BATCHING AND MIXING
5-694.400

5-694.401 CHECKING BATCH PLANT OPERATION

Check to ensure accuracy and dependable operation of the proposed equipment and methods prior to the start of concreting operations and after making any changes in the location or arrangement of the batching plant. Plant calibration is the responsibility of the Producer/Contractor.

Check the general layout of the plant before the equipment is erected to ensure efficient operation and adequate space for stockpiling and handling materials in compliance with specification requirements. Whenever possible, avoid the arrangement and erection of batching plants in congested locations which are not conducive to proper handling of materials. Small stockpiles result in segregation and non-uniformity of materials and very poor control of the concrete. Once a batching plant is erected in such a location, it is difficult to improve conditions. Experience has demonstrated that the most uniform concrete is produced when the batching plant is favored by adequate space for the maintenance of large stockpiles of materials.

When draining aggregates at the batch plant site, provide provisions for disposal of drainage water and for clear-cut separation of drained from undrained materials. Keep materials of different sources/classes or gradations separated. Sometimes, timber bulkheads are erected to save space in the Producer's storage yard. These are satisfactory if built properly.

Erect the weighing bins and hoppers on firm foundations to avoid settlement, which might affect the accuracy of the equipment.

At concrete batching sites, check that there is enough material in stockpiles to complete the concrete pour or the rate of aggregate delivery is sufficient to keep up with the required rate of concrete delivery. When using a collecting hopper for handling more than one size aggregate, empty entirely of one size material before placing another size material within. Check to assure that the conveyor and reflector chute used with the collecting hopper are clear of any accumulated materials. The discharge chute for deflecting the material into the various storage compartments must center over the correct compartment while it is charged with aggregate.

5-694.410 BATCHING EQUIPMENT

Check batching equipment before the operation begins. Inspect the equipment and review the procedures the Producer/Contractor will follow during batching. The batching apparatus and progress must meet specification requirements and produce uniform high quality concrete. The following information will aid the Inspector in evaluation of the equipment.

The batching equipment generally consists of a weigh hopper loaded from overhead bins by gravity, that discharges either into the truck below or onto a belt that goes to the mixer. Weigh the cementitious materials independently of aggregates either on separate scales or in separate compartments.

The gates controlling charging and discharging of the weigh hopper must tightly close and have operating interlocks when producing concrete. See Figure A 5-694.410. The charging device shall provide the capability of stopping the flow within the specified weighing tolerance and controlling the rate of flow of the material. The manner of attachment of vibration equipment or other aids to charging or discharging shall not interfere with the accuracy of the weighing.

Figure A 5-694.410

The Contractor should avoid overloading the weigh hopper or exceeding the scale capacity. The batches shall not overflow the weigh hopper or exceed the scale capacity. Sufficient clearance must exist above batching hoppers to permit removal of any overload. When fully batched into the hopper, the top of the material must not touch the charging bin above.

Cement weigh hoppers must have an access port to facilitate inspection of the interior. The installation of the dust seal between the storage bin and the weighing hopper must not affect the weighing accuracy. The weigh hopper shall have a coned bottom and a vibrator to ensure complete discharge.

Prior to mixing, carefully examine the mixer to assure that all requirements of Specification 2461.4C2 regarding blade wear, drum speed, timing, etc. are met. The mixer shall produce concrete at a rate applicable to the size of the pour and the type of operation. Mixers having capacities of 0.3 m^3 (10 ft^3) or more require automatic timers set in accordance with Specification 2461.4C2 or 2301.3F prior to any mixing operations. Figure B 5-694.410 shows a mixer dumping a load.

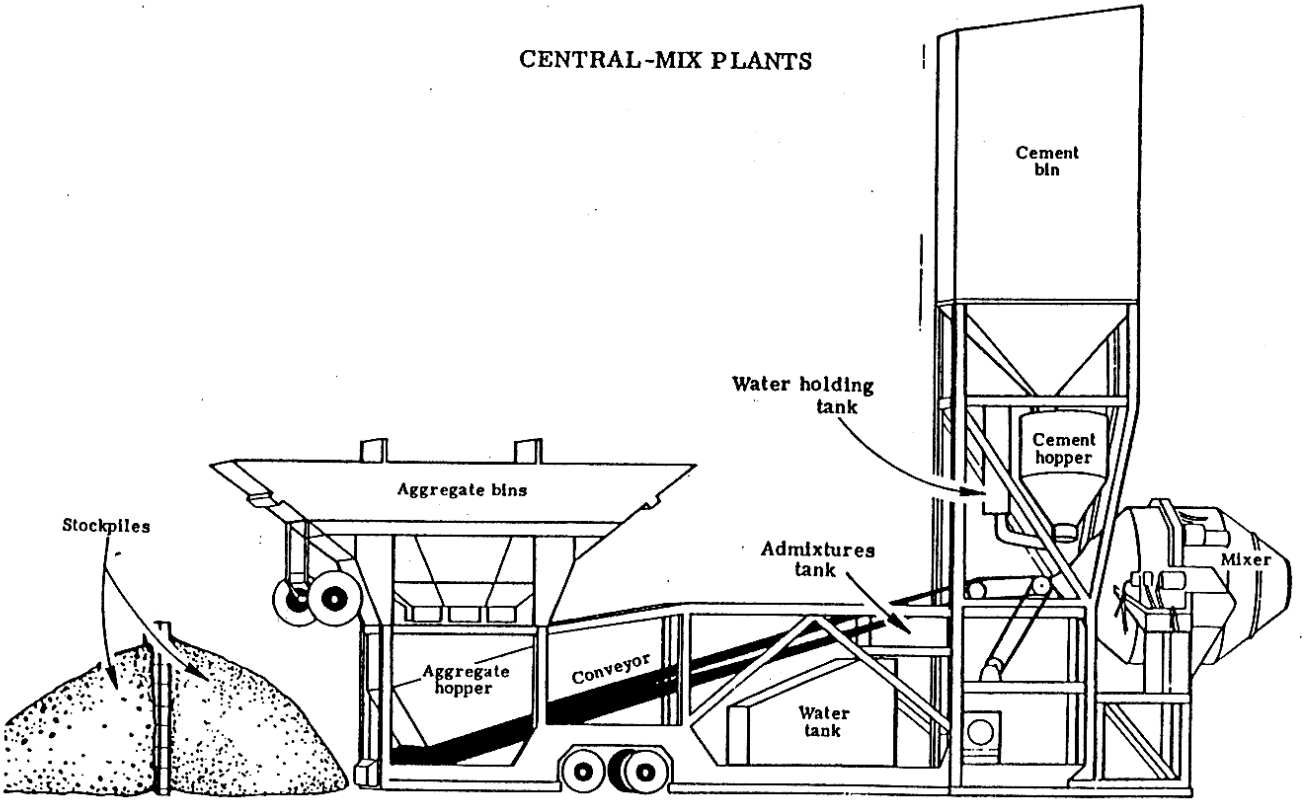


Figure B 5-694.410

Specification 2461.4C2f states that the mixing period begins when the last of the materials enter the mixer drum and ends when the discharge of the batch begins. Paving mixers, 0.75 m^3 (1 yd^3) or larger, are required to have a mixing time of 60 seconds. To attain this mixing time, consider other factors such as charging and discharging time in the total operating cycle. Specification 2301.3F1 states that when mixing operations are first started on a project, set the timing device to produce an operating cycle of 75 seconds for single drum and 55 seconds for dual drum mixers. See Figure C 5-694.410 for an example of a single drum mixer and Figure D 5-694.410 for an example of a dual drum mixer. This operating cycle is the time period between successive occurrences at some fixed point in the operation, for example, from bell to bell. Reduce the cycle time if, after the operating constants are determined, the Inspector is certain that each batch will have a full 60 seconds of mixing time during the operating cycle.

Special points to observe regarding batching are the following:

- For both single and dual-drum mixers, the water should start into the drum in advance of the solid materials and it should continue to flow into the drum until after all of the solid materials have entered.
- The drum must empty of the preceding batch before the solid materials of a new batch enter the drum.
- For dual-drum mixers, the first drum must empty completely and the transfer chute must close before the solid materials of a new batch enter the drum. Likewise, the second drum must empty and the discharge chute close before the transfer of the following batch from the first drum begins.
- The number of revolutions at mixing speed shall not exceed 150.

Figure C 5-694.410

Figure D 5-694.410

5-694.411 TYPES OF BATCHING EQUIPMENT

Batching equipment is designated as Manual, Semi-Automatic, and Automatic as defined below:

A. Manual
Batching equipment is charged by devices that are actuated manually, with the accuracy of the weighing operation being dependent upon the operator's visual observation of the scale. The charging device is actuated by either hand or by power assists. The weighing accuracy shall comply with tolerances per Specification 1901 and 2301.3F.

B. Semi-Automatic
Batching equipment is charged by devices, which are separately actuated manually for each material to allow weighing of the material. They are actuated automatically when reaching the designated mass (weight) of each material. The weighing accuracy shall comply with tolerances per Specification 1901 and 2301.3F.

C. Automatic
Batching equipment is charged by devices which when actuated by a single starter switch, will automatically start the weighing operation of all materials consecutively and stop automatically when reaching the designated mass (weight) of each material. Automatic batching equipment shall have suitable delivery interlocks per Specification 1901 & 2301.3F. See Figure A 5-694.411.

