Section 9 - Bridge Deck Rehabilitation Projects

9.1 Requirements

Prior to the Preliminary Submission, the following work shall be performed:

A. Review the Bridge Evaluation Survey Report or any prior Deck Evaluation Survey.

B. Perform an on-the-site observation to determine if a Bridge Deck Evaluation Survey is warranted.

C. Perform, if authorized, a Deck Evaluation Survey according to the guidance provided herein.

D. Perform a Field Survey to determine existing/as-built geometrics and deck profile elevations at 10 foot intervals.

E. Submit to the Bureau of Structural Engineering a report, in letter form, stating what the substandard conditions are. A determination will be made as to whether further studies are to be done to address the condition(s).

Adhere to the following criteria in developing contract documents:

A. Pavement surface removal should be scheduled for existing bridges with Hot Mix Asphalt (HMA) Overlays. Determine if waterproofing was also included and detail plans accordingly. Specifications in the Special Provisions should require that the existing waterproofing be removed and replaced with a new waterproofing membrane.

B. When a bare concrete deck is scheduled for an overlay, plans should be based on a detailed deck evaluation survey and outline the Repair Areas, Repair Material, etc.

C. Provisions for reinforcement steel quantity should be scheduled if it is determined that a reasonably large amount will be required. If not scheduled, the Special Provisions should be modified accordingly.

D. When a precast deck system or a prefabricated superstructure and deck system is the chosen structural solution for a rehabilitation project, an HMA overlay is permitted.

9.1.1 Resurfacing projects:

HMA overlays with water surface membrane or concrete thin overlay (less than one inch) may be scheduled for resurfacing projects, based on existing conditions and allowed overlay thickness. The Manager of Structural Engineering will approve the overlay system to be applied for the particular project and will verify that the additional dead load does not cause an overstress condition.

When specifying a overlay, the deck joints and approaches may have to be reconstructed due to the elevation change.

A. HMA overlays:

   When installation of HMA is approved, the existing condition of the deck concrete shall be documented by referencing the current Bridge Evaluation Report findings and updating the findings by a visit to the site. If directed by the Manager, Structural Engineering, a Deck Condition Survey report is to be generated, according to the provisions herein.

   The thickness of HMA overlays shall be noted on the Plans.

Installation of a waterproofing membrane shall be planned for prior to placing an HMA. In cases where HMA overlays are already part of the existing deck surface, replacements of such overlays is permitted. Removal of any existing membrane waterproofing is to be planned.

B. Concrete Overlays

The standard thickness varies from 5/8 inch to 1 inch when concrete overlay protective systems are planned. This thickness shall be noted on the Plans. This thickness may be used to establish a contract estimated quantity.

An additional 10% to 20% (depending on the concrete overlay area) should be added to the concrete overlay estimated quantity. This is based on the anticipation that additional thickness may be required at some locations to achieve the proposed plan profile elevations and cross-slopes.

9.1.2 Bridge Deck Patching and Repairs

Situations which would produce a concrete layer thickness in excess of 2 inches require special solutions. For example, if substructure settlements have resulted in significant lowering of the original plan/as-built profile elevations, jacking of the superstructure at selected locations may be considered and scheduled as a contract pay item when warranted. The deck surface treatment shall be in accordance with the overlay manufacture's recommendations.

Scarification may not be necessary when a overlay protective system is to be added and when the newly replaced or repaired bridge deck has not been opened to traffic or has been subjected to traffic and deicing chemicals for a relatively short time. Cleaning of the surface by sandblasting or shot blasting may suffice. Provisions should be included in the Special Provisions accordingly.

If new expansion joint assemblies are proposed and approved for scheduling as a contract pay item, a continuous sealer across the full width of the deck slab should be planned.

9.2 Deck Deterioration Quantity

A. Based on a study of an existing Bridge Evaluation Report and site visit, an approximation of required Type B and C repairs is to be noted on the plans.

B. To quantify an existing deck condition and required work, the following parameters may be used:

1% to 60% deck deterioration	Deck Patching/Repair with or without Overlay
50% to 100% deck deterioration	Deck Replacement

The overlapping percentages are intended to provide some flexibility in the decision making process. If the deck deterioration percentage falls in the overlapping percentages, then the following factors should also be considered in order to determine the final recommended repair:

- Adjacent Structure – Need to look at the condition of and what repair work is proposed for the adjacent structures in the corridor.
- Upcoming Project – If the bridge is included in a project that is in the pipeline.
- Traffic Volume – ADT in the heavy traffic areas.

9.3 NBI Coding

A. For decks receiving a overlay, Item 106 (year constructed) of the Structural Inventory and Appraisal will be updated to the year of reconstruction. The highest code that is used for a reconstructed deck is an "8". The coding of Item 58 (bridge deck condition) will be based on the actual condition of the deck in the field, but in no case less than a rating of "7".

