**Federal Contract # DTFH61-17D00001 – Task Order #1**

**LONG-TERM BRIDGE PERFORMANCE PROGRAM**

PROGRESS REPORT NO. 4

Report Period: January 1, 2018 – January 31, 2018

Prepared For:

**Federal Highway Administration**

Prepared By:



**A. Account of work performed in this period**

* 1. **Coordination and Meetings Between the Contractor, FHWA LTBP Team, and State Highway Departments**

The Rutgers team set up a meeting with FHWA for 2/23. This meeting will be held in TFHRC.

Co-PI: 8 hours (For December 2017 and January 2018)

* 1. **Data Gap Analysis**

Task 2.1: Examine, Characterize, and Summarize LTBP Protocols for Data Collection Efforts: Work continued on Task 2.1 for each of the four high priority performance issues. The database developed during this task was expanded in January with additional characterization fields. These fields include: Data Type, Data Use Case, Performance Metric, Priority Level, and Relative Cost. This not only increases the resolution of the data source characterization but will also provide the means for rank and prioritization tasks to be developed in Task 2.4.

Task 2.2: Develop Set of Data Collection Needs: A detailed, manual literature search continued in January. Focus was paid to pertinent service life design methodologies, available deterioration modeling approaches, and performance limit states. A subset of the notes from this search are provided in Appendices 1 and 2.

Task 2.3: Identify Data Gaps and Collection Strategies: This task is the culmination of the previous two tasks. That is, once the protocols have been examined, characterized, and structured, and once the set of data collection needs have been established this task is largely self-evident. As a result, the specific progress on this task is determined by the progress of the previous two tasks.

Task 2.4: Prioritization and Strategic Recommendations: Work has begun in developing a framework in which to rank and prioritize any identified data collection needs. To do this, relative costs, advantages, and disadvantages associated with data sources (both available and needed) have begun to be explored and documented. In addition, it is expected that life-cycle cost analysis (LCCA) will play a large roll in this prioritization. LCCA models analyze the costs related to all stages of an infrastructure application through-out its life cycle. Costs related to construction can be categorized by 1) agency costs, 2) user costs, and 3) environmental costs. Agency costs include all costs related to construction, repair, rehabilitation, and replacement during the service life of the structure. Users costs include traffic delay, increased risk of traffic crashes, and increased vehicle operating costs due to construction. Environmental costs are due to the pollution damage inflicted during the construction and maintenance processes.

Co-PI: 4 hours

Project Engineer: 172.50 hours

Staff Engineer: 84.00 hours

Project Support: 9 hours

* 1. **Communication**

The Rutgers team prepared the electronic version of the monthly progress report and submitted it to FHWA. Moreover, the Rutgers team updated the MS Project file showing the project milestone and submitted it to FHWA.

Co-PI: 21 hours (For December 2017 and January 2018)

**B. Work to be accomplished during the next period**

* 1. **Coordination and Meetings Between the Contractor, FHWA LTBP Team, and State Highway Departments**

The Rutgers team will attend the 2/23 meeting at TFHRC and will submit the meeting minutes to FHWA afterwards.

* 1. **Data Gap Analysis**

Future work will continue the characterization of current LTBP Data Collection Protocols with focus on prioritization and life cycle cost metrics to facilitate the prioritization and strategic recommendation activities in Task 2.4. The literature search will continue for Task 2.2 with focus also paid on non-model-based data needs. Meetings will be held with domain experts to ensure the characterizations and the recommendations made thus far are consistent with current best practices approaches.

* 1. **Communication**

The Rutgers team will prepare the electronic version of the monthly progress report and will submit it to FHWA. Moreover, the Rutgers team will submit the updated MS Project file to FHWA.

**C. Problems/Recommended Solutions**

No problems encountered during this period.

**D. How the results of the work performed supports one or more of the FHWA, DOT and LTBP Goals**

All of the work conducted under this task order aims to ensure that the LTBP program collects the data required to realize the following four use cases: (1) Advance research in bridge deterioration and predictive modeling, (2) Advance research in cost analysis, (3) Support improved bridge design methods, and (4) Quantify the effectiveness of bridge maintenance, preservation, repair, and rehabilitation strategies. These use cases encapsulate the overarching goals of the LTBP program and its vision for positively impacting the practice of bridge engineering.

**E. Purchases and Rentals**

Nothing was purchased or rented during this period.

**F. Travel Details for Reporting Period**

No travel occurred during this reporting period.

**G. Current and Cumulative Expenditures (cost shown includes benefits and overhead)**

|  |  |  |
| --- | --- | --- |
| **Institution** | **Current Expenditures**  **12/1/2017 – 12/31/2017** | **Cumulative Expenditures**  **10/1/2017 – 12/31/2017** |
| Rutgers, the State University of New Jersey | $ 30,150.50 | $ 103,522.00 |
| Bridge Intelligence LLC | $ 4,158.00 | $ 4,158.00 |

**H. Subcontractor’s Progress Report**

**Sub-recipient Name:** Bridge Intelligence LLC

**Subaward No:** 00000286

**Principal Investigator:** Hooman Parvardeh

**LTBP TSSC**

**Federal Contract # DTFH61-17-D00001**

PROGRESS REPORT NO. 1

For the Period from 12/1/2017 through 1/31/2018

# Accomplishments/Work Performed

The following is a complete account of all accomplishments and work performed on each task during this reporting period.