Figure A 5-694.411

5-694.412 REQUIREMENTS FOR PAVING BATCHING EQUIPMENT

Batching equipment used in conjunction with paving operations have further requirements in addition to those specified for other types of concreting operations.

The Contractor shall provide:

- Computerized batching is required.
- A computer-generated batch ticket showing the target and actual masses (weights) of all components. This shall serve as the materials recorder along with cementitious cut-offs.
- The water added to the mix by an electronic meter, approved by the Engineer, which records the amount of total water, including temper water, as part of each batch ticket.

5-694.430 CHECKING BATCHING AND MIXING EQUIPMENT

There are two items of equipment to closely observe at all times. These are the scales used for weighing the batch materials and the water measuring equipment. Check to make sure that this equipment meets accuracy requirements before the work begins. An approved scale company must check and calibrate the scales that have not received an approved inspection within six months prior to starting production. Thereafter, scales are checked and calibrated once each year. Additional calibrations are made at three-month intervals using the procedure described in 5-694.431 and 5-694.433. The Producer's Plant Personnel may perform these if observed by an Agency Inspector. If more than 45 days have elapsed since the full-scale check by a scale company, the first such check is made before operations begin. Spot-check the scale calibrations at least once each month. The Producer should check the scales for zero balance and the

effectiveness of the interlocking controls for the cement and aggregates at least twice each day and for sensitivity at least once each day. The Producer shall report defective controls in the plant diary.

The most accurate weighing systems include load cells. A load cell uses a strain gauge to measure the direct stress that is introduced into a metal element when it is subjected to a tensile or compressive force.

Load cells are attached to digital displays for easy reading and zeroing. They also feature programmable high/low set points. Signals for the load cells are sent electronically to the computer for accurate documentation. See Figure A 5-694.430.

Figure A 5-694.430

When weighing or measuring equipment is moved from one setup to another, the Producer/Contractor shall completely recalibrate it after erection at the new site. Erratic and inaccurate operation of the measuring equipment due to maladjustment or damage may result from impact and shock during the move.

Sluggishness of the working parts or a marked change in the level of material in the weighing hoppers may indicate inaccurate operation of the scales. Providing the batch composition and other conditions remain constant, the water setting at the mixer should also remain relatively constant. A decided change in the required mixer setting following an extended period of uniform operation indicates that something is wrong with the equipment and that an immediate check is required. In such cases, a thorough checking of the equipment is required in addition to re-calibration. Investigate the cause of the trouble and eliminate it.

In order to determine whether or not the concrete meets specification requirements for cement content, water-cement ratio, etc. the Inspector must know the exact amount of materials used in mixing the concrete.

The equipment used for proportioning the various materials in the batching operations shall comply with Specifications 1901.8 and 2461.4B. Specification 2461.4D for ready-mix work and 2301.3F for concrete paving projects also apply. The Producer/Contractor is required to furnish personnel and accessories needed to check the accuracy of the equipment. An Agency Monitor records the results, while offering other reasonable assistance to facilitate this calibration. The equipment must meet accuracy and sensitivity requirements within the specified tolerances at all times.

If water measuring equipment is inactive for any extended period of time, as over winter, the Producer/Contractor should dismantle and thoroughly clean and adjust before it is calibrated. Problems are frequently encountered with this type of equipment due to formation of scale and rust. This condition is aggravated considerably by long periods of inactivity or storage. The presence of scale or other foreign material in the system is invariably indicated by erratic operation. Erratic or inaccurate operation may also result from wear or maladjustment of the equipment, leaky valves, etc. When such inaccurate operation is encountered, immediate correction is required before mixing is allowed to start.

5-694.431 CALIBRATING WEIGHING EQUIPMENT

When a scale servicing company performs the required calibration they should generally follow the procedures outlined below:

A. Visual Inspection Prior to Test

- Clearance around hopper and lever system
- Dust curtain for slack - freedom
- Balance of scale
- Correct problems noted above, before proceeding on

B. Test Procedure

1. Balance Indicator: Check for repeatability. Note the hangers, materials used to hold weights, and the correction weights are included in the balance.
2. Sensitiveness: Check on non-automatic indicating scales. Twice the value of the minimum graduated interval on the beam allowed.
3. Fractional Poise: Check to capacity by 50 kg (100 lb.) increments; tolerance 0.5%.
4. Balance Check: Remove test weights and recheck balance device. This action should not change balance by more than one of the minimum graduations (plus or minus).
5. Empty Test: Apply test weight to empty scale, minimum load of 500 kg (1000 lb.), 1000 kg (2000 lb.) desirable (or to capacity of device, whichever is greater); tolerance 0.5%.
6. Balance Check: Remove test weights and re-check balance. The device should not change balance by more than one of the minimum graduations (plus or minus).
7. Half Normal Batch Capacity Test: Fill the hopper to about one-half the capacity of the device with batching materials, take reading, then apply test weights. Tolerance is applied only to the

total of the test weights used; tolerance 0.5%.

8. Balance Check: Remove test weights and recheck reading with materials. Reading should not change by more than one of the minimum graduations (plus or minus).
9. Full Normal Batch Capacity Test: Fill the hopper with batching material to as near capacity that will still allow the test weights to be applied without exceeding the capacity and take reading. The test weights tolerance of 0.5% is applied only to the total of the test weights used.
10. Balance Check: Remove test weights and recheck reading with materials. Reading should not change by more than one of the minimum graduations (plus or minus).
11. Electronic Indicators: Check for environmental factors such as R.F.I. interference from other electronic elements in the environment. Interference must not affect the device by more than two of the minimum graduations (plus or minus).

C. Spot Check Procedure

The usual procedure in making a spot check is to assure that the equipment is generally in good operating condition. The knife-edges or other working parts of the equipment shall have no binding or cramping. The Producer must have a sufficient number of test weights. Fully load the storage hoppers prior to the spot check.

The first step is to balance the scale at a load of zero with the weighing hopper clean and empty. On single beam scales, obtain the zero balance with the adjustable counter weight provided. For multiple beam scales, obtain zero balance first with the tare beam and then with each and all of the weight beams free to act with the tare beam. To prevent use with other beams, securely fasten in a zero position any of the multiple beams actually not required in the weighing operations when multiple beam scales are used. After zero balance is satisfied, one or more of the test weights is applied by means of a suitable hanger furnished by the Producer/Contractor. Knowing the mass (weight) of the hanger accessories is required because it is included as part of the applied load.

If the scale is to operate with a normal working load of about 250 kg (500 lb.), apply the test weights in 50 kg (100 lb.) increments until the calibration is carried up to 350 kg (700 or 800 lb.), including the mass (weight) of the hanger. For larger scales, fill the bins to within approximately 100 kg (200 lb.) of the expected operating point, then test weights in 50 kg (100 lb.) increments are applied until a point approximately 100 kg (200 lb.) over the operating point is reached. Each time a weight increment is applied, balance the scales and record a reading opposite the known applied load.

While carrying the spot check over the expected operating range, check the sensitivity of the equipment by temporarily applying an additional load equivalent to 0.2% of the load at that time. The additional load should throw the equipment out of balance.

If the equipment fails to meet requirements in any respect, a report should indicate the discrepancy. After the scales are repaired or otherwise rendered satisfactory, re-calibrate the scales and send a copy of the reports to the Project Engineer to document that the equipment complies with the specifications. A sample of the *Test of Weighing Equipment* (Form 2124) is shown in Figure A 5-694.717.

For paving projects over 750 m^3 (1000 yd^3), check the various interlocking devices to assure proper function. Check that the hopper inlet gate and the discharge gate cannot open at the same time. If one gate is open, the other gate is interlocked in the closed position. The cementitious scales shall have these same features, but in addition, the discharge gate is not capable of opening until the scale is in balance at full load. Once the discharge gate is open, it is not capable of closing until the tare beam or dial comes back to zero balance. The discharge gate of the cementitious hopper is always locked in the closed position during the weighing operation when the cementitious in the weighing hopper is outside the specified tolerance of 1%. Check this feature during the spot check by resetting the scale at balanced loads by an amount equivalent to (both plus and minus) slightly more than the 1% tolerance in mass (weight) permitted. If the discharge gate can open, the discharge-locking device is not functioning properly.

Do not use equipment for paving which does not have the required interlocking devices for controlling the batching operations as provided in Specification 2301.3F4.

5-694.432 AUTHORIZED SERVICE COMPANIES FOR SCALE CALIBRATIONS

A list of authorized service companies for scale calibrations is available on the Mn/DOT Concrete Engineering Unit website at www.mrr.dot.state.mn.us/pavement/concrete/concrete.asp.

5-694.433 CALIBRATING WATER MEASURING EQUIPMENT

Calibrate and spot check water weighing equipment in accordance with the following sections. Carefully calibrate water-measuring equipment before mixing operations begin, but after the mixer is in its operating position. See Figure A 5-694.433 for an example of a water meter and a water scale.

Figure A 5-694.433

Measure the mixing water on approved scales or by volume using an approved water-metering device. For approval, the water meter shall comply with the following:

1. It shall have a discharge indicator capable of setting to within 5 L (1 gal.) of a predetermined amount.

2. It shall have a positive automatic shutoff valve that stops the flow of water when the indicated amount of water is delivered.
3. It shall operate within a maximum delivery tolerance of 1% of the required water setting at the time of batching.
4. It shall bear an approved inspection seal displaying the date of the previous calibration and adjustment within 6 months of the date of use.

