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12 Bridge and culvert repair

12.1 Bridge repair

For bridge repair the office currently is in transition from the AASHTO 2002 Standard Specifications to the AASHTO LRFD Specifications. During the transition office policy is outlined below.

- The designer shall use the LRFD Specifications for a complete replacement of the superstructure involving both beams and deck. If the superstructure replacement results in additional load, the designer shall check the substructure using the 2002 Standard Specifications.
- The designer may use either the 2002 Standard Specifications or the LRFD Specifications for less significant repairs such as:
    - Minor widening with one or two new beam lines,
    - Replacement of the deck or barrier rails,
    - Repairs to piers or abutments,
    - Replacement of individual beams, or
    - Minor repairs to beams, bearings or barrier rails.

Using different specifications in design of bridge components can cause rating problems, however, and the designer shall consult with the Bridge Rating Engineer in cases where using the AASHTO LRFD Specifications may result in less capacity than the AASHTO 2002 Standard Specifications.

12.1.1 Policy overview

In general there are two types of bridge repair projects: programmed and not programmed. Programmed projects are either bridge repair projects or deck overlay projects. Projects that are not programmed are emergency repairs to bridges that have been damaged by vehicles with overheight loads, vehicle crashes, fire, fatigue, or accelerated deterioration.

Bridge repair projects can include a single repair, but most projects include multiple repairs. A project may involve any of the following:

- Deck repairs
- Joint repair or replacement,
- Bearing repair or replacement,
- Drain and scupper repair,
- Curb repair,
- Backwall and diaphragm repair,
- Barrier rail retrofit,
- Steel cover plate end retrofit,
- Steel member strengthening,
- Approach pavement replacement,
- Steel cleaning and painting, and
- Concrete surface sealing.

A repair project, as well as an overlay project, may involve paving of the adjacent roadway, strengthening of shoulders, replacing of guardrails, and other improvements to the highway. For that reason the designer will need to closely coordinate repair and overlay projects with the District and the Office of Design.

The basic purpose of a deck overlay project is to overlay the bridge deck with 1 3/4 inch (45 mm) of low slump concrete. Before the overlay is placed, concrete is removed from the original bridge deck, and the deck is repaired. If the deck has either a hot mix asphalt (HMA) overlay or a previous portland cement

concrete (PCC) overlay, the existing overlay always is removed before placing the new overlay. Deck overlay projects also may involve any of the bridge repairs listed above that are necessary to bring the structure to a reasonable condition, especially full depth deck repair, bridge joint repair or replacement, abutment backwall and diaphragm repair, and bridge rail retrofit.

When beginning a programmed project, the designer should

(1) Check the contract letting schedule;
(2) Review special instructions for other repairs adjacent to the bridge;
(3) Review current repair policies;
(4) Review the bridge files available in the Electronic Records Management System (ERMS), including plans, photos, and inspection reports;
(5) Determine the rated capacity of the bridge based on proposed repairs;
(6) Organize a checklist for the field exam;
(7) Conduct the field exam for the structure;
(8) Review the scope of project with the supervising Section Leader; and
(9) Write a concept letter.

After the concept is approved, the designer can begin final design.

Emergency repair projects must proceed on an accelerated schedule and close coordination with the District. In general an emergency project will include an evaluation for traffic restriction, a field exam, a concept, and a final design.

12.1.2 Design information

For a repair project, the designer needs to make use of information from other offices and groups at the Iowa Department of Transportation. The Bridge Maintenance and Inspection Unit will make recommendations for repair based on biennial inspections. The recommendations will be documented in the SIIMS database. The District will supply a deck sounding plot for a deck repair or overlay project, the Office of Location and Environment will provide paint scrape tests when requested, the Office of Materials will provide testing when needed, and the Office of Design will provide roadway information and traffic control information for repair projects. The Office of Traffic and Safety will review traffic control plans for high traffic areas.

Traffic volumes or Average Daily Traffic (ADT) on the title sheet of repair plans shall always be the sum of the ADT in both directions regardless of whether or not the highway is divided. The designer shall label the ADT on the plan title sheet as “Includes WB and EB Lanes” or “Includes NB and SB Lanes” as appropriate. Since ADT in both directions is required to establish traffic control plans, including the labels with ADT will remove any ambiguity. The ADT listed for repair of ramp bridges shall only include the ADT of the ramp and shall be labelled “Ramp lane(s) only.”

A deck sounding plot supplied by the District will be either a Delamtect plot or an audible/visual survey plot. The office prefers that deck soundings be performed with a Delamtect machine that provides both an electronic file of the Delamtect data and a paper plot indicating the location of spalled and patched areas. The electronic file permits the data to be downloaded into the computer aided design and drafting (CADD) system so that the spalled and patched areas easily can be incorporated into the deck repair plans.

If a Delamtect plot is not available, an audible/visual survey plot is acceptable. The plot should be on cross-section paper to a 1 to 10 scale in both longitudinal and transverse directions. All hollow, spalled, and patched areas should be on the plot.

The Bridge Maintenance and Inspection Unit often makes recommendations for repairs and includes them in the regular inspection report, which is available in the Electronic Records Management System (ERMS). The recommended repairs shall be included in the design plans when the repairs are of immediate concern and when they affect bridge load capacity. The need for these repairs should be

verified during the field exam. Based on observations from the field exam and the bridge documentation file, the supervising Section Leader will decide which repairs to include in the project.

Whenever a repair project involves painted parts of the existing bridge the paint shall be tested to determine whether it is expected to generate hazardous waste. Early in the design process the designer should contact the Office of Location and Environment to request a scrape test. Results of the scrape test shall be included on the plans. If the results of the scrape test and bridge repairs require removal of hazardous paint, the supervising Section Leader shall inform the Office of Location and Environment of the need for an Environmental Protection Agency (EPA) hazardous waste identification number for disposal of the paint.

The Office of Materials will be available to perform testing, such as deck cores and chloride content. Cores provide helpful information for large areas of suspected Class B bridge deck repair and for soundness of deck when considering a second overlay. The designer shall discuss need for testing with the supervising Section Leader.

New railing policy for interstate and primary highway bridges affects major repair projects involving deck replacement, superstructure replacement, and widening. If a major repair project is initiated in the Office of Design's Pre-Design Section, that section will determine the required Test Level (and associated height) for the railing. Otherwise, the Preliminary Bridge Section in the Office of Bridges and Structures will determine the required Test Level. However, new railings are not required if an interstate or primary highway project is determined to be a rail retrofit project. For rail retrofit projects the designer shall use the standard designs [OBS SS 1031-1031T].

The Office of Design will design the shouldering, guardrail, bridge approach pavement, and traffic control including floodlighting, traffic signals, and pavement markings that are required for deck repair plans. The Office of Bridges and Structures will be responsible for the temporary barrier rail (TBR) layouts except where the bridge has a sidewalk, bicycle lane, shared use path, or another special situation. In those situations the TBR layouts will be completed as a joint effort of the Office of Bridges and Structures and the Office of Design. For staged construction and other construction situations that involve traffic control in high traffic volume areas the designer should coordinate the design directly with the Office of Traffic and Safety and ensure that the Office of Design is informed of the traffic control plans.

In Chapter 11 of its Construction Manual, the Office of Construction has established limits for construction loading. If the limits are exceeded the contractor will be required to submit for review and approval a structural analysis by an Iowa-licensed engineer. Thus the designer may be required to review construction loads after letting of the repair contract.

12.1.3 Definitions

Bridge Deck Overlay consists of removing deck concrete to a depth ¼ inch (5mm) below the existing surface, transporting the existing concrete removed from the project, and placing a concrete course of a designated depth. See the Iowa DOT Standard Specifications for the complete definition [IDOT SS 2413.01,C,]. Also, see the office standard sheet [OBS SS 1038].

Class A bridge deck repair includes removing deck concrete less than full depth. See the Iowa DOT Standard Specifications for the complete definition [IDOT SS 2413.01, B, 1]. Also, see the office standard sheet [OBS SS 1038].

Class B bridge deck repair includes removing deck concrete for full depth. See the Iowa DOT Standard Specifications for the complete definition [IDOT SS 2413.01, B, 2]. Also, see the office standard sheet [OBS SS 1038].

Scrape test refers to the scratch test mentioned in the standard specifications [IDOT SS 2508.01]. Scrape test and scratch test are interchangeable terms for the same test.