B. For decks receiving patching, Item 106 will not be revised and the coding of Item 58 will be updated based on the actual condition of the deck in the field.

9.4 Machine Finishing For Repaired Concrete Deck Surface

A. Rapid set concrete, such as Rapid Set LMC, is permitted by approval of the Manager, Structural Engineering.

B. Design the bridge deck to minimize the areas that include small tight areas, unusual transition, or other geometric constraints. These may preclude machine finishing, requiring the use of hand tools, thereby increasing the project cost.

C. See Subsection 20.9 a. for criteria which could preclude use of machine finishing for bridge deck slab construction. These provisions shall also apply to concrete overlay protective system construction.

D. It shall be the responsibility of the Structural Design Engineer to show the following note on the plans in bridge deck areas where adverse conditions could conceivably preclude the use of machine finishing:

   "Note: Machine finishing of concrete surface not required. See Special Provisions."

   Or

   "Note: Machine finishing of concrete surface not required in areas designated. See Special Provisions."

   Whichever is applicable.

Unique specifications should be included in a project's Special Provisions.

9.5 Construction Document Development

A. In order to reduce construction costs, repair and resurfacing of deck deterioration of all bridges in a contract shall be accounted for under the single item "Concrete Deck Repair". This item will consist of constructing a modified standard "Type B" repair for all repairs. However, if a "Type C" repair is encountered, it shall be accordingly repaired, but still be included in the item "Concrete Deck Repair". Class A concrete or Type IA quick setting patch material is to be used for concrete deck repairs depending on available traffic windows. For depths more than 4 inches, patch materials and method of construction shall be approved by the RE. Special attention should be made to manufacturer's recommendations regarding application thickness and curing time.

B. All spall areas to be repaired must be clearly outlined on the plans. All previous spall repairs containing epoxy shall be removed. Engineering judgment should be used to determine if small isolated spalls in the deck should be included as part of an adjacent larger repair. The larger the repair patch, the easier it is for workers to remove the defective concrete and replace it with patch material.

C. All deck repair shall be finished utilizing a coarse broom finish unless the existing deck is already sawcut. This item is to be included in the price bid for the item

"Concrete Deck Repair". Large repair areas such as overall lane widths or decks already sawcut shall be finished with the item "Sawcut Grooved Deck Surface".

D. Construction joints are often used to limit the size of the repair due to lane closing restrictions. They may be placed at the contractor's option to provide a working edge for concrete finishing, to provide for a continuous joint replacement or to facilitate an end of the work day stoppage point. If warranted, suitable notes should be provided on the plans.

   The Designer should outline repair areas that do not form acute angles with the deck joints or other repair areas. There may be cases where new construction joints must be sawcut into the new concrete to provide the proper edge. Notes on the plans should instruct the Contractor to plan his work to avoid placing a construction joint at odd angles.

E. Notes on the plans should outline repair procedures. All existing reinforcing steel must be sandblasted or hydroblast cleaned prior to placement of patch material. The minimum depth of repair should not be less than 2 inches with a minimum of 1 inch removal of concrete below the bottom of the top mat of the existing reinforcement. In all cases, there should be enough space available for the maximum size of concrete aggregate to "fit" in any location within the volume of the repaired concrete deck.

   The plans must be specific about the concrete removal. Hydrodemolition is acceptable as a removal technique. The Contractor must provide necessary sediment control measures so as not to impact any surrounding areas or drainage systems and meet all environmental requirements.

   In removing deteriorated concrete, caution must be exercised so that the removal does not progress to sound concrete, or is limited to 1 inch below the top reinforcement.

   The Designer shall develop the plans so that this guidance is provided.

F. Details must be shown for treatment of repair areas which can not be completed during work hours due to unforeseen conditions. Use of cold patches or steel cover plates are permitted. A time limit of 2 days should be placed on the duration the temporary cover can remain in place. The price for placement, maintenance, and removal of the temporary cover and cold patch during repairs shall be included in the bid cost of "Concrete Deck Repairs".

G. Deck joints which exhibit leakage and/or edge spalling shall be repaired by replacing the Deck Joint Sealer and/or reconstructing the header and/or deck side of the joint utilizing the non-standard items "Deck Joint Reconstruction", "Sawcut Joint Reconstruction" or "Deck Joint Repairs". These items shall be measured in linear feet with the area to be repaired outlined in the plan view.

H. Where applicable, hot poured rubber asphalt joint sealer should be used to seal joints. Where possible, bituminized fiber joint filler should be placed below the hot poured rubber asphalt joint sealer.

