SECTION 414 OVERLAY CONCRETE

Sec. 414.01 General

Overlay concretes are not designed to increase the load-carrying capacity of the existing concrete. There are several reasons for placing an overlay. One is to remove approximately 1½ ″ (38 mm) of chloride contaminated surface concrete. Another is to reduce corrosion and protect aging, existing concrete roads and bridges from the harmful effects of salt, chlorides, and other roadway chemicals. It is easier for these chemicals to penetrate older, more permeable concrete and the overlay acts as a covering system to provide an extra layer of protection. An overlay can also be used to improve the ride quality of the bridge surface.

The two most common types of overlays are latex and silica fume concrete. The silica fume concrete may be batched at a ready-mix plant and shipped to the site in transit mix trucks in a similar fashion to structural concrete. The latex modified concrete is usually batched on site with the aid of a mobile mixer. In both cases it may be necessary to open the roadway to traffic as quickly as possible. In order to determine when the concrete overlay has sufficient strength to sustain ordinary traffic, and therefore may be opened for use, cylinder compressive strength tests are utilized. In addition, air content, consistency and other tests are performed.

Sec. 414.02 Mobile Mixer Calibration – Latex Modified Concrete

For latex modified concrete overlays the use of a calibrated mobile mixer is required. Each mixer must be individually calibrated. In addition, they must be recalibrated every 6 months thereafter, and after any change in materials including a change in source. A mixer that is calibrated and accepted in one district may be accepted in another at the discretion of the District Materials Engineer, provided the same materials are being used.

The calibration process is based on an approved mix design submitted by the contractor for the locally selected aggregates in Saturated Surface Dry (SSD) condition. The dry weight ratio of cement/fine aggregate/coarse aggregate in the SSD condition is approximately 1/2.5/2 with a latex modifier content of 3.5 gallons (13.25 L) per bag. The calibration counts are based on the discharge time for one 94 lb. (50 kg) bag of cement. Check that all scales and instruments used for weighing are approved and have current calibrations. Payment will be based upon the total number of calibrated counts. A recording meter, visible at all times and equipped with a ticket printout, should indicate the calibrated measurement.

The following data and calculations should be recorded on the worksheet. (See Appendix IV-E-1)

(a) Cement

The first step in the calibration procedure is to determine the amount of time and counts it takes to discharge 1 bag = 94 lbs. (50 kg) of cement. Select a container that can suitably hold the 94 lbs. (50 kg) of cement and determine the weight of the container when empty. Place the container under the chute of the mobile mixer and discharge an estimated 94 lbs. (50 kg) of cement while noting the meter count and the time in seconds. Weigh the full container and determine the weight of the cement only. If the cement weight is within tolerance of +4% (94 to 98 lbs) (50 to 52 kg), then record the noted time and count data on the calibration worksheet. If it is not within tolerance, then the data is invalid and shouldn't be recorded. This procedure must be repeated until 5 acceptable results are recorded.

Next, total the weight, time, and count columns.

The (total counts)/(total weight) gives the average number of counts per lb. (kg) of cement. This factor x 94 lbs. (50 kg) yields the calibrated cement meter count for one 94 lb. (50 kg) bag of cement. Record this result on the worksheet.

The (total time)/(total weight) gives the average discharge time per lb. (kg) of cement. This factor x 94 lbs. (50 kg) yields the calibrated time to discharge one 94 lb. (50 kg) bag of cement. Record this result on the worksheet.

Note that the calibration data found in this section is based upon 1 bag of cement. It will be necessary to adjust the results to determine the total counts needed when batching for a one yd^3 (one m^3) mix. This is done by multiplying the above count for one bag of cement by the number of bags required in a one yd^3(one m^3) mix. VDOT specifications require that a one yd^3 (one m^3) mix contain a minimum of seven bags (eight bags for one m^3) of cement. Therefore, the number of bags shown on the mix design (typically 7) x calibrated count for one bag (from above) = the total number of counts to produce one yd^3(one m^3). This value is recorded on the worksheet to the nearest whole number.