12.1.4 Abbreviations and notation

BRIS, BRridge Information System, a record of design projects on the Iowa Department of Transportation mainframe computer system (accessible from within the Iowa DOT only)
CADD, computer aided design and drafting
CIP, cast in place
CWPG, continuous welded plate girder
EPA, Environmental Protection Agency
ERMS, Electronic Records Management System (accessible from within the Iowa DOT only)
HMA, hot mix asphalt, which includes asphalt cement as a binder. Many older Iowa DOT documents refer to this material as asphalt cement concrete (ACC).
NDT, nondestructive testing
NHS, National Highway System, composed of Interstate and Commercial and Industrial Network. See the detailed listing of highways and map in the manual introduction [BDM 1.3].
OLE, Office of Location and Environment
PCC, portland cement concrete
PPCB, pretensioned prestressed concrete beam
RSB, rolled steel beam
SIIMS, Structure Inventory and Inspection Management System
TBR, temporary barrier rail

12.1.5 References

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12.1.6 Field exams

A programmed bridge repair or overlay project is initiated by the District in cooperation with the Office of Bridges and Structures. It is the designer’s responsibility to do the following:

- Review the request;
- Request a survey of site utilities from the District;
- Review the bridge plan, inspection, and rating files;
- Check the bridge rating;
- Arrange a field exam of the bridge;
- Conduct the field exam;
- Consult with the supervising Section Leader; and
- Prepare a concept statement [BDM 12.1.11].

All items should be completed before preparing plans and specifications for the repairs.

During 2003 the bridge inspection and other documentation files were scanned and converted to electronic form. The bridge plan, inspection, photo, rating, and other files now are available in the Iowa DOT's Electronic Records Management System (ERMS). From within the office, the designer should access ERMS and review the files for the bridge to be repaired, especially the plans and the full-depth inspection report. (Consultant designers will be provided the appropriate electronic files for the bridge.)

The designer should check the design history for the bridge and print all original plans and previous repair plans in order to have the documents available during the field exam. If the bridge has not been coded for repair, the designer should notify the bridge maintenance and inspection group of the planned repair so that inspection teams can schedule their regular biennial inspections for the bridge with due consideration of the repair project.

After reviewing the repair request and the bridge files in ERMS, the designer should plan for and schedule the field exam. The field exam should include input from the District and the Office of Design. When organizing the field exam the designer should contact the District Maintenance Manager and the appropriate section leader in the Office of Design so that representatives from those offices can participate in the field exam. The field exam date should be coordinated with the Office of Design, the District Maintenance Manager, and others (See the cc: list for the Concept Statement in the commentary [BDM C12.1.11].) so that all interested parties can attend.

Although a programmed repair project initially may be proposed as a deck overlay, the project may need to include several other repairs to bring the bridge to an acceptable condition. The additional repairs may involve joint and backwall repair, retrofit barrier rails, guardrail update, and approach work. Usually all of the repair work is performed under traffic and thus will require traffic control. In many cases the repairs will require staging.

The following guidelines provide an organized process for examining the bridge. Although the guidelines cover typical repairs, the designer should document any additional conditions that may need repair. In addition to written notes, the designer should make dimensioned sketches and take ample photographs.

(1) Deck
   (a) If possible, check the depth of the cover over the top reinforcement, to determine if concrete can be removed to the one-quarter-inch (5 mm) deep specification requirement for Bridge Deck Overlay, except in areas planned for Class A bridge deck repair or Class B bridge deck repair [IDOT SS 2413.01].
   (b) Check the underside of the deck for possible full depth repair areas, which are identified as Class B bridge deck repair [IDOT SS 2413.01, B]. While in the field, draw a sketch with dimensions to locate the Class B repair, and locate the areas on the plans. If the Class B repair has an area more than 5 square yards (4.2 m²) a separate bid item is required, otherwise it is covered by the standard specifications [IDOT SS 2413.05].
   (c) Check for any areas of the curb that need repair. Make sketches of the areas in the field, and locate them on the plans. Usually curb repair is included in the bid item "Concrete Repair" quantity. Additional information regarding the repair is given in a standard note [BDM 13.5.2, E431] and on a standard sheet [OBS SS 1045].

(2) Joints
- (a) If the joint is an expansion joint, check the joint opening, and record the air temperature. Even if the joint is closed, it does not automatically need to be repaired or replaced. If there is no distress or deterioration of the substructure due to the lack of expansion room or deterioration of the bridge seat due to runoff, the existing joint probably will be retained. Based on the information the designer obtains during the field exam, the supervising Section Leader will decide whether or not to repair the joint.
- (b) Check soundness of the joint anchorage, both to the superstructure and the substructure.
- (c) If the existing joint is a compression seal, note the position of the seal in the joint and the keeper bar condition.
- (d) If the existing joint is a sliding plate joint, plan to add raise plates unless the joint requires remodeling or replacement. Give special consideration to the condition of prestressed concrete beam ends. If the ends are deteriorating, consider replacing the joint.
- (e) If the existing joint is a strip seal, check leakage, tears in the seal, detail at curbs, and turn-up detail at the barrier rail. Plan to carry to the field exam the special tool required to remove cap screws that hold the barrier cover plate on the rail.
- (f) If the existing joint is a finger joint, plan to taper the overlay to avoid replacing the joint. Review this decision with the Chief Structural Engineer. If the joint has no neoprene trough to direct runoff away from bearings and beam ends, consider retrofitting the joint to add the trough with appropriate drainage details.
- (g) Note the existing condition of fixed joint materials.

(3) Approaches
- (a) Note the condition and size of the joint between the bridge and approach pavement. Record the type and condition of joint material.
- (b) Look for and document evidence of approach pavement repairs, settlement, erosion, and voids. If a portland cement concrete (PCC) approach slab has been mud-jacked to fill voids, there will be filled core holes visible in the top of the slab. Another typical repair is a localized and tapered hot mix asphalt (HMA) overlay.
- (c) Note the type of approach surface: HMA, PCC, or gravel. Possible repairs are an HMA wedge, a PCC wedge, or a slab replacement. The proposed repair needs to be coordinated with the Office of Design.
- (d) If the approach is full depth HMA, a pressure relief joint is not required. However, if the approach is PCC full depth or PCC with an HMA overlay, a pressure relief joint is required.
- (e) Document any existing relief joints. Record width, location, and condition.

(4) End posts and wings
- (a) Determine if posts or walls are broken. Photograph any damage.
- (b) Determine if a guardrail is attached to each end post or wing and the type of guardrail.

(5) Backwalls
- (a) If the full-depth inspection report in the bridge documentation file recommends any backwall repairs, examine the locations of those recommended repairs first.
- (b) Check the top of the backwall for any spalling or crushing. Because overlays on the backwall have not performed well, the current office philosophy is to replace some or all of the backwall. The designer will need to develop details; no standard is available.
- (c) If the backwall condition is uncertain, recommend repair. Examine cracks carefully to be certain they are not just shrinkage cracks. Document fully any possible repair areas with photos and sketches with dimensions.
- (d) Consider replacing only the bad sections rather than the entire backwall. Weigh the decision against bearing settings, expansion device openings, and other related factors.
- (e) Measure and record the distance from the centerline of each beam bearing to the face of the backwall.

(6) Bridge bearings and seats

(a) Note condition of the bearings. If settlement or impact is causing damage to the end of the superstructure or bearing seats, consider replacing the bearings and additional necessary repairs.
(b) Plan to reset bearings only if the existing setting is critical. However, often the bearings are reset if the entire backwall is replaced.
(c) If the bridge seat is spalled in the bearing area, sound the area well with a hammer, and sketch the proposed repair area with dimensions.

(7) Drains and scuppers
(a) Drains should have been extended by maintenance crews. Discuss any missing extensions with the supervising Section Leader because it may be advisable to have the extensions added by maintenance crews rather than the repair contractor.
(b) Do not plan to extend the drains on a slab bridge because there are no beams to be deteriorated by deicer runoff.
(c) Curb scuppers at the ends of the bridge may need to be plugged or reconstructed. Consider the effects of drainage across a deck joint if proposing to plug scuppers, and consider the locations of drain tubes if proposing to reconstruct scuppers.

(8) Railing
(a) Measure and record the heights of the curbs and rails. The dimensions are very helpful for determining whether there is an overlay already on the deck and for planning retrofit cast-in-place (CIP) barrier height.
(b) As part of an overlay project, the railing will be updated to current safety standards [BDM 12.1.9.2.2]. A CIP barrier rail will be added, if one is not already in place. Before the field exam, check the full depth inspection report and the office mainframe program, BRridge Information System (BRIS), to determine if a CIP barrier rail has been added during a previous project. Existing metal railing, whether steel or aluminum, is removed and becomes the property of the contractor in almost all cases, even if the rail does not interfere with the CIP barrier rail. Exceptions to metal rail removal or to rail becoming the contractor's property should be confirmed with the District.
(c) If the curb is narrow, measure it to determine if the standard 10-inch (255-mm) wide CIP retrofit barrier rail [OBS SS 1031] will need to be modified to fit.
(d) On interstate and primary highway systems for deck replacement, superstructure replacement, and widening projects there are additional railing considerations [BDM 12.1.9.2.2]. Plan to take field measurements accordingly. Note however that railing retrofit projects shall continue to use the standard retrofit rails, which are 2 ft -10 in tall.
(e) The Office of Design will plan the guardrail arrangement. On short bridges the Office of Design may run the guardrail across the length of the bridge and attach it to the CIP barrier rail or to the existing concrete rail.

(9) Paint
(a) In general, painting of the bridge is avoided in the repair plans. There are environmental concerns due to use of lead-based paints in the past, and the new painting specifications require careful attention to surface preparation, disposal, and paint system. However, painting is included in some areas such as raise plates for a sliding plate joint, heat-straightened beams, and strengthened beams.