Unless evidence is furnished indicating that the water meter was calibrated and adjusted within the previous six months by an authorized service agency as listed on the Mn/DOT Concrete Engineering Unit website, recalibrate and adjust prior to use in accordance with the weighing procedures given in this Manual. Spot check the water meter for accuracy at least once each month as the work progresses. Any platform scale used in the calibration of water meters is subject to the requirements for scale accuracy and calibration and adjustment provisions set forth in Specification 2461.4D4.

Report all calibrations of water-measuring equipment on the *Test of Weighing Equipment* (Form 2124). See 5-694.717.

An authorized service agency or the Producer/Contractor under the supervision of the Engineer may perform the meter calibration.

5-694.434 WATER METER CALIBRATION

A. Visual Inspection Prior to Test

1. Check for partially collapsed lines, leaks, or restrictions that would divert or otherwise hamper the flow of water to the meter.
2. Inspect gears, pivots, etc., for excessive wear.
3. Check legibility of dials, numerals, and pointers.
4. Correct any problems noted above before proceeding.

B. Test Procedure
(NOTE: Disregard Temperature Corrections)

1. Obtain a good quality platform scale and calibrate it in accordance with 5-694.431.
2. Place clean 220 L (55 gal.) drum or other suitable container on scale and record tare mass (weight). Run approximately 50 L (15 gal.) of water into drum, record mass (weight) of water (total mass (weight) less tare) and record water meter reading. Repeat 3 times.
3. Dump out water, re-tare drum and follow procedure in B2 above for the 100 and 150 L (30 and 45 gal.) levels.
4. Compare meter measurements with computed volume, based on 1 L = 1 kg (1 gal. = 8.33 lb.). The comparison shall agree with the Specifications for the work. If they are not in agreement, do not batch concrete until the equipment meets the requirements. This will usually require repair or replacement of the meter and re-calibration.
5. The quantity of water discharged may not agree exactly with any of the indicator settings. While it is desirable that the settings and the discharged volume agree, such agreement is not

absolutely essential for practical operation. If exact agreement is not found and shifting of the indicator cannot provide agreement, the Inspector may prepare a calibration chart by plotting the actual discharges against their corresponding indicator settings and drawing a smooth curve through these points. Do this only when the discrepancies between indicator settings and actual discharges are all in the same direction. If the opposite condition is found where the actual discharges run alternately or erratically plus or minus with respect to the indicator settings, the equipment is mechanically defective and unsatisfactory. The Producer/Contractor must repair the equipment and put in proper working condition before the mixing operations begin.

5-694.435 SPOT CHECKING OF WATER MEASURING EQUIPMENT

Once a month or whenever the mixer is moved to a new location, perform a spot check for comparison with the previous calibration. If there is disagreement between the spot check and the calibration, the Producer/Contractor needs to make a complete re-calibration.

Conduct the spot check as outlined in calibration procedure 5-694.434, item B1 - B5, except check only at the 150 L (45 gal.) level and do not send the information to the Mn/DOT Concrete Engineering Unit.

5-694.440 CERTIFIED READY-MIX CONCRETE

Mn/DOT has developed a certification program for the quality control of concrete production for ready-mix concrete plants. **It is the Prime Contractor's responsibility to make certain that a certified ready-mix plant produces all ready-mix concrete used on the Contract.** Other than small quantities as defined in the Schedule of Materials Control, concrete supplied from ready-mix is certified by the Producer to meet Mn/DOT Specifications. Ready-mix concrete is addressed in Specification 2461.4D.

Ready-mix concrete shall meet the same general requirements as job mix concrete. Since commercial plants supply other users during the same general period as they furnish the Agency with certified ready-mix concrete, the problem of good inspection is considerably more complicated than when using job mixed concrete. At the ready-mix concrete plant, the concrete aggregates may vary to a greater degree, both in moisture content and in gradation.

5-694.441 STEPS IN CERTIFYING A READY-MIX PLANT

Prior to the beginning of the project or once per calendar year, an Agency Representative shall perform a thorough on-site inspection of the concrete plant and complete a *Concrete Plant Contact Report* (Form 2163). The *Contact Report* (See 5-694.716) contains the necessary information to assure that the plant can produce concrete meeting Specifications, and has a signature block for the Ready-Mix Producer Representative certifying that the Producer will maintain the plant in that condition.

1. An Agency Representative will meet at the ready-mix plant with the Producer's Level II Technician. Together they will do a complete walk-through inspection of the plant.

2. Completely fill-out the *Contact Report*. The Producer's Level II Technician should help with operation and equipment questions.
3. The plant must have its scales calibrated by an approved scale company within the last six months (Specification 1901, 2461.4D, and 2301.3F for concrete paving shall apply). Enter results on scale company forms or Mn/DOT *Test of Weighing Equipment* (Form 2124). See 5-694.717.
4. Lab scales and equipment are calibrated annually before the Agency project begins. Equipment and scales meeting the tolerances are dated using tape or other marking methods.
5. The aggregate testing is done by Mn/DOT Certified Level I or II Technician. Their names, certification numbers, and a cell phone number for the Level II Technician are posted at the plant site at all times.
6. The plant must use certified cements, fly ash, slag, and Mn/DOT approved admixtures. Check the Mn/DOT Concrete Engineering Unit website for a list of approved materials at www.mrr.dot.state.mn.us/pavement/concrete/products.asp.
7. Observe/discuss materials handling operations with the Producer/Contractor to ensure that stockpiles are not segregated, contaminated, or have non-uniform moisture contents. Refer to 5-694.124 and Specification 2461.4A1.
8. Watch aggregate handling closely. Discontinue operations that result in segregation. The Inspector should see that baffles are in place and working properly where they are needed to reduce and control coarse aggregate segregation.
9. Assure that the plant is using aggregate sources that have a history of meeting Mn/DOT quality requirements. For aggregate quality information, contact the District Materials Engineer or the Mn/DOT Concrete Engineering Unit at 651-779-5573.
10. In the Metro District, generation of a completely computerized Certificate of Compliance is required. Out-state Districts, under certain conditions, are allowed the option of a handwritten *Certificate of Compliance* (Form 0042). See Figure B 5-694.723.
11. Mechanical shakers are required for both fine and coarse aggregate gradations.
12. A copy of Mn/DOT's Concrete Manual is required at the plant site.
13. A sitemap identifying the contents of all stockpiles, bins, and silos must be posted at the plant site.

5-694.442 CONTRACTOR RESPONSIBILITY

The Contractor shall obtain all of the ready-mix concrete used on the Contract from a Certified Ready-Mix Concrete Plant meeting all of the pertinent requirements of Specifications 1604 and 2461 and the following. See 5-694.012 for a checklist for Ready-Mix Producers.

A. Certificate of Compliance

It is the Contractor's responsibility to ensure that the Ready-Mix Concrete Producer adheres to all of the following requirements.

With each truckload of concrete, supply a signed Certificate of Compliance that the concrete complies with the Contract requirements. See Figure B 5-694.723 for an example of a handwritten *Certificate of Compliance.*

The Certificate of Compliance shall include:

1. Name of the Ready-Mix Concrete Plant
2. Name of the Contractor
3. Date
4. State Project Number (S.P.)
5. Bridge Number (when applicable)
6. Time concrete was batched/discharged
7. Truck number
8. Quantity of concrete in this load
9. Running total quantity of this concrete mix batched on this day for this project
10. Type of concrete (Mn/DOT Mix Designation Number)
11. Cement brand and production mill
12. Fly ash brand and production power plant
13. Admixture brand and product name
14. Pit number for each aggregate source
15. Admixture quantity per 100 wt. or ml/ m^3 (oz/yd^3) for:
    - air-entraining admixtures
    - water reducing admixtures
    - other admixtures
16. Design masses (weights) per m^3 (yd^3) for:
    - cement
    - fly ash
    - each coarse aggregate fraction
    - fine aggregate (sand)
17. Design water mass (weight)
18. Target and Actual batched masses (weights) for:
    - cement
    - fly ash
    - each coarse aggregate fraction
    - fine aggregate (sand)
    - actual water added
    - any temper water added
    - total water
19. The ticket shall also include the following information printed with enough room beside each item to allow the Agency Field Inspector to record the appropriate test results: air content, air temperature, concrete temperature, slump, cylinder number, and location/part of structure

Items 11, 12, 13, 14, and 16 are needed only on the first Certificate per day per mix designation or when one of these items changes.

NOTE: The Certificate of Compliance shall consist of a single sheet maximum. Projects administered by the Metro District require a computerized Certificate of Compliance. If the computer that generates the Certificate of Compliance malfunctions, the Producer may finish any pours that are in progress provided the plant issues handwritten Certificates of Compliance on the

most current version of Mn/DOT's *Certificate of Compliance* (Form 0042). New pours are not permitted to begin without a working computerized Certificate of Compliance.

As an option for Out-state Districts, the Ready-Mix Producer may use handwritten Certificates of Compliance, which are the most current version of Mn/DOT's *Certificate of Compliance* (Form 0042). The form must contain all of the information required above including water measurements.

B. Contractor Sampling and Testing Requirements

The Certified Ready-Mix Concrete Plant will provide testing as outlined below.

