SECTION 710 -- CONCRETE BRIDGE DECK REPAIR WITH SILICA FUME CONCRETE

710.01 -- Description

1. This work shall consist of the removal of the existing deck surfacing, resurfacing with silicia fume (SF) concrete, and other incidental work as shown in the plans.

2. A pre-placement conference at a time mutually agreed upon shall be held before the initial placement of SF concrete. Representatives of the admixture manufacturers, the concrete producer, the Contractor, and the NDR Concrete Materials Section shall meet with the project manager to discuss the following:

a. Mix proportions.

b. Batching sequence.

c. Batch size.

d. Work schedule.

e. Applicable specifications and special notes.

f. All equipment that will be used.

g. Delivery details.

h. Special training for finishers.

i. Duties of all personnel.

j. Overlay construction details.

k. Testing requirements.

l. Acceptance criteria.

m. Contingency plans.

n. Methods of measurements.

o. Basis of payment.

710.02 -- Material Requirements

1. a. Materials shall conform to the requirements in Table 710.01.

Table 710.01

Material Requirements	
Applicable Materials	**Section**
Portland Cement Concrete	1002
Curing Materials	1010, 1011
Fine Aggregate for Concrete Bridge Deck Overlays	1033
Coarse Aggregate for Concrete Bridge Deck Overlays	1033
Water for Concrete	1005
Silica Fume	1009

b. Coarse aggregate for use in SF concrete shall be at a moisture greater than or equal to saturated surface dry for the 24 hour period before it is used.

2. Grout for bonding plastic concrete to cured concrete shall be SF concrete without coarse aggregates. The grout shall be applied to the old concrete surface in a thin, even coating using a stiff broom. The aggregate in the concrete shall be broomed into piles and removed from the deck before the placement of the new concrete. For sealing vertical joints, this concrete may be thinned to a consistency similar to common house paint.

710.03 -- Equipment

1. Machines with oil leaks or drips shall not be used on the prepared deck surface.

2. Surface preparation equipment shall be of the following types:

a. Concrete saws capable of sawing to a specified depth.

b. Scarifying equipment capable of uniformly cutting the existing concrete surface to the depths required.

c. Sandblasting equipment able to remove rust and concrete from exposed reinforcing bars. The equipment shall also be able to remove loose and fractured particles from the prepared concrete surface.

d. Power-driven hand tools will be allowed with the following restrictions:

(1) Jackhammers with a mass greater than the nominal 27 kg class shall not be used.

(2) Jackhammers or chipping tools shall not be operated at an angle greater than 45 degrees measured from the deck surface.

(3) Chipping hammers with a mass greater than the 13.5 kg class shall not be used to remove concrete from beneath reinforcing bars in Class II repair.

3. a. The placing and finishing equipment shall include adequate hand tools for brooming in the grout and for distributing the plastic mix and working it down to

approximately the correct level for striking off with the screed. Approved hand-operated vibrators may be used in small, otherwise inaccessible areas.

b. (1) An approved finishing machine shall be used. It shall comply with the requirements of Section 603 and the following additional requirements. The machine shall be inspected and approved in advance of the start of concrete placement.

(2) The finishing machine shall be self-propelled, capable of forward and reverse movement under positive control.

(3) The finishing machine shall be equipped to travel on rails. Rails shall be sufficiently rigid that they will not deflect under the mass of the machine. Rails shall be securely anchored to provide stability in all directions. The method of anchoring shall not damage the concrete overlay. Supports for rails shall be fully adjustable (not shimmed) to obtain the correct profile.

(4) When placing concrete in a lane abutting a previously completed lane, that side of the finisher adjacent to the completed lane shall be equipped to travel on the completed lane.

(5) Design of the finishing machine and associated equipment shall be such that positive machine finishing of the plastic concrete will be obtained as near the face of existing curbs as is possible. The length of the finishing shall be sufficient to extend at least 150 mm beyond the line where a saw cut is intended to form the edge of a subsequent placement and shall overlap the sawed edge of a previously placed lane at least 25 mm.

4. a. The Contractor shall proportion, mix, place, and finish at least 2 m^3/h.

b. The finishing machine shall be operated so that the time between depositing the concrete on the deck and finishing shall not exceed 10 minutes.

