

MICHIGAN  
DEPARTMENT OF TRANSPORTATION  
SPECIAL PROVISION  
FOR  
**QUALITY INDEX FOR PORTLAND CEMENT CONCRETE**

CFS:CPM

1 of 11

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**a. Description.** This special provision establishes pay factor and price adjustments for Portland cement concrete based on Department administered Quality Assurance (QA) testing of 28-day compressive strength and fresh concrete air content of Portland cement concrete (PCC). Perform all work in accordance with the standard specifications and this special provision.

Percent-within-limits (PWL) analysis for payment adjustments apply for mainline, shoulder, miscellaneous concrete pavement (including ramps), and concrete pavement overlay applications. Non-PWL analysis for payment adjustments apply for all other applications.

1. Terminology.

**Acceptable Quality Level (AQL).** The threshold limit that would warrant 100 percent payment for the production lot of concrete.

**Air Content of Fresh Concrete.** The recorded air content of fresh concrete sampled and tested according to this special provision.

**Air Content Test Results.** The recorded air content of fresh concrete corresponding to the strength test specimens that were molded for acceptance.

**Base Price.** Price established by the Department to be used in calculating incentives or adjustments to pay items and shown in the contract.

**Dispute Resolution.** The process used to referee discrepancies between the Contractor's QC test results and the Department's QA test results. Dispute resolution applies for PWL quality index analysis of 28-day compressive strength only.

**Non-PWL Applications.** All concrete applications that are not subject to percent within limits (PWL) analysis for payment. Quality index analysis using PWL will not apply. Pay factor determination and price adjustment will be according to subsection d.2 of this special provision.

**Pay Factor (PF).** The factor that is determined according to subsections d.1 and d.2 of this special provision, used to calculate the price adjustment for a discrete quantity of concrete relative to its respective level of quality. Pay factor determination for PWL applications will be according to subsection d.1 of this special provision using the MDOT Concrete PWL Worksheet. Pay factor determination for non-PWL applications will be according to subsection d.2 of this special provision.

**Percent Within Limits (PWL).** The method used to determine acceptance and payment for mainline, shoulder, miscellaneous concrete pavement (including ramps), and concrete

pavement overlays. PWL will not apply for temporary concrete pavement or bridge approach slab applications. The PWL is the cumulative area under a standard curve that represents the estimated percentage of a production lot that falls above the Lower Specification Limit (LSL), beneath the Upper Specification Limit (USL), or between the LSL and USL.

**Price Adjustment (ADJ).** The price adjustment applied to the quantity of concrete represented by the respective quality index analysis described in subsections d.1 through d.3 of this special provision. The maximum potential positive price adjustment (quality initiative) for concrete acceptance items subject to PWL quality index analysis is five percent of the base price for the pay item. Non-PWL applications and small incidental quantities, regardless of the pay item, are not eligible for positive price adjustment (quality initiative) consideration.

**Production Lot.** A discrete cubic yard quantity of concrete containing the same JMF and used for the same application, typically made up of five sublots, as described in subsection c. of this special provision.

**Quality Index.** The calculated percent of material that meets specification.

**Quality Index Parameter.** The quality characteristics that are evaluated under the Department's QA program and on which payment for material is based. The quality index parameters used for price adjustment are 28-day compressive strength and air content of fresh concrete.

**Quality Initiative.** A budgeted amount established to cover the potential positive price adjustment for concrete acceptance items subject to PWL quality index analysis only. Non-PWL applications and small incidental quantities, regardless of the pay item, are not eligible for positive price adjustment (quality initiative) consideration.

**Rejectable Quality Level (RQL).** The threshold limit (defined in Table 1) for the quality index parameters that if not met, would require rejection of the concrete production lot. RQL only applies for PWL quality index analysis.

**Sample.** A representative quantity of concrete taken during production that is used to measure the quality characteristics of the concrete.

**Specification Limits.** The threshold values placed on a quality characteristic used to evaluate the quality of the material.

**Strength Sample Test Result.** The average of the two companion 28-day compressive strength test specimens taken from the same sample of concrete is considered a strength sample test result. For PWL quality index analysis, described in subsection d.1 of this special provision, each individual strength test specimen from the sample of concrete is considered a strength sample test result.

**Strength Test Specimen.** A strength test specimen is an individual 6-inch by 12-inch strength test cylinder or 4-inch by 8-inch strength test cylinder molded and cured according to *AASHTO T 23/ASTM C31* and tested according to *AASHTO T 22/ASTM C39*. All respective QC or QA strength test specimens must be the same nominal size. Strength test specimen cylinder size of 4-inch by 8-inch is permitted only if the nominal maximum coarse aggregate particle size, as specified for the coarse aggregate in the concrete mixture, is 1-inch or less (not permitted for Grade 3500HP concrete).

**Sublot.** A portion of a production lot represented by a complete set of QA tests, as described in subsection c. of this special provision. The Engineer and the Contractor may agree to reduce the typical subplot size based on project staging or other project conditions.

**b. Materials.** Mixture requirements will be in accordance with section 1004 of the Standard Specifications for Construction, unless otherwise specified in the contract.

**c. Sampling.** Sampling will be in accordance with subsections 1003.03.H and 1003.03.L of the Standard Specifications for Construction, except as modified herein. A sample is defined as a representative quantity of concrete taken during production which is used to measure the quality characteristics for the concrete. Compressive strength specimens for each sample consist of two cylinders, either 4-inch by 8-inch or 6-inch by 12-inch.

