIC-001, Concrete Deterioration

FLD-DC-VIC-002, Concrete Substructure Condition Assessment

FLD-DC-VIC-003, Concrete Deck—Spalls and Delamination

FLD-DC-VIC-004, Concrete Superstructure and Substructure—Spalls and Delamination

FLD-DC-VIC-005, Concrete—Cracking

FLD-DC-VIC-006, Concrete—Abrasion

FLD-DC-VIC-007, Concrete—Sulfate Attack

CONCRETE DETERIORATION

LTBP Protocol #: FLD-DC-VIC-001

1. DATA COLLECTED

1.1 None. This protocol provides a list of protocols to guide visual inspection and data recording of a bridge with a concrete deck and superstructure.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*: None.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Use the segmentation and numbering system for the superstructure (FLD-OP-SC-002, Structure Segmentation and Element Identification System) so defects can be located and noted by the unique element identifier.

3.2 Use FLD-OP-SC-003, Determination of Local Origins for Elements, to establish a local origin on each element.

3.3 Use the data collection grid (FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks) to locate defects on the deck.

3.4 Use the following protocols for finding defects and recording characteristics:

3.4.1 Deck and superstructure:

3.4.1.1 For potential spalls and delaminations on the deck: FLD-DC-VIC-003, Concrete Deck—Spalls and Delamination.

3.4.1.2 For each instance of spalls and delaminations on the superstructure: FLD-DC-VIC-004, Concrete Superstructure and Substructure—Spalls and Delamination.

3.4.1.3 For each instance of cracking: FLD-DC-VIC-005, Concrete—Cracking.

3.4.1.4 For each instance of abrasion: FLD-DC-VIC-006, Concrete—Abrasion.

3.4.1.5 For each instance of sulfate attack: FLD-DC-VIC-007, Concrete—Sulfate Attack.

3.4.2 Bearings:

3.4.2.1 FLD-DC-VIS-001, Elastomeric Bearings.

3.4.2.2 FLD-DC-VIB-002, Rocker Bearings.

3.5 Documenting defects:

3.5.1 Take photographs of defects using FLD-DC-PH-002, Photographing for Documentation Purposes, and create a photo log.

3.5.2 Use sketches as needed to document defects and supplement the photographs.

3.6 Storing data, documents, and images:

3.6.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.6.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.7 Reporting: Transfer all metadata, data, documents, and images to Federal Highway Administration (FHWA), and/or upload all metadata, data, documents, and images into the Long-Term Bridge Performance (LTBP) Bridge Portal.

4. DATA COLLECTION TABLE

4.1 None.

5. CRITERIA FOR DATA VALIDATION

5.1 None.

6. COMMENTARY/BACKGROUND

6.1 This protocol provides guidance for planning the detailed visual inspection of a concrete bridge deck and superstructure that consists of reinforced or prestressed concrete members as well as a reinforced or prestressed concrete deck.

6.2 A bridge superstructure is that portion of a bridge that receives and supports traffic loads (distributed by the bridge deck) and, in turn, transfers these loads to the bridge substructure, via the bridge bearings. A concrete superstructure can consist of girders (such as American Association of State Highway and Transportation Officials (AASHTO) standard Type I though VI I-girders, AASHTO Pavement Condition Index (PCI) standard bulb tee girders, AASHTO/PCI standard pretensioned spread or adjacent box beams, specific State standard pretensioned concrete I-girders or bulb-tee girders, pretensioned U-beams, cast-in-place posttensioned box girders, and segmental girders), diaphragms, and girder ends made continuous for a live load.

6.3 Bearings are considered elements of the superstructure.

7. REFERENCES

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-005, Personnel Qualifications.

7.1.3 FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks.

7.1.4 FLD-OP-SC-002, Structure Segmentation and Element Identification System.

7.1.5 FLD-OP-SC-003, Determination of Local Origins for Elements.

7.1.6 FLD-DC-VIB-001, Elastomeric Bearings.

7.1.7 FLD-DC-VIB-002, Rocker Bearings.

7.1.8 FLD-DC-VIC-003, Concrete Deck—Spalls and Delamination.

7.1.9 FLD-DC-VIC-004, Concrete Superstructure and Substructure—Spalls and Delamination.

7.1.10 FLD-DC-VIC-005, Concrete—Cracking.

7.1.11 FLD-DC-VIC-006, Concrete—Abrasion.

7.1.12 FLD-DC-VIC-007, Concrete—Sulfate Attack.

7.1.13 FLD-DC-PH-002, Photographing for Documentation Purposes.

7.1.14 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.15 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*:

7.2.1 FHWA-NHI-12-053, Bridge Inspector's Reference Manual, Federal Highway Administration, Washington, DC, 2012.

CONCRETE SUBSTRUCTURE CONDITION ASSESSMENT

LTBP Protocol # FLD-DC-VIC-002

1. DATA COLLECTED

1.1 None. This protocol provides a list of protocols to guide visual inspection and data recording of the concrete substructure of a bridge or span.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*: None.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Use the segmentation and numbering system for the superstructure (FLD-OP-SC-002, Structure Segmentation and Element Identification System) so defects can be located and noted by the unique element identifier.

3.2 Use FLD-OP-SC-003, Determination of Local Origins for Elements, to establish a local origin on each element.

3.3 For concrete pier caps, piers, pile caps, piles (if visible), footings, abutments, and wingwalls, use the following protocols for finding defects and recording characteristics:

3.4 For each instance of spalling and delamination on the substructure: FLD-DC-VIC-004, Concrete Superstructure and Substructure—Spalls and Delamination.

3.4.1 For each instance of cracking: FLD-DC-VIC-005, Concrete—Cracking

3.4.2 For each instance of abrasion: FLD-DC-VIC-006, Concrete—Abrasion.

3.4.3 For each instance of sulfate attack: FLD-DC-VIC-007, Concrete—Sulfate Attack.

3.5 Documenting defects:

3.5.1 Take photographs using FLD-DC-PH-002, Photographing for Documentation Purposes, and create a photo log.

3.5.2 Use sketches as needed to document defects and supplement the photographs.

3.6 Storing data, documents, and images:

3.6.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.6.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.7 Reporting: Transfer all metadata, data, documents, and images to Federal Highway Administration (FHWA), and/or upload all metadata, data, documents, and images into the Long-Term Bridge Performance (LTBP) Bridge Portal.

4. DATA COLLECTION TABLE

4.1 None.

5. CRITERIA FOR DATA VALIDATION

5.1 None.

6. COMMENTARY/BACKGROUND

6.1 This protocol provides guidance for planning the detailed visual inspection of a concrete bridge substructure that consists of reinforced or prestressed concrete members.

6.2 The bridge substructure includes all elements supporting the superstructure and retaining the approach roadway backfill. These elements include piles, pile caps, piers, pier caps, footings, piles, drilled shafts, abutments (including breastwalls, bridge seats, and backwalls), wingwalls, columns, stemwalls, and cap beams. The substructure can be generalized as an abutment or pier/pier bent, which can be constructed of concrete, reinforced concrete, masonry, stone, steel, timber, or a combination of these materials.

7. REFERENCES

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-005, Personnel Qualifications.

7.1.3 FLD-OP-SC-002, Structure Segmentation and Element Identification System.

7.1.4 FLD-OP-SC-003, Determination of Local Origins for Elements.

7.1.5 FLD-DC-VIC-004 Concrete Superstructure and Substructure—Spalls and Delamination.

7.1.6 FLD-DC-VIC-005, Concrete—Cracking.

7.1.7 FLD-DC-VIC-006, Concrete—Abrasion.

7.1.8 FLD-DC-VIC-007, Concrete—Sulfate Attack.

7.1.9 FLD-DC-PH-002, Photographing for Documentation Purposes.

7.1.10 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.11 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*:

7.2.1 FHWA-NHI-12-053, Bridge Inspector's Reference Manual, Federal Highway Administration, Washington, DC, 2012.

Long-Term Bridge Performance Program

CONCRETE DECK— SPALLS AND DELAMINATION

LTBP Protocol #: FLD-DC-VIC-003

1. DATA COLLECTED

1.1 Description and location of spalls and delaminations on concrete deck.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

2.1.2 Ladder, access platform, snooper, bucket truck, man lift, and/or high-reach equipment (if necessary).

2.1.3 Chain or a series of medium weight chains attached to a T-shaped handle.

2.1.4 Sounding hammer.

2.1.5 Wire brush or hand broom.

2.1.6 Tape measure.

2.1.7 6-ft folding rule.

2.1.8 Measuring wheel.

2.1.9 Laser measuring device (optional).

2.1.10 Temporary marker.

2.1.11 Digital camera.

2.1.12 Pencil, sketch pad, and clipboard.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Use the data collection grid (FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks) to locate defects on the deck.

3.2 Cleaning:

3.2.1 Use the wire brush or hand broom to clean the concrete element by brushing away any debris so any defects are visible.

3.2.2 Remove, collect, and discard all concrete that is loose enough to move without fracturing additional surfaces.

3.3 Deck delamination survey:

3.3.1 Using a sweeping motion, pull the chain drag over approximately 3 ft of the concrete deck surface at a time, with only the chains dragging on the deck surface. Listen for the sound of ringing chains to change to a hollow, dull, popping sound as the chains go over the surface of a delamination.

3.3.2 Once the chain drag has detected a debonded area, determine the size and edges of the delamination by using a hand-held sounding hammer. Lightly tap the area where the hollow sound is heard, and work in a line.

3.3.3 Using a temporary marker, outline the boundary of each individual area of the deck surface where the hollow sound is heard. Add a hatch pattern to the area to clearly show the area on the deck in pictures. Mark the corners of a rectangle that encompasses the maximum length and maximum width of the area of spalling or delamination.

3.3.4 Measure and record the dimensions of each area of delamination or spalling at its maximum length and width.

3.3.5 For each area of delamination or spalling on the deck, determine and record the coordinates of the four corners of the rectangle using *x* and *y* coordinates from the rectangular grid system (FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks).

3.4 For each instance of exposed steel reinforcement and/or tendons or strands:

3.4.1 Using a temporary marker, outline the boundary of each individual area of the deck surface where the steel reinforcement and/or tendons or strands are exposed. Also, mark the corners of a rectangle that encompasses the maximum length and maximum width of the area of spalling or delamination.

3.4.2 Measure and record the dimensions of each area of exposed steel reinforcement and/or tendons or strands at its maximum length and width.

3.4.3 For each area of exposed steel reinforcement and/or tendons or strands on the deck, determine and record the coordinates of the four corners of the rectangle using *x* and *y* coordinates from the rectangular grid system (FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks).

3.4.4 Clean with a wire brush, and measure and record the amount of section loss in the exposed steel reinforcement and tendons or strands (if applicable). If necessary, obtain the original cross-section from the existing documentation for the bridge (PRE-ED-BD-001, Plans and Specifications for Bridge Design and Construction).

3.5 Documenting defects:

3.5.1 Take photographs of defects using FLD-DC-PH-002, Photographing for Documentation Purposes, and create a photo log.

3.5.2 Use sketches as needed to document spall and/or delamination and supplement the photographs.

3.6 Storing data, documents, and images:

3.6.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.6.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.7 Reporting: Transfer all metadata, data, documents, and images to FHWA, and/or upload all metadata, data, documents, and images into the Long-Term Bridge Performance (LTBP) Bridge Portal.