710.04 -- Construction Methods

1. Concrete Removal Requirements:

a. (1) The Contractor shall remove, scarify, and/or chip the old concrete deck to the depths indicated in the plans and until all unsound concrete is removed. Where scarify equipment cannot be used, hand chipping will be required.

(2) (i) At points where removal of unsound concrete is adjacent to reinforcing bars or the removal of active corrosion leaves over two-thirds of the bar diameter exposed, the removal shall be continued to a depth that will allow new concrete to bond to the entire periphery of the exposed bar.

(ii) At least 19 mm clearance shall be required around the bar.

(iii) Care shall be exercised to prevent cutting or otherwise damaging any exposed reinforcing bars.

(3) Any removals shall be carefully done to prevent damage to the bottom of the adjacent slab and to leave removal boundaries which will allow complete filling with plastic concrete.

(4) The Contractor shall take the necessary precautions to prevent damage to persons or property beneath the structure from falling rubble.

b. Removal work is divided into 3 classes according to the depth of material removed:

(1) Class I Repair - covers concrete removal from the deck surface to a depth shown in the plans (varies with each project).

(2) Class II Repair - covers concrete removal from the lower limit shown in the plans for Class I Repair to the mid-depth of the slab.

(3) Class III Repair - covers concrete removal depths from the mid-depth of the slab through the entire remaining deck.

c. Where machine scarifying is employed to remove concrete, extreme care shall be used to avoid cutting reinforcing bars. An occasional bar may be cut to as much as 25 percent of its diameter without impairing the structure; but if a substantial number of bars are damaged, machine scarifying will be prohibited and other methods required. Any damage shall be repaired by the Contractor at no additional cost to the Department.

d. (1) Wherever removal of unsound concrete extends to a depth exceeding 50 percent of the original deck thickness, the remaining thickness shall be removed to the full depth of the slab; and such areas of removal shall be classified as "Class III Repair".

(2) When concrete removal is at approximately mid-depth of the slab, the Engineer shall determine if, in his/her judgment, the concrete quality and structural integrity of the remaining thickness requires full depth removal.

e. Any concrete removal which is necessary to allow striking the full required overlay thickness down to meet roadway joints, floor drains, or other fixtures will be considered to be "Class II Repair".

2. Preparation of the Surface:

a. The Contractor shall sandblast and clean all exposed reinforcing bars, all prepared concrete surfaces, the portion of the bridge curb and all surfaces of steel roadway joints which will be in contact with the overlay concrete, and all edges of previously placed lanes not more than 24 hours before concrete placement.

b. In cases where the placement of the overlay concrete is delayed beyond 24 hours after the sand blasting has been completed, the formation of incidental rust on the rebars due to humidity or rain shall not be cause for re-sand blasting.

c. All debris and rubble resulting from deck removal shall be thoroughly swept up and disposed of in a manner satisfactory to the Engineer.

d. Any areas of the prepared deck surface contaminated by oil leaks or substances detrimental to a good bond shall be thoroughly cleaned by an approved detergent method or shall be removed to such a depth as may be necessary.

3. Proportioning and Mixing:

a. Measuring and handling materials shall meet the requirements of National Ready Mixed Concrete Association's *Quality Control Manual*, Section 3.

b. (1) The suggested batching sequence is as follows:

(i) Put in 75 percent of the water with the air entrainer and water reducer.

(ii) Add in silica fume and mix for 50 revolutions.

(iii) Batch aggregates and cement.

(iv) Add remaining water and mix for 20 revolutions.

(v) The high range water reducer may be added on the project site during Step (ii), if necessary. Air entraining admixture may be added at the project site if the supplier has approval from the NDR Materials and Tests Division.

(2) The Contractor must demonstrate to the Engineer the procedure for adding air entraining high range water reducing admixtures. The admixture shall be spread over the entire concrete surface inside the mixing truck and then mixed.

c. The testing for slump shall commence after the concrete is discharged and shall be performed as frequently as necessary to maintain control. The maximum allowable slump shall be 125 mm. There shall not be more than 50 mm of slump difference between any of the loads of concrete placed. The slump shall be increased by the addition of Type F, high range water reducer.

d. Water shall not be added at the project site. Only enough water to rinse the charging hopper and fins after the addition of the admixture is allowed. This water must be estimated and recorded on the proportioning report.

e. (1) A 2 m^3 trial placement is required at least 2 weeks before placing the bridge deck. The Contractor will be required to demonstrate proper batching, placement, finishing, and curing of SF concrete. The concrete placed during trial placement must meet these *Specifications*. If there are problems, the Engineer may require the Contractor to produce more trial batches.