(10) Beams
(a) Observe in general for corrosion, cracks, impact areas, damage, or sag. Take special note of prestressed concrete beam ends and deterioration at bridge deck joints. Document any significant observations with sketches and photographs.

(11) Substructure
(a) Examine the substructure for repair needs, especially below-deck joints and areas identified in the full depth inspection report. Sound any potential areas of repair with a hammer. Document the areas with sketches and photographs. Consult with the

supervising Section Leader regarding which areas to repair and which method to use for the repairs.

(12) Traffic
- (a) Note any situation that would affect traffic controls during repair, such as field entrances, intersections, medians, sidewalks, bicycle lanes, and shared use paths. Usually the Office of Bridges and Structures will develop the TBR layout, but the repair designer will need to consult with the Office of Design for special situations such as those noted above. Keep in mind that special approach signing will be required if a traffic lane is less than 14.5 feet (4.420 m). In special situations the Methods Section of the Office of Design will develop the layout.
- (b) The designer shall notify the Office of Traffic and Safety early in the design process when the repair project is on a roadway with high traffic volume and work directly with the Office of Traffic and Safety in developing the traffic control plan, ensuring that the Office of Design is informed.

(13) Guardrail
- (a) Guardrail often is updated on bridge repair and overlay projects. The Office of Design will decide whether to update the guardrail and will prepare any necessary plans.

(14) Rating
- (a) Before an overlay or a retrofit cast-in-place (CIP) barrier rail is added, the designer shall check the bridge rating as outlined in the next article [BDM 12.1.7]. The current rating will be in the full depth inspection report

(15) General
- (a) Repair only what needs to be repaired. Review any questionable repair items with the supervising Section Leader.
- (b) The designer should review examples of other, similar repair plans.
- (c) The designer shall use the applicable standard CADD notes [BDM 13].

12.1.7 Rating [AASHTO-I 3.23, 3.24]

Before planning improvements the designer shall check the bridge rating according to the guidelines in this article, which generally are based on the AASHTO Standard Specifications. The office does not intend to improve a bridge and then require it to be posted for reduced loads.

To determine if a bridge has adequate capacity for an overlay and/or a cast-in-place barrier rail, follow the guidelines below. Be alert for unusual situations that may require a rating even if the guidelines indicate that no rating is required. Consult with the Bridge Rating Engineer if there are any questions.

(1) Does the project involve widening?
- (a) Yes: Check the bridge capacity.
- (b) No: Go to (2).

(2) Is the operating rating less than HS-25.0?
- (a) Yes: Check the bridge capacity.
- (b) No: No check is needed.
- (c) Unknown: Go to (3).

(3) Was the bridge built before 1960?
- (a) Yes: Check the bridge capacity.
- (b) No: Go to (4).

(4) Was the design load less than HS-20?
- (a) Yes: Check the bridge capacity.

(b) No: No check is needed.

When rating a bridge, use the load factor design method, wherever possible. Rate beams, girders, and longitudinal slab strips at the operating level for Iowa legal load trucks (but not for a HS-20 truck). For rating steel beams or girders, follow the guidelines in Table 12.1.7-1 for bridges without shear connectors and the guidelines in Table 12.1.7-2 for bridges with shear connectors. Note that for bridges with shear connectors, deck reinforcing should be considered part of the cross section in negative moment regions.

Table 12.1.7-1. Guidelines for rating steel beam bridges without shear connectors (noncomposite bridges)

Beam Cross Section	Load Type	Load Distribution
Beam only	Beam weight	Directly to beam
	Deck weight	Based on simple span deck between each pair of beams and overhanging deck edge to exterior beam
Beam with strengthening angles(1)	Overlay weight	Equally to all beams
	Curb, existing rail, and new concrete barrier rail weights	For bridge widths not exceeding 44 feet (13.200 m), equally to all beams; for bridge widths greater than 44 feet (13.200 m), one-half to exterior beam, one-quarter to the first interior beam, and one-quarter to the second interior beam
	Legal live load and impact	According to AASHTO specifications [AASHTO-I 3.23.1 and 3.23.2]

Table note:

(1) In the unusual cases where strengthening angles are added to steel beams, the angles are to be included in the beam cross section for all loads applied after the angles are installed.

Table 12.1.7-2. Guidelines for rating steel beam bridges with shear connectors (composite bridges)

Beam Cross Section	Load Type	Load Distribution
Beam only	Beam weight	Directly to beam
	Deck weight	Based on simple span between each pair of beams and overhanging deck edge to exterior beam
	Curb weight, if curb is poured with deck	Directly to exterior beam
In positive moment regions, composite beam including deck(1); in negative moment regions, composite beam including longitudinal deck reinforcing	Curb weight, if curb is not poured with deck, and existing rail weight	For bridge widths not exceeding 44 feet (13.200 m), equally to all beams; for bridge widths greater than 44 feet (13.200 m), one-half to exterior beam, one-quarter to the first interior beam, and one-quarter to the second interior beam
In positive moment regions, composite beam including strengthening angles(2) and deck(1); in negative moment regions, composite beam including strengthening angles(2) and longitudinal deck reinforcing	Overlay weight	Equally to all beams
	New concrete barrier rail weight	For bridge widths not exceeding 44 feet (13.200 m), equally to all beams; for bridge widths greater than 44 feet (13.200 m), one-half to exterior beam, one-quarter to the first interior beam, and one-quarter to the second interior beam
	Legal live load and impact	According to AASHTO Standard Specifications [AASHTO-I 3.23.1 and 3.23.2]

Table notes:

(1) The office prefers not to include a concrete overlay in the composite cross section. If it appears that an overlay must be included for a successful rating, consult with the supervising Section Leader and the Bridge Rating Engineer.
(2) In unusual cases where strengthening angles are added to steel beams, the angles are to be included in the beam cross section for all loads applied after the angles are installed.

The office has strengthened steel beam or girder bridges by bolting on angles when bending stresses have approached or exceeded $0.65F_y$, and the method may be used with permission of the supervising Section Leader. If strengthening angles are to be added, the designer shall proceed as follows. Specify that the angles are to be in place before an overlay and new concrete barrier rail are added to the side being strengthened. If possible, strengthen to $0.55F_y$ with Iowa legal loads. Deduct for bolt holes when checking beam stresses in tension regions. Require Charpy V-notch testing for the strengthening angles.

For rating concrete tee girders, generally follow the guidelines in Table 12.1.7-2 for composite bridges but adapt the guidelines for the tee girders. Check both bending and shear.

For rating concrete slab bridges, the designer shall follow the guidelines in Table 12.1.7-3 for a one-foot (300-mm) wide longitudinal strip. Check bending but not shear [AASHTO-I 3.24.4]. Note that the rating distribution of the curb, rail, and concrete barrier rail weights is different than for design.

Table 12.1.7-3. Guidelines for rating slab bridges

Longitudinal Strip Cross Section	Load Type	Load Distribution
One-foot (300 mm) wide by thickness at 6.50 feet (1.950 m) from gutterline, if slab thickness varies	Slab and overlay weights	Directly to longitudinal strip
	Curb, rail, and concrete barrier rail weights	Equally over the entire bridge width (total load times ratio of strip width to bridge width)
	Legal live load and impact	According to AASHTO Standard Specifications [AASHTO-I 3.24.3.2]

12.1.8 Staging

12.1.8.1 Structural considerations

For most bridge repair projects it is assumed that construction can take place without cranes, construction vehicles, construction equipment, and concentrated quantities of construction materials on the bridge. However, the designer should consider potential construction loads when planning for repairs and review any critical situations with the supervising Section Leader. If the contractor needs to place significant loads on the bridge, the contractor will be required to submit structural analysis by an Iowa-licensed engineer for approval as required in Chapter 11 of the Office of Construction's Construction Manual. Thus the bridge designer should be prepared to review construction loading after letting of the bridge contract.

If deck surface removal will seriously weaken a main reinforced concrete structural member such as a concrete slab, a concrete tee, or a concrete box, the designer shall consider the following three options:

- Repair in narrow longitudinal strips with traffic staging.
- Provide falsework with traffic staging and repair.
- Close the road, arrange for a detour, and provide falsework and repair.

Repair in narrow longitudinal strips is the much-preferred option. For this option, removal and repair shall be staged to maintain a functioning portion of a concrete box or tee girder flange at all times. When the work sequence is critical, the designer shall include on the plans clear and specific notes regarding the sequence.

The second option should be avoided because falsework behavior during repairs is complex and difficult to control. It is doubtful that original stresses in main bridge members can be duplicated or that design stresses will be achieved in the field. The third option generally should be avoided because of the inconvenience to the public.

Full-depth Class B repair over a steel beam with shear connectors may be a difficult problem. For ease of construction it may be desirable to end the full depth removal at the centerline of the beam, but this would result in poor shear connection and questionable strength for part of the composite compression flange. For full-depth replacement on composite beams, plan details shall be specific about removal terminations and construction staging. In cases where extensive Class B repair is indicated, the designer should consider complete deck removal and appropriate staging to minimize overstressing caused by live load applied to composite sections.