(b) Fine Aggregate

All calculations are based on fine aggregate weight in the SSD condition, which must be adjusted using the actual moisture content. The weight of sand in the SSD condition is taken from the approved VDOT mix design. However, this value must be adjusted in the following manner: Divide the sand weight taken from the approved design by the number of bags (typically 7) in the design mix. This yields the (sand weight)/(bag of cement) in SSD condition. If the sand is not SSD then the weight must be adjusted using the appropriate free moisture content. The final value is the target sand weight for the calibration process. It is the weight that must be discharged in the calibrated time found in the previous paragraph (a). However, to ease the process, since this weight would be difficult to secure and move, it is permissible to use ½ the target weight of the sand and ½ the calibrated discharge time while calibrating.

The next step is to adjust the sand gate using the sand dial. The purpose is to produce a rate that results in the required weight of sand discharging in the required discharge time. After the dial is set, discharge the sand for the calibrated time (or ½ time if used) into a suitable container and determine the weight of the sand alone. If the weight is within tolerance (±2%) of the previously calculated target weight, then record the dial setting and the lbs. (kg) of sand on the calibration sheet. If the weight is not within tolerance, then discard the results and choose a new dial setting accordingly. Repeat the process at the dial setting until five consecutive, suitable readings are recorded.

(c) Coarse Aggregate

All calculations are based on the coarse aggregate weight in the SSD condition, which must be adjusted using the moisture content. The weight of stone in the SSD condition is taken from an approved VDOT mix design. However, this value must be corrected in the following manner: Divide the stone weight taken from the approved design by the number of bags (typically 7) in the design mix. This yields the (stone weight)/(bag of cement) in SSD condition. If the stone is not SSD then the weight must be corrected using the appropriate moisture content. The final value is the target stone weight for the calibration process. It is the weight that must be discharged in the calibrated time found in paragraph (a). However it is permissible to use ½ the target weight of the stone and ½ the calibrated discharge time for the same reasons as stated in the fine aggregate section.

The next step is to adjust the stone gate using the stone dial. The purpose is to produce a rate that results in the required weight of stone discharging in the required discharge time. After setting the dial on the first estimate, discharge the stone for the calibrated time (or ½ time if used) into a suitable container and determine the weight of the stone alone. If the weight is within tolerance (±2%) of the previously calculated target weight, then record the dial setting and the lbs. (kg) of stone on the calibration worksheet. If the weight is not within tolerance, then discard the results and choose a new dial setting accordingly. Repeat the process at the dial setting until five consecutive, suitable readings are recorded.

(d) Latex

A latex sample must be taken on the project and submitted to the Materials section for each district per contractor per year. The total gallons (liters) of latex required can be found on the approved mix design. Divide this value by the number of cement bags (typically 7), to determine the latex (in gallons (liters)) per bag of cement. This value needs to be converted to determine the latex (in lbs. (kg)) per bag of cement so that it can be weighed out. The conversion factor is the specific gravity of the latex multiplied by 8.33 lbs/gal (4.84 kg/L). The specific gravity can be found on the Materials Safety Data Sheet (MSDS) for the latex that is being used. The conversion factor is then multiplied by the amount of latex (in gallons (liters)/bag) to determine the weight of latex (in lbs (kg).). The resulting value for latex in lbs. (kg) is the target weight that must be used in the calibration process.

The next step is to adjust the flow setting to the best estimate of what will be necessary. After setting the flow rate, discharge the latex for the calibrated time found in paragraph (a) into a suitable container and determine the weight of the latex. If the weight is within the tolerance for latex (±1%), then record the flow setting and the weight of the latex. If it is not within tolerance, discard the results and adjust the dial setting accordingly. Repeat the process at the dial setting until five consecutive, suitable readings are recorded.

(e) Water

The total gallons (L) of water required can be found on the approved mix design. Divide this number by the number of cement bags (typically 7), to determine the water in gallons (L) per bag of cement. It is important to note that this value must be adjusted based on the free moisture that was found in the aggregates in paragraphs b and c. The amount of water must also be adjusted based on the water content of the latex mixture. Once the final, adjusted value has been determined, it needs to be multiplied by a factor of 8.33 lbs./gal (4.84 kg/L) to determine the water in lbs. (kg) per bag of cement so that it can be weighed out. This value of water in lbs. (kg) is the target weight to be used in the calibration process.

