20.1 Deck Overlay and Concrete Rehabilitation - General

This section covers the work required to repair and resurface existing bridge decks with steel fiber-reinforced concrete overlay. This work is usually carried out on one half of the deck at a time, while traffic is maintained on the other half. This section describes the materials, equipment and construction practice requirement to place acceptable concrete overlay.

20.2 Environmental Constraints

Be aware of any environmental constraints.

- Concrete must not enter into the water channel.
- Debris must not be thrown into the water channel.
- Ensure sandblasting operations meet all requirements.
- Ensure that the bridge site and the concrete batch site are satisfactorily cleaned up.

20.3 Safety

Refer to the Alberta's Occupational Health and Safety Regulation, General Safety Requirements for specific approval safety requirements:

- Part 3 Health and Safety Plan
- Part 4 Hazard Assessment, Elimination and Control
- Part 15 Personal Protective Equipment
- Part 16 Powered Mobile Equipment
- Issue "STOP WORK" order to the Contractor if necessary.
- Be aware of the danger of workers close proximity to traffic.
- Ensure Contractor schedules daily safety meetings to remind workers about traffic hazards.

20.4 Bridge Inspector's Record

The Bridge Inspector should keep an accurate record of the following information:

- Discussions with the Contractor regarding traffic control, and other potential issues.
- Profile elevations at 3m intervals of existing ACP and milled surface along centrelines and gutter lines.
- Plotted elevations and new grade line.
- Deck joint elevations and gap settings, where applicable
- Areas of partial and full depth repairs
- Screed-rail elevations as compared to the proposed grade line
- Dry-run thickness
- Quantity calculations
- Equipment calibrations
- Quality control data
- Any rejected concrete
- Weather conditions

20.5 Deck Surface Preparation

The following steps should be taken to ensure that the deck area to be overlayed is properly prepared:

- Remove all ACP, tack coat and 5 mm of underlying concrete
- Remove all deteriorated concrete.
- Sandblast the area to be overlayed including any exposed reinforcing steel.

20.6 Surface Removal and Disposal

All ACP, tack coat, and 5 mm of the underlying deck and roof slab concrete is to be removed. On bridges not having deck joints, a saw cut shall be made, through the full depth and width of the asphalt concrete at both ends of the bridge prior to cold milling should be made.

- Thickness of the ACP will vary and care should be taken not to remove more than 10 mm of concrete from the deck surface. The reinforcing steel in the existing deck shall not be damaged by the milling procedures.

- The Bridge Inspector should check to ensure roto-milling is carried out as close as possible to all curbs, paving lips, drains and deck joints without causing damage. Manual chipping equipment will be required for use in these areas.

- All debris should be disposed of in an approved area.

20.6.1 Identifying Areas for Partial and Full Depth Removal

The Bridge Inspector shall mark out those areas to be chipped for partial or full depth removal by visual observation, sounding or by chain dragging. Since most of the concrete decks have been tested with the half cell method and the C.S.E. readings have been plotted, these plots should be available at the site to assist in identifying areas with deteriorated concrete.

- For any area with spalls and delaminations, the concrete removal should extend below the top layer of reinforcing steel.

20.6.2 Removal of Existing Concrete

Concrete should be removed in such a manner as to prevent damage to adjacent concrete, and other components and utilities that are to remain in place. This includes reinforcing steel, pre-stressing tendons, shear connectors, structural steel and expansion assemblies that remain in the structure.

- Concrete removal should not take place within 1 m of newly placed concrete for a minimum period of 48 hours.

- Corroded reinforcing shall be replaced if the section loss is 20% or greater.

- Only small chipping hammers are to be used for removal of concrete around reinforcing bars.

- Only chipping and/or jack hammers should be used for concrete removal in locations within 100 mm from concrete to remain in place, for the removal of concrete adjacent to the deck joints and for the removal of the concrete above the steel girders which are integral with the deck.

- Air hammers should not contact reinforcing steel in a manner that will cause de-bonding of the reinforcing steel in the adjacent concrete areas that are not being removed.

20.6.3 Partial Depth Removal and Replacement

All unsound concrete should be removed as specified to provide a sound surface on which to bond the new overlay concrete.

- Partially exposed rebar should be entirely exposed by removal of the concrete to a depth of 25 mm below the rebar.