4. DATA COLLECTION TABLE

4.1 Table:

#	FIELD NAME	DATA TYPE	ACCURACY	UNIT	FIELD DESCRIPTION	ROW COLOR
1	State	Text			State Code, e.g., Virginia = VA	Green
2	NBI structure number	Text			Item 8, Structure Number from NBI Coding Guide	Green
3	Structure name	Text			Descriptive name for the bridge, e.g., Route 15 SB over I–66	Green
4	Protocol name	Text			Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text			First name(s) Last name(s)	Green
7	Date data were collected	Text	Exact date		mm/dd/yyyy	Green
FOR DELAMINATIONS AND SPALLS ON THE DECK						Pink
8	Location of defect: span number	Text			Example: Span 1; evaluate each span individually, and record data on each individual defect	Blue
9	Location of defect on the deck	Text			Describe the location of defect on the deck e.g., lane number, right or left shoulder	Yellow
10	Type of defect	Text			Delamination or Spall	Yellow
11	Location of corner 1	Number	1	in.	(*x*,*y*) coordinates of the four corners of a rectangle encompassing the deteriorated area	Yellow
12	Location of corner 2	Number	1	in.		Yellow
13	Location of corner 3	Number	1	in.		Yellow
14	Location of corner 4	Number	1	in.		Yellow
15	Maximum length defect	Number	1	in.	Measured parallel to the *x*-axis	Yellow
16	Maximum width of defect	Number	1	in.	Measured parallel to the *y*-axis	Yellow
17	Maximum depth of defect	Number	0.125	in.		Yellow
18	Defect photos and sketches	Number	0.125	in.	Document typical abraded areas with photos and/or sketches	Yellow
19	Comments	Text				Orange
FOR EXPOSED STEEL REINFORCEMENT AND/OR TENDONS/STRANDS						Pink
20	Location of defect: span number	Text			Example: Span 1; evaluate each span individually, and record data on each individual defect	Blue
21	Location of defect on the deck	Text			Describe the location of defect on the deck e.g., lane number, right or left shoulder	Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
22	Condition of reinforcement and/or prestressing strands or tendons	Text			Steel reinforcement and/or prestressing strands or tendons not exposed, Visible corroded section, Loss of section, and/or Other (specify under comments)	Yellow
23	Location of corner 1	Number	1	in.	(*x*,*y*) coordinates of the four corners of a rectangle encompassing the deteriorated area	Yellow
24	Location of corner 2	Number	1	in.		Yellow
25	Location of corner 3	Number	1	in.		Yellow
26	Location of corner 4	Number	1	in.		Yellow
27	Maximum length defect	Number	1	in.	Measured parallel to the *x*-axis	Yellow
28	Maximum width of defect	Number	1	in.	Measured parallel to the *y*-axis	Yellow
29	Maximum depth of defect	Number	0.125	in.		Yellow
30	Defect photos and sketches	Number	0.125	in.	Document typical abraded areas with photos and/or sketches	Yellow
31	Comments	Text				Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
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Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. Criteria for Data Validation

5.1 Compare measurements with measurements from previous inspections of the same structure to make sure that values make sense.

5.2 Compare measurements with photo documentation to make sure results shown in photos are consistent with items measured.

5.3 If an element's condition is improved when compared to the condition documented in a previous inspection, check with the State department of transportation to determine if any maintenance, repair, and/or bridge preservation actions have occurred. If so, document these maintenance, repair, and/or bridge preservation actions using appropriate protocols.

6. COMMENTARY/BACKGROUND

6.1 This protocol provides guidance on locating and measuring the extent of spalls and delaminations on concrete decks and for conducting a chain drag survey in which the sounds from chains dragged over a concrete surface are used to detect delaminations. A dull or hollow sound of the chain links indicates delaminated areas, and a clear ringing sound indicates nondelaminated concrete.

NOTE—Sounding may be more difficult in areas of significant traffic or other noises.

6.2 The chain drag is an easy and inexpensive method of locating delaminations on bridge decks. This procedure can require multiple technicians if the structure is long and/or has multiple lanes. Refer to ASTM D4580/D4580M-12, Standard Practice for Measuring Delaminations in Concrete Bridge Decks by Sounding, for further guidance on proper chain types and configurations.

6.3 A spall is a depression in concrete caused by a separation of a portion of the surface concrete, revealing a fracture parallel with or slightly inclined to the surface. A delamination is a surface separation of concrete into layers. Spalls and delaminations may have numerous and distinct causes on a structure, including the following:

6.3.1 Collisions.

6.3.2 Earthquakes.

6.3.3 Overstresses.

6.3.4 Alkali-silica reaction (ASR).

6.3.5 Reinforcement/prestressing corrosion.

6.3.6 Formation of ettringite.

6.3.7 Freeze-thaw cycling.

6.4 Spalls are identified by a loss of concrete material from the surface and may be several inches deep. A delamination might eventually result in a loss of material (i.e., become a spall). Both defects may change the structural performance of the component or expose reinforcement or prestressing tendons or strands to corrosive agents.

7. REFERENCES

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-005, Personnel Qualifications.

7.1.3 PRE-ED-BD-001, Plans and Specifications for Bridge Design and Construction.

7.1.4 FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks.

7.1.5 FLD-DC-PH-002, Photographing for Documentation Purposes.

7.1.6 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.7 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*:

7.2.1 Federal Highway Administration (FHWA)-NHI-12-053, Bridge Inspector's Reference Manual, Federal Highway Administration, Washington, DC, 2012.

7.2.2 ASTM D4580/D4580M-12, Standard Practice for Measuring Delaminations in Concrete Bridge Decks by Sounding, ASTM International, West Conshohocken, PA, 2012.

CONCRETE SUPERSTRUCTURE AND SUBSTRUCTURE—SPALLS AND DELAMINATIONS

LTBP Protocol #: FLD-DC-VIC-004

1. DATA COLLECTED

1.1 Description and location of spalls and delaminations on concrete superstructures and substructures.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

2.1.2 Ladder, access platform, snooper, bucket truck, man lift, and/or high-reach equipment (if necessary).

2.1.3 Sounding hammer.

2.1.4 Wire brush or hand broom.

2.1.5 Tape measure.

2.1.6 6-ft folding rule.

2.1.7 Caliper.

2.1.8 Waders or a boat (if necessary).

2.1.9 Laser measuring device (optional).

2.1.10 Temporary marker.

2.1.11 Digital camera.

2.1.12 Pencil, sketch pad, clipboard.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Use the segmentation and numbering system (FLD-OP-SC-002, Structure Segmentation and Element Identification System) to locate and document defects by the unique element identifier.

3.2 Use FLD-OP-SC-003, Determination of Local Origins for Elements, to establish a local origin on each element of the superstructure and substructure. Establish the two relevant coordinate axes for each face of each element being evaluated.

3.3 Cleaning: Use the wire brush or hand broom to clean the concrete element by brushing away any debris so any defects are visible.

3.4 Measuring, recording, and evaluating characteristics of spalls and delaminations:

3.4.1 For any suspected defect area, strike the concrete surface with a sounding hammer, and listen for any hollow sounding areas in concrete; remove any loose concrete.

3.4.2 Mark the limits of each area of delamination or spalling on the element with a temporary marker, and mark the corners of a rectangle that encompasses the maximum length and maximum width of the area of delamination or spalling.

3.4.3 Measure and record the dimensions of each area of delamination or spalling at its maximum length and width.

3.4.4 For each area of delamination or spalling on the element, document on which superstructure or substructure element (FLD-OP-SC-002, Structure Segmentation and Element Identification System) and on what area of the element the delamination or spalling is located. Using the element local origin as point (0,0,0), determine and record the coordinates of the four corners of the rectangle.

3.5 For each instance of exposed steel reinforcement and tendons or strands:

3.5.1 Record the type and unique element identifier of the element where the steel reinforcement and/or tendons or strands are exposed.

3.5.2 Mark the length of the exposed steel reinforcement and/or tendons or strands with a temporary marker, and photograph the damage.

3.5.3 Measure the length of the exposed steel reinforcement and/or tendons or strands.

3.5.4 Document the location of exposed steel reinforcement and/or tendons or strands by determining and recording the coordinates of the beginning and the end of the affected portion of the element.

3.5.5 Clean with a wire brush, and measure and record the amount of section loss in the exposed steel reinforcement and/or tendons or strands (if applicable). If necessary, obtain the original cross-section from the existing documentation for the bridge (PRE-ED-BD-001, Plans and Specifications for Bridge Design and Construction).

3.6 Documenting defects:

3.6.1 Take photographs of defects using FLD-DC-PH-002, Photographing for Documentation Purposes, and create a photo log.

3.6.2 Use sketches to document spalls and delaminations and supplement the photographs.

3.7 Storing data, documents, and images:

3.7.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.7.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.8 Reporting: Transfer all metadata, data, documents, and images to Federal Highway Administration (FHWA), and/or upload all metadata, data, documents, and images into the Long-Term Bridge Performance (LTBP) Bridge Portal.

4. DATA COLLECTION TABLE

4.1 Table:

#	FIELD NAME	DATA TYPE	ACCURACY	UNIT	FIELD DESCRIPTION	ROW COLOR
1	State	Text			State Code; e.g., Virginia = VA	Green
2	NBI structure number	Text			Item 8, structure number; from NBI Coding Guide	Green
3	Structure name	Text			Descriptive name for the bridge; e.g., Route 15 SB over I–66	Green
4	Protocol name	Text			Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text			First name(s) Last name(s)	Green
7	Date data were collected	Text	Exact date		mm/dd/yyyy	Green
FOR SPALLS AND DELAMINATIONS						Pink
8	Location of the defect: element type and identifier	Text			Example: Pier P1; evaluate each element individually and record data on each individual defect	Blue
9	Location of the defect on the element	Text			Example: top of pier cap	Yellow
10	Type of defect	Text			Delamination Spall	Yellow
11	Pair of coordinates used to locate the defect on element	Text			(*x*,*y*), (*x*,*z*), or (*y*,*z*)	Yellow
12	Location of corner 1	Number	1	in.	(*x*,*y*) coordinates of the four corners of a rectangle encompassing the deteriorated area	Yellow
13	Location of corner 2	Number	1	in.		Yellow
14	Location of corner 3	Number	1	in.		Yellow
15	Location of corner 4	Number	1	in.		Yellow
16	Maximum length of the defect	Number	1	in.		Yellow
17	Maximum width of the defect	Number	1	in.		Yellow
18	Maximum depth of the defect	Number	0.125	in.		Yellow
19	Defect photos and/or sketches	BLOB			Document typical defects with photos and/or sketches	Yellow
20	Comments	Text				Orange
FOR EXPOSED STEEL REINFORCEMENT AND/OR TENDONS/STRANDS						Pink
21	Location of the defect: element type and identifier	Text			Example: Girder 1A; evaluate each element individually and record data on each individual defect	Blue
22	Location of the defect on the element	Text			Example: bottom flange of girder	Yellow
23	Condition of reinforcement and/or prestressing strands or tendons	Text			Visible corroded section, Loss of section, and/or Other (specify under comments)	Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
24	Location of the beginning of the defect: *x*-coordinate	Number	1	in.	Measured from the element local origin to the beginning of the defect	Yellow
25	Location of the end of the defect: *x*-coordinate	Number	1	in.	Measured from the element local origin to the end of the defect	Yellow
26	Length of defect	Number	1	in.		Yellow
27	Defect photos	BLOB			Document typical defects with photos and/or sketches	Yellow
28	Comments	Text				Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. Criteria for Data Validation

5.1 Compare measurements with measurements from previous inspections of the same structure to make sure that values make sense.

5.2 Compare measurements with photo documentation to make sure results shown in photos are consistent with items measured.

5.3 If an element's condition is improved when compared to the condition documented in a previous inspection, check with the State department of transportation to determine if any maintenance, repair, and/or bridge preservation actions have occurred. If so, document these maintenance, repair, and/or bridge preservation actions using appropriate protocols.

6. Commentary/Background

6.1 This protocol provides guidance on locating and measuring the extent of spalls and delaminations on concrete superstructure and substructure elements.

6.2 A spall is a depression in concrete caused by a separation of a portion of the surface concrete, revealing a fracture parallel with or slightly inclined to the surface. A delamination is a surface separation of concrete into layers. Spalls and delaminations may have numerous and distinct causes, including the following:

6.2.1 Collisions.

6.2.2 Earthquakes.

6.2.3 Overstresses.

6.2.4 Alkali-silica reaction (ASR).

6.2.5 Reinforcement/prestressing corrosion.

6.2.6 Formation of ettringite.

6.2.7 Freeze-thaw cycling.

6.3 Spalls are identified by a loss of concrete material from the surface and may be several inches deep. A delamination might eventually result in a loss of material (i.e., become a spall). Both defects may change the structural performance of the component or expose reinforcement or prestressing tendons/strands to corrosive agents.

7. References

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-005, Personnel Qualifications.