1. All testing and plant operations are overseen by a Mn/DOT Certified Plant Level II Quality Control Supervisor who is on site, or accessible by cellular phone to reach the site within an hour.
2. The Quality Control Supervisor will maintain or oversee the maintenance of a plant diary. The diary documents quantities produced each day, tests performed, material problems, breakdowns, weather, etc., all to the approval of the Engineer. See 5-694.726.
3. All testing is performed at the plant site by Mn/DOT Certified Technicians.
4. Mechanical shakers are required for sieve analysis of fine and coarse aggregates.
5. Testing shall comply with Mn/DOT Specifications and procedures and according to the following list of tests and standards.

AASHTO T 27	Sieve Analysis of Fine and Coarse Aggregates
AASHTO T 255	Total Moisture Content of Aggregate by Drying
AASHTO M 92	Wire-Cloth Sieves for Testing Purposes. The sieves shall comply with the requirements of 5-693.420B of the Department's Bituminous Manual "Equipment Calibration and Verification Policies and Procedures for Laboratory Certification".
AASHTO M 231	Weighing Devices used in the Testing of Materials

6. The Certified Technician furnishes cement and fly ash samples on request. Only certified cement and fly ash are allowed. When sampling is required, the Agency should monitor whenever possible.
7. The Producer/Contractor provides a minimum of one moisture test and one gradation test per day when more than 20 m^3 (yd^3) are produced each day.
   a. Perform moisture tests on all aggregates at the rate of 1 per 200 m^3 (yd^3).
   b. Run gradations on fine (sand) aggregate at the rate of 1 per 200 m^3 (yd^3).
   c. Run gradations on coarse fractions at the rate of 1 per 100 m^3 (yd^3).
   d. Complete initial tests prior to concrete production each day.
   e. Provide additional tests when the condition of the material substantially changes.
   f. Provide a split companion sample of aggregate gradations and retain for one week for Agency gradation testing.
   g. Chart and display the data at the plant for:
      1) Moisture content (including weekly moisture probe checks, if applicable)
      2) Coarse aggregate and the 2.36 mm (#8), 600 µm (#30), and 300 µm (#50) sieves

3) Agency companion and verification (audit) gradations on the same chart as the Ready-Mix Producer.

h. Document the results of all gradations on the *Weekly Concrete Aggregate Report* (Form 2449) and keep supporting documentation for all testing on file at the plant site. See 5-694.721.

NOTE: The Producer may choose to determine moisture content in the fine aggregate by use of an approved moisture probe. See 5-694.142D for approval requirements.

5-694.443 AGENCY RESPONSIBILITY

For Certified Concrete Ready-Mix Plants, the following summarizes the Agency's responsibilities.

A. Plant Responsibilities for Certified Ready-Mix Plants

See 5-694.011 for a checklist for Ready-Mix Concrete Plant inspection.

B. Office Responsibilities for Certified Ready-Mix Plants

1. At the end of each week of production, the Producer's Level II Technician must fax or deliver a completed copy of the *Weekly Concrete Aggregate Report* (Form 2449) to the Agency. See 5-694.721. The Producer must leave a space between each gradation test for the Agency to record companion gradation results. The Agency records all companion results and sends a copy back to the Producer for charting. If allowable variations are exceeded (as described in the Specifications), the conflicting results are circled and the Producer's Level II Technician is notified.
2. Send the Contractor a completed copy of the "*Weekly Certified Ready-Mix Plant Report"* (Form 24143). See 5-694.724. Circle any failing verification results. The Agency Lab should run companion and verification samples, preferably the same day the concrete is placed but not later than the following day. **Report any failing tests to the Contractor's Level II Technician as soon as possible so corrective action can prevent further failures.**
3. Report failing verification samples to the Project Engineer. Discuss repeated verification failures with the Mn/DOT Concrete Engineering Unit for possible de-certification of the concrete plant, technician or source of aggregate. Contact the Mn/DOT Concrete Engineering Unit regarding questions on price reductions or refer to the current Schedule of Price Reductions.
4. Each week, Project Engineers should receive copies of Form 24143 and Form 2449.

5-694.444 MITIGATING TESTING VERIFICATION PROBLEMS

It is imperative that all parties are notified when testing compliance problems occur to provide for corrective action. If the gradation tests on split samples from quality control or verification samples result in a variation between the Producer and the Agency greater than that set forth below, the 2 parties will cooperatively take and split a new sample. The Producer's representative will test the sample while witnessed by the Agency Plant Monitor. This will serve as a check on the process to correct deviations from the standard testing procedure. If this problem continues, the Project Engineer, District Materials Engineer and the Mn/DOT Concrete Engineer

will make a total review of the plant. If results still do not agree, the parties should resolve the dispute by third party resolution according to procedures described in Section 5-691.350 of the Mn/DOT Contract Administration Manual.

Allowable variations on percent passing any sieve:

Sieve	% Allowed
50 mm - 9.5 mm (2 in. - 3/8 in.)	+ or - 6
4.75 mm - 600 μm (#4 - #30)	+ or - 4
300 μm (#50)	+ or - 3
150 μm (#100)	+ or - 2
75 μm (#200)	+ or - 0.6

The Agency and Producer must test all verification samples. The Producer has the option to use the companion to the verification sample as part of the process control testing.

It is important to review test data to assure that the verification test results are in the same statistical family of data as the Producer's QC tests. It is not expected that the comparison between verification sample test results and process control tests will correlate as well as split samples from verification or the Producer's process control tests. If in the judgement of the Engineer these tests do not correlate, investigate the problem. Inconsistencies in test results should trigger additional visits to the plant and additional sampling and testing. Possible causes for variations may include: dirty or defective screens, not thoroughly sieving samples, segregated samples, improper sampling or splitting techniques, etc.

The Ready-Mix Producer, after an acceptable time period, may request a reduction in testing rates if past results warrant. Only the Mn/DOT Concrete Engineer can approve this request. This approval is based only on extraordinary procedures performed by the Aggregate Supplier and Ready-Mix Producer to insure consistency and quality control. Extra fractions and bins are an example of such a procedure.

5-694.445 AGENCY RESPONSE TO NON-COMPLIANCE WITH THE CERTIFIED PLANT REQUIREMENTS

If a proposed plant cannot produce concrete, perform testing, or report information as required during completion of the Concrete Plant Contact Report, concrete is not acceptable from this plant.

DO NOT ACCEPT concrete on the Project if:

1. Companion samples or verification acceptance samples fail to meet requirements.
2. A review of the plant indicates that there is cause for concern in the quality of the concrete.
3. A plant fails to comply with any part of the certification program.

If concrete is inadvertently placed in the work, it is subject to Mn/DOT Specification 1512, Unacceptable and Unauthorized Work. Price Reductions are determined according to the Schedule of Price Reductions for Failing Materials for Concrete, Bituminous, and Grading & Base Construction based on Agency verification samples.

The project may begin after review and approval of the Concrete Plant Contact Report. Any procedural changes that cause non-compliance with this program will result in decertification of the plant and cessation of further production of concrete for this Project. Decertification will also occur at any plant that continually produces concrete that is noncompliant as detailed above. Complete disregard of this specification or fraudulent test reports are grounds for immediate Decertification.

Decertification could include any or all, but is not limited to, the following actions:

1. Revocation of Plant Certification.
2. Revocation of Technician Certification for individual(s) involved.
3. Loss of bidding privileges as determined by the State Construction Engineer.
4. Criminal prosecution for fraud as determined by the Attorney General.

The Mn/DOT Concrete Engineer determines any Decertification actions.

5-694.446 FIELD INSPECTION OF CERTIFIED READY-MIX CONCRETE

Close coordination is required between the Plant Operator, Plant Monitor, and Project Inspectors to assure satisfactory concrete placement at the job site.

It is satisfactory to add water to the ready-mix truck on the project whenever the slump of the concrete is below the minimum required for the specific mix, provided the Inspector checks the Certificate of Compliance to determine if adding the proposed amount does not exceed the tolerances permitted. When water is added, the measured quantity is handwritten on the Certificate of Compliance. The Inspector must include this added water with the total water on the Certificate of Compliance when making out the *Weekly Concrete Report* (Form 2448). See 5-694.727. Do not use water to re-temper old concrete.

On bridge deck concrete, the water/cementitious ratio shall not exceed 0.44.

5-694.450 LOW SLUMP CONCRETE OVERLAYS

Mn/DOT has developed a report for documenting low slump concrete for bridge deck overlays. This form is called the *Weekly Report of "Low Slump Concrete"* (Form 21412). See 5-694.762.

The batch quantities for the fine aggregate are based on a specific gravity of 2.65. Normally, the specific gravity of concrete sand is close enough to 2.65 so that the batch quantity of sand only needs correction for moisture content. However, the specific gravity of Class A coarse aggregates vary significantly with each source.

Always adjust the 3U17A concrete mix design weights based on the specific gravity of the coarse aggregate. Obtain the specific gravity of Class A material from sources other than listed on the back of the *Weekly Report of "Low Slump Concrete"* (Form 21412) and the corresponding batch quantities from the Mn/DOT Concrete Engineering Unit. Use only Mn/DOT approved water reducers and air-entraining agents. Compatibility of admixtures is critical.