12.1.8.2 Construction considerations

For bridge roadway widths to a maximum of 44 feet (13.200 m) when standard traffic control layouts apply, no construction joints need to be shown on the overlay plans. The construction joint for these standard situations is at the centerline of the approach roadway.

Standard temporary barrier rail (TBR) layouts will need to include a minimum traffic lane width. If traffic lanes place traffic on the approach shoulder, the shoulder may need to be strengthened. TBR layouts developed by the bridge designer should be given to the Office of Design as soon as possible to aid in road plan development. If the bridge has a sidewalk, bicycle lane, shared use path, or other special situation the designer will need to consult with the Office of Design while developing the TBR layout.

Traffic lanes should be at least 14.50 feet (4.420 m) wide. If it appears that traffic lanes must be narrower, consult with the supervising Section Leader. Although concrete TBR is much-preferred, steel TBR may be required for narrow lanes.

The designer shall contact the Office of Design whenever the first or both of the following narrow construction lane conditions apply:

- The roadway width between barriers during construction is less than 14.50 feet (4.420 m). In this case the Office of Design needs to provide details for signing in advance of the work area.
- The roadway width during construction is less than 10.50 feet (3.200 m) on primary highways or 12.42 feet (3.780 m) on interstate highways. In these cases the Office of Traffic and Safety will need to review the TBR design.

Staging for high peak hourly traffic volume in one direction may require more than one lane open to traffic for that direction at certain times. Check with the Office of Traffic and Safety for traffic routing through the project site, and keep the District informed of the proposed traffic routing.

For special traffic control layouts, overlay construction joint locations need to be determined and shown on the bridge plans. Construction joint locations should be established on the basis of TBR dimensions, finishing machine dimensions and limitations [BDM C12.1.8.2], roadway width, and minimum number of required traffic lanes. The designer shall inform the Office of Traffic and Safety of the bridge staging so that office can develop the traffic control layout. The Office of Traffic and Safety also will need to include on road plans a tabulation for control devices under the “Traffic Control” bid item.

12.1.8.3 Temporary barrier rail [AASHTO-I 3.24.5.2]

Except for special circumstances such as urban applications, extremely narrow roadways, and low traffic counts [OD SRP TC-211], temporary barrier rail (TBR) shall be used for bridge deck repairs. Example TBR layouts for several standard bridge roadways are given in the commentary [BDM C12.1.8.3]. Bridge plans shall include a bid item for temporary barrier rail, and the contractor will be paid for the measured length of all setups as noted in the standard specifications [IDOT SS 2528.04, C, and 2528.05, C]. Traffic control layouts, either standard or special, will determine the number and extent of TBR sections. TBR should be flared at 6:1 in accordance with standard plan sheets [OBS SS 1049, 1050, 1056, and 1058].

Special traffic control layouts (such as for ramp bridges, flared roadways, high traffic volume roadways, and bridges with sidewalks, bicycle lanes, or shared use paths) may require the bridge designer to establish the construction staging before completion of the traffic control plan. In these cases the TBR layout will be specific for the project site, and the designer shall consult with the Office of Design and Office of Traffic and Safety.

Placing of the TBR during staged construction should be planned carefully with respect to the existing superstructure at each stage. Office policy is to place the TBR along the centerline of an existing beam wherever possible. If the TBR must be placed on a deck cantilever, the designer shall consult with the supervising Section Leader and shall follow the guidelines below.

- Place the TBR on the deck cantilever, limiting the placement so that the traffic side of the barrier face is a maximum of one foot (300 mm) from the centerline of the stage exterior beam. Also, provide a minimum of 6 inches (150 mm) clearance from the outside edge of the TBR to the edge of the deck. The maximum temporary deck cantilever length should be approximately 3.50 feet (1.060 m).
- Check the transverse top slab reinforcement due to a distributed load from a collision on the TBR. The collision load may occur at the TBR joint where the anchorage is located. Use the effective length of slab for continuous concrete parapet found in the AASHTO Standard Specifications [AASHTO-I 3.24.5.2]. For allowable stress analysis of the reinforcing steel, use 75% of yield. When performing the analysis, consider loss of slab concrete and corrosion of reinforcement. Because the situation is temporary, the designer may exercise some flexibility in the analysis.

Tie-downs are required for TBR near drop-offs. For severe dropoffs such as the edge of a bridge deck, tie-downs are required when the backside of the TBR to deck edge is less than 3.75 feet (1.150 m). With a Type B tie down strap the backside of the TBR may be as close as 6 inches (150 mm) to the edge of a bridge deck [OD DM 9B-9].

12.1.9 Programmed projects

12.1.9.1 Repair

12.1.9.1.1 Deck repairs

The bridge maintenance file will contain a sketch of the bridge deck, but the sketch will not show all areas that need repair. Because of traffic the bridge inspection crew may not sound all areas and may do so in a zigzag pattern. The designer should consider the sounding plot provided by the District to be the primary source for deck repair information.

Unless the bridge deck has an existing hot mix asphalt (HMA) overlay or an existing PCC overlay, for each deck repair project the District will provide a Delamtect or an audible/visual sounding plot that indicates areas of repair. Each sounding plot should include an estimate of the total quantity of hollow, spalled, and patched areas.

When the District submits a Delamtect plot, the designer shall estimate Class A bridge deck repair [BDM 12.1.3] as specified in standard notes [BDM 13.5.2, E400C or E400D]. For the repair plans, the designer shall add the following to the plot: centerline of piers, centerline of roadway, north arrow, and date of completion.

When the District submits an audible/visual survey, the designer should increase the estimated repair area by 25% and include it as the basic quantity of Class A bridge deck repair [BDM 13.5.2, E400A or E400E]. The 25% increase is based on past experience.

When soundings indicate repair areas exceeding 50% (1.25*37.5%) of the total deck area, consult the supervising Section Leader to determine if the entire deck should have Class A bridge deck repair or if the deck should be replaced.

Sounding plots shall not be given on the repair plans for bridges with an existing PCC overlay [BDM 13.5.2, E400B]. Instead, show existence and thickness of PCC overlays on the plans, and provide a bid quantity item for removal of the PCC overlay. If the District does provide soundings through an existing PCC overlay, it is office policy to disregard the soundings because they typically are unreliable. Estimate Class A bridge deck repair as 20% of deck area for bridges with existing PCC overlays.

Sounding plots shall not be given on the repair plans for bridges with an existing HMA overlay [BDM 13.5.2, E400B]. Instead, show existence and thickness of HMA on the plans, and provide a bid quantity item for removal of the HMA. If the District does provide soundings through an existing HMA overlay, it is office policy to disregard the soundings because they typically are unreliable. Estimate Class A repair as 50% of deck area for HMA-covered bridges, except as noted below for short simple spans. In all cases, consult the supervising Section Leader for the percentage to use.

HMA-covered decks of short simple spans to approximately 50 feet (15.240 m) should be considered for Class A repair over the entire floor. Age of asphalt cover and age of bridge should enter into this decision. In general, decks covered by asphalt for 15 years or more should receive complete Class A repair.

Because of structural concerns the designer should give continuous concrete slabs and tee girders a careful appraisal for Class A repair. If the deck is asphalt covered, cores or excavation of the HMA may be necessary to determine condition of the concrete in the negative moment regions.

Some older concrete slab bridges do not have a top reinforcing mat in the positive moment region. For those areas without a top mat, require Class A repair with a minimum of 1½ inches (40 mm) removal.

The designer is responsible for identification of full-depth, Class B repair areas. The designer should not include a token amount of Class B repair if none is anticipated because the standard specifications provide for a contingency amount of Class B repair up to 5 square yards (4 square meters) [IDOT SS 2413.05].

The upper boundary for Class A or Class B repair is defined as the lower boundary for overlay [IDOT SS 2413.01 and OBS SS 1038]. For situations where there will be no overlay, the Class A or Class B repair will extend to the original deck surface. This exception must be noted in the design plans. The plans also should note that the finishing and curing is as required for an overlay.

IDOT SS 2413 requires contractors to clean epoxy coated reinforcing with hand tools in order to prevent damage to the coating. The IDOT Standard Specifications do not currently address repairs to exposed epoxy coated reinforcement which is damaged or deteriorated in deck repair situations. OBS has determined that, in most cases, epoxy coating need not be repaired since any repairs to the coating are likely to be difficult and relatively ineffective. Unless determined otherwise, plans involving deck repair may remain silent with respect to damaged epoxy-coating.

12.1.9.1.2 Overlays

The usual preparation for a deck overlay is to remove deck concrete to ¼ inch (5 mm) below the original surface [IDOT SS 2413.01, C, and OBS SS 1038]. Where the overlay preparation will be greater than that amount, the designer shall identify the locations on the design plans and redefine the classification between overlay and repair by means of plan notes.

Currently, hydrodemolition [per IDOT SS 2413.03, C.2.b] will only be permitted on an overlay project when requested by the District or Chief Structural Engineer. Refer to OBS SS 1069 for the appropriate notes to include in the plan set.