7.1.3 PRE-ED-BD-001, Plans and Specifications for Bridge Design and Construction.

7.1.4 FLD-OP-SC-002, Structure Segmentation and Element Identification System.

7.1.5 FLD-OP-SC-003, Determination of Local Origins for Elements.

7.1.6 FLD-DC-PH-002, Photographing for Documentation Purposes.

7.1.7 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.8 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*:

7.2.1 FHWA-NHI-12-053, Bridge Inspector's Reference Manual, Federal Highway Administration, Washington, DC, 2012.

Long-Term Bridge Performance Program

CONCRETE—CRACKING

LTBP Protocol # FLD-DC-VIC-005

1. DATA COLLECTED

1.1 Description and location of cracking of concrete bridge elements, including the deck, superstructure, and substructure.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

2.1.2 Ladder, access platform, snooper, bucket truck, man lift, and/or high-reach equipment (if necessary).

2.1.3 Sounding hammer.

2.1.4 Crack comparison cards (gage).

2.1.5 Tape measure.

2.1.6 6-ft folding rule.

2.1.7 Measuring wheel.

2.1.8 Laser measuring device (optional).

2.1.9 Plumb bob.

2.1.10 Slide caliper.

2.1.11 Hand compass or other angle-measuring device.

2.1.12 Level.

2.1.13 Wire brush or hand broom.

2.1.14 Waders.

2.1.15 Small boat.

2.1.16 Temporary marker.

2.1.17 Digital camera.

2.1.18 Pencil, sketch pad, and clipboard.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications

3. METHODOLOGY

3.1 Use the data collection grid (FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks) to locate defects on the deck.

3.2 Use the segmentation and numbering system (FLD-OP-SC-002, Structure Segmentation and Element Identification System) to locate and document defects by unique element identifier.

3.3 Use FLD-OP-SC-003, Determination of Local Origins for Elements, to establish a local origin on each element on the superstructure and substructure.

3.4 Cleaning: Use the wire brush or hand broom to clean the concrete element by brushing away any debris so any cracks are visible.

3.5 On reinforced concrete elements, including decks, for individual cracks with a width equal to or greater than 0.025 inches at the point of the widest opening:

3.5.1 Mark the ends of the cracks on the bridge component with a temporary marker, and photograph.

3.5.2 If the crack is on the deck, record the location of the beginning and the end of each crack using (x,y) coordinates from the rectangular grid system following FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks. The database calculates the orientation of each crack using the (x,y) coordinates.

3.5.3 For cracks on other concrete components (other than round pier columns), document the unique element identifier of the superstructure or substructure element on which the crack is located. Use FLD-OP-SC-003, Determination of Local Origins for Elements, to establish a local origin on each element, and document the beginning and ending points of the crack using the (x,y,z) coordinates.

3.5.3.1 If the crack is on a round concrete pier column, using the local element origin as point (0,0), determine and record the (z,c) coordinates of the beginning and ending points of the crack.

3.5.4 Record the length of the crack (from one end to the other in a straight line) in decimal inches using the tape measure, measuring wheel, and/or laser measuring device.

3.5.5 Record the orientation of the crack (degrees) using a plump bob, compass, or other angle-measuring device.

3.5.6 Measure the maximum crack width (opening) with the crack comparison card (crack gage).

3.5.7 If possible, measure or estimate the maximum depth of the crack.

3.5.8 Identify and record other crack characteristics (if any), such as presence of moisture, efflorescence, rust, or exposed rebar.

3.5.9 In prestressed concrete bridge structural elements, if the crack exceeds the width of 0.005 inches, then the team leader should notify the bridge owner and Federal Highway Administration (FHWA) Long-Term Bridge Performance (LTBP) Program.

3.6 On prestressed concrete elements, for individual cracks with a width equal to or greater than 0.005 inches at the point of the widest opening:

3.6.1 Mark the ends of the cracks on the bridge component with a temporary marker, and photograph.

3.6.2 Document the unique element identifier of the element on which the crack is located. Use FLD-OP-SC-003, Determination of Local Origins for Elements, to establish a local origin on each element and document the beginning and ending points of the crack using the (x,y,z) coordinates.

3.6.3 Record the length of the crack (from one end to the other in a straight line) in decimal inches using the tape measure, measuring wheel, and/or laser measuring device.

3.6.4 Record the orientation of the crack (degrees) using a plump bob, compass, or other angle-measuring device.

3.6.5 Measure the maximum crack width (opening) with the crack comparison card (crack gage).

3.6.6 If possible, measure or estimate the maximum depth of the crack.

3.6.7 Identify and record other crack characteristics (if any), such as presence of moisture, efflorescence, rust, or exposed rebar.

3.6.8 In prestressed concrete bridge structural elements, if the crack exceeds the width of 0.006 inches, then the team leader should notify the bridge owner and FHWA LTBP.

3.7 For crack networks (also known as alligator cracking, area cracking, map cracking, or crazing):

3.7.1 Treat the area of cracking as a single defect in the same manner as area defects, such as scaling, delamination, etc.

3.7.2 Outline the boundaries of the network cracking on the concrete surface with a temporary marker and photograph it. Document all visible cracks with sketches and/or photographs (FLD-DC-PH-002, Photographing for Documentation Purposes) that capture the entire area. Also, mark the corners of a rectangle that encompasses the maximum length and maximum width of the area of network cracking.

3.7.3 Measure and record the dimensions of each area of network cracking at its maximum length and width.

3.7.3.1 If the area of network cracking is on the deck, determine and record the coordinates of the four corners of the rectangle using (*x*,*y*) coordinates from the rectangular grid system created using FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks.

3.7.3.2 For each area of network cracking on other concrete elements (other than round pier columns), document on which superstructure or substructure element and on what area of the element the area of network cracking is located. Using the element local origin as point (0,0,0), determine and record the (x,*y*,*z*) coordinates of the four corners of the rectangle.

3.7.3.3 If the area of network cracking is on a round concrete pier column, using the local element origin as point (0,0), determine and record the (*z*,*c*) coordinates of the four corners of the rectangle.

3.7.4 If possible, measure or estimate the maximum depth of the cracks.

3.7.5 Identify and record other crack characteristics (if any), such as presence of moisture, efflorescence, rust, or exposed rebar.

3.8 For areas that show signs of moisture or efflorescence:

3.8.1 Treat the area of moisture or efflorescence as a single defect in the same manner as area defects, such as scaling, delamination, etc.

3.8.2 Outline the boundaries of the moisture or efflorescence on the concrete surface with a temporary marker, and photograph it. Also, mark the corners of a rectangle that encompasses the maximum length and maximum width of the area of moisture or efflorescence.

3.8.3 Measure and record the dimensions of each area of moisture or efflorescence at its maximum length and width.

3.8.3.1 If the area of moisture or efflorescence is on the deck, determine and record the coordinates of the four corners of the rectangle using (*x*,*y*) coordinates from the rectangular grid system created using FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks.

3.8.3.2 For each area of moisture or efflorescence on other concrete elements (other than round pier columns), document which superstructure or substructure element and on what area of the element the area of network cracking is located. Using the element local origin as point (0,0,0), determine and record the (x,*y*,*z*) coordinates of the four corners of the rectangle.

3.8.3.3 If the area of moisture or efflorescence is on a round concrete pier column, using the local element origin as point (0,0), determine and record the (*z*,*c*) coordinates of the four corners of the rectangle.

3.9 Documenting defects:

3.9.1 Take photographs of cracking using FLD-DC-PH-002, Photographing for Documentation Purposes, and create a photo log.

3.9.2 Use sketches as needed to document cracking and supplement the photographs.

3.10 Storing data, documents, and images:

3.10.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.10.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.11 Reporting: Transfer all metadata, data, documents, and images to FHWA, and/or upload all metadata, data, documents, and images into the LTBP Bridge Portal.

4. DATA COLLECTION TABLE

4.1 Table:

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
1	State	Text			State Code, e.g., Virginia = VA	Green
2	NBI structure number	Text			Item 8, Structure Number from NBI Coding Guide	Green
3	Structure name	Text			Descriptive name for the bridge, e.g., Route 15 SB over I–66	Green
4	Protocol name	Text			Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text			First name(s) Last name(s)	Green
7	Date data were collected	Text	Exact date		mm/dd/yyyy	Green
For Individual Cracks on the Concrete Deck or Other Concrete Element						Pink
8	Location of crack: span number	Text			Evaluate each span individually and record data on each individual crack	Blue
9	Location of crack: element type and unique identifier	Text			Record the bridge element containing the crack (for example, deck, abutment, girder)	Blue
10	Location of crack on the deck or element	Text			Describe the location of crack on the bridge element (for example, lane number, right or left shoulder, substructure unit,	Blue

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
					backwall of abutment, web of prestressed concrete girder, etc.)	
11	Location of the beginning of the crack	Number	1	in.	On the deck: (*x*,*y*) coordinates of the ends of the crack On other concrete elements: (*x*,*y*,*z*) coordinates of the ends of the crack	Yellow
12	Location of the end of the crack	Number	1	in.		Yellow
13	Maximum crack depth	Number	0.125	in.	If measurable	Yellow
14	Maximum crack width (opening)	Number	See note	in.	Note: required accuracy depends on the maximum crack width; see section 6.4.3	Yellow
15	Crack length	Number	1	in.	Measured in a straight line from the beginning to the end of crack	Yellow
16	Crack orientation	Number	1	Degrees		Yellow
17	Other crack characteristics	Text			Indicate presence of moisture, efflorescence, rust, exposed rebar, or other (specify under comments)	Yellow
18	Photos or sketches of individual cracks	BLOB			Document each crack with photo(s) or sketch(es)	Yellow
19	Comments	Text				Orange
For Crack networks on the Concrete Deck or Other Concrete Element						Pink
20	Location of crack network: span number	Text			Evaluate each span individually and record data on each individual crack network	Blue
21	Location of crack network: element type and unique identifier	Text			Record the bridge element containing the crack network (for example, deck, abutment, girder)	Blue
22	Location of crack network on the deck or element	Text			Describe the location of crack network on the bridge element (e.g., lane number, right or left shoulder, substructure unit, backwall of abutment, web of prestressed concrete girder, etc.)	Blue
23	Location of corner 1	Number	1	in.	(*x*,*y*,*z*) coordinates of the four corners of a rectangle encompassing the deteriorated area	Yellow
24	Location of corner 2	Number	1	in.		Yellow
25	Location of corner 3	Number	1	in.		Yellow
26	Location of corner 4	Number	1	in.		Yellow
27	Maximum crack depth	Number	0.125	in.	If measurable	Yellow
28	Maximum crack width (opening)	Number	See note	in.	Note: required accuracy depends on the maximum crack width; see section 6.4.3	Yellow
29	Crack length	Number	1	in.	Maximum length (opening) of the longest continuous crack	Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
30	Other crack characteristics	Text			Indicate presence of moisture, efflorescence, rust, or other (specify under comments)	Yellow
31	Photos or sketches of typical crack networks	BLOB			Document typical crack networks with photos or sketches	Yellow
32	Comments	Text				Orange
For Areas of Moisture or Efflorescence on the Concrete Deck or Other Concrete Element						Pink
33	Location of moisture or efflorescence: span number	Text			Evaluate each span individually and record data on each individual area of moisture or efflorescence	Blue
34	Location of moisture or efflorescence: element type and unique identifier	Text			Record the bridge element containing the moisture or efflorescence (for example deck, abutment, girder)	Blue
35	Location of moisture or efflorescence on the deck or element	Text			Describe the location of moisture or efflorescence on the bridge element (e.g., lane number, right or left shoulder, substructure unit, backwall of abutment, web of prestressed concrete girder, etc.)	Blue
36	Location of corner 1	Number	1	in.	(*x*,*y*) coordinates of the four corners of a rectangle encompassing the deteriorated area	Yellow
37	Location of corner 2	Number	1	in.		Yellow
38	Location of corner 3	Number	1	in.		Yellow
39	Location of corner 4	Number	1	in.		Yellow
40	Photos or sketches of typical crack networks	BLOB			Document typical crack networks with photos or sketches	Yellow
41	Comments	Text				Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. Criteria for Data Validation

5.1 Compare measurements with measurements from previous inspections of the same structure to make sure that values make sense.

5.2 Compare measurements with photo documentation to make sure results shown in photos are consistent with items measured.

5.3 If an element's condition is improved when compared to the condition documented in a previous inspection, check with the State department of transportation to determine if any maintenance, repair, and/or bridge preservation actions have occurred. If so, document these maintenance, repair, and/or bridge preservation actions using appropriate protocols.

6. COMMENTARY/BACKGROUND

6.1 This protocol provides guidance on locating individual cracks as well as areas of map cracking on concrete elements. Instructions are provided for documenting the location, orientation, width, and depth (if possible) of individual cracks and the location and extent of areas of map cracking.