There is not a requirement to determine the moisture content of the aggregates. Run a minimum of one gradation of stockpiled aggregates prior to commencing operations and each time aggregate is delivered to the site. Monthly, submit one laboratory sample for gradation of both fine and coarse aggregate during operations. Visually inspect the aggregates for correct class of aggregate, segregation, and excessive moisture. For calibration purposes, assume arbitrary moisture content of 3% for the fine aggregate, but no moisture for the coarse aggregate.

NOTE: Concrete mixes for patching (3U37A) or other uses are available by contacting the Mn/DOT Concrete Engineering Unit, at 651-779-5573.

5-694.451 LOW SLUMP CONCRETE BATCHING REQUIREMENTS

Continuous mixers at the job site produce grade 3U17A concrete for low slump bridge deck overlays. If the 3U17A mix for purposes other than an overlay is required by the proposal, use either a paddle type or a continuous mixer. When using a paddle type mixer, batch the materials by mass (weight). The 3% moisture assumption for the fine aggregate is used only to adjust the batched quantity. Continuous mixers used for low slump concrete overlays in Minnesota are called Concrete-Mobiles and they require calibration.

5-694.452 LOW SLUMP CONCRETE OVERLAY PROCESS

The process of performing a low slump overlay begins with surface preparation. Surface preparation includes sand blasting the existing surface and placement of concrete around the joints. Inspectors are advised to visually inspect the surface and drag a chain to detect defective areas. When defects are observed, take conventional corrective actions, such as chipping off loose concrete prior to the overlay. The “dry-run” is the process of moving the paver over the structural deck and spot-checking for minimum overlay thickness. Application of a bonding grout facilitates an adequate bond with the overlay.

Concrete is conveyed by buggies from the Concrete-Mobile to the paver. The paver trims and consolidates the concrete to the prescribed elevation. For surface texturing, an astroturf drag is usually attached to a finishing bridge that runs behind the paver.

The following pictures illustrate some activities in a low slump overlay process.

Figure A 5-694.452 shows batching on site using a Concrete-Mobile. The Contractor shall calibrate the Concrete-Mobile prior to commencement of any project, and whenever there is a observed discrepancy in yield or a change in conditions.

Figure B 5-694.452 shows the preparation of the finishing bridge. The astroturf is attached to the bridge, but tentatively folded.

In Figure C 5-694.452 the existing joint over an abutment has been removed prior to replacement. This step does not occur in new construction.

Figure D 5-694.452 shows the E8S joint placed prior to the overlay activity. Sufficient strength gain is required to carry loaded buggies across the E8S joint prior to low slump overlay placement. A low slump mix is shown in Figure E 5-694.452. The bonding grout is placed a few minutes ahead of the low slump overlay.

The Contractor is placing the low slump concrete overlay in Figure F 5-694.452. Arrows indicate direction of motion of parts of the paver.

Figure G 5-694.452 shows the view from behind the paver. The finishing tool is modified with a cutting tool for joint re-establishment.

The final finish using astroturf drag is shown in Figure H 5-694.452. The chain provides constant pressure for uniform texturing. Joint establishment must precede the texturing.

Figure A 5-694.452

Figure B 5-694.452

Figure C 5-694.452

Figure D 5-694.452

Figure E 5-694.452

Figure F 5-694.452

Figure G 5-694.452

Figure H 5-694.452

5-694.453 OPERATING PRINCIPLE OF "CONCRETE-MOBILES" (Continuous Mixers)

The heart of the Concrete-Mobile is a device called a "Cement Meter Feeder" which provides a uniform flow of cement to the concrete mix. All of the other ingredients including aggregates, water reducer, air-entraining admixture, water, etc., are proportioned to this uniform flow of cement.

- The cement meter feeder is a rotary vane type.
- The cement in the cement bin is in an unpacked condition and flows into the meter pockets or sections similar to water flow.
- The cement is brought to the space immediately over the cement meter feeder wheel by a cross-auger. It is next dislodged as the wheel revolves at the bottom by gravity and the two hammers striking the pocket by spring action. These two hammers ride on the bottom of the cement meter feeder.
- As the cement meter feeder revolves, the ramps or wedges on the cement meter feeder cock the hammer springs.
- After the ramp or wedge clears the hammers, the spring causes the hammers to strike the pocket sharply and this dislodges the cement.
- The Inspector hears the sounds of the hammers striking the cement meter feeder and the springs are observed from the rear of the Concrete-Mobile.
- The cement then drops on the aggregates previously placed on the main conveyor belt.
- Since an aggregate proportioning device is not as accurate as batching by mass (weight), an additional 2% of cement is automatically added to the mix.
- The fine aggregate and the coarse aggregate are stored in separate bins. Each aggregate bin is controlled by a positive gate that allows selection of the correct proportion of fine and coarse aggregate by the Operator.
- The admixtures are forced into the mix by air pressure on each tank. There are two tanks provided using a HiFlo (large) tank for water reducer and LoFlo (small) tank for air-entraining agent. It is extremely important that both admixtures are diluted and thoroughly mixed before placement in the tanks. The admixtures are selected from the Mn/DOT Approved products list at www.mrr.dot.state.mn.us/pavement/concrete/products.asp.

5-694.454 PROJECT CALIBRATION OF CONCRETE MOBILE

See 5-694.761 for the Concrete Mobile Calibration Worksheet.

This calibration procedure is applicable to mechanical and all-hydraulic Concrete Mobiles. It also applies to the Magnum Concrete Mobile with certain exceptions. **Calibrations are based on 45 kg (100 lb.) quantities. These values are not exactly equal but these quantities are used for convenience.** Exceptions are identified where they occur. Each Concrete Mobile Model has a unique number of revolutions and length of time to deliver 45 kg (100 lb.) of cement for state work.

A. Cement Check Calibration

The list of items required by the Contractor are:

- A scale with a capacity of 225 kg (500 lb.). Check the accuracy of the scale by weighing a known quantity of about 135 kg (300 lb.). Adjust the scale as necessary.
- A box or other container to catch the discharged material on the scale.
- A suitable deflector (sheet metal, etc.) to deflect the falling material into the container.

Project personnel verify the cement output. The cement check procedure is as follows:

1. Check to see that the aggregate bins and the main conveyor belts are empty and clean.
2. Clean and free-up cement deposits from the cement meter feeder.
3. Check the spring hammers and the cement meter register for proper operation.
4. Check all bin vibrators for operation (two for cement bin, two for sand bin).
5. Ensure that the cement bin aeration system is operating properly and that the air breather hole is open to atmospheric pressure.
6. Ensure the Concrete Mobile is properly grounded. (Each truck has two ground straps. If the truck is not grounded, the cement has a tendency to develop a static charge and may bridge.)
7. Place the mix-conveyor in the travel position and fix the piece of sheet metal into the bottom end of the mix conveyor as a deflector for material falling off the main conveyor belt.
8. With the cement meter register engaged, run out sufficient cement for charging the belt and ensuring that uniform discharge is occurring.
9. Zero the meter, place the box or other container on the scale, and position so all the discharged cement is caught.
10. Engage the main conveyor and allow the equipment to run until the meter register reaches 45 kg (100 lb.) of cement. Record the number of revolutions and the time in seconds.
11. Engage the main conveyor and allow the equipment to run until the meter register reaches 3 times the known number of revolutions required for 45 kg (100 lb.) of cement.
12. Stop the main conveyor. Weigh the material and record the net mass (weight). The cement should weigh between 135 and 138 kg (300 and 306 lb.).
13. If the net mass (weight) does not fall between 135 and 138 kg (300 and 306 lb.) of cement, empty the box and repeat the test 2 more times. If the average of the 3 tests falls between 135 and 138 kg (300 and 306 lb.), accept the established meter count and proceed to Sand and Stone Dial Check.

If the meter count does not fall within 135 and 138 kg (300 and 306 lb.), correct the meter count as follows:

Example:
Original meter count = 70 revolutions
Original cement weight = 46 kg (102 lb.)
Original time constant = 30 seconds
Average mass (weight) for 3 times the number of revolutions = 150 kg (331 lb.)

Determine the new meter count:

$$\text{New Meter Count} = \frac{3 \text{ x Original Cement Mass (Wt.) x Original Meter Count}}{\text{Average Cement Mass (Wt.) from 3 Tests}}$$

$$\text{New Meter Count} = \frac{3 \times 46 \text{ kg (102 lb.)} \times 70 \text{ Revs}}{150 \text{ kg (331 lb.)}}$$

$$\text{New Meter Count} = 64.4 \text{ Revs}$$

To carry the correction further, correct the time required to measure 46 kg (102 lb.) of cement. Use the time constant later when calculating the HiFlo and LoFlo admixture settings. Determine the new Meter Count first.

Determine the new time constant:

$$\text{New Time Constant} = \frac{\text{New Meter Count x Original Time Constant}}{\text{Original Meter Count}}$$

$$\text{New Time Constant} = \frac{64.4 \text{ Revs} \times 30 \text{ seconds}}{70 \text{ Revs}}$$

$$\text{New Time Constant} = 27.6 \text{sec}$$

The "time constant" is the time required to produce 45 kg (100 lb.) of cement.
The "meter count" is the number of revolutions to produce 45 kg (100 lb.) of cement.

Use the new Meter Count and Time Constant instead of the previous meter count for calibration purposes and for producing all concrete for the project. The terms "Meter Count" and "Time Constant" used hereinafter means the corrected version if re-calibration was required.