For an overlay, the deck surface raise shall be 1½ inches (40 mm). This amount of raise is intended to provide at least 1 3/4 inches (45 mm) of thickness for the overlay. Where the end of the overlay is not

armored, the designer shall provide Class A repair for a distance of 2 feet (600 mm) from the end of the overlay [OBS SS 1040].

There are some cases where the roadway crown or the longitudinal profile could be altered by varying the thickness of the overlay. Unless the crown or profile is intolerable, it is best to detail a constant surface raise over the entire deck area.

If at all possible, the surface raise should be carried uniformly from end to end of the bridge. Because it usually is not cost effective to add raise plates to finger joints the designer should consider tapering the overlay to meet these joints. In most instances an overlay taper will be the best solution at a finger joint.

Where a taper is necessary, set the taper at 1½ inches to 40 feet (40 mm to 12.000 m), subject to approval of the Office of Design, and core out the deck for a minimum thickness of 1½ inches (40 mm). On the plans the taper area should be indicated by redefining the lower boundary of the overlay as the lower boundary of preparation for taper.

The standard specifications allow either Class O concrete [OM IM 529] or Class HPC-O concrete for bridge deck overlays [IDOT SS 2413.02, D]. Latex modified concrete no longer is allowed.

12.1.9.1.3 Deck joints

Whether a joint is replaced, repaired, or left in place should be based on both the condition of the joint and the condition of the bridge seat. The designer shall follow the guidelines below.

(1) If there is salt damage to the bridge seat, design a new waterproof joint even if the existing joint is sound.
(2) If there is no salt damage to the bridge seat, retain the existing joint if it is sound.
(3) If the project includes backwall or joint repair, replace or modify the joint to prevent leakage.
(4) If existing sliding plates are retained, clean the existing plates, paint with rust inhibitor type primer and final coat, and add raise plates. See the cleaned painted raise plate note [BDM 13.5.2, E470 (M470)].
(5) Unarmored concrete slab ends may be raised and left unarmored, but the end of the overlay shall have a Class A repair for a distance of 2 feet (600 mm) [BDM 12.1.9.1.2, OBS SS 1040].
(6) Unarmored compression seals may be used at joints that have little or no movement. The maximum width for unarmored compression seals shall be 1 5/8 inches (40 mm) because slab edges ravel badly at wider joint openings.
(7) Use a strip seal for modification or replacement of joints with movement. List on the plans the total design movement in inches (mm) for the strip seal.
(8) Galvanize joint armor and steel extrusions, including extrusions to be welded to existing sliding plates.
(9) If possible, taper an overlay to finger joints to avoid requiring raise plates. Review the design with the supervising Section Leader.
(10) If an existing finger joint has no drainage trough, consider adding the trough.

12.1.9.1.4 Drains and scuppers

Due to past maintenance programs, all drain tubes now should be extended below the exterior beams. If drain tubes are not extended, it is office policy not to extend them as part of a bridge repair or overlay project.

Curb scuppers, which are 5- to 6-foot (1.520- to 1.830-m) long curb openings at the bridge ends, should be plugged or reconstructed. If the designer chooses to plug scuppers, the designer will need to consider the effect of drainage across a deck joint. If the designer chooses to reconstruct scuppers, the designer will need to remodel each scupper to accommodate a drain tube.

12.1.9.1.5 Curbs

Repairs to the top and batter face of curbs shall meet the requirements for structural concrete repair [IDOT SS 2426]. The repairs require a bid item for concrete repair, and the standard sheet for concrete repairs [OBS SS 1045] shall be included in the design plans.

In the field there has been difficulty with the combination of curb reconstruction and Class B deck repair. If Class B deck repair is adjacent to curbs, the designer must consider the problem of curb removal and curb support. Notes on the plans regarding construction sequence and procedures need to be very clear.

When curbs are to be reconstructed for their entire cross section, they shall be constructed with Class D concrete before the overlay placement is started. The designer should include bid item “Structural Concrete” and note on the plans that the concrete shall be Class D. The designer also should note on the plans that the deck repair quantity will not include the plan area under the curbs.

12.1.9.1.6 Miscellaneous concrete

Miscellaneous concrete repairs shall be in accordance with the standard sheet for concrete repairs [OBS SS 1045] and the standard specifications for structural concrete repair [IDOT SS 2426].

12.1.9.1.7 Backwalls and diaphragms

Class C structural concrete shall be used for reconstruction of diaphragms and backwalls. New concrete should be placed to the final riding surface as shown in Figure 12.1.9.1.7 and finished [BDM 13.5.2, E461]. Plans should provide specific details showing the limits of Class C concrete. Depending on the depth of the reconstruction, the limits may be given in one of two ways.

(1) If the reconstruction involves a large concrete quantity and reinforcing steel, the backwall detail can note an upper limit for Class C concrete, which then is included as a bid item.
(2) If the reconstruction involves little concrete below the bottom of the deck and no reinforcing steel, the repair can be included as “Deck Repair Class B” area. The designer shall note on the plans that the cost of all removal and all concrete replacement below the bottom of the deck is to be included in the price bid for “Deck Repair Class B”.

When replacing backwalls full height, the designer should incorporate existing rebar into new work only for tie purposes. Existing bars should be exposed and cut off to the specified development length. The existing rebar should not be considered for strength in the new work. New bars should be doweled into the existing concrete to satisfy strength requirements.

When doing repair projects that involve replacing the backwall and modifying the expansion device, the designer shall indicate on the plans that the vertical face of the existing expansion joint be cleaned and painted as indicated in Figure 12.1.9.1.7. Cleaning and painting should be similar to that specified for raise plates on sliding plate expansion devices [BDM 12.1.9.1.3].

The tops of the new diaphragms and backwalls shall not be sealed with concrete sealer.

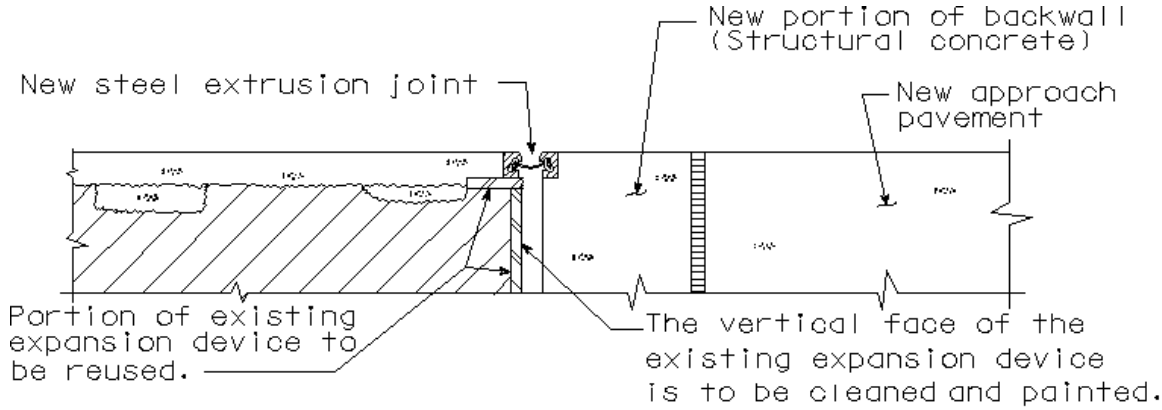

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Figure 12.1.9.1.7. Backwall replacement with remodeled expansion joint

If backwalls are not reconstructed, as a minimum the designer shall rebuild the wall to the top of the paving notch.

12.1.9.1.8 Shotcrete

Currently the office does not use shotcrete for bridge repairs. Any exceptions shall be approved by the Chief Structural Engineer.

12.1.9.1.9 Asbestos

In unusual cases the asbestos inspection by the Office of Location and Environment will determine that asbestos materials are present in a bridge to be repaired. The usual procedure is to remove the asbestos materials in advance of repair with a separate contract so that the repair project can proceed without delay. The designer should note on the plans that the asbestos removal will be accomplished before the repair contract is issued.

If asbestos materials cannot be removed in advance of a repair project the designer shall be very specific on the plans to require in a general note in the form of CADD Note E485 that the asbestos materials need to be removed before any demolition or other repair activities commence. The designer also shall include in the plans a bid item for removal of asbestos with a reference note listing the asbestos material, amount to be removed, and Standard Specifications reference for asbestos removal [IDOT SS 2536].

12.1.9.2 Retrofit

12.1.9.2.1 Doweled bars

To meet the TL-4 retrofit barrier rail design, dowels intended to attach the rail shall be placed in 10-inch (255-mm) deep holes [OBS SS 1031-1031F]. Dowels intended to attach other structural components may be placed in deep or shallow holes depending on design conditions. For a deep hole (The hole is deep enough to fully develop the dowel.) the designer shall follow the guidelines below for choosing the dowel-setting material.