6.2 Cracks may be due to the following:

6.2.1 Chemical: alkali-silica reaction (ASR); internal or external sulphate attack.

6.2.2 Structural (live or dead loads).

6.2.3 Steel reinforcement or prestressing corrosion.

6.2.4 Creep or shrinkage.

6.2.5 Ground motion.

6.2.6 Collisions, earthquakes, or other sudden and external solicitations.

6.3 Cracks resulting from any of the conditions in section 6.2 may lead to significant damage and are important to the performance of the element that has cracked.

6.4 This protocol contains two different values for crack width—one value for reinforced concrete bridge members and a different value for prestressed concrete bridge members. Some States do not allow any tension in prestressed concrete bridge members (pretensioned and posttensioned). Therefore, even a small crack width in a prestressed concrete bridge member is important. States do allow some cracking in reinforced concrete bridge members, and designers assume that the rebars will carry the load in the areas of the member where tension cracks and rebars are present. Therefore, a somewhat larger crack width may be used for reinforced concrete bridge members.

6.4.1 For reinforced concrete elements, including decks, all cracks where the maximum width of the crack is 0.025 inches or greater will be measured and recorded.

6.4.2 For prestressed concrete bridge elements (pretensioned and posttensioned), all cracks where the maximum width of the crack is 0.005 inches or greater will be measured and recorded.

6.4.3 The required accuracy of the crack width measurement will vary according to the maximum width of the crack. This measurement is to be made with a typical crack gage card as follows:

6.4.3.1 Crack widths less than 0.020 inches – required accuracy is to the nearest 0.002 inches.

6.4.3.2 Crack widths above 0.020 inches but below 0.040 inches – required accuracy is to the nearest 0.005 inches.

6.4.3.3 Crack widths above 0.040 inches but below 1.00 inches – required accuracy is to the nearest 0.01 inches.

6.5 The LTBP Program is trying to better understand why bridges deteriorate over time, and the accurate measurement of crack widths is important for research purposes. Because of this, it is important to measure and track the locations, orientations (angles), and widths of cracks over time with sufficient scale to assist in evaluating the performance of concrete elements.

6.6 The presence of moisture in a concrete component is typically the result of cracks in the concrete wide enough to allow water to follow a path for the full thickness of the component. Efflorescence is the result of moisture passing through concrete that leaves light-colored or brown deposits on the concrete surface where the moisture exits. The deposits are formed by a combination of the calcium carbonate leaching out of the cement and the recrystallization of carbonate and chloride compounds. The following are typical locations to look for signs of water infiltration with efflorescence:

6.6.1 Bare deck undersides.

6.6.2 Superstructure: headwalls and spandrel walls.

6.6.3 Substructure: abutment breastwalls, backwalls, and wingwalls.

6.7 This evaluation requires that the inspector has arm's-length access to every part of the structure (arm's-length access is the generally admitted distance from which cracks of this size are detectable).

7. References

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-005, Personnel Qualifications.

7.1.3 FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks.

7.1.4 FLD-OP-SC-002, Structure Segmentation and Segmentation and Element System.

7.1.5 FLD-OP-SC-003, Determination of Local Origins for Elements.

7.1.6 FLD-DC-PH-002, Photographing for Documentation Purposes.

7.1.7 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.8 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*:

7.2.1 FHWA-NHI-12-053, Bridge Inspector's Reference Manual, Federal Highway Administration, Washington, DC, 2012.

Long-Term Bridge Performance Program

CONCRETE—ABRASION

LTBP Protocol #: FLD-DC-VIC-006

1. DATA COLLECTED

1.1 Description and location of abrasion damage on concrete bridge elements.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

2.1.2 Ladder, access platform, snooper, bucket truck, man lift, and/or high-reach equipment (if necessary).

2.1.3 Waders or a boat (if necessary).

2.1.4 Sounding hammer.

2.1.5 Wire brush or hand broom.

2.1.6 Tape measure.

2.1.7 6-ft folding rule.

2.1.8 Measuring wheel.

2.1.9 Laser measuring device (optional).

2.1.10 Slide caliper.

2.1.11 Temporary marker.

2.1.12 Digital camera.

2.1.13 Pencil, sketch pad, and clipboard.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Use the data collection grid (FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks) to locate defects on the deck.

3.2 Use the segmentation and numbering system (FLD-OP-SC-002, Structure Segmentation and Element Identification System) to locate and document defects by the unique element identifier.

3.3 Use FLD-OP-SC-003, Determination of Local Origins for Elements, to establish a local origin on each element of the superstructure and substructure. Establish the two relevant coordinate axes for each face of each element being evaluated.

3.4 Cleaning: Use the wire brush or hand broom to clean the concrete element by brushing away any debris so any defects are visible.

3.5 Measuring, recording, and evaluating characteristics of abraded areas of the concrete

3.5.1 Mark the limits of each abraded area on the element with a temporary marker, and mark the corners of a rectangle that encompasses the maximum length and maximum width of the area of the abraded area.

3.5.2 Measure and record the dimensions of each abraded area at its maximum length and width.

3.5.2.1 If the abraded area is on the deck, determine and record the coordinates of the four corners of the rectangle using *x*-, *y*-, and *z*-coordinates from the rectangular grid system created using FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks.

3.5.2.2 For each abraded area on other concrete elements, document which superstructure or substructure element and on what area of the element the sulfate attack is located. Using the element local origin as point (0,0,0), determine and record the coordinates of the four corners of the rectangle.

3.5.3 For each instance of exposed steel reinforcement and/or tendons or strands:

3.5.3.1 Record the type and unique element identifier of the superstructure element where the steel reinforcement and/or tendons or strands are exposed.

3.5.3.2 Mark the length of the exposed steel reinforcement and tendons or strands with a temporary marker and photograph the damage.

3.5.3.3 Measure the length of the exposed steel reinforcement and/or tendons or strands.

3.5.4 Document the location of exposed steel reinforcement and/or tendons or strands by determining and recording the coordinates of the beginning and the end of the affected portion of the element.

3.5.5 Clean with a wire brush, and measure and record the amount of section loss in the exposed steel reinforcement and/or tendons or strands (if applicable). If necessary, the original cross-section can be obtained from the existing documentation for the bridge (PRE-ED-BD-001, Plans and Specifications for Bridge Design and Construction).

3.6 Documenting defects:

3.6.1 Take photographs of defects using FLD-DC-PH-002, Photographing for Documentation Purposes, and create a photo log.

3.6.2 Use sketches as needed to document abrasion and supplement the photographs.

3.7 Storing data, documents, and images:

3.7.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.7.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.8 Reporting: Transfer all metadata, data, documents, and images to Federal Highway Administration (FHWA), and/or upload all metadata, data, documents, and images into the Long-Term Bridge Performance (LTBP) Bridge Portal.

4. DATA COLLECTION TABLE

4.1 Table:

#	FIELD NAME	DATA TYPE	ACCURACY	UNIT	FIELD DESCRIPTION	ROW COLOR
1	State	Text			State Code; e.g., Virginia = VA	Green
2	NBI structure number	Text			Item 8, structure number; from NBI Coding Guide	Green
3	Structure name	Text			Descriptive name for the bridge; e.g., Route 15 SB over I–66	Green
4	Protocol name	Text			Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text			First name(s) Last name(s)	Green
7	Date data were collected	Text	Exact date		mm/dd/yyyy	Green
FOR ABRADED AREAS ON THE DECK						Pink
8	Location of defect: span number	Text			Example: Span 1; evaluate each span individually and record data on each individual defect	Blue
9	Location of defect on the deck	Text			Describe the location of defect on the deck e.g., lane number, right or left shoulder	Yellow
10	Location of corner 1	Number	1	in.	(*x*,*y*) coordinates of the four corners of a rectangle encompassing the deteriorated area	Yellow
11	Location of corner 2	Number	1	in.		Yellow
12	Location of corner 3	Number	1	in.		Yellow
13	Location of corner 4	Number	1	in.		Yellow
14	Maximum length defect	Number	1	in.	Measured parallel to the *x*-axis	Yellow
15	Maximum width of defect	Number	1	in.	Measured parallel to the *y*-axis	Yellow
16	Maximum depth of defect	Number	0.125	in.		Yellow
17	Defect photos and sketches	Number	0.125	in.	Document typical abraded areas with photos and/or sketches	Yellow
18	Comments	Text				Orange
FOR ABRADED AREAS ON A SUPERSTRUCTURE OR SUBSTRUCTURE ELEMENT						Pink
19	Location of the defect: element type and identifier	Text			Example: Pier column P1A; evaluate each element individually and record data on each individual defect	Blue
20	Location of the defect on the element	Text			Example: upstream face of the column	Yellow
21	Location of corner 1	Number	1	in.	(*x*,*y*,*z*) coordinates of the four corners of a rectangle encompassing the deteriorated area	Yellow
22	Location of corner 2	Number	1	in.		Yellow
23	Location of corner 3	Number	1	in.		Yellow
24	Location of corner 4	Number	1	in.		Yellow
25	Maximum length of the defect	Number	1	in.		Yellow
26	Maximum width of the defect	Number	1	in.		Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
27	Maximum depth of the defect	Number	0.125	in.		Yellow
28	Defect photos and sketches	BLOB			Document typical corroded areas with photos and/or sketches	Yellow
29	Comments	Text				Orange
For Exposed Steel Reinforcement and/or Tendons/Strands						Pink
30	Location of the defect: element type and identifier	Text			Example: Girder 1A: evaluate each element individually and record data on each individual defect	Blue
31	Location of the defect on the element	Text			Example: bottom flange of the girder	Yellow
32	Condition of reinforcement and/or prestressing strands/tendons	Text			Steel reinforcement and/or prestressing strands or tendons not exposed, Visible corroded section, Loss of section, and/or Other (specify under comments)	Yellow
33	Location of the beginning of the defect: *x*-coordinate	Number	1	in.	Measured from the element local origin to the beginning of the defect	Yellow
34	Location of the end of the defect: *x*-coordinate	Number	1	in.	Measured from the element local origin to the end of the defect	Yellow
35	Length of defect	Number	1	in.		Yellow
36	Defect photos and sketches	BLOB			Document typical defects with photos and/or sketches	Yellow
37	Comments	Text				Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. Criteria for Data Validation

5.1 Compare measurements with measurements from previous inspections of the same structure to make sure that values make sense.

5.2 Compare measurements with photo documentation to make sure results shown in photos are consistent with items measured.

5.3 If an element's condition is improved when compared to the condition documented in a previous inspection, check with the State department of transportation to determine if any maintenance, repair, and/or bridge preservation actions have occurred. If so, document these maintenance, repair, and/or bridge preservation actions using appropriate protocols.

6. COMMENTARY/BACKGROUND

6.1 This protocol guides visual inspection of the damage caused by abrasion.

6.2 Abrasions are often found on substructure elements in the waterway within the wet zone. This abrasion is due to debris, transported by the flow of water, striking or grinding against the concrete surface. Concrete superstructures may see abrasion in cases where low freeboard exists over tidal waterways.

6.3 Concrete surfaces abraded by waterborne debris are typically rough and may contain localized depressions that sometimes expose the reinforcing steel.

6.4 Mechanical abrasion consists of a progressive removal of aggregates and matrix on concrete surfaces, caused by debris or rolling and grinding against a concrete surface.

6.5 During the visual inspection, if reinforcing steel is visible, observe and notate corrosion and section loss. A visual inspection of concrete substructure elements below the waterline may be needed.

7. REFERENCES

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-005, Personnel Qualifications.

7.1.3 PRE-ED-BD-001, Plans and Specifications for Bridge Design and Construction.

7.1.4 FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks.

7.1.5 FLD-OP-SC-002, Structure Segmentation and Element Identification System.

7.1.6 FLD-OP-SC-003, Determination of Local Origins for Elements.

7.1.7 FLD-DC-PH-002, Photographing for Documentation Purposes.

7.1.8 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.9 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*:

7.2.1 FHWA-NHI-12-053, Bridge Inspector's Reference Manual, Federal Highway Administration, Washington, DC, 2012.

CONCRETE—SULFATE ATTACK

LTBP Protocol #: FLD-DC-VIC-007

1. DATA COLLECTED

1.1 Description and location of areas affected by sulfate attack on concrete bridge elements.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

2.1.2 Ladder, access platform, snooper, bucket truck, man lift, and/or high-reach equipment (if necessary).

2.1.3 Tape measure.

2.1.4 6-ft folding rule.