B. Sand and Stone Dial Checks for Fine and Coarse Aggregate

Check the dial indicators for the sand and stone gates annually to ensure the pointers have not slipped on the shafts and that wear on the bottom of the gates is not excessive. The calibration procedures are identical for both the sand and stone gate. The standard Concrete Mobile uses a 76.2 mm x 76.2 mm x 203.2 mm (3 in. x 3 in. x 8 in.) hardwood block as a calibration device that

is placed on the belt lengthwise. The gate is lowered until it just touches the block and is then tightened by the hand-wheel as shown on the dial. The pointer should read between 6.2 and 6.6. (Note that the dial is a reference point and does not measure the gate opening in millimeters (inches) or other dimension.) If the dial reading is not within tolerance, loosen the setscrews and adjust the pointer to 6.4. (The Magnum Concrete Mobile uses a 42.86 mm (1-11/16 in.) hardwood block and the same procedure except the sand dial pointer should read between 7.8 and 8.0 and the stone dial pointer should read between 7.4 and 7.6.)

C. Aggregate Calibration

The aggregates are proportioned per 45 kg (100 lb.) of cement. For the 3U17A concrete mix using 815 kg/m^3 (1374 lb/yd^3) of concrete sand and 914 kg (1540 lb.) of Concrete Trap Rock, the amount of each aggregate is determined by dividing by 11, which is equal to 496 kg of cement divided by 45 kg. This results in 74 kg of sand and 83 kg of stone required per 45 kg (100 lb.) of cement for the mix. Note that the moisture content of the sand is assumed to be 3%. The corrected quantities therefore are as follows:

Proportions per 45 kg (100 lb.) of cement:

Sand (adjusted for 3% MC)	1.03 x 74 kg (164 lb.)	=	76 kg (169 lb.)
Stone (Concrete Trap Rock)		=	83 kg (184 lb.)

Empty the cement bin before proceeding to the next step. Retain this cement in a clean drum or other container for use in the slurry if the Contractor so desires.

D. Procedure for Sand Gate Calibration (Cement and Stone Bins empty)

The equipment required is the same as that required for the cement check.

1. After inspecting the bins for cleanliness, fill the sand bin with the sand used for the project.
2. Make sure none of the sand overflows into the stone bin.
3. Set the sand dial pointer at 2.0 (6.0 Magnum) and run out sufficient material to load the belt and ensure uniform discharge.
4. Zero the cement meter and place the box and scale under the raised mix-conveyor and allow it to run until the meter-register reading equals the reading for 45 kg (100 lb.) of cement.
5. Stop the conveyor, weigh the box and record the result.

Perform the same test with the sand dial pointer set at 3.0 and then 4.0 (7.5 and 9.0-Magnum). Run out sufficient material to pre-load the belt, etc. for each new setting. Obtain the net mass (weight) of the sand and plot the 3 results as shown in the example, Figure D 5-694.454. The results should plot in a reasonably straight line. If they do not, rerun the gate settings that appear out of line. Empty the sand bin.

E. Procedure for Stone Gate Calibration (cement and sand bins empty)

Equipment needed is the same as for Sand Gate Calibration.

1. Fill the stone bin with care to prevent the coarse aggregate from spilling over into the sand bin.
2. Set the stone dial pointer at 3.0 (7.0 - Magnum) and run out sufficient material to load the belt and ensure uniform discharge.

3. Zero the cement meter and place the box and scale under the raised mix conveyor to catch all the material that is discharged.
4. Engage the main conveyor and allow it to run until the meter-register reading equals the reading for 45 kg (100 lb.) of cement.
5. Stop the conveyor and weigh the box, recording the results.

Perform the same test with the stone dial pointer at 4.0 and then 5.0 (9.0 and 11.0-Magnum). Run out sufficient material to pre-load the belt, etc. for each new setting. Obtain the net mass (weight) of the stone for the stone dial settings by subtracting the mass (weight) of the box. Plot as shown in Figure D 5-694.454. Again, the results should plot in a reasonably straight line; if it does not, run additional tests as required.

F. Calibration of the HiFlo and LoFlo Systems

In the interest of uniformity, prepare the Water Reducer as follows:

- Place 22.7 L (6 gal.) of approved water reducer in a clean 208.2 L (55 gal.) drum.
- Fill the drum with water and agitate to thoroughly mix. This is a 1:7 solution (8 total parts to the solution) with sufficient accuracy for calculating the HiFlo setting to an accuracy of 97% or more.

1. HiFlo Setting Calculations

For illustrative purposes, assume the maximum dosage is 118 ml/45 kg (4 oz./100 lb.) of cement and that the particular Concrete Mobile delivers 45 kg (100 lb.) of cement every 70 revolutions in 30 seconds).

The HiFlo system is calibrated in L/min. (qts./min.):

Delivers 90 kg (200 lb.) of cement in one minute =

$90/45 \times 118 \text{ mL} = 236 \text{ mL}$ OR $2 \times 4 \text{ oz.} = 8 \text{ oz.}$ of water reducer required per minute

1:7 solution = 8 parts of solution:

$8 \times 236 \text{ mL} = 1888 \text{ mL}$ solution per minute OR $8 \times 8 \text{ oz.} = 64 \text{ oz.}$ solution per minute

Approximately 1.9 L/min. OR $\dfrac{64 \text{ oz.}}{32 \text{ oz. per quart}} = 2 \text{ qts. of solution per minute}$

From the HiFlo diagram Fig. A 5 - 694.454 - setting = 2.2

(Use Fig. B 5 - 694.454 for Magnum Concrete Mobile)

Air Entraining Agent (AEA) - Place 18.9 L (5 gal.) of an approved air-entraining agent in a clean 208.2 L (55 gal.) drum. Fill the drum with water and agitate to thoroughly mix. This is a 1:10 solution (11 parts to the solution).

2. LoFlo Setting Calculations

For illustrative purposes, assume 22 ml/45 kg (0.75 oz./100 lb.) of cement will result in 6.5% of entrained air in the mix. (Actual requirement is determined by actual air tests since temperature and other factors affect the dosage.) Also assume the particular Concrete Mobile delivers 45 kg (100 lb.) of cement in 30 seconds.

The LoFlo system is calibrated in L/min. (oz./min.):

Delivers 90 kg (200 lb.) of cement in one minute =

$2 \times 22 \text{ mL} = 44 \text{ mL}$ OR $2 \times 0.75 \text{ oz.} = 1.5 \text{ oz.}$ of AEA required per minute

1:10 solution = 11 parts of solution:

$11 \times 44 \text{ mL} = 484 \text{ mL}$ solution per minute OR $11 \times 1.5 \text{ oz.} = 16.5 \text{ oz.}$ solution per minute

From the LoFlo diagram Fig. A 5 - 694.454 - setting = 0.8

(Use Fig. B 5 - 694.454 for Magnum Concrete Mobile)

NOTE: The floats for the HiFlo and LoFlo systems will only operate when the Concrete Mobile is mixing concrete. The cleanliness and proper operation of both systems is shown if the floats return to zero when mixing is stopped. Likewise if the floats do not return to the zero position, it is an indication the system is not functioning properly and corrective action is necessary.

3. HiFlo Setting Procedure for Non-Standard Float Valves

Equipment Required:

- Clean plastic or metal pail (provided by Contractor)
- Scale used for calibration (provided by Contractor
- Stop watch (provided by Department)

Fill the HiFlo tank with water. Empty or shut off the LoFlo system. Assure that the air system is in operation and the Air Pressure Regulator - Pressure Gauge is at the prescribed pressure of 100 kPa or 175 kPa Magnum (15 psi standard, 25 psi Magnum).

The calibration procedures consist of operating the HiFlo system by passing the main conveyor (belt) control during a time interval for 2 or more HiFlo float settings. This procedure eliminates actuation of the belt, cement meter and the quick-acting water valves so that only liquid from the HiFlo tank drops into the mixing chamber. Initial step: weigh and record the tare mass (weight) of the pail.

Run 1. Actuate the HiFlo system as described above and set the float at a reading of 1.0. Stop the HiFlo system; place the pail under the pipes to catch the water; simultaneously actuate the HiFlo system and the stopwatch. After 60 seconds, release the HiFlo valve. Remove the pail and weigh the pail and liquid. Record the results.

Run 2. Follow the same procedure as for Run 1 except with a float setting of 2.0.

Upon completion of Runs 1 and 2, convert the mass of the liquid to liters (quarts). (NOTE: One liter of water has a mass of 1 kg (1 gal. of water weighs 8.33 lb. and there are 4 qts. per gal.).

On graph paper, plot the results of the two runs as shown in the example. The required liters (quarts) of solution per minute are calculated, as prescribed in paragraph A above, and the correct setting is selected from the graph.