(2) Removal of the trial batches is the responsibility of the Contractor.

4. Placing and Finishing Requirements:

a. (1) The Contractor shall thoroughly clean the deck, then saturate it with water 2 hours before concrete placement. Immediately before applying the grout, the deck shall be in a damp condition. Any excess water shall be removed.

(2) Immediately ahead of concrete placement, the entire surface shall be thoroughly covered with a thin layer of grout. Grout shall be thoroughly scrubbed into the wet surface with a stiff broom. The rate of progress shall be limited so that the broomed grout does not dry out before it is covered with the concrete. Grout that is allowed to become dry and chalky shall be blast cleaned and replaced at no additional cost to the Department.

(3) (i) Concrete placement shall be continuous.

(ii) Fresh concrete 75 mm or more in thickness shall be internally vibrated in addition to surface screeding.

(iii) The forward speed of the finishing machine shall be adjusted to the average progress of the concrete production in order that the strike-off operations shall be as continuous and uninterrupted as possible. Hand finishing with a wood float may be required to produce a tight uniform surface.

(iv) The addition of water directly to the surface during the finishing operations will not be allowed. Humidity shall be maintained above the surface of the concrete by an approved fogging system capable of maintaining a constant fog over the entire surface of the fresh concrete until the curing cover is applied. Sprinklers are not allowed.

(4) The elapsed time between depositing the concrete on the deck and screeding shall not exceed 10 minutes.

(5) Use of approved admixture finishing aids is allowed but shall not be used in place of fogging.

(6) (i) During delays of 30 minutes or less, the placement shall be protected from drying by fogging.

(ii) If the concrete placement is delayed more than 30 minutes, further placement shall be discontinued and may be resumed only after 48 hours of cure have elapsed. This restriction does not prohibit continuation of the placement provided a gap is left in the placement. This gap shall be sufficient in length to allow the finishing machine to clear the previously placed concrete.

b. (1) The floor surface shall be tested for smoothness with a 3 m straightedge while the concrete is still plastic.

(2) The straightedge shall be held in successive positions parallel to the road centerline and in contact with the surface.

(3) The whole area shall be tested from one side of the floor to the other as necessary. The straightedge shall be advanced along the deck in successive stages of not more than one half its length.

(4) Any depressions found shall be immediately filled with freshly mixed concrete, struck off, and refinished. High areas shall be cut down and refinished.

(5) The straightedge testing and refloating shall continue until the entire surface has no deviations from the straightedge that are greater than 3 mm and the floor has the required grade and contour.

(6) When the surface area is so small it will not allow use of a 3 m straightedge, special tools shall be employed to ensure that there are no deviations in the required longitudinal grade or contour lines in excess of 3 mm in 3 m.

c. Individual areas of Class III removal requiring full depth slab placement shall be poured on forms. Any such areas exceeding 1 m^2 will require two-stage concrete placement. The first stage shall be poured up to the lower limit of Class I removal area or to match adjacent areas of Class II removal. This partial placement shall be made with 47BD concrete in compliance with the pertinent provisions of these *Specifications*.

d. Partial placements shall be given a 72-hour wet-burlap cure and shall be sandblasted and cleaned before proceeding with the general concrete overlay.

e. (1) Longitudinal construction joints shall be provided as shown in the plans. If not shown, locations will be subject to the Engineer's approval. Longitudinal joints shall not be located in the traffic wheel paths if avoidable.

(2) (i) A transverse construction joint shall be constructed in case of a delay in the placement operations exceeding 30 minutes.

(ii) Transverse construction joints shall be minimized.

(iii) These joints shall be made against a bulkhead.

(iv) These joints must be sawed back as described in this Subsection.

(3) Bulkheads or steel dam plates to be used at roadway joints shall be installed to accurate grade and crown.