2.1.5 Sounding hammer.

2.1.6 Wire brush or hand brush.

2.1.7 Crack comparison card (gage).

2.1.8 Measuring wheel.

2.1.9 Waders or a boat (if necessary).

2.1.10 Slide caliper.

2.1.11 Laser measuring device (optional).

2.1.12 Temporary marker.

2.1.13 Digital camera.

2.1.14 Pencil, pad, and clipboard.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Use the data collection grid (FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks) to locate defects on the deck.

3.2 Use the segmentation and numbering system (FLD-OP-SC-002, Structure Segmentation and Element Identification System) to locate and document defects by the unique element identifier. Establish the two relevant coordinate axes for each face of each element being evaluated.

3.3 Use FLD-OP-SC-003, Determination of Local Origins for Elements, to establish a local origin on each element of the superstructure and substructure.

3.4 Cleaning: Use the wire brush or hand broom to clean the concrete element by brushing away any debris so that any defects are visible.

3.5 Identification: Identify probable sulfate attack through visual inspection.

3.6 Measuring, recording, and evaluating characteristics of areas of the concrete exhibiting signs of sulfate attack:

3.6.1 For each area of suspected sulfate attack, strike the concrete surface with a sounding hammer and remove any concrete that is loose. Measure and record each spall and/or delamination following FLD-DC-VIC-003, Concrete Deck—Spalls and Delamination, or FLD-DC-VIC-004, Concrete Superstructure and Substructure—Spalls and Delamination.

3.6.2 Mark the limits of each area of suspected sulfate attack on the element with a temporary marker and mark the corners of a rectangle that encompasses the maximum length and maximum width of the area of suspected sulfate attack.

3.6.3 Measure and record the dimensions of each area of suspected sulfate attack at its maximum length and width.

3.6.3.1 If the area of suspected sulfate attack is on the deck, determine and record the coordinates of the four corners of the rectangle using *x* and *y* coordinates from the rectangular grid system created using FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks.

3.6.3.2 For each area of suspected sulfate attack on other concrete elements, document on which superstructure or substructure element and on what area of the element the sulfate attack is located. Using the element local origin as point (0,0,0), determine and record the coordinates of the four corners of the rectangle.

3.6.4 Measure and record any cracks following FLD-DC-VIC-005, Concrete—Cracking.

3.7 For each instance of exposed steel reinforcement and tendons or strands:

3.7.1 Record the type and unique element identifier of the superstructure element where the steel reinforcement and/or tendons or strands are exposed.

3.7.2 Mark the length of the exposed steel reinforcement and tendons or strands with a temporary marker and photograph the damage.

3.7.3 Measure the length of the exposed steel reinforcement and/or tendons or strands.

3.7.4 Document the location of exposed steel reinforcement and tendons or strands by determining and recording the coordinates of the beginning and the end of the affected portion of the element.

3.7.5 Clean with a wire brush, and measure and record the amount of section loss in the exposed steel reinforcement and/or tendons or strands (if applicable). If necessary, obtain the original cross-section from the existing documentation for the bridge (PRE-ED-BD-001, Plans and Specifications for Bridge Design and Construction).

3.8 Documenting defects:

3.8.1 Take photographs of defects using FLD-DC-PH-002, Photographing for Documentation Purposes, and create a photo log.

3.8.2 Use sketches as needed to document spalls and delaminations and supplement the photographs.

3.9 Storing data, documents, and images:

3.9.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.9.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.10 Reporting: Transfer all metadata, data, documents, and images to Federal Highway Administration (FHWA), and/or upload all metadata, data, documents, and images into the Long-Term Bridge Performance (LTBP) Bridge Portal.

4. DATA COLLECTION TABLE

4.1 Table:

#	FIELD NAME	DATA TYPE	ACCURACY	UNIT	FIELD DESCRIPTION	ROW COLOR
1	State	Text			State Code; e.g., Virginia = VA	Green
2	NBI structure number	Text			Item 8, structure number; from NBI Coding Guide	Green
3	Structure name	Text			Descriptive name for the bridge; e.g., Route 15 SB over I–66	Green
4	Protocol name	Text			Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text			First name(s) Last name(s)	Green
7	Date data were collected	Text	Exact date		mm/dd/yyyy	Green
FOR SULFATE ATTACK ON THE DECK						Pink
8	Location of defect: span number	Text			Example: Span 1; evaluate each span individually and record data on each individual defect	Blue
9	Location of defect on the deck	Text			Describe the location of defect on the deck (e.g., lane number, right or left shoulder)	Yellow
10	Location of corner 1	Number	1	in.	(*x*,*y*) coordinates of the four corners of a rectangle encompassing the deteriorated area	Yellow
11	Location of corner 2	Number	1	in.		Yellow
12	Location of corner 3	Number	1	in.		Yellow
13	Location of corner 4	Number	1	in.		Yellow
14	Maximum length defect	Number	1	in.	Measured parallel to the *x*-axis	Yellow
15	Maximum width of defect	Number	1	in.	Measured parallel to the *y*-axis	Yellow
16	Defect characteristics	List			Spalls Concrete crazing Microcracking Concrete swelling Efflorescence Concrete friability Other (specify under comments)	Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
17	Defect photos and sketches	BLOB			Document typical corroded areas with photos and/or sketches	Yellow
18	Comments	Text				Orange
For Sulfate Attack on a Superstructure or Substructure Element						Pink
19	Location of the defect: element type and identifier	Text			Example: Girder 1A; evaluate each element individually and record data on each individual defect data on each individual defect	Blue
20	Location of the defect on the element	Text			Example: bottom flange of girder	Yellow
21	Pair of coordinates used to locate the defect on element	Text			(*x*,*y*), (*x*,*z*), or (*y*,*z*)	Yellow
22	Location of corner 1	Number	1	in.	(*x*,*y*) coordinates of the four corners of a rectangle encompassing the deteriorated area	Yellow
23	Location of corner 2	Number	1	in.		Yellow
24	Location of corner 3	Number	1	in.		Yellow
25	Location of corner 4	Number	1	in.		Yellow
26	Maximum length of the defect	Number	1	in.		Yellow
27	Maximum width of the defect	Number	1	in.		Yellow
28	Defect characteristics	List			Spalls Concrete crazing Microcracking Concrete swelling Efflorescence Concrete friability Other (specify under comments)	Yellow
29	Defect photos and sketches	BLOB			Document typical corroded areas with photos and/or sketches	Yellow
30	Comments	Text				Orange
For Exposed Steel Reinforcement and/or Tendons/Strands						Pink
31	Location of the defect: element type and identifier	Text			Example: Girder 1A; evaluate each element individually and record data on each individual defect data on each individual defect	Blue
32	Location of the defect on the element	Text			Example: bottom flange of girder	Blue
33	Condition of reinforcement and/or prestressing strands/tendons	Text			Reinforcement and/or prestressing strands or tendons not exposed Visibly corroded section Loss of section Other (specify under comments)	Yellow
34	Location of the beginning of the defect: *x*-coordinate	Number	1	in.	Measured from the element local origin to the beginning of the defect	Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
35	Location of the end of the defect: *x*-coordinate	Number	1	in.	Measured from the element local origin to the end of the defect	Yellow
36	Length of impact damage	Number	1	in.		Yellow
37	Defect photos and sketches	BLOB			Document typical defects with photos and/or sketches	Yellow
38	Comments	Text				Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. Criteria for Data Validation

5.1 Compare measurements with measurements from previous inspections of the same structure to make sure that values make sense.

5.2 Compare measurements with photo documentation to make sure results shown in photos are consistent with items measured.

5.3 If an element's condition is improved when compared to the condition documented in a previous inspection, check with the State department of transportation to determine if any maintenance, repair, and/or bridge preservation actions have occurred. If so, document these maintenance, repair, and/or bridge preservation actions using appropriate protocols.

6. Commentary/Background

6.1 This protocol provides guidance for identifying, locating, and measuring the extent of sulfate attack.

6.2 External sulfate attack is the most common type of distress and typically occurs where water containing dissolved sulfate penetrates the concrete. Consequences include extensive cracking, expansion of concrete, loss of bond between the cement paste and aggregate, alteration of paste composition with ettringite formation, and, in later stages, gypsum formation. The effect of these changes is an overall loss of concrete strength.

External sources of sulfate that can cause sulfate attack include seawater, oxidation of sulfide minerals in clay adjacent to the concrete (sulfuric acid formation), and bacterial action in sewers (sulfur dioxide then sulfuric acid formation).

6.3 Internal sulfate attack occurs when a source of sulfate is incorporated into the concrete mix. Examples include using sulfate-rich aggregate, an excess of gypsum in the cement, or contamination. External sulfate attack can come from sulfates present in the soil or in the water. See PRE-ED-BD-002, Bridge Construction Records, for mix design properties.

6.4 Delayed ettringite formation (DEF) is a special case of internal sulfate attack and occurs in concrete that has been cured at elevated temperatures. DEF requires wet conditions to occur, causes expansion of the concrete due to ettringite formation within the paste, and can cause serious damage. If DEF is suspected, check curing records to see if the internal curing temperature of the concrete member ever exceeded 150 °F (PRE-ED-BD-002, Bridge Construction Records).

6.5 Thaumasite sulfate attack (TSA) can form in concrete and in mortar. The cement hydration products normally present are decomposed as a result of both sulfate attack and of carbonation. Thaumasite typically forms at temperatures between 39 °F and 50 °F and results in severe weakening. As it forms, the concrete or mortar converts to a friable material often described as a "mush." Concrete severely affected by thaumasite formation is easily broken with the fingers, and the coarse aggregate can be lifted out.

7. References

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-005, Personnel Qualifications.

7.1.3 PRE-ED-BD-002, Bridge Construction Records.

7.1.4 FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks.

7.1.5 FLD-OP-SC-002, Structure Segmentation and Element Identification System.

7.1.6 FLD-OP-SC-003, Determination of Local Origins for Elements.

7.1.7 FLD-DC-VIC-003, Concrete Deck—Spalls and Delamination.

7.1.8 FLD-DC-VIC-004, Concrete Superstructure and Substructure—Spalls and Delamination.

7.1.9 FLD-DC-VIC-005, Concrete—Cracking.

7.1.10 FLD-DC-PH-002, Photographing for Documentation Purposes.

7.1.11 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.12 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*:

7.2.1 FHWA-NHI-12-053, Bridge Inspector's Reference Manual, Federal Highway Administration, Washington, DC, 2012.

VISUAL INSPECTION—BEARINGS PROTOCOLS (VIB)

FLD-DC-VIB-001, Elastomeric Bearings

FLD-DC-VIB-002, Rocker Bearings

Long-Term Bridge Performance Program

ELASTOMERIC BEARINGS

LTBP Protocol #: FLD-DC-VIB-001

1. DATA COLLECTED

1.1 General condition of elastomeric bearings and surrounding components, including:

1.1.1 Bulging, splitting, and/or tearing of the neoprene pad.

1.1.2 Condition of the steel reinforcing plates (if visible) if the bearing is a laminated neoprene pad.

1.1.3 Longitudinal/lateral displacements and rotation of the neoprene pad.

1.1.4 Excessive strain due to growth in the lengths and widths of unlaminated (plain) neoprene pads.

1.1.5 Connections between the neoprene pad and the sole plate and masonry plate, between the sole plate and the beam bottom flange, and between the masonry plate and the pier or abutment.

1.1.6 Cracking, spalls, or delaminations in the abutment seat or pier cap.

1.1.7 Condition of the anchor bolts.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

2.1.2 Ladder, access platform, snooper, bucket truck, man lift, and/or high-reach equipment (if necessary).

2.1.3 Wire brush or hand broom.

2.1.4 Tape measure.

2.1.5 6-ft folding rule.

2.1.6 Crack gage.

2.1.7 Slide caliper.

2.1.8 Digital level.

2.1.9 Plumb bob.

2.1.10 Laser measuring device (optional).

2.1.11 Hand compass or other angle-measuring device.

2.1.12 Thermometer.

2.1.13 Mirror.

2.1.14 Temporary marker.

2.1.15 Digital camera.

2.1.16 Pencil, sketch pad, and clipboard.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Use the segmentation and numbering system for the superstructure (FLD-OP-SC-002, Structure Segmentation and Element Identification System) to identify the bearings being evaluated.