   Where defects due to spalling at joint sealers occur, the joint should be repaired according to appropriate details.

   Where abutment deck joints are reconstructed, hot poured sealant should be placed between the abutment header and approach slab.

9.6 Safety Upgrades

A. For decks that are to have an overlay installed, the following upgrades shall be planned:

   1. All geometric standards will be met or, a design exception will be prepared.

   2. On NHS bridges, provision of upgraded beam guide rail attachment and transition, installation of guide rail or other crashworthy retrofit barrier system across the structure or replacement of parapets and subsequent guide rail installation will be required.

      For non-NHS bridges, if full safety upgrades are not practical, as determined by the Bureau of Structural Engineering, and there is no accident history, then attachments and transitions which consist of at least reduced post spacings and connections with a history of satisfactory performance will be considered acceptable.

B. For decks that are to be patched between 20% and 30% of the total deck areas and/or are to receive an HMA overlay:

   1. On NHS bridges evaluate the need to upgrade or retrofit the existing bridge parapets. Factors such as accident data, loading, geometry, cost and impact of an improvement should be evaluated. The evaluation is to be provided to the Manager, Structural Engineering for determination on including an upgrade or retrofit of the existing condition into a project.

   2. For non-NHS bridges, if full safety upgrades are not practical, as determined by the Bureau of Structural Engineering, and there is no accident history, then attachments and transitions which consist of at least reduced post spacings acceptable.

C. If it is determined that upgrading or retrofitting an existing guide rail connection is warranted, then the method to design an improvement; such as, construction of an end pylon section, may be based on AASHTO LRFD Bridge Design Specifications, Design Forces for Traffic Railings in Section 13.

9.7 Deck Evaluation Survey

A. Description of Survey and Testing

   Testing and evaluation of concrete bridge decks consists of visual observations, delamination or debonding detection, concrete sampling for chloride analysis, and electrical potential measurement (half-cell testing). All of these bridge deck evaluation techniques are used to detect existing defects and actively deteriorating conditions of the deck. The following descriptions are intended to provide information and procedures for these bridge deck evaluation techniques. These techniques should be used in sequence and, if warranted, in combination. By using the combined results, engineers can better evaluate the condition of any bridge deck.

   1. Visual Survey

      The first step for deck evaluation is a visual observation to determine the extent of spalling, cracking and scaling. The information from visual surveys is used to determine further deck condition survey needs. Visual surveys are generally expressed in terms of the amount of spalling and patching as a percent of the total deck area.

2. Concrete Delamination Detection (Chain Drag) or Ground Penetrating Radar (GPR)

   A delamination survey provides information on the subsurface condition of concrete bridge decks. A chain drag or GPR can be used to survey concrete bridge decks for delaminations.

3. Ground Penetrating Radar (GPR) or Portable Seismic Pavement Analyzer (PSPA) equipment may also be used to assess delamination reinforcement steel cover and, as permitted by the specific equipment, other deck slab condition information.

4. Chloride Analysis

   Chloride analysis provides a quantitative measure of the chloride ion contamination of concrete at selected levels in the deck. The "threshold" chloride content, or amount of chloride needed to initiate corrosion, is approximately 2.0 lbs. of chloride per cubic yard of concrete.

5. Half-Cell Test

   The purpose of half-cell testing is to determine the areas in the deck in which active corrosion is present.

   Research tests have demonstrated that a potential difference more negative than -0.35 volts indicates a high degree of probability of active corrosion of the reinforcing steel. Potential readings not greater than -0.20 volts indicate the probability of inactive or no corrosion, while potential readings between -0.20 volts and -0.35 volts indicate the possibility of active corrosion. Surveys are temperature sensitive and should only be performed if the ambient air temperature has been above 40^{o} F for a minimum of 72 hours immediately prior to the date of the survey.

6. Pachometer Test

   In order to properly establish the deck condition, establishing the depth of cover over the top reinforcement is necessary. This will provide the evaluator with needed information to properly judge the existing condition versus what is the required minimum depth of cover.

B. Procedures for Performing Deck Evaluation Surveys

1. Visual Observations

   a. Study the deficiencies of either the asphalt overlay or the concrete deck wearing surface (e.g. spalling, cracking, scaling, warping, asphalt creep, alligator cracks, etc.). Include the location and size of deficiencies, if any.

   b. Observe the underside of the deck and record the approximate size and location of all areas exhibiting cracks with or without efflorescence. Also, record all areas having concrete spalled from the bottom reinforcing.

   c. If the structure does not have an asphalt overlay over the concrete deck, determine the percentage of spalls and/or patches in the exposed concrete deck. Decks covered with asphalt should be similarly inspected, with a general condition statement made about the asphalt surface.

   d. Record the percentage of noted deficiencies for use in the final deck condition determination.