# Task 1: (Coordination and Meetings between the Rutgers and FHWA LTBP Team)

During this period, Mr. Parvardeh prepared for the December Monthly call with FHWA. He participated in the call and prepared and submitted the minutes of the conference call.

Number of hours during this period: 8 hours

This task is approximately 10% complete.

# Task 2: (Data Gap Analysis)

During this period, Mr. Parvardeh reviewed the overall scope of the task as required by FHWA. Moreover, he reviewed the monthly progress of the task for October and December.

Number of hours during this period: 4 hours

This task is approximately 10% complete.

# Task 3: (Communication)

During this period, Mr. Parvardeh performed the following tasks:

* Modified the MS Project to be ready for monthly progress submittal
* Prepared and submitted monthly progress report for November including updated MS project
* Prepared and submitted monthly progress report for December including updated MS project

Number of hours during this period: 21 hours

This task is approximately 15% complete.

# Work Anticipated During the Next Period

During the next period, Mr. Parvardeh will perform the following tasks:

* Set up, prepare, participate in the monthly conference call
* Prepare and submit minutes for the monthly conference call
* Support the LTBP Data Gap Analysis effort
* Prepare and submit monthly progress report

# Changes /Problems

None.

# Participants & charged Level of Efforts

|  |  |  |  |
| --- | --- | --- | --- |
| **Personnel Name** | **Role/Contribution** | **Total Hours** | **Billed Cost** |
| Hooman Parvardeh | Principal | 33 | $ 4,158.00 |

# Travel

None.

**I. Appendices**

# Appendix 1 – Notes on Design for Service Life

**Four design methodologies:**

1. Full Probabilistic
2. Partial Factor
3. Deemed-to-Satisfy
4. Avoidance of Deterioration

**Full Probabilistic**

Six limit states identified:

1. Carbonation-induced Depassivation

* Depends on the specified concrete mix, execution, and placement.
* Can we get concrete mix design for each bridge?
* Parameters can be directly measured through material sampling and testing.

1. Chloride-induced Depassivation

* Chloride depth is time and depth dependent.
* For the design of a new structure, the parameters, should be estimated by examining similar structures (with similar mix, execution, and exposure) or from the literature.
* In the case of existing structures, these parameters may be directly measured from the structure of interest with parameters requiring observations at two different times separated by a sufficient interval.
* Can we get depth of chloride ingress?
* Are there records for deicing chemicals used?

1. Corrosion-induced cracking and spalling

* Are there records of time to first observation of corrosion induced cracking?
* There is no widely accepted model capable of simulating the progression from depassivation to rebar corrosion and then from rebar corrosion to corrosion-induced cracking and spalling of concrete.



1. Freeze-thaw damage resulting in a local loss of mechanical properties, cracking, scaling and loss of cross-section not in the presence of de-icing agents and sea water

* What records are available that can identify this type of freeze thaw damage?
* How can we identify this as the source of damage and not another source or combination?
* Won’t have data for freeze-thaw scaling not in presence of de-icing chemicals because states will use de-icing chemicals to combat freeze/thaw effects.

1. Freeze-thaw scaling of concrete in the presence of de-icing agents or sea water

* Clearly chloride induced corrosion from de-icing agents after cracking, but how can these sources be individually identified?

1. Freeze-thaw induced deflection and collapse

**Partial Factor Methods**

Partial factor method limit states based on full probabilistic methods 1-3 above:

1. Depassivation due to carbonation (uncracked concrete)

* This limit state is violated when the design depassivation due to carbonation at the end of the service life is greater than the design cover of the concrete provided.
* What is the design service life?
* What was the ACTUAL cover thickness at time of construction?
* What is the cover thickness now?

1. Depassivation due to chloride ingress (uncracked concrete)

* Same as above…

1. Freeze-thaw damage (not in the presence of de-icing agents and seawater)

* Is a factor of “Degree of Saturatiuon”…how can we quantify this on a macro-level?

**Deemed-to-Satisfy Guidance**

1. Concrete material specifications – inclusive of acceptable types and classes of constituents, water/cement ratio, cement content, compressive strength, air-content, etc.

* Can we get the concrete design mixture?
* How does this vary by state?

1. Concrete cover dimensions

* This varies from state to state.
* What are the design cover specifications by state?
* What are the construction quality protocols for each state?

1. Crack control approaches – inclusive of maximum rebar sizes and spacing

* What are the state specifications?
* How is this controlled by the construction contractor?
* Again, what are the construction quality protocols?

1. Coatings – inclusive of steel coatings and membranes/overlays for concrete

* Also varies by state, what are states using now?
* What have states used in the past?