3.2 Measuring, recording, and evaluating characteristics of bearings:

3.2.1 Record the ambient temperatures above the deck and at the location of the bearing at the time of visual inspection.

3.2.2 Record if the bearing is a fixed or a moveable bearing. Examine the bearing. If it is a moveable bearing, does it still allow movement?

3.2.3 Record if the bearing is still in its proper alignment.

3.3 Measuring, recording, and evaluating characteristics of neoprene:

3.3.1 Use a wire brush or hand broom to clean the bearing area to allow close visual inspection.

3.3.2 Record if the elastomeric bearing is a plain neoprene pad or a laminated neoprene pad.

3.3.3 Measure bearing thickness, length and width, and any longitudinal and lateral displacements or rotations.

3.3.4 Examine the neoprene pad (plain or laminated) for defects on contact surfaces, bulging and split or torn surfaces, and excessive longitudinal and/or lateral displacements and rotations.

3.3.4.1 If there are splits or tears in the neoprene, check for steel shim exposure and condition, if exposed.

3.3.4.2 If there are splits in the neoprene, measure the length, width, and depth of each split.

3.3.4.3 If there is bulging, measure the amount of bulge using the slide caliper.

3.3.4.4 To determine rotation, measure the displacement of the top of the bearing face versus the bottom of the bearing face.

3.3.4.5 Use a mirror, if necessary, to examine the vertical surface of the bearing closest to the abutment backwall.

3.3.5 Is there a restraining device to keep the neoprene pad from moving horizontally from its original position? If so, record it and take a photograph of a typical restraining device.

3.4 Measuring, recording, and evaluating characteristics of the sole plate:

3.4.1 Examine the connection of the sole plate to the girder. Record any loss of bond and connection between the sole plate and the girder.

3.4.2 Examine the sole plate, and record any cracks, corrosion, and/or section loss of the sole plate.

3.5 Measuring, recording, and evaluating characteristics of the masonry plate:

3.5.1 Examine the connection of the masonry plate to the bearing device and the masonry plate to the abutment or pier. Record any loss of connection.

3.5.2 Examine the masonry plate, and record any cracks, corrosion, and/or loss of section.

3.6 Measuring, recording, and evaluating characteristics of the anchor bolt:

3.6.1 Examine the anchor bolts connecting the masonry plate to the pier or abutment. Record the diameter of the bolts.

3.6.2 Record any missing bolts, nuts, or washers.

3.6.3 Record any rust or corrosion of the bolts.

3.6.4 Examine the concrete around the anchor bolt and record if any part of the main body (shank) of the anchor bolt is exposed.

3.7 Measuring, recording, and evaluating characteristics of concrete surface (under and next to the bearing):

3.7.1 Check the condition of the concrete surfaces under and next to the bearing and record any defects.

3.7.2 Check for spalls and/or cracks in the pier or abutment top surface.

3.8 Documenting defects:

3.8.1 Take photographs of defects using FLD-DC-PH-002, Photographing for Documentation Purposes, and create a photo log.

3.8.2 Use sketches to document spalls and cracking and supplement the photographs.

3.9 Storing data, documents, and images:

3.9.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.9.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.10 Reporting: Transfer all metadata, data, documents, and images to Federal Highway Administration (FHWA), and/or upload all metadata, data, documents, and images into the Long-Term Bridge Performance (LTBP) Bridge Portal.

4. DATA COLLECTION TABLE

4.1 Table:

#	FIELD NAME	DATA TYPE	ACCURACY	UNIT	FIELD DESCRIPTION	ROW COLOR
1	State	Text			State Code, e.g., Virginia = VA	Green
2	NBI structure number	Text			Item 8, Structure Number from NBI Coding Guide	Green
3	Structure name	Text			Descriptive name for the bridge, e.g., Route 15 SB over I–66	Green
4	Protocol name	Text			Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text			First name(s) Last name(s)	Green
7	Date data were collected	Text	Exact Date		mm/dd/yyyy	Green
8	Ambient temperature above deck	Number	1	°F		Green
9	Bearing number	Text			Evaluate and record data for each individual bearing	Blue
10	Ambient temperature at bearing location	Number	1	°F		Yellow
11	Is the bearing fixed or moveable?	Predefined list			Fixed or Movable	Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
12	If it is a moveable bearing, does it still allow movement?	Predefined list			Yes, No, or Not Applicable	Yellow
13	Is the bearing still in its proper alignment?	Predefined list			Yes or No	Yellow
14	Is bearing plain neoprene pad or a laminated neoprene pad?	Predefined list			Plain or laminated	Yellow
15	Neoprene condition	Text			Indicate no visible defects or document the presence of splits or tears, bulging, steel shim (plate) exposure, corroded shims (steel plates), presence of oxidation, and/or other defect (specify under comments)	Yellow
16	Sole plate connection to girder—surface bond condition	Text			Indicate no visible defects or document the presence of bond or no bond, movement of sole plate, and/or other defect (specify under comments)	Yellow
17	Sole plate condition	Text			Record any corrosion or section loss	Yellow
18	Masonry plate connection to the abutment or pier	Text			Record any loss of connection	Yellow
19	Masonry plate condition	Text			Record any corrosion or section loss	Yellow
20	Diameter of anchor bolts	Number	0.125	in.		Yellow
21	Condition of the anchor bolts	Text			Record any missing bolts, nuts, or washers; any rust or corrosion of the bolts; if the anchor bolt is partially exposed	Yellow
22	Condition of the concrete under and next to the bearing	Text			Indicate no visible defects or document the presence of shear cracks, spalling, on abutment seat or pier cap, and/or other defect (specify under comments)	Yellow
23	Rotation of neoprene pad	Number	1	Degrees		Yellow
24	Longitudinal displacement of neoprene pad	Number	0.125	in.		Yellow
25	Lateral displacement of neoprene pad	Number	0.125	in.		Yellow
26	Length of neoprene pad	Number	0.125	in.		Yellow
27	Width of neoprene pad	Number	0.125	in.		Yellow
28	Height (thickness) measurement of pad	Number	0.125	in.		Yellow
29	Defect photos	BLOB				Yellow
30	Comments	Text				Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. Criteria for Data Validation

5.1 Compare measurements with measurements from previous inspections of the same structure to make sure that values make sense.

5.2 Compare measurements with photo documentation to make sure results shown in photos are consistent with items measured.

5.3 If an element's condition is improved when compared to the condition documented in a previous inspection, check with the State department of transportation to determine if any maintenance, repair, and/or bridge preservation actions have occurred. If so, document these maintenance, repair, and/or bridge preservation actions using appropriate protocols.

6. Commentary/Background

6.1 This protocol provides guidance on evaluating the condition of elastomeric bearings and for collecting data that help determine if the bearing is functioning as intended.

6.2 Elastomeric bearings are either reinforced (laminated) or nonreinforced (unlaminated). Steel plates (shims) are used as the reinforcing material in the rubber (neoprene) pad.

6.3 Sole plates are attached to the underside of bridge girders and transfer the force from the bridge girder to the bearing device.

6.4 The bearing device sits on top of a masonry plate. Masonry plates are attached to piers and abutments and transfer the force from the bearing device to the pier or abutment.

6.5 Anchor bolts are used to attach the masonry plate to the pier or abutment. The body of an anchor bolt (shank) should not be visible. Only the head of the anchor bolt, a nut, and a washer should be visible. If the body (shank) of the anchor bolt is visible, then the anchor bolts are said to be exposed.

7. References

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-005, Personnel Qualifications.

7.1.3 FLD-OP-SC-002, Structure Segmentation and Element Identification System.

7.1.4 FLD-DC-PH-002, Photographing for Documentation Purposes.

7.1.5 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.6 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*:

7.2.1 FHWA. (2012). Bridge Inspector's Reference Manual – Report No. FHWA-NHI-12-053, Federal Highway Administration, Washington, DC.

ROCKER BEARINGS

LTBP Protocol #: FLD-DC-VIB-002

1. DATA COLLECTED

1.1 General condition of rocker bearings and surrounding components, including:

1.1.1 Longitudinal/lateral shift of rockers.

1.1.2 Excessive rotation of rockers.

1.1.3 Proper seating and uplifting of rockers and girders.

1.1.4 Exposed pintles.

1.1.5 Missing nuts.

1.1.6 Condition of the anchor bolts.

1.1.7 Corrosion and pack rust between rockers and masonry plates; corrosion of other bearing parts.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

2.1.2 Ladder, access platform, snooper, bucket truck, man lift, and/or high-reach equipment (if necessary).

2.1.3 Wire brush or hand broom.

2.1.4 Tape measure.

2.1.5 6-ft folding rule.

2.1.6 Crack gage.

2.1.7 Digital level.

2.1.8 Thermometer.

2.1.9 Mirror.

2.1.10 Plumb bob.

2.1.11 Laser measuring device (optional).

2.1.12 Hand compass or other angle-measuring device.

2.1.13 Temporary marker.

2.1.14 Digital camera.

2.1.15 Pencil, sketch pad, and clipboard.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Use the segmentation and numbering system for the superstructure (FLD-OP-SC-002, Structure Segmentation and Element Identification System) to identify the bearing being evaluated.

3.2 Measuring, recording, and evaluating characteristics of bearings:

3.2.1 Record the ambient temperatures above the deck and at the location of the bearing at the time of evaluation.

3.2.2 Record if the bearing is a fixed or a moveable (expansion) bearing.

3.2.3 Record if the bearing is still in its proper alignment.

3.3 Measuring, recording, and evaluating characteristics of rocker assembly:

3.3.1 Clean the bearing area by removing any debris or excessive corrosion products.

3.3.2 Record the conditions of the rocker and pin, noting if there is any corrosion or loss of section.

3.3.3 Does the bearing still rock (still allow movement), or is it "frozen?"

3.3.4 Measure the longitudinal and lateral shift and displacement (movements), as well as rotation (tilt angle).

3.3.5 Note any exposed, loose, cracked, broken pintles.

3.3.6 Look for vertical movement and uplifting of girders under a live load.

3.3.7 Use a mirror, if necessary, to examine the bearing area closest to the abutment backwall.

3.4 Measuring, recording, and evaluating characteristics of sole plate assembly:

3.4.1 Examine the connection of the sole plate to the girder. Record any loss of bond or connection between the sole plate and the girder.

3.4.2 Examine the sole plate, and record any cracks, corrosion, or section loss of the sole plate.

3.5 Measuring, recording, and evaluating characteristics of the masonry plate:

3.5.1 Examine the connection of the masonry plate to the bearing device and the masonry plate to the abutment or pier. Record any loss of connection.

3.5.2 Examine the masonry plate and record any cracks, corrosion, or section loss.

3.6 Measuring, recording, and evaluating characteristics of anchor bolts:

3.6.1 Examine the anchor bolts connecting the masonry plate to the pier or abutment. Record the diameter of the bolts.

3.6.2 Record any missing bolts, nuts, or washers.

3.6.3 Record any rust or corrosion of the bolts.

3.6.4 Examine the concrete around the anchor bolt and record if any part of the main body (shank) of the anchor bolt is exposed.

3.7 Measuring, recording, and evaluating characteristics of concrete surface (under and next to the bearing):

3.7.1 Check the condition of the concrete surfaces under and next to the bearing and record any defects.

3.7.2 Check for spalls, section loss, or cracks in the pier or abutment top surface.

3.8 Documenting defects:

3.8.1 Take photographs of any defects using FLD-DC-PH-002, Photographing for Documentation Purposes, and create a photo log.

3.8.2 Use sketches as needed to document defects and supplement the photographs.

3.9 Storing data, documents, and images:

3.9.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.9.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.10 Reporting: Transfer all metadata, data, documents, and images to Federal Highway Administration (FHWA), and/or upload all metadata, data, documents, and images into the Long-Term Bridge Performance (LTBP) Bridge Portal.