(4) Rails for the finishing machine shall be set to the grade established by the Engineer to achieve the desired profile and to produce the minimum required overlay thickness over all points on the prepared deck surface. Before beginning concrete placement, a block with a thickness equal to the minimum overlay thickness shall be attached to the finishing machine screed and the machine operated over the prepared deck. All concrete failing to clear the block shall be removed.

(5) At transverse and longitudinal construction joints, the edge of the previously placed concrete shall be sawed back to a straight and vertical edge before all abutting concrete is placed. Slurry from wet sawing shall be thoroughly removed from the prepared deck surface.

f. All reinforcing steel which does not have sufficient clearance shall be depressed and fastened down. If necessary, concrete shall be removed beneath reinforcing bars to allow depressing the bars. Concrete so removed shall be classified as Class II Repair. If the areas where reinforcing bars lack sufficient clearance are extensive, the Engineer may modify the profile grade to obtain the desired clearance without depressing the reinforcing bars.

g. Forms shall be provided in areas of Class III Repair requiring full depth slab replacement. Forms for small areas (1 m^2 or less) may be wired to the reinforcing bars for support. Forms for larger areas shall be supported by blocking from the beams.

h. The delivery truck may be positioned on the prepared deck to discharge the concrete directly in front of the finishing machine or may be located off the bridge deck and the concrete transported to the finisher by means of an approved system. In either case, equipment and operations shall be closely observed to ensure that no foreign materials are brought onto the prepared and cleaned deck surface.

i. (1) The Contractor shall finish concrete bridge decks with an approved mechanical, self-propelled finishing machine.

(2) The finishing machine shall consist of 1 or more devices mounted on a rigid frame, capable of striking off and finishing the surface either transversely or longitudinally. Finishing machines shall be of sufficient size to finish the entire width of the bridge deck in 1 pass.

(3) (i) The machine shall be supported on adjustable rails or tracks of sufficient strength to prevent deflection between rail supports.

(ii) Preferably, the rails shall be installed outside the slab limits and shall be set and maintained true to the desired grade, line, and cross section during the entire finishing operation.

(iii) Rail supports shall be unyielding, and falsework or forms shall be strengthened as necessary to support the imposed load without deflection.

(iv) Rail supports located within the limits of the slab shall be constructed to allow their removal to at least 50 mm below the slab surface. The resulting holes in the concrete slab shall be acceptably filled during the final finishing operation.

(v) Supports shall not be welded to the girders.

(4) The finishing machine shall make at least 2 passes over the bridge floor at such intervals as will give proper consolidation and produce the desired surface condition. The concrete shall not be disturbed or worked further, except that any remaining

surface irregularities or mortar ridges shall be immediately removed by use of a long-handled float or straightedge.

(5) The Engineer may require the Contractor to submit a complete description of the proposed method for handling, placing, and finishing the slab, including the equipment for transporting and delivering the concrete, the finishing machine, and complete details of the supports for such equipment. Approval by the Engineer will not relieve the Contractor of the responsibility for the satisfactory performance of his/her methods and equipment.

j. (1) (i) Once the Contractor achieves a tight uniform surface, the overlay surface shall be textured with a corrugated bull float or a mechanical tiner.

(ii) The texturing requires 3 mm deep transverse grooves approximately 3 mm wide and spaced at 12 to 18 mm on center.

(iii) This operation shall be done at such time and in such manner that the desired texture is achieved with a minimum displacement of coarse aggregate particles.

(iv) The textured surface shall be discontinued 600 mm from the bridge curb.

k. As soon as finishing has been completed, all vertical joints with adjacent concrete shall be sealed by painting with thinned grout.

l. (1) (i) The surface shall be covered with wet burlap as soon as it will support a single layer of wet burlap without deformation.

(ii) Care shall be exercised to ensure that the burlap is well drained and that the surface is not damaged.

(iii) The surface shall be fogged until burlap can be supported.

(2) The Contractor shall cure the concrete with wet burlap for at least 120 hours. The burlap shall be kept continuously wet by means of a sprinkling or wetting system. However, after 96 hours, the Contractor may cover the wet burlap with a layer of 100 µm (minimum) polyethylene film for a minimum of 24 hours in lieu of continuing the sprinkling or wetting system. The polyethylene film shall be fastened down along all edges throughout the curing period to prevent drying. Polyethylene film shall meet the requirements of Section 1010.