- Polymer grout: All dowels may use an approved polymer grout system [IDOT SS 2301.03, E, OM IM 491.11]. Different polymer grouts are approved for vertical or horizontal installation. Holes are to be 1/8 inch (3 mm) larger in diameter than the nominal size of the dowels.
- Hydraulic cement grout: Only those dowels that are set vertical or with a slope not less than 1:1 may use the hydraulic cement grout system. Holes drilled for the dowels are to be 2 1/2 times the dowel diameter and are to be blown clean with compressed air immediately prior to placing grout. The hydraulic cement grout system shall be approved in advance [OM IM 491.13].

If the hole for setting a dowel is shallow, 4 to 6 inches (100 to 150 mm) deep, the designer shall use only an approved polymer grout system. When the dowel is subjected to intermittent tension, the designer shall limit tension to the allowable value given in Table 12.1.9.2.1, which is based on a factor of safety of four applied to average pullout value. The minimum factor of safety based on 7-day pullout test criteria [OM IM 491.11] will be less than four but greater than two. Dowels with an approved polymer grout system shall not be subjected to permanent tension.

Table 12.1.9.2.1. Allowable intermittent tension values for short #6 (#20) rebar dowels set in epoxy in 7/8-inch (22-mm) diameter holes

Embedment, Inches (mm)	Allowable Intermittent Tension Load, kips (kN)	
	#6 (#20) black dowel	#6 (#20) epoxy dowel

4 (100)	3.775 (16.79)	2.828 (12.58)
6 (150)	5.000 (22.24)	3.744 (16.65)

To ensure full capacity all dowels shall be placed a minimum of 4 inches (100 mm) from center of dowel to edge of concrete.

12.1.9.2.2TL-4 barrier rails

Office policy is to upgrade existing barrier rails on bridges in the vicinity of road construction projects. The standard Iowa retrofit barrier rail [OBS SS 1031-1031T] carries a Test Level-4 (TL-4) rating [BDM 12.1.5]. If a bridge has no concrete barrier rails or outdated barrier rails, the bridge should be retrofitted with current barrier rails as part of a repair, overlay, or paving project.

With a rating of TL-4 the standard retrofit barrier rail is adequate for retrofit rail projects on the interstate or primary highway systems. However, for deck replacement, superstructure replacement, or widening projects on those systems the designer shall consider the need for taller rails with a TL-5 rating. More information is given in the railings article [BDM 5.8.1.2.1]. Questions should be referred to the Chief Structural Engineer.

A retrofit barrier rail consists of both a standard section and two end sections. The standard section is of constant cross section, and the end sections include turnouts with connections to thrie beam guardrail. Because the new thrie beam connection requires a significant amount of reinforcement, which is inconsistent with reasonable dowel placement, the modified end section will require use of the Office of Design's connection to existing endposts [OD SRP BA-202].

Both the standard rail section and the end sections usually are replaced in the same project but, in some cases when the standard section is adequate, only the end sections are replaced. The decision is based on the adequacy of both standard and end sections and the need to provide for connection to guardrail. Standard sheets provide details for retrofit rails for several usual conditions [OBS SS 1031-1031T].

When a bridge repair includes an overlay or updated end rail section, there may be need to apply sealer to the traffic faces and tops of existing rails. If the barrier has severe deterioration, consider whether repairs need to be made first before sealing, or if the sealing is worth the cost. Do not seal rails unless other repairs require traffic control for both sides of the bridge. If existing rails are to be sealed use CADD Note E463/M463 [BDM 13.5.2].

New concrete barrier rails shall not be sealed. The sealant may prevent proper curing of the concrete.

12.1.9.2.2.1 Standard section [AASHTO-I 2.7.1.3]

Except for the unusual case where TL-5 rails are required, if no concrete barrier rails or retrofit barrier rails are present, new 34-inch (865-mm) height, TL-4 retrofit barrier rails shall be added to the bridge. The designer shall check capacity of exterior beams to carry the new barrier rails.

For a bridge on a National Highway System (NHS) route [BDM 1.3], existing concrete barrier rails or retrofit barrier rails are adequate if they have a final height after overlay, if overlay is part of the project, of at least 29 inches (735 mm) above the riding surface at the gutter line. On other routes they are adequate if they have a final height after overlay, if overlay is part of the project, of at least 27 inches (685 mm) above the riding surface at the gutter line. When the existing concrete barrier rails or existing retrofit barrier rails do not meet the applicable requirement, they shall be increased to a height of 34 inches (865 mm).

Thickness of retrofit barrier rails shall be 10 inches (255 mm) [OBS SS 1031, 1031C, 1031E] if the bridge does not have electrical conduit installed in the existing curb and will not have conduit in the retrofit rail. If the existing curb contains conduit or if conduit will be installed in the retrofit rail, the thickness shall be 14 inches (355 mm) [OBS SS 1031D, 1031F]. In cases where the curb contains conduit, the thicker rail is necessary to avoid penetrating the conduit with holes for dowel anchorage [BDM 13.5.2, E490 (M490)]. In

cases where conduit is installed in the retrofit rails no more than two conduits may be placed in one rail, and the maximum conduit sizes are two 2-inch (51-mm) or one 2-inch (51-mm) and one 3-inch (76-mm).

Under the AASHTO Standard Specifications a barrier rail standard section shall be designed for a 10-kip (45-kN) force at the top edge [AASHTO-I 2.7.1.3].

If concrete retrofit barrier rail is being installed, any existing steel rail shall be removed. Unless otherwise requested by the District, the rail shall become the property of the contractor [BDM 13.5.2, E441A (M441A)]. In most cases existing aluminum rail should be removed, but the District may request that it be left in place behind the new concrete barrier rail. When the aluminum rail is removed, the District may request that the rail remain the property of the state [BDM 13.5.2, E441B (M441B)] or that it become the property of the contractor [BDM 13.5.2, E441A (M441A)].

If a bridge has both an existing concrete barrier rail and a metal rail, the District shall make the decision to remove the metal rail or leave it in place.

When metal rails are to be removed, the designer shall include the following in “Retrofit Barrier Railing Notes.”

- A note "Existing bridge rail is not to be removed until authorized by the Engineer.”
- A scrape test note for a steel rail.
- A standard note describing the rail and disposition of the rail after removal [BDM 13.5.2, E441A, E441B (M441A, M441B)].

12.1.9.2.2.2 End sections [AASHTO-I 2.7.1.3]

In general, existing concrete end sections or retrofit end sections are judged to be adequate if they meet both of the following criteria:

- End sections will have a final height at least 32 inches (815 mm) above the riding surface at the gutter line after overlay, if overlay is part of the project.
- End sections include a turnout at least 24 inches (610 mm) long by 6 inches (155 mm) deep.

For each bridge the designer shall verify the adequacy of any existing end sections with the Office of Design.

When existing end sections are judged to be adequate, thrie beam guardrail will be attached by drilling holes in the end sections. See the Office of Design standard sheet [OD SRP BA-202] for details.

For a dual bridge it is not necessary to update the thrie beam connection for the trailing end because guardrail will not be used in a head-to-head staging operation.

When concrete end sections are judged to be inadequate, or end sections are not present, new end sections are required. End section height shall be 34 inches (865 mm) above the final riding surface at the gutter line to allow for a thrie-beam connection. The 34-inch (865-mm) height shall be maintained for a distance of 30 inches (765 mm) back from the turnout and then sloped down at 1:10 to the height of the standard section if it is less than 34 inches (865 mm). If the 1:10 slope is difficult to achieve, see additional guidelines for sloped transitions in the commentary for this article [BDM C12.1.9.2.2.2].

If expansion joints exist at the end of the bridge deck, the end sections should be separated from the standard rail section at the expansion joints. If the gap between a detached end section and a standard end section exceeds 4 inches (100 mm), a curb plate is required. A less-preferred option at expansion joints is to cantilever the end sections over the deck expansion joints.

At the joint with the standard section, end sections preferably should be the same thickness but may be thicker than the standard section.

Under the AASHTO Standard Specifications an end section shall be designed for a 10-kip (45-kN) force at the top edge [AASHTO-I 2.7.1.3]. If end sections cannot be attached to existing curbs and wing walls to

resist the load, an acceptable option is to place supporting footings to a depth at least 48 inches (1.220 m) below ground line.

No portion of an existing curb shall protrude from the turnout. When necessary, parts of existing curbs should be removed.

Guardrail information is to be furnished by the Office of Design and included in the final plans.

12.1.9.2.3 Cover plates

When a project includes replacing the deck of a cover-plated steel I-beam bridge the designer shall discuss the cover plate repair options with the supervising Section Leader. Two of the options that should be considered are peening of cover plate end welds and bolted cover plate end splices.

12.1.9.2.4 Other

Reserved

12.1.9.3 Strengthening steel members

12.1.9.3.1 Beams and girders

Structural steel repair material for main members shall meet Charpy V-Notch toughness requirements [IDOT SS 4152.02] and be so noted on the plans. Strengthening angles for a main member, although technically not considered main members themselves, will need to meet Charpy requirements because of the sizable stress range to which they are subjected.

On repair plans, where there is a small amount of miscellaneous structural steel, a note should specify whether Charpy V-Notch toughness is or is not required.