4. Data Collection Table

4.1 Table:

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
1	State	Text			State Code, e.g., Virginia = VA	Green
2	NBI structure number	Text			Item 8, Structure Number from NBI Coding Guide	Green
3	Structure name	Text			Descriptive name for the bridge, e.g., Route 15 SB over I–66	Green
4	Protocol name	Text			Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text			First name(s) Last name(s)	Green
7	Date data were collected	Text	Exact date		mm/dd/yyyy	Green
8	Ambient temperature above deck	Number	1	°F		Green
9	Bearing number	Text			Evaluate and record data for each individual bearing	Blue
10	Ambient temperature at bearing location	Number	1	°F		Yellow
11	Is the bearing fixed or moveable (allows for expansion)?	Predefined list			Fixed or movable	Yellow
12	If it is a moveable bearing, does it still allow for expansion?	Predefined list			Yes, No, or Not Applicable	Yellow
13	Is the bearing still in its proper alignment?	Predefined list			Yes or No	Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
14	Condition of the rocker	Predefined list			Indicate no visible defects or document the presence of cracks, corrosion, and/or section loss	Yellow
15	Condition of the pin	Text			Indicate no visible defects or document the presence of cracks, corrosion, and/or section loss	Yellow
16	Longitudinal shift/displacement	Number	0.125	in.		Yellow
17	Lateral shift/displacement	Number	0.125	in.		Yellow
18	Rotation/tilt	Number	1	Degrees		Yellow
19	Condition of pintles	Text			Indicate no visible defects, or document any exposed, loose, or cracked pintles.	Yellow
20	Uplift	Text			Describe any uplift under live load	Yellow
21	Sole plate connection to girder—Surface bond condition	Text			Indicate no visible defects or document the presence of bond or no bond, movement of sole plate, and other defect (specify under comments)	Yellow
22	Sole plate condition	Text			Record any corrosion or section loss	Yellow
23	Masonry plate connection to the abutment or pier	Text			Record any loss of connection	Yellow
24	Masonry plate condition	Text			Record any corrosion or section loss	Yellow
25	Diameter of anchor bolts	Number	0.125	in.		Yellow
26	Condition of the anchor bolts	Text			Record any missing bolts, nuts, washers, or loose bolts; any rust or corrosion of the bolts; or if the anchor bolt is partially exposed	Yellow
27	Condition of the concrete under and next to the bearing	Text			Indicate no visible defects or document the presence of shear cracks, spalling, on abutment seat or pier cap, and/or other defects (specify under comments)	Yellow
28	Defect photos	BLOB			Document typical defects with photos	Yellow
29	Comments	Text				Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. CRITERIA FOR DATA VALIDATION

5.1 Compare measurements with measurements from previous inspections of the same structure to make sure that values make sense.

5.2 Compare measurements with photo documentation to make sure results shown in photos are consistent with items measured.

5.3 If an element's condition is improved when compared to the condition documented in a previous inspection, check with the State department of transportation to determine if any maintenance, repair, and/or bridge preservation actions have occurred. If so, document these maintenance, repair, and/or bridge preservation actions using appropriate protocols.

6. COMMENTARY/BACKGROUND

6.1 This protocol provides guidance on evaluating the condition of rocker bearings and for collecting data that help determine if the bearing is functioning as intended.

6.1.1 Sole plates are attached to the underside of bridge girders and transfer the force from the bridge girder to the bearing device.

6.1.2 The bearing device sits on top of a masonry plate. Masonry plates are attached to piers and abutments and transfer the force from the bearing device to the pier or abutment.

6.1.3 Anchor bolts are used to attach the masonry plate to the pier or abutment. The body of an anchor bolt (shank) should not be visible. Only the head of the anchor bolt, a nut, and a washer should be visible. If the body (shank) of the anchor bolt is visible, then the anchor bolts are said to be exposed.

6.1.4 The rotation or tilt of the rocker can be determined by measuring the vertical height from the masonry plate to the bottom horizontal edge of the rockers at the front and back sides and the length of the rocker horizontal surface.

6.1.5 Measure the longitudinal shift, if any, by measuring the distance from the center line of the rocker to the center line of the masonry plate.

6.1.6 Determine the lateral shift by noting any lateral shift of the rockers with respect to keeper plates.

6.1.7 A pintle is a pin set into the masonry plate to prevent the rocker from sliding off the masonry plate while allowing rotation to occur.

7. REFERENCES

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-005, Personnel Qualifications.

7.1.3 FLD-OP-SC-002, Structure Segmentation and Element Identification System.

7.1.4 FLD-DC-PH-002, Photographing for Documentation Purposes.

7.1.5 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.6 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*:

7.2.1 FHWA-NHI-12-053, Bridge Inspector's Reference Manual, Federal Highway Administration, Washington, DC, 2012.

VISUAL INSPECTION—JOINTS PROTOCOLS (VIJ)

FLD-DC-VIJ-001, Drainage System on Bridge Decks and Approach Slabs

FLD-DC-VIJ-002, Expansion Joints

DRAINAGE SYSTEM ON BRIDGE DECKS AND APPROACH SLABS

LTBP Protocol #: FLD-DC-VIJ-001

1. DATA COLLECTED

1.1 Ponding and drainage locations and data from visual inspection of drainage systems for bridge decks and approaches for functionality and evidence of ponding.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

2.1.2 Ladder, access platform, snooper bucket truck, man lift, and/or high-reach equipment (if necessary).

2.1.3 Tape measure.

2.1.4 6-ft folding rule.

2.1.5 Mirror.

2.1.6 Broom or shovel.

2.1.7 Temporary marker.

2.1.8 Digital camera.

2.1.9 Pencil, sketch pad, and clipboard.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Use the data collection grid (FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks) to locate defects on the deck and on both approach slabs.

3.2 If possible, perform the visual inspection of the drainage system during a rain event.

3.3 Check for ponding and signs of water staining on the deck and approach slabs to determine possible limits of water ponding.

3.4 Record the type and location of visible defects: ponding or signs of water staining.

3.5 Examine the inlets, outlet pipes, and downspout pipe (if any) in each span for collecting debris or signs of blockage. Record instances of debris or blockage.

3.6 Look underneath deck for signs of drainage leakage.

3.7 Check connections and supports to the outlet pipes and downspout pipes attached to the superstructure and substructure. Record locations of any loose connections or missing supports. Record any instance of water from drains falling directly onto a bridge member, such as girders, bearings, and pile and pier caps.

3.8 Documenting defects:

3.8.1 Take photographs of defects using FLD-DC-PH-002, Photographing for Documentation Purposes, and create a photo log.

3.8.2 Use sketches as needed to document ponding, debris-laden inlets, or signs of blockages, and supplement the photographs.

3.9 Storing data, documents, and images:

3.9.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.9.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.10 Reporting: Transfer all metadata, data, documents, and images to Federal Highway Administration (FHWA), and/or upload all metadata, data, documents, and images into the Long-Term Bridge Performance (LTBP) Bridge Portal.

4. Data Collection Table

4.1 Table:

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
1	State	Text			State Code; e.g., Virginia = VA	Green
2	NBI structure number	Text			Item 8, structure number; from NBI Coding Guide	Green
3	Structure name	Text			Descriptive name for the bridge; e.g., Route 15 SB over I–66	Green
4	Protocol name	Text			Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text			First name(s) Last name(s)	Green
7	Date data was collected	Text	Exact date		mm/dd/yyyy	Green
	Ponding or Water Stains					Pink
8	Defect type	List			Presence of ponded water Presence of water stains	Blue
9	Location of defect (*x*-coordinate)	Number	1	in.	Transverse distance from origin	Yellow
10	Location of defect (*y*-coordinate)	Number	1	in.	Longitudinal distance from origin	Yellow
11	Defect site	Text			Describe the location of data collection on the bridge (e.g., span number, lane number, right or left shoulder, substructure unit, etc.)	Yellow
12	Defect photos and sketches	BLOB			Document all separate defects with photos and/or sketches	Yellow
13	Comments	Text				Orange

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
Damaged or Blocked Drainage Inlets						Pink
14	Defect type	List			Fully blocked inlet Partially blocked inlet Damaged inlet	Blue
15	Location of defect: (*x*-coordinate of center of the drainage inlet)	Number	1	in.	Transverse distance from origin	Yellow
16	Location of defect: (*y*-coordinate of center of the drainage inlet)	Number	1	in.	Longitudinal distance from origin	Yellow
17	Defect photos and sketches	BLOB			Document typical defects with photos and/or sketches	Yellow
18	Comments	Text				Orange
Damaged or Blocked Drainage Downspout Outlets						Pink
19	Defect description	List			Select all that apply: • Full blockage of outlet • Partial blockage of outlet • Loose connections and supports for pipes • Missing connections and supports for pipes • Drainage water falling directly onto bridge member below	Blue
20	Location of defect on superstructure or substructure	Text			e.g., pier column 1A, 5 ft above ground elevation	Yellow
21	Defect photos and sketches	BLOB			If defects are present, document typical defects with photos and/or sketches	Yellow
22	Comments	Text			If drainage water is falling directly onto a bridge member, please note onto which bridge member the water is falling. Put other comments in this field.	Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
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Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. CRITERIA FOR DATA VALIDATION

5.1 Compare measurements with measurements from previous inspections of the same structure to make sure that values make sense.

5.2 Compare measurements with photo documentation to make sure results shown in photos are consistent with items measured.

5.3 If an element's condition is improved when compared to the condition documented in a previous inspection, check with the State department of transportation to determine if any maintenance, repair, and/or bridge preservation actions have occurred. If so, document these maintenance, repair, and/or bridge preservation actions using appropriate protocols.

6. COMMENTARY/BACKGROUND

6.1 This protocol provides guidance for identifying, locating, and measuring the extent of defects in the bridge drainage system as well as evidence of water ponding on the deck or the approach slab.

6.2 The proper functioning of the bridge's drainage system is crucial for directing storm water and snow melt off the bridge deck and approach slabs. The basic elements of a bridge drainage system consist of the following:

6.2.1 Deck cross slope.

6.2.2 Deck drains or inlets.

6.2.3 Downspout pipes.

6.2.4 Outlet pipes

6.3 The primary reason for drainage failure is debris clogging the deck drain (scupper) and/or downspouts. When drainage pipes and inlets become clogged, the water from the deck collects along the gutter line and ponding of water occurs.

6.4 Ponding can have the following consequences:

6.4.1 Increased risk of water infiltration and chemical attacks on the decks and safety barriers at the interface with the deck.

6.4.2 Hazards to the motoring public.

6.4.3 Erosion of embankment slopes.

6.4.4 Possible settlement of the bridge approach slabs.

6.4.5 Water falling from the bridge's drainage system directly onto other bridge members below (such as girders, girder ends, bearings, and pile/pier caps) can cause premature deterioration of these bridge members and/or exacerbate existing corrosion.

7. REFERENCES

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-005, Personnel Qualifications.

7.1.3 FLD-OP-SC-001, Data Collection Grid and Coordinate System for Bridge Decks.

7.1.4 FLD-DC-PH-002, Photographing for Documentation Purposes.

7.1.5 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.6 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*:

7.2.1 FHWA-NHI-12-053, Bridge Inspector's Reference Manual, Federal Highway Administration, Washington, DC, 2012.

EXPANSION JOINTS

LTBP Protocol #: FLD-DC-VIJ-002

1. DATA COLLECTED

1.1 Condition and functioning of expansion joints and adjacent elements.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

2.1.2 Ladder, access platform, snooper, bucket truck, man lift, and/or high-reach equipment.

2.1.3 Tape measure.

2.1.4 6-ft folding rule.

2.1.5 Measuring wheel.

2.1.6 Thermometer.

2.1.7 Digital camera.

2.1.8 Temporary marker.

2.1.9 Pencil, sketch pad, and clipboard.

2.2 *Personnel*: PRE-PL-LO-005, Personnel Qualifications.

3. METHODOLOGY

3.1 Measure the ambient air temperature at the top surface of the deck joint at the same time the joint openings are measured. Record the ambient temperature and the time of day when the temperature was measured.

3.2 Use FLD-OP-SC-002, Structure Segmentation and Element Identification System, to identify the expansion joint being evaluated.

3.3 Use FLD-OP-SC-003, Determination of Local Origins for Elements, to establish the local origin for each joint on the bridge.

3.4 Identify and record if the joint is open or sealed. Record if the joint is armored or not.

3.5 Measuring joint openings:

3.5.1 Measure the joint opening at both ends and at midlength of the joint. Record the joint opening width and the *y*-coordinates of the points where the opening width is measured.

3.5.2 Measure any horizontal misalignment at the ends of the joint. Record the amount of horizontal misalignment and the *y*-coordinates of the points where the horizontal misalignment is measured.