(3) Hours during which the temperature is below 10°C will not be counted as acceptable curing hours, and the curing period shall be extended accordingly.

m. No loads other than construction equipment shall be allowed on any portion of the concrete deck which has undergone preparation and removal of the old concrete surface. No construction load will be allowed which exceeds either a 3625 kg wheel load or a

7250 kg axle load. Any combination of axles closer than 1.2 m center-to-center will be considered to be one axle.

n. Adequate precautions shall be taken to protect freshly placed concrete from sudden or unexpected rain. The Engineer may order removal of any concrete damaged by rain.

o. The bridge deck may be opened to traffic after 120 hours of acceptable cure time.

p. (1) Class SF concrete for bridge deck overlays shall be placed when the rate of evaporation will not exceed 0.75 kg/m²/h.

(2) The rate of evaporation will be obtained by measuring the relative humidity near the deck, the wind velocity, the air temperature, and the deck temperature.

(3) The concrete mix temperature will be used in place of the deck temperature once placement has begun.

(4) If the rate of evaporation approaches 0.67 kg/m²/h, the Contractor must notify the Engineer regarding the additional actions that will be taken to prevent plastic shrinkage cracking.

(5) The rate of evaporation shall be obtained by using the nomograph shown in Figure 710.01.

q. (1) Furthermore, Class SF concrete for bridge deck overlays shall not be placed when the ambient air temperature is above 25°C.

(2) Unsuitable climatic conditions may require that the concrete be placed at night.

(3) The Contractor shall provide adequate lighting for any night work.

5. The Contractor shall paint all exposed metal, except weathering grade steel, as prescribed in Section 709.

6. Acceptance:

a. Compressive strength tests shall be made in accordance with AASHTO T 22. The 7-day compressive strength shall be 35 MPa.

b. (1) Before opening for traffic, the new overlay will be examined by the Engineer using visual and sounding techniques. All areas that either display cracks or that are not bonded to the underlying deck will be removed and repaired as specified for Class II Repair.

(2) All small cracks that are not significant enough to require removal of the overlay shall be filled completely with an approved crack filler in accordance with the manufacturer's recommendations.

c. (1) The Contractor shall take every reasonable precaution to produce a smooth-riding concrete surface.

(2) Immediately after the curing period is completed, the deck surface shall be tested for surface irregularities with a 3 m straightedge or other device for measuring deviations from a plane. High spots in excess of 3 mm in 3 m shall be plainly marked. The Contractor shall eliminate such high spots by the use of approved grinding tools or other approved methods.

(3) The surfaces adjacent to longitudinal construction joints shall also match within 3 mm. Irregularities greater than 3 mm shall be removed by grinding to provide a smooth transition over the joint.

d. Surface defects shall be corrected by the Contractor at no additional cost to the Department.