- All exposed rebar surfaces should be sandblasted to a white metal finish immediately prior to casting the overlay.

- It should be noted that flash rust can occur on the sandblasted reinforcing when the concrete is pre-wetted to saturate surface dry (SSD) condition prior to the pour.

- It is recommended, for long decks, to sandblast the concrete and reinforcing steel to 95% completion and brush blast prior to wetting down the deck the night before the pour date.

- Removed deck concrete should be replaced monolithically with the deck overlay concrete.

20.6.4 Full Depth Removal and Patching

Where the deck deterioration extends completely through, as possibly evidenced by areas of dark or white alkali staining on the underside of the deck, all unsound concrete should be removed as specified and replaced with fiber-reinforced concrete, monolithic with the placement of the overlay. Full depth patching exceeding 2 m^2 should be carried out prior to casting of the overlay to avoid dislodging the formwork by screed action.

- The perimeter of all patches should be as square as possible to eliminate broken and feathered edges.

- All exposed rebar should allow for new overlay concrete completely around rebars.

- All exposed surfaces are to be sandblasted and blown clean immediately prior to casting.

- The underside of the deck should be formed to neatly restore the original lines of the concrete.

- Before placing a concrete patch, the surface of the adjoining concrete should be saturated with water for a period of no less than 30 minutes and coated with a bonding agent immediately ahead of the fresh concrete.

- The concrete must be adequately vibrated, and trowelled smooth and flush to the existing concrete.

- Pre-soaked burlap must be placed on the concrete patch immediately after trowelling and kept continuously wet for the next 72 hours.

20.6.5 Deck Surface Preparation

The entire deck surface including patched areas should be sandblasted just prior to overlaying so that rusting of the exposed reinforcing steel is avoided.

- Provide adequate shielding to protect traffic or exposed epoxy rebar or bridgerails.

- When sandblasting the curb face, ensure that only the portion to be covered by the overlay is sandblasted. The remaining portion of the curb must be protected from sandblasting.

- Sandblasting should be sufficient to uniformly expose fine aggregate.

- Clean the deck surface so that it is free of all sand, dust and other contaminants.

20.7 Mixing Overlay Concrete

The Contractor has the option to mix the overlay concrete at a qualified concrete batch plant or at the bridge site on mixer trucks. However when mixing at a batch plant, the delivery and discharge time shall be in conformance with the applicable specification.

20.7.1 Pre-Bagging for Site Batching

The fine and coarse aggregates, cement, fibres (if necessary) and silica fume are measured and pre-mixed together and packaged in suitable bags. The site mixing shall conform to the applicable specification.

20.8 Slump and Air Retention

The type of air entrainment agent (AEA) and superplasticizer (SP) systems used will affect the slump and air retention.

Mix deigns for overlay concrete shall include the following considerations:

- Slump loss based on 1.15 mm per minute. CSA requires slump to be measured to the nearest 10 mm.
- Air loss based on 0.03 % per minute. CSA requires air to be measured to the nearest 0.1%.
- 6% air is the minimum requirement to obtain the required air void spacing factor not exceeding 230 μm.
- 40mm slump is considered the minimum requirement to properly complete the texturing procedures.

20.9 Inspection and Testing

Tests for air content, slump, temperature and compressive strength should be taken as follows:

20.9.1 Air Content

This test should be made for each batch prior to placing and will be sampled and tested in accordance with CAN/CSA A23.2-4C.

- The required air content considering the retention requirement is 5 – 8%.
- Adjustments in the field should be made for concrete not meeting the air content requirement.
- If additional air entrainment is required, it should be compatible with other admixtures.
- Concrete loads not meeting the specified air content should be rejected.

20.9.2 Slump

A slump test should be made for each batch prior to placing and will be sampled and tested in accordance with CAN/CSA A23.2-5C.

- The required slump considering the retention requirement is 80 – 110 mm.
- Adjustments to the mix in the field should be made for concrete not meeting the slump requirement.
- If additional superplasticizer is required, it should be compatible with other mixtures.

20.9.3 Temperature

Temperature of the concrete should not be less than 10^{o}C, nor more than 18^{o}C at the time of placing and should be maintained below this maximum temperature with the inclusion of ice to the mix as approved by the Bridge Project Engineer.