Example:

Assume the constants for a particular truck (Magnum):

- 29.5 revolutions at 20.7 seconds (second gear)
- Tare of pail = 0.7 kg (1.5 lb.)
- 18 mL (4 oz.) water reducer dosage per 45 kg (100 lb.) of cement

$$\frac{60\,\text{sec.}}{20.7\,\text{sec.}} \times 45\,\text{kg}\,(100\,\text{lb.}) = 130\,\text{kg}\,(290\,\text{lb.})\,\text{cement}/\text{min.}$$

$$\frac{130\,\text{kg cement}/\text{min.}}{45\,\text{kg cement}} \quad \textit{or} \quad \frac{290\,\text{lb. cement}/\text{min.}}{100\,\text{lb. cement}} = 2.90/\text{min.}$$

$$2.90/\text{min.} \times 18\,\text{mL} \times 8\,\text{parts of solution} = 2738\,\text{mL}\,(2.75\,\text{L})\,\text{per min. of solution required} \quad \text{OR}$$

$$2.90/\text{min.} \times 4\,\text{oz.} \times \frac{1\,\text{qt.}}{32\,\text{oz.}} \times 8\,\text{parts of solution} = 2.90\,\text{qts. per min. of solution required}$$

Run 1. HiFlo Setting 1.0

Mass of Pail and Liquid	*3.2 kg (7.0 lb.)*
Tare	*- 0.7 kg (1.5 lb.)*
Mass of Liquid	*2.5 kg (5.5 lb.)*

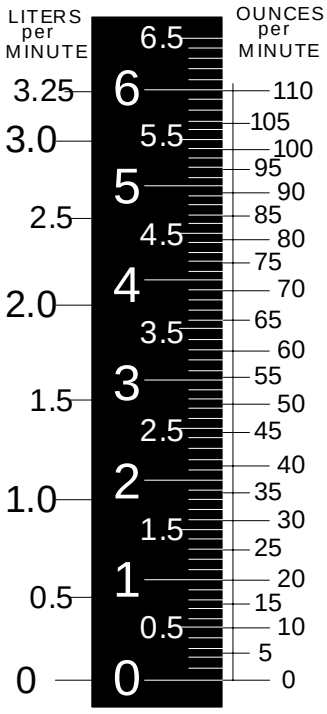
$$2.5\,kg = 2.5\,L/min. \quad OR \quad 5.5\,lb. \times \frac{1\,lb.}{8.33\,gal.} = 2.64\,qts./min.$$

Run 2. HiFlo Setting 1.0

Mass of Pail and Liquid	*5.7 kg (12.5 lb.)*
Tare	*- 0.7 kg (1.5 lb.)*
Mass of Liquid	*5.0 kg (11.0 lb.)*

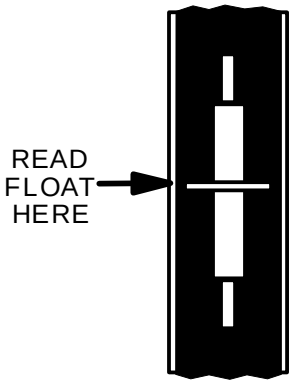
$$5.0\,kg = 5.0\,L/min. \quad OR \quad 11.0\,lb. \times \frac{1\,lb.}{8.33\,gal.} = 5.28\,qts./min.$$

From Figure C 5 - 694.555, the HiFlo setting is 1.1.