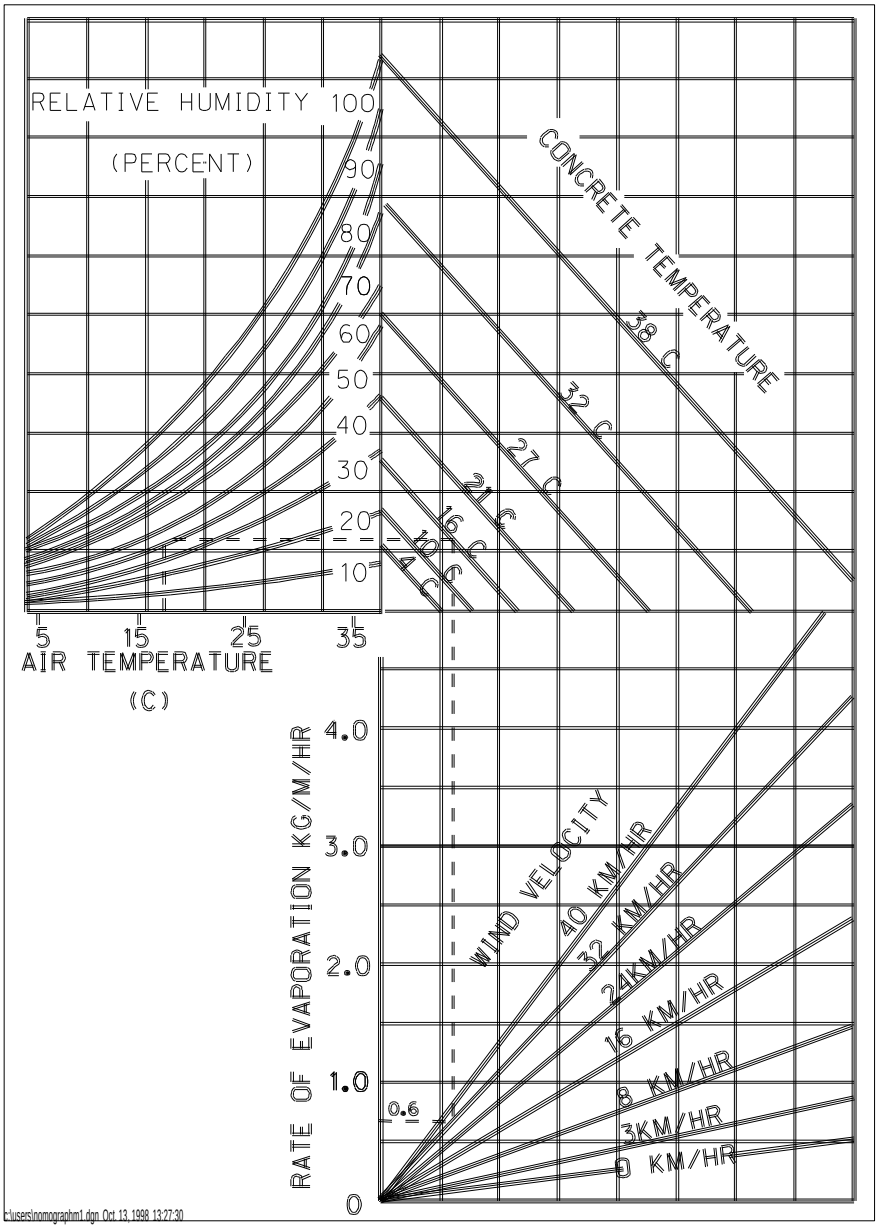
710.05 -- Method of Measurement

1. "Class I Repair", "Class II Repair", and "Class III Repair" will be measured for payment by the square meters of deck area repaired in accordance with each classification, as determined by field measurements.

2. "Placing, Finishing, and Curing Concrete Overlay - SF" will be measured for payment by the square meters of deck surface overlayed as determined by field measurement.

Figure 710.01

EVAPORATION NOMOGRAPH



TO USE THIS CHART:

1. Enter with air temperature, move up to relative humidity.
2. Move right to concrete temperature.
3. Move down to wind velocity.
4. Move left: read approx. rate of evaporation.

IF THE EVAPORATION RATE IS 0.67 kg/m^2/h, THEN THE CONTRACTOR SHALL TAKE ACTIONS TO PREVENT PLASTIC SHRINKAGE CRACKING.

3. "Concrete for Overlay - SF" shall be measured for payment by the cubic meters of concrete placed in the structure (based on truck load tickets). Unacceptable concrete and any waste shall be deducted from the volume for which payment is made.

4. "Trial Placement" is measured by the each. A trial placement shall include the 2 m^3 of concrete and all work for forming, placing, finishing, and curing the placement sample.

710.06 -- Basis of Payment

1.

Pay Item	Pay Unit
Class I Repair	Square Meter (m^2)
Class II Repair	Square Meter (m^2)
Class III Repair	Square Meter (m^2)
Placing, Finishing, and Curing Concrete Overlay - SF	Square Meter (m^2)
Concrete for Overlays - SF	Cubic Meter (m^3)
Trial Placement	Lump Sum (LS)

2. See Sections 602 and 603 for smoothness, quality, and thickness pay factors.

3. a. "Trial Placement" is only paid for once no matter how many trial placements are necessary to demonstrate that the system works.

b. When the trial placement must be removed, the removal is subsidiary to "Trial Placement".

4. The Contractor shall make arrangements for the admixture manufacturer and the concrete producer representatives to attend the pre-placement conference at no additional cost to the Department.

5. Payment is full compensation for all work prescribed in this Section.