The next step is to adjust the flow setting to the best estimate of what will be necessary. After setting the flow rate, discharge the water for the calibrated time found in paragraph (a) into a suitable container and determine the weight of the water. If the weight is within the tolerance for water (±1%), then record the flow setting and the weight of the water. If it is not within tolerance, discard the results and adjust the dial setting accordingly. Repeat the process at the dial setting until five acceptable readings are recorded.

(f) Yield Test

There shall be one yield test per truck per day of batching. Also a yield test should be performed by the Contractor prior to deck placement for each mixing unit, when each unit is moved from the job site for recharging, when the source of stockpiled materials is changed and when there is reason to believe the calibration may be erroneous. The box must be built to a volume of ¼ yd^3 (0.20 m^3) A common set of box dimensions is 3′* 3′* 9″ (1.0 m* 1.0 m * 0.20m). The first step in the process is to batch a load of concrete using the previously determined calibration settings and total counts.

Note that for anything other than a one yd^3(one m^3) batch, the total counts must be adjusted accordingly. For example, a ¼ yd^3 (0.25 m^3) batch would require ¼ the total counts. Calculate the adjusted total counts for the yield box being used and record the result on the bottom of the worksheet. See paragraph (a) on determining the total counts.

The box should then be completely filled with concrete while noting the total number of counts used. This value must be within ± 1% of the calibrated counts that was determined earlier. If it is within tolerance, then it becomes the new calibrated total count. If they still don't fall within the required range, the calibration process must be redone.

Sec. 414.03 Testing

(a) Latex Modified Concrete

1. General

Compressive strength specimens are to be made by casting fresh concrete in cylindrical molds. Records should be kept in accordance with paragraphs (b and f) below.

2. Sampling

Concrete for the test specimens should be taken immediately before placement begins or shortly thereafter. The sample from which test specimens are made should be representative of the entire batch.

Air content tests should be made by the pressure method in accordance with AASHTO T152. The frequency of tests is to be one per truck for each load of material it carries. In other words, a truck that finishes batching and is reloaded, must also be retested. The current air content requirements for latex can be found in Table II-17 of the VDOT Road and Bridge Specifications. Should a test on a batch reveal the concrete to be out of the specification range, the inspector should immediately perform a recheck on the same batch. If the retest confirms the results of the original test, then this should be cause for rejection.

Consistency tests should be made by the slump method in accordance with AASHTO T119, with the following additions. For the latex modified concrete, the slump should be measured approximately 4½ minutes after discharge from the mobile mixer. This is done in order to allow the cement in the mix to fully dampen. The only mixing of the concrete occurs in the augured trough, and this is not enough to fully wet the cement. The 4½ minute waiting period allows the water to blend throughout the mix and wet all of the cement. After this initial time period, the slump usually remains stable for approximately the next 20-30 minutes, during which time the concrete will have been consolidated, screeded, and finished. The frequency of consistency tests should be equivalent to the frequency of the air content tests. The current consistency requirements for latex modified concrete can be found in Table II-17 of the VDOT Road and Bridge Specifications.

It is the contractor’s responsibility to make any acceptable corrections to adjust the air content or slump to within specification levels. These corrections are detailed in Sec 4xx.04 (b).

A yield test must also be performed during each day of overlay work to ensure that accurate payment is being made. Instructions on the yield test may be found in the previous section (4xx.02 (f)) on calibration for latex overlays.

3. Molding and Curing

Molding and curing of the cylinder specimens should be performed as outlined in AASHTO T23, or with the necessary modifications as noted in Sec 411.02 (c), with the following exceptions: the latex cylinders must be submerged for the balance of seven days after their arrival at the Laboratory and then air cured for the remainder of the 28 day curing period.

4. Frequency of Sampling

For latex modified concrete, one set of 5 cylinders must be taken for every day of placement with a minimum of one set per bridge. Any placement over 25 yd^3 (20 m^3) will require an additional set of cylinders at every 25 yd^3 (20 m^3).