- Care should be taken to maintain the design water-cement ratio.
- The temperature should be taken for each batch.

20.9.4 Compressive Strengths

Making and curing test cylinders shall be carried out in accordance with CAN/CSA A23.2-3C.

- Suitable all weather storage for test cylinders as per Section 5.3.2.1 of CAN/CSA A23.2-4C, for a period of up to 48 hours until removed from the site, should be available.
- One "Strength Test" consisting of one cylinder for 7 days and three cylinders for 28 days testing is required for approximately each 10 m^3 of concrete poured.
- Additional cylinders may be cast for strength testing at other ages.

20.10 Handling and Placing Concrete

In general, adequate arrangement should be made to ensure disruption of the pour would not happen due to equipment failure.

- The equipment should be suitable for the job and clean and free of coatings of hardened concrete, which would interfere with its proper function.

20.10.1 Finishing Machine

Acceptable finishing machines are Gomaco Model CA450, Bidwell Model RF200 or Model 364, which should be provided in good working condition and with proper alignment.

- The length of the screed should be sufficient to extend at least 150 mm beyond the line of the saw cut.

20.10.2 Screed Guide Rail

Rails should be installed to suit the profile of the required surface and to ensure a smooth and continuous surface from end to end of the bridge.

- Guide rail must be located outside finished surface of the pour, and should be installed so that a whole day's pour may be made without resetting rails.
- Rails should be installed with supports at 350mm maximum spacing.
- The support should be fully adjustable by screw mechanism. No shims to be used.
- No deflection of rails between supports should be tolerated.

20.10.3 Work-Bridges

Two work-bridges are required of adequate length and sufficient strength to support two workers to completely span the width of the pour.

- The work-bridges should be supported parallel to the concrete surface and at least 250 mm above it.
- One work-bridge is used to accommodate the concrete finishers and the Bridge Inspector for straightedge checking and it should have a minimum width of 800 mm.
- The second work-bridge will enable placing of the burlap and initial sprinkling with water.
- The work-bridges should be rigid enough that dynamic deflections are not noticeable.

20.10.4 Dry Run

The screed rails should be properly set to ensure longitudinal and transverse drainage from the deck without pond areas or "bird baths".

- Sufficient screed guide rails for the whole contemplated pour should be set out, adjusted for height by the Contractor and then independently checked by the Bridge Inspector the day prior to the pour.

- The system for anchorage of the supporting rails should provide horizontal and vertical stability.

- Hold-down devices shot into the concrete should not be used.

- The minimum thickness of overlay will normally be 50 mm, or as determined by the Bridge Project Engineer.

- Measurements are made at 3m intervals for payment purposes.

20.10.5 Cement Slurry Grout

The grout for bonding the new concrete overlay to the existing deck consists of equal parts by weight of 4% silica fume, 46% type 10 Portland Cement and 50% sand of maximum 2.5 mm size mixed with sufficient water to form a slurry.

- Prior to the slurry grout application and after all deck preparations are complete, the entire deck should be continuously soaked with clean water for a minimum of 3 hours or more depending upon the porosity of the substrate concrete.

- Immediately preceding the concrete placing operation the deck should be blown free of all surface water.

- The slurry grout should be applied immediately prior to placing the new concrete, and in no case should the grout be permitted to dry before the placing of the concrete.

- The consistency of the slurry should be such that it can be applied with a stiff brush or broom to the existing concrete surface in a thin even coating that will not run or puddle in low spots.

- For sealing vertical joints between adjacent lanes and at curbs, the grout should be thinned to paint consistency.

- Mixed grout not yet deposited, should be re-agitated at frequent intervals to prevent segregation.

- Any grout that has not been placed within 45 minutes must be rejected.

20.10.6 Concrete Placement

It is important that every precaution necessary be taken to produce quality concrete with a smooth riding bridge deck that is within the tolerances indicated in the Specifications.

- Concrete should not be placed when the air temperature is below $+5^{o}C$ or above $+25^{o}C$, nor in the event of rain or excessive wind or dust, nor when other conditions as judged by the Bridge Project Engineer are considered detrimental to the concrete pour.

- Concrete placing should normally be between the hours of 6:00 p.m. to 10:00 a.m.

- Night pours should require proper lighting.