2. Concrete Delamination Detection

Chain Drag or GPR

Plot delaminated deck areas on a scaled map of the bridge deck.

3. Chloride Analysis

   a. Select random sample locations for chloride testing using statistical methods and plot the locations on a plan view of the deck. As a minimum requirement, 10 locations per every 6000 square yard area should be tested.

   b. After the lab has analyzed the samples taken, calculate the percentage of the samples with a chloride content greater than or equal 2 lbs/cu.yd. from:

$$\frac{\text{No. of Samples with Cl. greater than or equal to 2 lbs/cu.yd. x 100}}{\text{Total No. of Samples}} = \_\_\%$$

4. Half-Cell Test

   Calculate the percentage of possible corrosion affected deck area from the results by counting the number of tests points equal to or more negative than -0.35 volts.

$$\frac{\text{No. of Samples More Negative than -0.35 volts x 100}}{\text{Total No. of Samples}} = \_\_\%$$

5. Pachometer Survey

   Perform a Pachometer Survey to determine the depth of the concrete cover over the reinforcement steel. The equipment shall be calibrated according to the equipment manufacturer's specifications.

9.8 Determining Deck Condition And Extent Of Work

Evaluation of Field Survey Results

If a detailed study as described in Section 9.7 is not available, use Section 9.2. When a detailed study has been performed, use the following categories to establish the condition of a bridge deck:

9.8.1 Category 1 - Extensive Active Corrosion

5% or more of the deck area spalled

Or

40% or more of the deck area deteriorated or contaminated as indicated by any nonduplicating combination of the following:

(1) spalls, (2) delamination, and (3) corrosion potentials more negative than - 0.35 volts (CSE)

Or

40% of the area of the bridge deck indicated by random chloride sampling to contain greater than 2.0 pounds of chloride per cubic yard of concrete at the level of the top rebars.

9.8.2 Category 2 - Moderate Active Corrosion

0 to 5% of the deck area spalled,

Or

5 to 40% of the deck area deteriorated or contaminated as indicated by any nonduplicating combination of the following: (1) spalls, (2) delaminations, and (3) corrosion potential more negative than -0.35 volts (CSE),

Or

5 to 40% of the area of the bridge deck indicated by random chloride sampling to contain greater than 2.0 pounds of chloride per cubic yard of concrete at the level of the top rebars.

9.8.3 Category 3 - Light to No Active Corrosion

No spalls,

Or

0 to 5% of the deck area deteriorated or contaminated as indicated by any nonduplicating combination of the following: (1) delaminations, (2) corrosion potentials more negative than -0.35 volts (CSE),

Or

0 to 5% of the area of the bridge deck indicated by random chloride sampling to contain greater than 2.0 pounds of chloride per cubic yard of concrete at the level of the top rebars.

9.9 Recommended Restoration Procedures

Based on the foregoing categorization of the condition of the bridge deck, Table 9.1, which details rehabilitation and reconstruction alternates, has been developed.

Table 9.1 Restoration Procedures

Category	Procedures	Restoration (Considered Permanent)	Restoration (Estimated extended life 10 to 15 yrs)
Structurally Inadequate		Complete Deck Replacement (Unless restorable)	
1. Extensive Active Corrosion	Required Restoration Work	Complete Deck Replacement	Removal of all deteriorated concrete. Follow the repair procedure approved for the protective system selected.
	Testing Steps (see below)	Steps 1 through 5 as necessary. (Probably only steps 1 & 2)	Steps 1 & 2 only, except all the testing steps on the first five (5) bridge decks (spans) plus 10% of the remaining bridge decks.
	Suggested Protective Systems	Membrane with HMA overlay*; Concrete Thin (less than 1") Overlay Protective System. *	Membrane with HMA overlay**; Concrete Thin (less than 1") Overlay Protective System. **
2. Moderate Active Corrosion		Same as Category 1 above or Same as Category 3 below, as determined by the State.	Same as Category 1
3. Light To No Active	Required Restoration Work	Removal and Replacement of all areas of deterioration and chloride contaminated concrete as determined by corrosion potentials and/or chloride sampling. (Less than 5% of the deck area is bad).	Same as Category 1 Note: For this category of condition, permanent restoration is recommended.
	Testing Steps	Steps 1 through 5.	Same as Category 1
	Suggested Protective System	Membrane with HMA overlay*; Concrete Thin (less than 1") Overlay Protective System. *	Membrane with HMA overlay**; Concrete Thin (less than 1") Overlay Protective System. **

* When approved prior to Preliminary Plan ** Submission on a project to project basis

Testing Steps:

1.	Visual	3.	Electrical Potential	5.	Chloride Content
2.	Delamination	4.	Pachometer Survey		