5. Testing

Compressive strength specimens should be tested in accordance with Sec 411.02 (e). The additional 2 cylinders (from the set of 5) submitted to the Materials Division will be used for permeability testing.

6. Reports

It is the responsibility of the project inspector to ensure that field data for cylinders will be recorded on Forms TL-13 and TL-28A. Lab tests will be reported on TL-26.

(b) Silica Fume

1. General

Compressive strength specimens are to be made by casting fresh concrete in cylindrical molds. Records should be kept of all tests in accordance with paragraphs (b and f) below.

2. Sampling

Concrete for the test specimens should be taken immediately before placement begins. The sample from which test specimens are made should be representative of the entire batch. An air content and consistency test should be made from the same batch of concrete from which the cylinders are cast, and the data recorded as for the other tests.

Air content tests should be made by the pressure method in accordance with AASHTO T152. The frequency of tests is to be one for each load of concrete. The current air content requirements for silica fume can be found in Table II-17 of the VDOT Road and Bridge Specifications. Should a test on a batch reveal the concrete to be out of the specification range, the inspector should immediately perform a recheck on the same batch. If the retest confirms the results of the original test, then this should be cause for rejection.

Consistency tests should be made by the slump method in accordance with AASHTO T119. The frequency of consistency tests should be equivalent to the frequency of the air content tests. The current consistency requirements for silica fume can be found in Table II-17 of the VDOT Road and Bridge Specifications.

It is the contractor’s responsibility to make any acceptable corrections to adjust the air content or slump to within specification levels. These corrections are detailed in Sec 4xx.04 (b).

3. Molding and Curing

Molding and curing of the cylinder specimens should be performed as outlined in AASHTO T23, or with the necessary modifications as noted in Sec 411.02 (c).

4. Frequency of Sampling

For a silica fume overlay, one set of 5 cylinders must be taken for every day of placement with a minimum of one set per bridge deck. Any placement over 25 yd^3 (20 m^3) will require an additional set of cylinders at every 25 yd^3(20 m^3).

5. Testing

Compressive strength specimens should be tested in accordance with Sec 411.02 (e). The additional 2 cylinders (from the set of 5) submitted to the Materials Division will be used for permeability testing.

6. Reports

It is the responsibility of the project inspector to ensure that field data for cylinders will be recorded on Forms TL-13 and TL-28A. Lab tests will be reported on TL-26

Sec. 414.04 Placement Procedures

A majority of the problems that occur with both latex and silica fume concretes are related to construction activities. Usually, the problems are caused by: 1) poor bonding that leads to delaminations; 2) lack of consolidation which leads to delaminations and high permeability; 3) and inadequate curing that leads to cracking and high permeability. The following procedures are designed to minimize the occurrence of these problems and apply to both latex and silica fume concretes unless otherwise noted.

(a) Surface Preparation

Within 24 hours immediately preceding the beginning of the overlay operations, the entire surface to be overlaid and the edge of previously placed overlay should be thoroughly cleaned. The surface of the base concrete should be cleaned using milling, shotblasting, waterblasting, sandblasting, or any combination of these methods. The cleansing should remove laitance, expose the surface coarse aggregate (minimum 25% of the surface area), and leave a rough surface texture. The purpose of these procedures is to establish a fresh fracture face on the area to be overlaid. A fresh, clean face on the aggregate is needed for proper bonding. Dust, contaminants and laitance, reduce the ability of the overlay to bond to the bridge deck.

The surface of the deck should be free of contaminants and should be thoroughly and continuously soaked at least one hour prior to the placement of the overlay. After wetting, the surface should be covered with plastic. At the time of the application of the bonding layer, the surface should be visibly moist but free of any standing water. Dry areas should be rewetted, and all standing water in depressions should be blown out with oil-free compressed air.

The bonding layer should consist of a portion of the concrete brushed onto the surface. Excess aggregate remaining after brushing should be removed. Care should be taken to ensure that all surfaces receive a thorough, even coating of mortar about 1/8 in. (3.175 mm) in thickness. The rate of progress should be such that the bonding layer does not become dry before the overlay is applied. This is usually a maximum of 3 to 5 ft. (0.9 to 1.5 m) in front of the placement of the overlay.