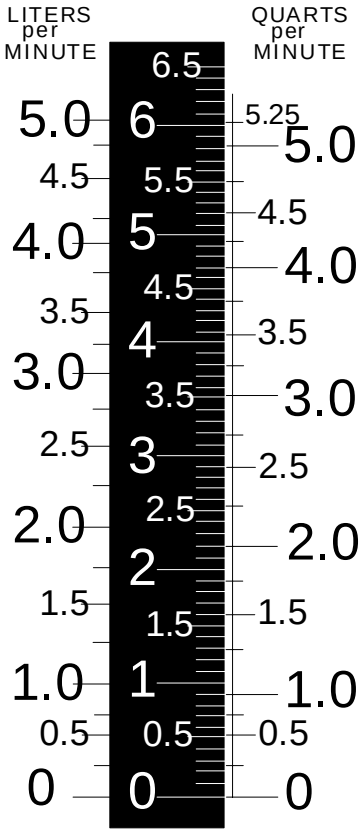
LO-FLO SYSTEM

STAINLESS STEEL FLOAT



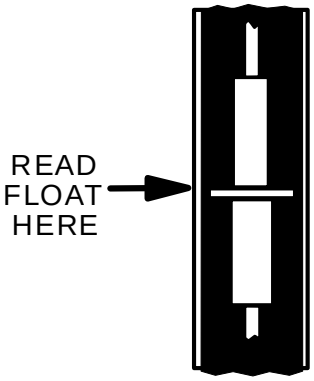
STANDARD

CONCRETE-MOBILE



HI-FLO SYSTEM

STAINLESS STEEL FLOAT



STANDARD

CONCRETE-MOBILE

Figure A 5-694.454

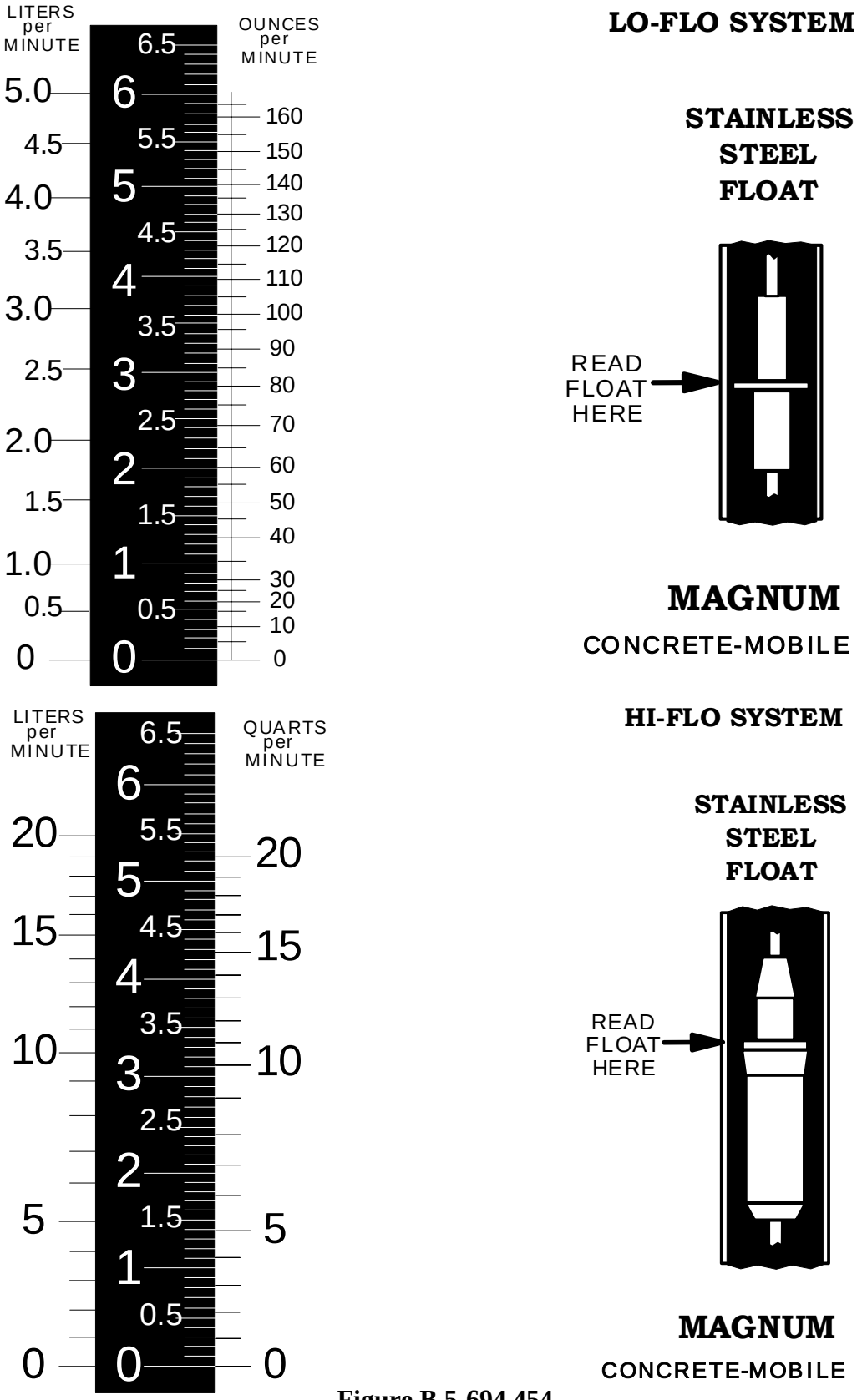


Figure B 5-694.454

HI-FLO CALIBRATION EXAMPLE

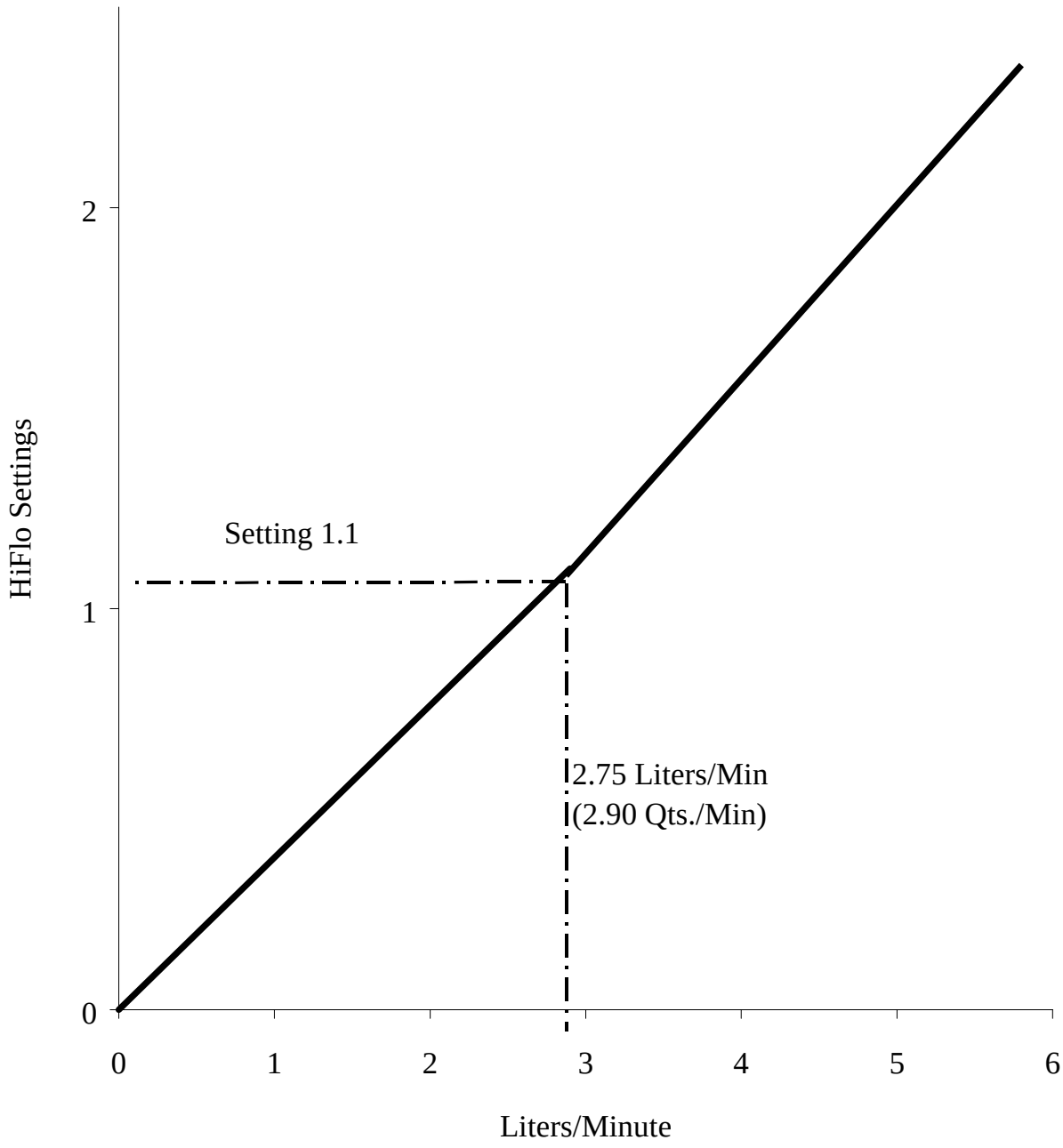


Figure C 5-694.454

Real Good Concrete Co. 1
Constants: 72.5 Rev. @ 31.0 Seconds (Corrected)
Aggregates: FA Concrete S & G
CA Concrete Trap Rock

Mn/DOT 3U17A Concrete Mix
Calibrated by D.A. Caswell

Materials/C.M. (C.Y.)	3U17A
Cement	496 kg (836 lb.)
Air	6 1/2%
FA	815 kg (1374 lb.)
CA	914 kg (1540 lb.)
WR	1.95 mL/kg (3 oz./cwt.)

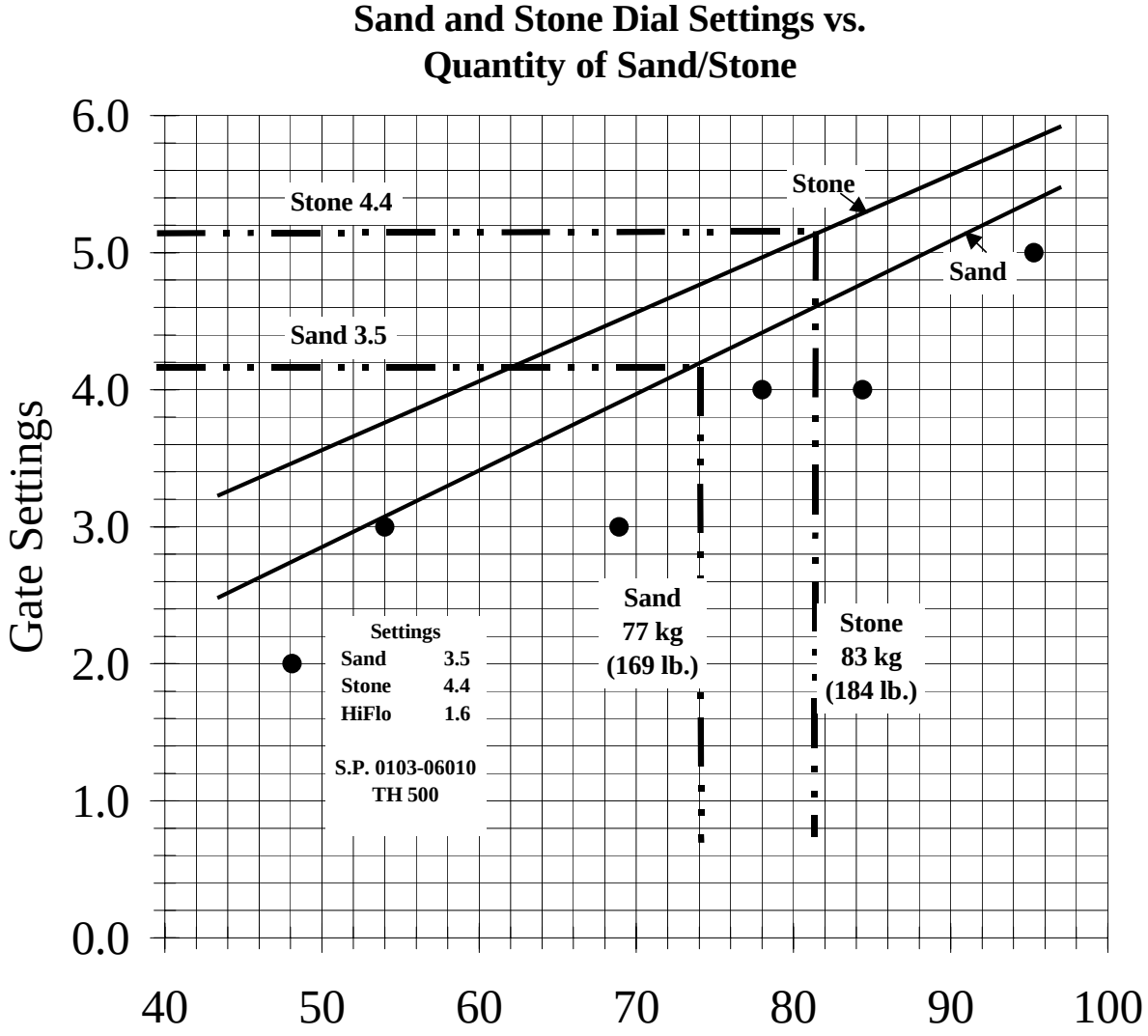


Figure D 5-694.454

5-694.455 LOW SLUMP CONCRETE OVERLAY USING TYPE IP CEMENT

Upon completion of calculations and the subsequent data plot, include a copy of both the calculations and the plot for project files.

Type IP cement (Portland-Pozzolan) is authorized for Low Slump Concrete Bridge Deck Overlays. If the Contractor elects to use Type IP cement, place the entire overlay on a bridge using Type IP cement. In other words, paving portions of the overlay on a particular bridge with Type IP cement is not permitted. The overlay must have either all Type I cement or all Type IP. The concrete mix for low slump overlays using Type IP cement is 3U17A (IP) to differentiate from the regular mix.

The design is as follows:

Low Slump Concrete Mix Design 3U17A (IP)
Mix Design Based on kg/m^3 (lb/yd^3)

Strength:	39 MPa (5600 psi) concrete at 28 days	
Water:	160 kg (270 lb.),	0.1602 m^3 (4.334 ft^3)
Air:	6.5%,	0.0650 m^3 (1.755 ft^3)
Type IP Cement (Sp.G – 2.97):	496 kg (836 lb.),	0.1278 m^3 (4.518 ft^3)
FA (Specification 3126):	803 kg (1353 lb.),	827 kg damp (1394 lb. damp)
CA* Class A (Specification 3137):		
152003 New Ulm Quartzite	(Sp.G - 2.63)	614 kg (1364 lb.)
173006 St Cloud Granite	(Sp.G - 2.72)	634 kg (1411 lb.)
194009 Dresser Trap Rock	(Sp.G - 2.97)	693 kg (1540 lb.)
106002 Ortonville Stone	(Sp.G - 2.64)	616 kg (1369 lb.)
117001 Sioux Quartzite	(Sp.G - 2.65)	618 kg (1374 lb.)
187002 Granite Falls Granite	(Sp.G - 2.67)	623 kg (1385 lb.)

Water Reducer: Maximum amount according to Manufacturer's recommendations.
Slump: 20 mm ± 5 mm (3/4 in. ± 1/4 in.)

* If a coarse aggregate other than listed is used, obtain the concrete mix design from the Mn/DOT Concrete Engineering Unit.