12.1.9.3.2 Other

Reserved

12.1.9.4 Replacements

12.1.9.4.1 Approach pavement

The designer shall inform the Office of Design if there is a need to remove approach pavement to facilitate repair of a backwall or modify a paving notch. For replacing the approach pavement, the designer should request appropriate details from the Office of Design. The designer should specify that the pavement joint between the bridge and approach slab be placed by the bridge contractor.

In cases not involving backwall repair the Office of Design in coordination with District personnel and the Office of Bridges and Structures will make the decision to replace or not to replace approach pavement.

If approach pavement is to remain in place, the Office of Design will provide details for pavement adjustments. The adjustments may be an HMA runout taper or a tapered PCC overlay.

12.1.9.4.2 Decks

Generally deck replacements that do not involve widening or other alterations to the superstructure configuration of a bridge do not require a situation plan (or TS&L) prepared by the preliminary bridge section. Therefore a final design section will be responsible for the typical bridge deck replacement project. Because deck replacements will require closing part or all of a bridge, the final designer should consider accelerated construction methods in order to minimize traffic disruption and work with the Office of Design as needed to coordinate adjacent construction work.

In order to properly specify deck elevations on the plans for a deck replacement, the final designer shall request a survey of the existing deck. A bridge occasionally will settle several inches during years of service and, without the survey, elevations for the new deck will not be accurate for the intended deck thickness.

In relatively old bridges, steel beams or girders may not be composite with the deck. In those cases the designer should consider adding shear studs to make the superstructure composite.

Before shear studs were commonly available, angle-plus-bar shear lugs were in use in Iowa from about 1947 to 1970 to provide composite action between steel beams and concrete decks. Because the AASHTO Standard or LRFD Specifications do not give a method for determining nominal resistance of the lugs, the commentary for this article [BDM C12.1.9.4.2] has a method that was checked with laboratory tests. The designer shall check composite shear capacity of the existing lugs and provide additional shear studs on the project plans as needed.

The designer also shall provide for a field inspection of top flanges and shear lugs after deck removal. Any cracks, gouges, nicks, and cuts in tension flanges and in shear lugs above tension flanges need to be ground out or otherwise repaired. After all damage has been assessed and repaired the contractor shall be required to provide additional shear studs to compensate for the shear lug damage. The designer shall consult with the Chief Structural Engineer for any project involving shear lugs.

For a deck replacement project fatigue of a steel superstructure is an important consideration. Cover plated beams may have a relatively short remaining fatigue life, and the designer should consider retrofit options given in the cover plate article [BDM 12.1.9.2.3].

For deck replacements the designer also needs to address potential lateral buckling of steel beams in superstructures with integral abutments. During service conditions with the deck in place, closely spaced shear connectors prevent lateral buckling of the beams when they are in compression along with the deck and pushing against the abutments. However, when the deck is removed there is no compression resistance from it, and the lateral support for the beams is widely spaced at diaphragms only. If a temperature rise in the bare superstructure is large enough, the beams will not be able to push the abutments back into the approach fills, and the beams will buckle laterally between diaphragms.

12.1.9.4.3 Other

Reserved

12.1.9.5 Coatings

12.1.9.5.1 Scrape tests

Scrape tests are required whenever any steel is to be removed or repaired, including the following:

- Removal of an existing bridge with painted steel,
- Removal of existing painted steel handrail,
- Cleaning and painting of steel, such as raise plates and strengthening angles, and
- Painting of steel beams.

The designer should request scrape test results from the Office of Location and Environment at the time design plans are being prepared. If results are not available at turn-in time, the designer shall notify the supervising Section Leader.

Scrape test results shall be given on the plans in the format of a standard note [BDM 13.5.2, E480].

12.1.9.5.2 Cleaning and painting

Many bridge repair projects require small amounts of field painting. The designer needs to be very specific in identifying the areas to be painted and, as needed, to include special details to clarify the

extent of the painting. If the areas to be painted are not clearly identified, or if the plans suggest that additional areas need painting, a contractor will not be able to prepare a proper bid.

Table 12.1.9.5.2 lists examples of typical field painting and plan notes [BDM 13.5.2, 13.10.2] required for each example. Removal of non-hazardous paint [IDOT SS 2508.01, A], removal of hazardous paint [IDOT SS 2508.01, B], and painting of structural steel [IDOT SS 2508.02] shall be in accordance with the standard specifications.

Table 12.1.9.5.2. Typical field painting examples and plan notes

Field Painting Example	Scrape Test	Containment	Cleaning and Painting
New raise plate above existing expansion device	E480/M480		E470, M470
New strip seal device replacement for existing sliding plate expansion device	E480/M480		E471/M471
Existing masonry and sole plates	E480/M480	E474/M474	E473/M473
New strengthening angles added to existing steel beams	E480/M480	E474/M474	E1000, M1000, E472C/M472C

For the examples in the table, bid items for “Painting Structural Steel” and “Containment” shall be included on the plans. For painting areas other than those in the table, the plan notes and bid items will be determined on a case-by-case basis with approval of the supervising Section Leader.

If the existing paint system includes excessive amounts of leachable chromium or lead, the paint is considered to be hazardous. For projects with hazardous paint systems, additional precautions for removal and disposal of paint are required [IDOT SS 2508.01, B]. The Iowa DOT is obligated to obtain an EPA hazardous waste identification number, and the supervising Section Leader shall contact the Office of Location and Environment (OLE) to inform them of the need to obtain the number. If the bridge already has an EPA number, it may be placed on the plans based on consultation with OLE. If the bridge does not have an EPA number, the number cannot be placed on the plans because the contractor needs to generate waste before the number can be obtained.

12.1.9.5.3 Concrete sealer

As part of a repair or overlay project, the concrete barrier rails, curbs, and adjacent roadway surface shall be sealed [IDOT SS 2413.03, G]. The sealer should be applied continuously from the outside top edge of the rail to a line on the roadway surface one foot (300 mm) from the curb. Cost of the sealer should be made incidental to a bid item such as “Concrete Repair”, “Repair Beam Ends”, “Bridge Deck Overlay”, or “Structural Concrete”.

The bridge seats under joints also should be sealed [IDOT SS 2403.03, P, 3]. If abutments or piers have extensive scale and/or map cracking, sealing to the ground line may be justified. If abutment backwalls and diaphragms are replaced, the tops are not to be sealed.

The designer shall specify any other areas of the bridge that are to be sealed.

12.1.9.5.4 Other

Reserved

12.1.10 Emergency projects

Quite regularly overpasses are struck and damaged by vehicles with overheight loads. Emergency repair projects for such damage must proceed on an accelerated schedule and close coordination with the District. In general an emergency repair project will include an evaluation for traffic restriction, a field exam, a concept, and a final design.

After discovering the damage, the first problem facing the District is to determine if immediate traffic restriction is needed. There is no substitute for sound engineering judgment, but traffic restriction must be considered if any of the following conditions are observed:

- Open cracks or severe section loss in the lower flange or web of a damaged beam or girder,
- Severed prestressing strands or strands that are visibly deformed in a pretensioned prestressed concrete beam (PPCB),
- Significant misalignment (either horizontal or vertical) of the lower flange, or
- An open horizontal crack at the junction of the web and the top flange of a PPCB.

The District will consider safety when proposing traffic restrictions.

If the damage is severe, or possibly severe, the District should report the damage immediately by telephone to the Office of Bridges and Structures. At the time of the call, the decision on traffic restriction should be confirmed. The telephone report of the incident must include at least the following information:

- Positive identification of the bridge, including the bridge number,
- Positive identification of the beams or girders that were damaged,
- A description of the damage with respect to the conditions listed above,
- Approximately when the bridge was damaged, and
- What traffic restriction, if any, has been installed.

If the damage is severe, shortly after the report the Office of Bridges and Structures will arrange to inspect the bridge. The persons conducting the field exam will need to work with bridge or field maintenance to reserve a high lift and arrange traffic control.

In preparation for an inspection of an overheight collision, the repair designer should do the following.

- Review the bridge maintenance folder to determine:
  - If there has been a history of collisions on the bridge and whether there have been repairs due to collision damage,
  - If there is current damage that hasn't been repaired, and
  - The documented clearance at the site.
- Make copies of the plans to take to the site.
- Review with maintenance any information that is available on the collision and any traffic restrictions that are currently in place because of the collision.
- Reserve the digital camera.
- Check out hardhat, vest, tape measure, level, clipboard, flashlight, and ruler.
- Check out flashing emergency light for vehicle.

12.1.10.1 PPCB overpass repair

The following items are guidelines for the field exam of a PPCB bridge.

- Check for cracks or severe section loss in the lower flange or in the web of each damaged beam. Estimate loss of section.
- Check for severed prestressing strands or strands that are visibly deformed. Record number and location.
- Check for an open horizontal crack at the junction of the web and the top flange in each damaged beam.
- Determine any displacement between cracked sections.
- Determine if cracks extend completely through each cracked member by measuring along both interior and exterior surfaces.
- Inspect diaphragms.
- Inspect slab at beam-to-slab connections.
- Inspect beams adjacent to obviously damaged members to make sure all damage has been found.
- Note any existing collision damage from past accidents.