(b) Mix Adjustments

Latex - In the event of a low slump value, the addition of latex to the mix is acceptable, but under no circumstances should water in excess of the approved mix design be added to improve slump, workability or any other characteristics. In the case of a high slump value, it should be water and not latex, that is removed to adjust the slump to an acceptable level.

A low air content may be corrected by raising the height of the chute. This will increase the mix time and should force more air into the concrete. A high air content may be corrected through the use of a chemical defoamer. This agent will eliminate air bubbles in the mix.

Silica Fume - Addition of a High Range Water Reducing Admixture (HRWRA) at the plant enables the dispersion of cement and silica fume particles leading to improved properties. Thorough mixing is essential for uniformity. If HRWRA is also added at the job site, it should be dispensed by means of a wand so that HRWRA is directly placed on concrete. Mix a minimum of 70 revolutions to ensure complete mixing dispersion.

(c) Consolidation and Finishing

The finishing machine should be capable of forward and reverse motion under positive control. If traveling in reverse, the screed should clear the finished surface. The finishing machine should be equipped with an auger strike-off, a vibrating element with a minimum frequency of 3000 vpm, a roller, a pan float, and a burlap drag. The concrete should also be consolidated using surface type or immersion type vibrators in areas in which the vibrating element of the screed does not reach. This is to include both transverse and longitudinal joints. Immersion type vibrators shall also be used where the thickness exceeds 3″ (75 mm).

(d) Curing

The curing of the concrete should begin immediately after screeding and shall conform to current VDOT specifications. It is the contractor's responsibility to provide equipment for a check of the surface evaporation rate. The check should be made every hour and the results reported to the inspector. The nomograph for determining the surface evaporation rate can be found in the manual of instructions on page IV-C-1. If the evaporation rate is more than 0.10 lb/ft^2/hr (0.49 kg/m^2/hr), the potential for cracking is very high, and placement is not recommended. The contractor should ensure that crack free concrete will be provided based on this knowledge. If the prevailing conditions result in a rate higher than 0.05 lb/ft^2/hr (0.24 kg/m^2/hr), the contractor should use one or more fog misting devices, or other such necessary measures, to reduce the rate of evaporation from the concrete during placement. Fog misting should be maintained starting immediately after screeding and should continue over the screeded area until the wet burlap is placed. The wet burlap should be placed as soon as possible after the finishing operation, but no later than 20 minutes after the finishing is completed. Additional measures to reduce evaporation (wind screens, shading covers, cooling concrete, etc.) should be used at the option of the contractor. Wet burlap should be thoroughly saturated over its entire area, but should be drained of excess water.

(e) Limitations

Concrete temperature should not be more than 15° F (8° C) higher than the ambient air temperature during the placement operation. This is done to avoid temperature differentials that lead to higher evaporation rates and an increase in plastic shrinkage cracking. If the ambient air temperature falls below 50° F (10° C) during the curing period, insulating blankets or external heating should be used as necessary so that the concrete temperature is kept above 50° F (10° C).

All defective areas including, but not limited to delaminations, cracking, or lack of consolidation should be repaired or replaced at the contractor's expense as approved by the engineer.

SECTION 415 SUMMARY OF IMPORTANT FACTORS

To obtain uniformly high strength concrete, the large number of possible variables must be controlled within as narrow limits as practicable. The most important of these factors in concrete construction which must be kept as constant as possible are as follows:

(1) Constant weight of cement in each batch.

(2) Constant volume of water, and as little as possible to ensure workability.

(3) Constant weight and grading of both coarse and fine aggregates.

(4) Thorough mixing through time control.

(5) Maintenance of workability through consistency tests.

(6) Thorough compaction of concrete to reduce air and water voids.

(7) Prevention of segregation at all times.

(8) Proper wetting of subgrade and forms.

(9) Immediate protection and retention of water in concrete until sufficiently cured.

(10) In cold or hot weather, maintenance of concrete at the time of placing and during the curing thereafter at temperatures as specified in the Road and Bridge Specifications.