- Placement of the concrete should be a continuous operation throughout the pour.

- Concrete should be placed so as to avoid segregation of materials.

- Sufficient vibration should be provided to proper compact the mix. Excessive vibration may cause segregation.

- No more than 10 minutes should elapse between discharge truck mixers. If the delay in placing exceed 10 minutes, the exposed edge of the overlay concrete should immediately be covered with wet burlap. If the cement slurry grout is allowed to dry, it should be removed by sandblasting.

- In the event that due to equipment breakdown, concrete placement is stopped or delayed for a period of 60 minutes or more, further placement should be discontinued and may be resume only after a period of not less than 12 hours.

- The fill-in section should be placed after a period of not less than 12 hours.

- The edge of any discontinued overlay should be sawcut and sandblasted before placing further overlay concrete.

- Concrete should not be placed adjacent to a surface course less than 72 hours old. This restriction does not apply to continuation of placement in a lane or strip beyond a joint in the same lane or strip.

- The width of initial overlay sections placed should extend at least 150 mm beyond the longitudinal joint.

- Prior to placing subsequent sections, the surface course previously placed is to be saw-cut along the longitudinal joint, excess overlay concrete removed, and the edge and the area sandblasted.

20.10.7 Screeding Concrete

The finishing machine should be moved slowly and at a uniform rate and screeding should be completed in no more than two passes.

- The newly placed concrete may require "re-screeding" if the desired grade line is not obtained.

- The screeded surface should not be walked on or otherwise damaged.

- Hand finishing will be required in areas adjacent to curbs, which are inaccessible to the screed.

- Concrete adjacent to deck drains should be hand finished to proper drainage.

20.10.8 Bull Floating

The concrete surface produced behind the finishing machine should be magnesium floated the minimum amount necessary to ensure that the surface is free from open texturing, plucked aggregate and local projections or depressions.

20.10.9 Straight Edge Checking

After bull floating and prior to texturing, the Contractor should check the grade and tolerance of the surface of the overlay with a minimum 3m long straight edge.

- The entire surface should be checked, and any areas not meeting the requirements of the Specifications should be corrected.

- Care should be taken to preserve the crown and cross-section of the roadway.

- Special attention will be required to ensure that there is a smooth transition between the newly placed concrete and deck joints.

20.10.10 Sealing Joints

Upon completion of straight edge checking of the second pour, the vertical joint with the first half (or any transverse joints) should be sealed by "painting" with grout.

20.10.11 Surface Texture

After the concrete has been checked by straight edge it should be given a suitable texture with an approved texture tool having a single row of tines with rounded leading edges.

- The desired texture is transverse grooving which may vary from 1.5 mm width at 10 mm centres to 5 mm width at 20 mm centres, and the groove depth should be 3 mm to 5 mm.

- Texturing shall be done at such a time and in such a manner, that the desired texture can be achieved while minimizing the displacement of the larger aggregate particles or fibres.

- It is essential that the concrete overlay surface not be "torn" during this operation.

- Achieving a satisfactory texture on a fibre reinforced concrete is difficult requiring a worker competent in this work.

- Several types of wire brooms, rakes and combs should be available at site so that the one giving the best result can be selected.

- Following the surface texturing, 300mm of the overlay along the curb should be trowelled smooth and the surface left closed so that a gutter is formed.

- In the event the texture is not satisfactory, sawcut grooves may require to be cut in the concrete surface after initial curing.

20.10.12 End of Overlay at Abutments

The overlay should be placed to match the deck joints, or as determined by the Bridge Project Engineer.

20.10.13 Surface Defects and Tolerances

The finished surface of the deck should conform to the grades and contours required.

- The surface should be free from open texturing, plucked aggregate or fibres, and local projections.

- Except across the crown, the surface should be such that when tested with a 3 m long straight edge placed anywhere in any direction on the surface, there should not be a gap greater than 3 mm between the bottom of the straight edge and the surface of the deck.

- Areas that do not meet the required surface tolerance should be clearly marked out, removed and replaced.

- If the surface is damaged in any way by construction operations, or if the overlay shows signs of distress or scaling prior to final completion, it should be cut out and replaced.

20.11 Wet Burlap or Filter Fabric Curing

Following sealing the overlay joints with grout, and surface texturing, the overlay should be covered promptly with a single layer of clean, wet burlap or filter fabric.