- Measure vertical clearance at point of impact.
- Sketch plan and elevation views of each damaged beam. Include dimensions.
- Take as many photos as possible, including dimension references such as rulers or extended tape measures. Key photo locations to sketches.
- Obtain a copy of the collision report from the Iowa State Patrol, if a report is available.
- Review traffic restrictions to make sure they are adequate.
- Recommend whether a diaper is needed to protect the public from loose concrete.

At the time of the field exam, usually it is possible to determine the necessity for continued traffic restriction.

Beams that are severely damaged often will continue to drop concrete onto the roadway below for several days. If there is any chance that chunks of loose concrete will drop, a canvas diaper should be draped around and below the damaged area. If possible, installation of this diaper should be delayed until after the field exam.

Options for a damaged beam include the following:

- Replace the beam,
- Repair damage and install a steel sleeve,
- Repair damage and place epoxy wrapping,
- Clean and coat exposed strands,
- Inject epoxy in cracks, or
- Do nothing.

If the severity of the beam damage is moderate, the office prefers to make the decision to repair or replace the beam within a few days after the field exam. The decision can be difficult and can best be made back in the office in consultation with the supervising Section Leader and Assistant Bridge Engineer. Replacement of a PPCB costs about $45,000, and the cost will enter into the decision.

After the basic decisions regarding the repair are made, it is the designer's responsibility to write a concept for the repair project and prepare final plans as quickly as possible.

If the decision is made to replace a PPCB, the designer should detail deck removal at the face of the adjacent beam. During construction it is difficult to cut the deck between beams because the deck must be cut from both below and above. Any concrete diaphragms attached to the beam to be replaced also should be removed and replaced, which will not require the contractor to save any of the diaphragm reinforcing steel.

12.1.10.2 Steel beam or girder overpass repair

The following items are guidelines for the field exam of a rolled steel beam (RSB) or CWPG bridge.

- Note torn members and missing pieces of the superstructure.
- Using a level or string line, measure the horizontal and vertical displacement of each damaged beam or girder at the impact location and at any kinks or angular displacements at other locations.
- Measure rotations of damaged members.
- Measure gouges in damaged members for loss of section.
- If no cracks are visible but may be suspected, discuss the situation with the supervising Section Leader, and consider requesting nondestructive testing (NDT) of the damaged areas.
- Inspect each damaged beam or girder at restrained locations such as the diaphragms. Check for cracks or broken welds where the diaphragm stiffener is connected, and check diaphragm connections at adjacent girders where impact may have been absorbed.
- Inspect adjacent beams or girders to make sure all damage has been found.
- Check for damage to the slab at beam or girder to slab connections.
- Check for buckling of diaphragms or other diaphragm damage.

- Check for weld or bolt damage at diaphragm connections.
- Note any existing collision damage from past accidents.
- Measure vertical clearance at point of impact.
- Sketch plan and elevation views of each damaged beam or girder. Include dimensions.
- Take as many photos as possible, including dimension references such as rulers or extended tape measures. Key photo locations to sketches.
- Obtain a copy of the collision report from the Iowa State Patrol, if a report is available.
- Review traffic restrictions to make sure they are adequate.

At the time of the field exam, usually it is possible to determine the necessity for continued traffic restriction.

Options for a damaged beam or girder include the following:

- Replace a section of the member,
- Heat-straighten the member,
- Grind out gouges and nicks,
- Repair damage, or
- Do nothing.

If the severity of the beam or girder damage is moderate, the office prefers to make the decision to repair or replace the beam within a few days after the field exam. The decision shall be made back in the office in consultation with the supervising Section Leader and Assistant Bridge Engineer.

After the basic decisions regarding the repair are made, it is the designer's responsibility to write a concept for the repair project and prepare final plans as quickly as possible.

If the decision is made to replace a RSB or CWPG, the designer should detail deck removal at the face of the adjacent member. During construction it is difficult to cut the deck between members because the deck must be cut from both below and above.

12.1.10.3 Other

Reserved

12.1.11 Concept statements

Because bridge repair projects need to be tailored to a variety of existing conditions, repair projects cannot be developed in the same way as new or replacement projects. Administrative and funding procedures within the Iowa Department of Transportation are different for new and for repair projects. For programmed bridge repairs the Office of Bridges and Structures is responsible for developing the project concept with the approval of the Office of Design and the District.

In general there are three types of repair projects: programmed bridge repairs, programmed overlays, and emergency repairs. The designer shall follow the procedures below for each repair type.

Programmed bridge repairs are initiated and programmed by the District in cooperation with the Office of Bridges and Structures, but the repairs are described only in general terms. It is necessary for the office to determine the repairs in detail.

- The assigned designer from the Office of Bridges and Structures shall visit the project site, preferably with a representative from the District, to ascertain the details of the required repairs.
- The designer shall write a concept letter to the District Maintenance Manager listing the work to be accomplished and the estimated cost. The designer shall obtain a rough estimate of traffic control and roadway costs from the Office of Design to include in the concept letter. See the example format for the letter in the commentary for this article.
- If the designer receives comments during the review period stated in the letter, at the end of the period the designer shall write a second letter to the District Maintenance Manager listing the

revised work to be accomplished. The revised work will consist of the original concept plus or minus any items agreed upon during the review period. The second letter will constitute the approved concept and shall be used for plan development. If no comments are received, the first concept letter is considered final and shall be used for plan development.

Overlay projects also are initiated and programmed by the District. These projects usually involve other items such as retrofit rails, joint work, and concrete repair. The designer should develop an individual concept letter for each bridge overlay project. The bulleted steps above for programmed repairs shall be followed.

Emergency repairs typically are necessary due to collision damage, such as when an overhead structure is struck by a vehicle with an overheight load. No funds are programmed for these emergency repairs, and contingency funding must be approved to accomplish any repairs. Aside from the funding, the repair project is developed in a similar way to a programmed project but at an accelerated pace. The Office of Bridges and Structures inspects the damage when requested to do so and develops a concept letter reporting the damage, giving repair recommendations, and estimating costs. In general the concept letter should have a format similar to the letter for programmed repairs in the commentary for this article. Discussions with the District at the concept stage are used to determine if the repairs will be done by Iowa Department of Transportation forces or by contract. Necessary funding usually is obtained with a staff action for contingency funds written by the Bridge Maintenance Engineer.

12.1.12 Design documents

12.1.12.1 Drawings

The following outline covers the drawings required for a repair project. However, each project is unique and may require additional plans, details, and notes. The outline is only the first step in developing a set of repair plans.

(1) Situation Plan
The designer should show the following items on the situation plan.
- (a) Centerline, highway number, lane direction of approach roadway
- (b) Centerline, highway number of roadway lanes over passed; centerline of track and railroad over passed; general channel limits and name of stream over passed
- (c) North arrow
- (d) Location of dual structure. Indicate which of the dual structures is to be repaired.
- (e) Roadway width and span lengths
- (f) Bridge deck overlay limits
- (g) Joint locations
- (h) Notes keyed to area locations for repairs other than the deck
- (i) Stationing, especially at abutment bearings. The Office of Design will use this stationing in their traffic control layout.
- (j) Approach formed beam guardrail
- (k) Design history

(2) General Plan
Usually a general plan is not required because the traffic control plan provides sufficient information.

(3) Roadway Cross Section
For a deck overlay project the designer should show a reasonably complete cross section. Although the general notes state that old plans are available, the contractor seldom will use the old plans during construction. Stringer or girder web spacing and the existing slab thickness are especially important when unexpected Class B repair is found. If traffic control is different from the standard layouts, the designer may need to show construction staging.

The roadway cross section should show the following items.

(a) Roadway width, curb width, centerline of roadway
(b) Crown coordinates
(c) Stage joints. For staging construction for box or tee girders the designer shall avoid establishing a stage joint in the critical part of the effective flange. The designer should consider composite construction carefully when establishing joints.

(4) Delamtect Sheet
In many cases additional hand-drawn information from the field will need to be added to the electronic Delamtect file. Detailed instructions for adding the information are given in the commentary [BDM C12.1.12.1].

(5) Notes
See standard sheets [OBS SS 1039] and subsequent articles in this manual [BDM 13.3, 13.5, and 13.10] for typical deck repair notes. In the manual, explanations with notes will provide additional information.

12.1.12.2 Specifications

Unless the project includes extensive structural repairs, no design specifications or design stresses need to be noted on the plans.

In most cases the Iowa DOT Standard Specifications are adequate for repair projects; however, if additional specifications are required, the designer shall list the applicable Supplemental Specifications, Developmental Specifications, and Special Provisions.

12.1.12.3 Notification of repairs

After the repair design is complete, the designer should notify the bridge maintenance and inspection group again with the specific repairs, design number, and schedule for contract letting. After the construction is completed, the repair plans will be included in the file for the bridge so that the plans are available to inspection teams and designers in the future.

12.2 Culvert repair

Reserved