3.5.3 Measure any vertical misalignments between the two sides of the joint. Record the amount of vertical misalignment and the *y*-coordinates of the points where the vertical misalignment is measured.

3.6 Measuring vertical misalignment at the beginning of the bridge:

3.6.1 Examine the vertical alignment between the top of each abutment backwall and the end of the approach slab at the end of the bridge where traffic enters. Measure any vertical misalignments between the abutment backwall and the end of the approach slab. Record the amount of vertical misalignment and the *y*-coordinates of the points where the vertical misalignment is measured.

3.6.2 Record the difference in elevation, if any.

3.7 Evaluation of elements adjacent to joints:

3.7.1 Examine the concrete deck adjacent to the edge of the open joint (or adjacent to the joint armor, if any) for cracks, delaminations, and spalling of the adjacent concrete.

3.7.2 If the open joint is armored, examine the metal armor for cracks, corrosion, pitting, loss of section, and/or misaligned plates.

3.7.3 Examine the drainage trough (if any) under the joint, and describe the type and extent of debris as well as any defects in the trough that result in leakage on the superstructure or substructure elements.

3.7.4 Examine the abutment seat and walls, the bearings, and the beam ends below the joint opening for evidence of damage from leakage or water staining.

3.7.5 Measure the total length of the joint where the abutment seat, backwall, bearings, and/or the beam ends below the joint show evidence of active water leakage or water stains.

3.8 Evaluation of joint sealing material:

3.8.1 Identify the specific type of joint seal, such as asphalt plug, compression seal, modular joint, etc.

3.8.2 Record the type and amount of debris (if any) in the joint.

3.8.3 Clear joint of all debris, if necessary, and examine the joint sealing material for cracks, splits, or gouges in the elastomeric material or the asphalt plug. Make note of any joint material that has separated from the joint sidewall or joint material that is loose and sticking above the top deck surface.

3.9 Documenting defects:

3.9.1 Take photographs of defects using FLD-DC-PH-002, Photographing for Documentation Purposes, and create a photo log.

3.9.2 Use sketches to document section loss and cracking and supplement the photographs.

3.10 Storing data, documents, and images:

3.10.1 FLD-DS-LS-001, Data, Document, and Image Storage—Local, for local storage.

3.10.2 FLD-DS-RS-001, Data, Document, and Image Storage—Remote, for remote storage.

3.11 Reporting: Transfer all metadata, data, documents, and images to Federal Highway Administration (FHWA), and/or upload all metadata, data, documents, and images into the Long-Term Bridge Performance (LTBP) Bridge Portal.

4. Data Collection Table

4.1 Table:

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
1	State	Text			State Code; e.g., Virginia = VA	Green
2	NBI structure number	Text			Item 8, structure number; from NBI Coding Guide	Green
3	Structure name	Text			Descriptive name for the bridge; e.g., Route 15 SB over I–66	Green
4	Protocol name	Text			Title of the protocol	Green
5	Protocol version	Text	Month and year		Month and year the protocol version was published; e.g., May 2015	Green
6	Personnel performing data collection activities	Text			First name(s) Last name(s)	Green
7	Date data were collected	Text	Exact date		mm/dd/yyyy	Green
8	Ambient air temperature at deck level	Number	1	ºF	Record the temperature at the time that the joint openings are measured	Green
Open Joints and Sealed Joints						Pink
9	Joint number	Text			Evaluate and record data for each individual joint	Blue
10	Type of joint	Predefined list			Open joint Sealed joint	Yellow
11	Is the joint armored?	Predefined list			Yes or No	Yellow
12	Joint openings	Number	0.125	in.	Take three readings at each end and in the middle; record the opening and the *y*-coordinates.	Yellow
13	Horizontal misalignment	Number	0.125	in.	Take readings at each end of the joint; record the reading and the *y*-coordinates.	Yellow
14	Vertical misalignment of joint	Number	0.125	in.	Take multiple readings, if necessary; record the amount of vertical misalignment and the *y*-coordinate.	Yellow
15	Vertical misalignment of abutment and approach slab/pavement	Number	0.125	in.	Take multiple readings, if necessary; record the amount of vertical misalignment and the *y*-coordinate(s).	Yellow
16	Damage to adjacent deck slab	Predefined list			Select all that apply: • Cracks • Delamination • Spalling • Other (please specify in comments)	Yellow
17	Length of joint with evidence of damage to the deck	Number	1	ft	Sum of the individual lengths if more than one distinct length	Yellow
18	Damage to joint armoring (if any)	Predefined list			Select all that apply: • Cracks • Corrosion • Pitting • Loss of section • Misaligned plates	Yellow

#	Field Name	Data Type	Accuracy	Unit	Field Description	Row Color
					• Other (please specify in comments)	
19	Length of joint with evidence of damage to the joint armoring	Number	1	ft	Sum of the individual lengths if more than one distinct length	Yellow
20	Condition of drainage trough (if any)	Predefined list			No visible defects Dirt and/or debris Cracks, tears, etc. Other (please specify in comments)	Yellow
21	Length of joint with evidence of damage to the drainage trough				Sum of the individual lengths if more than one distinct length	Yellow
22	Evidence of joint leakage	Predefined list			Select that apply: • Deterioration of beam ends • Corrosion/deterioration of bearings • Damage to abutment cap or backwall • Water/water stains on abutment elements • Other (please specify in comments)	Yellow
23	Length of joint with evidence of leakage	Number	1	ft	Sum of the individual lengths if more than one distinct length	Yellow
24	Defect photos	BLOB			Document typical defects with photos	Yellow
25	Comments	Text				Orange
Sealed Joints Only						Pink
26	Type of joint seal	Predefined list			Asphalt plug Compression seal Reinforced elastomeric Modular joint Other	Yellow
27	Debris in the joint?	Predefined list			Yes or No	Yellow
28	Length of joint with debris	Number	1	ft	Sum of the individual lengths if more than one distinct length	Yellow
29	Condition of anchor bolts (if any)	Predefined list			No visible defects Corrosion present Pitting rust Loss of section Cracking Missing anchor bolts Other (such as misaligned parts; specify under comments)	Yellow
30	Condition of joint seal material	Predefined list			No visible defects Cracks, splits, or gouges Joint material debonded from sides of joints Joint material	Yellow
31	Location of defect in seal	Number	1	in.	*y*-coordinates at the beginning and ending of the defect	Yellow
32	Defect photos	BLOB			Document typical defects with photos	Yellow
33	Comments	Text				Orange

4.2 Table Key:

Column Descriptions	
#	Sequential number of data item
Field Name	Data field name
Data Type	Type of data, such as text, number, binary large object (BLOB), or PDF file
Accuracy	Accuracy to which the data are recorded
Unit	Unit in which a measurement is taken and recorded
Field Description	Commentary on the data
Row Color Key	
Green	Data items only entered once for each protocol for each day the protocol is applied
Pink	Logical breakdown of data by elements or defect types (not always used)
Blue	Data identifying the element being evaluated or the type of defect being identified
Yellow	LTBP data reported individually for each element or defect identified
Orange	Comments on the data collection or data entered

5. Criteria for Data Validation

5.1 Compare measurements with measurements from previous inspections of the same structure to make sure values make sense.

5.2 Compare measurements with photo documentation to make sure results shown in photos are consistent with items measured.

5.3 If an element's condition is improved when compared to the condition documented in a previous inspection, check with the State department of transportation to determine if any maintenance, repair, and/or bridge preservation actions have occurred. If so, document these maintenance, repair, and/or bridge preservation actions using appropriate protocols.

6. Commentary/Background

6.1 This protocol provides guidance on evaluating the condition of expansion joints and for collecting data that help determine if the joint is functioning as intended.

7. References

7.1 *LTBP Protocols*:

7.1.1 PRE-PL-LO-004, Personal Health and Safety Plan.

7.1.2 PRE-PL-LO-005, Personnel Qualifications.

7.1.3 FLD-OP-SC-002, Structure Segmentation and Element Identification System.

7.1.4 FLD-OP-SC-003, Determination of Local Origins for Elements.

7.1.5 FLD-DC-PH-002, Photographing for Documentation Purposes.

7.1.6 FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.1.7 FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*:

7.2.1 FHWA-NHI-12-053, Bridge Inspector's Reference Manual, Federal Highway Administration, Washington, DC, 2012.

LOCAL STORAGE PROTOCOLS (LS)

FLD-DS-LS-001, Data, Document, and Image Storage—Local

DATA, DOCUMENT, AND IMAGE STORAGE—LOCAL

LTBP Protocol #: FLD-DS-LS-001

1. DATA COLLECTED

1.1 None. This protocol provides the requirements for local data, document, and image storage during field assessment.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 External hard drive with appropriate space for backups.

2.1.2 Laptop computer.

2.2 *Personnel*: None.

3. METHODOLOGY

3.1 Ensure that all data, documents, and images are stored on several devices.

3.2 When possible, use the data storage within the data collection device itself.

3.3 Back up data to a laptop internal hard drive every hour or at a reasonable breaking point in the assessment technique, whichever is more frequent.

3.4 Back up the laptop internal hard drive to an external hard drive every 4 hours.

3.5 Further backup requirements are discussed in FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

4. DATA COLLECTION TABLE

4.1 None.

5. CRITERIA FOR DATA VALIDATION

5.1 Identify a team member responsible for validating that data are stored appropriately.

6. COMMENTARY/BACKGROUND

6.1 Local storage occurs for all data collection techniques at three distinct physical locations (data collection device, laptop, and external hard drive) as described herein. The goal is to maximize redundancy in data storage without slowing or otherwise adversely affecting field data collection operations.

6.2 Cameras, data acquisition systems, and NDE equipment all typically provide local data storage on the equipment. These devices are augmented with both an internal laptop hard drive and an external hard drive.

6.3 The frequency of backup from device to computer depends on the data collection assessment technique. For the Long-Term Bridge Performance (LTBP) Program, the desired frequency is the most frequent between the following intervals: every hour or a reasonable breaking point in the assessment technique (e.g., between load stages or between application techniques). Certain data (video) may require constant writing on the laptop internal drive. Avoid duplicate data. When backing up the laptop, make a full backup (not a differential backup) of the laptop to an external drive, and encrypt the hard drive to protect data in the event of loss of the physical hardware.

7. REFERENCES

7.1 *LTBP Protocols*: FLD-DS-RS-001, Data, Document, and Image Storage—Remote.

7.2 *External*: None.

REMOTE STORAGE PROTOCOLS (RS)

FLD-DS-RS-001, Data, Document, and Image Storage—Remote

DATA, DOCUMENT, AND IMAGE STORAGE—REMOTE

LTBP Protocol #: FLD-DS-RS-001

1. DATA COLLECTED

1.1 None. This protocol provides requirements for remote storage of data, documents, and images during field assessment.

2. ONSITE EQUIPMENT AND PERSONNEL REQUIREMENTS

2.1 *Equipment*:

2.1.1 Laptop computer.

2.1.2 Network connection or wireless hotspot.

2.1.3 Data storage space on a secure network or cloud-based location.

2.2 *Personnel*: None.

3. METHODOLOGY

3.1 Ensure that all data, documents, and images are stored and backed up remotely on a daily basis in a secure network or cloud-based storage location until integration into the Long-Term Bridge Performance (LTBP) Bridge Portal is complete.

3.2 If data are stored on a network server, the server must reside behind the corporate firewall of the data collection contractor. This network server must have standard daily backup regiments, mirroring, and other protections typically provided to corporate servers.

4. DATA COLLECTION TABLE

4.1 None.

5. CRITERIA FOR DATA VALIDATION

5.1 Identify a team member responsible for validating that data are stored appropriately.

6. COMMENTARY/BACKGROUND

6.1 The goal is to maximize redundancy in data storage without creating unnecessary overhead or otherwise adversely affecting data collection operations. This effort starts during field data collection and continues after leaving the bridge.

6.2 Corporate cloud-based storage is preferred over commercial services but is not required. Remote network access allows periodic backups of collected field data to a cloud service while still on the bridge. Consider the following important factors when selecting a cloud service:

6.2.1 Cost.

6.2.2 Sync speed.

6.2.3 Security specifications.

7. REFERENCES

7.1 *LTBP Protocols*: FLD-DS-LS-001, Data, Document, and Image Storage—Local.

7.2 *External*: None.