- The curing material should be applied as soon as the surface will not excessively be marred by so doing, normally within 30 minutes after the concrete has been deposited on the deck or as determined by the Bridge Inspector.

- The curing material should be overlapped by 150 mm.

- The burlap should be presoaked in drums or by other suitable methods before being used for curing.

- Moist curing should be maintained for 7 days.

- The curing material should be kept continuously wet by means of an automatic sprinkling system or other approved method.

20.12 Concrete Sealer

Concrete sealer such as silane (Type 1c, 100% silane) may be applied only to dry concrete, which has cured a minimum of 14 days and air dry for a day. Silane sealer will not penetrate a wet concrete surface.

- In order to ensure uniform and sufficient coverage rates, the sealer should be applied to the concrete surface in measured volumes of sealing compound to dimensional areas using a minimum of 2 coats, at the application approved rate.

- After sealing, traffic should not be allowed on the overlay until the sealer has dried.

- The sealer should be protected from rain or splash until it has sufficiently cured.

20.13 Checklist

20.13.1 Bridge Inspector's Responsibilities

- Ensure proper traffic control and safety to the public, are in place.

- Ensure proper saw cutting prior to milling.

- Check depth of milling to prevent over milling.

- Ensure milling is carried out next to curbs, paving lips, drains and deck joints without causing damage.

- Mark out unsound concrete areas for removal (partial and full depth).

- Advise on disposal of debris.

- Set the deck profile and advise on the minimum thickness of overlay (normally 50 mm) and be present at the "Dry Run" to ensure all operations have been completed.

- Ensure testing by Contractor of the mix concrete for the following:
  - Air content
  - Slump
  - Temperature
  - Compressive strength cylinders - 4 per 10 m^3 of concrete placed

20.13.2 Bridge Project Engineer's Responsibilities

- Mix design for overlay concrete to be forwarded for approval.

- Advise on the conditions when the overlay concrete is to be poured (temperature and need for ice, wind, dust, time of day, etc.).

- Advise on the course of action if the pour is delayed.
- Advise on the acceptability of the texturing operation (determine repair option).
- Advise on the end treatment at the abutments.
- Approval of the type and duration of the wet curing.
- Approve the application rate of the concrete sealer.

SECTION 20

DECK OVERLAY AND CONCRETE REHABILITATION

20-1 Chipping partial and/or full depth repair areas on bridge deck.

20-4 Typical forming of full depth repair at the underside of deck.

20-2 Full depth repair area

20-5 Full depth and partial depth repair in one area.

20-3 Full depth repair areas chipped out.

20-6 Substantial full depth repair area.

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20-7 Substantial full depth repair area.

20-10 Sawcuting and chipping deck concrete for pier deck joint replacement

20-8 Preparation and forming of full depth repair prior to pouring of concrete.

20-11 Abutment deck joint in place and ready for concrete pour

20-9 Full depth repair areas cast and cured prior to overlay concrete. Partial depth concrete placed monolithic with deck overlay concrete

20-12 Placing and finishing deck overlay concrete

SECTION 20

DECK OVERLAY AND CONCRETE REHABILITATION

20-13 Surface preparation consists of sandblasting deck concrete

20-16 Grout slurry being applied to deck prior to concrete placement

20-14 Typical sandblasted deck surface

20-17 Placing abutment deck joint concrete monolithic with deck overlay concrete

20-15 Wet deck

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DECK OVERLAY AND CONCRETE REHABILITATION

20-19 Fog misting overlay concrete

20-22 Abutment deck joint complete

20-20 Installation of abutment joint compression seal

20-23 Approach guardrail upgrading - Retrofit thrie-beam transition

20-21 Abutment joint deck detail at curb

20-24 Retrofit thrie-beam transition post detail

SECTION 20

DECK OVERLAY AND CONCRETE REHABILITATION

20-25 Site Batching

20-28 Placing and finishing deck overlay concrete with screeding machine

20.26 Applying slurry grout in front of finishing machine

20-29 Surface texture consists of transverse grooving

20-27 Fibre-reinforced concrete deck overlay is usually carried out on one half of the deck at a time, while traffic is maintained on the other half

20-30 Wet curing of deck overlay concrete