1. Replaceable elements
2. Element-specific guidance

**Exposure Classes**

A common approach to structuring “deemed to satisfy” provisions is through the definition of exposure classes (or categories). In general, an exposure class indicates the harshness of the environment that a bridge or element will be exposed to throughout its service life. Once defined for a bridge or element, this exposure class then triggers specific “deemed-to-satisfy” provisions, with more stringent provisions keyed to harsher exposure classes.

* What states are using exposure classes?
* What are they?
* How are they using them?

… *ACI Guide to Durable Concrete (ACI 201)*

# Appendix 2 – Summary of Design Methodology and Model/Limit-States

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Methodology** | **Model/Limit State** | **Inputs** | **Outputs** | **Justification** | **Comments** | **References** |
|  |  |  |  |  |  |  |
| Full Probabilistic & Partial Factor Methodologies for Service Life Design | Carbonation-Induced Depassivation | Concrete Mix Design (design strength, additives, etc.)  Construction Quality (comp. strength at construction, porosity, initial cracking, etc.) | Service Life (years, or some other metric) | The design concrete mix and quality of concrete mix at time of construction has a direct influence on probabilistic design methodologies as well as the long term performance and duration of in-service life of the concrete deck. | It's difficult to measure "Service Life" as no widely accepted definition exists. | ISO 16294 ISO 16240 (2012)\* fib bulletin 34 (2006) |
|  | Chloride-Induced Depassivation | Depth of Chloride Ingress at time t | Depth of Chloride Ingress at time t | Can be input or output (input for new strcutres output for exisiting).  Design of new strutures: parameters can be estimated by examining existing structures (in terms of design mix, execution, and exposure).  For existing structures: parameters can be measured directly. |  | ISO 16294 ISO 16240 (2012)\* fib bulletin 34 (2006) |
|  | Corrosion-Induced Cracking and Spalling | Time to first observation of corrosion,   initial cracking/crack profile | Service Life (years, or some other metric) | Time to corrosion of rebar is a rather influencial parameters for these probabilistic models. | There is no widely accepted model capable of simulating the progression from depassivation to rebar corrosion and then from rebar corrosion to corrosion-induced cracking and spalling of concrete. | ISO 16294 ISO 16240 (2012)\* fib bulletin 34 (2006) |
|  | Freeze-Thaw Damage | Number of freeze-thaws  Deicing Chemicals Used  Degree of Saturation | Level of damage that occurs | Does the type of de-icing agent affect damage? Freeze-thaw may be a route cause of rebar corrosion (cracking leads to further moisture and chloride ingress, leads to corrosion and deeper freeze-thaw damage) | Won’t have data for freeze-thaw scaling not in presence of de-icing chemicals because states will use de-icing chemicals to combat freeze/thaw effects.  Clearly chloride induced corrosion from de-icing agents after cracking, but how can these sources be individually identified? | ISO 16294 ISO 16240 (2012)\* fib bulletin 34 (2006) |
| Deemed-to-Satisfy | Concrete Material Specifications | Acceptable types and classes of constituents, water/cement ratio, cement content, compressive strength, air-content, etc. | Service Life (years, or some other metric) | Most deemed-to-satisfy guidance specs are "blanket"-type solutions that have been derived through hueristics.   Fully quantifying the extent to which certain deemed-to-satisfy methodologies are followed and the effect of these methodologies would largely impact design for service life. | Can we collect concrete design mixture?  How does this vary by state? | ISO 16294 ISO 16240 (2012)\* fib bulletin 34 (2006) NCHRP Synthesis 333 (NCHRP 2014)\* |
|  | Concrete Cover | Depth of Concrete Cover  Construction Quality | Time to initial corrosion,   Service Life (years, or some other metric) | Same as above | What is the design concrete cover by state?  What is the ACTUAL concrete cover at time of construction | ISO 16240 (2012) fib bulletin 34 (2006) ACI 201 |
|  | Crack Control | State Design Specifications  Construction Quality | Time to initial corrosion,   Service Life (years, or some other metric) | Same as above | What are the approaches taken by each state?  How is cracking conrtolled during construction? (quality control protocols) | SHRP 2 R19B Eurocode,  Australian Bridge Design Code, FDOT Structures Manual, AASHTO LRFD, Canadian Highway Design Code |
|  | Rebar Type/Coating | Type of Rebar   Coating | Time to initial corrosion and extent of corrosion damage  Service Life (years, or some other metric) | Same as above | What is current practice by state?  What have the states ued in the past and how has that performed? | Eurocode,  Australian Bridge Design Code, FDOT Structures Manual, AASHTO LRFD, Canadian Highway Design Code |
|  | Exposure Classes | Definition of Exposure Classes |  | A common approach to structuring “deemed to satisfy” provisions is through the definition of exposure classes (or categories). In general, an exposure class indicates the harshness of the environment that a bridge or element will be exposed to throughout its service life. Once defined for a bridge or element, this exposure class then triggers specific “deemed-to-satisfy” provisions, with more stringent provisions keyed to harsher exposure classes. | What states are using exposure classes?  What are they?  How are they using them? | Eurocode,  Australian Bridge Design Code, FDOT Structures Manual, AASHTO LRFD, Canadian Highway Design Code |