1. **PWL Applications.** Production lots for PWL analysis are made of at least five approximately equal sublots. The Engineer may approve occasional small individual quantities of concrete to be combined with a larger production lot provided they are of the same grade, contain the same Job Mix Formula (JMF), and are used for the same PWL application.

The random number method for PWL sampling will be used to determine the sampling locations. A random number will be generated for each subplot. The sampling frequency for a production lot is one QA sample per subplot.

If a subplot is not completed in sufficient quantity to permit it to be randomly sampled during its production day, as planned, the quantity of concrete for the subplot that was not placed as part of the day's production will be sampled during the following production day in accordance with the original random number sampling protocol. The random sample will then represent the total quantity of concrete for the subplot placed over the respective multiple days of production.

If the quantity of a grade of concrete to be sampled on the last day of production for the project is not sufficient to make up three or more equivalent sublots, combine the test results for these one or two remaining sublots, or fraction thereof, with the previous day's production lot for quality index analysis.

The Engineer will mold and cure two additional compressive strength cylinders, in the same manner as the QA specimens, that are to be retained in the event of dispute resolution.

2. **Non-PWL Applications.** See subsection 1003.03.L of the Standard Specifications for Construction.

3. **Small Incidental Quantities.** See subsection 1003.03.J in the Standard Specifications for Construction for reduced sampling and testing for small incidental quantities.

**d. Quality Index Analysis.** The Engineer's QA test results will be used to determine the pay factor (PF) and price adjustment (ADJ). The Contractor QC test results will not be used for PF and ADJ analysis. The Engineer will complete PF and ADJ analysis within 7 working days after completion of all 28-day compressive strength testing for the represented production lot or quantity of concrete. All values for PWL, overall lot pay factor (OLPF), and PF are in percent. PWL values are rounded to the nearest whole number. PF and OLPF values are rounded to

two decimal places.

1. PWL Applications. The PWL, PF, OLPF, and associated ADJ will be determined using the MDOT Concrete PWL Worksheet. The acceptable quality level (AQL), rejectable quality limit (RQL), lower specification limit (LSL), and upper specification limit (USP) are shown in Table 1. The Engineer will perform the quality index analysis for all concrete represented by lot size and makeup necessary for random sampling.

**Table 1: Quality Index Parameter Specification Limits for PWL Applications**

Quality Index Parameters	Grade of Concrete
	3500/3500HP
<b>28-Day Compressive Strength</b>	
Specification Limit – Lower (LSL) (psi)	3500
Specification Limit – Upper (USL)	N/A
Acceptable Quality Level (AQL)	95 PWL
Rejectable Quality Level (RQL)	50 PWL
Rejection Limit for an Individual Strength Sample Test Result (psi)	2500
<b>Air Content of Fresh Concrete</b>	
Specification Limit – Lower (LSL) (percent)	5.5
Specification Limit – Upper (USL) (percent)	8.5
Acceptable Quality Level (AQL)	90 PWL
Rejectable Quality Level (RQL)	50 PWL
Suspension Limits (percent)	< 5.0 or > 9.0

A. Pay Factor Determination for PWL Applications. The MDOT Concrete PWL Worksheet uses the following formulas to calculate the PF and associated ADJ for each production lot. The maximum calculated numerical values for PF and OLPF will not exceed 105.00.

(1) Pay Factor for 28-day Compressive Strength (PFs). If PWL for 28-day compressive strength (PWLs) is 95 to 100 inclusive, use the following formula to determine PFs:

$$\text{PFs} = 5 + \text{PWLs}$$

If PWLs is from 50 to less than 95, use the following formula to determine PFs:

$$\text{PFs} = 47.22 + (0.5556 \times \text{PWLs})$$

If PWLs is less than 50, the production lot is rejectable and the Engineer will require additional evaluation to decide what further action may be warranted as described in section e of this special provision.

(2) Pay Factor for Air Content of Fresh Concrete (PFac). If PWL for air content of fresh concrete (PWLac) is 70 to 100 inclusive, use the following formula to determine PFac:

$$\text{PFac} = 55 + (0.5 \times \text{PWLac})$$

If PWLac is from 50 to less than 70, use the following formula to determine PFac:

$$\text{PFac} = 37.5 + (0.75 \times \text{PWLac})$$

If PWLac is less than 50, the Engineer will elect to do one of the following:

(a) Require removal and replacement of the entire production lot with new testing conducted on the replacement concrete and repeat the evaluation procedure.

(b) Provided no individual test results for the production lot are outside the suspension limits for air content, allow the production lot to remain in place and apply an Overall Lot Pay Factor (OLPF) of 50.00.

(c) Allow submittal of a corrective action plan for the Engineer's approval. If the Engineer does not approve the plan for corrective action, subsections d.1.A.(2).(a) or d.1.A.(2).(b) of this special provision will be applied, as determined by the Engineer. All costs associated with plan submittal and corrective action under this subsection will be borne by the Contractor. Positive ADJ (quality initiative) will not apply for production lots subject to corrective action.

(3) Overall Lot Pay Factor (OLPF). Use the following formula to calculate the OLPF:

$$\text{OLPF} = (0.60 \times \text{PFs}) + (0.40 \times \text{PFac})$$

B. Price Adjustment for PWL Applications. Both pay factors (PFs and PFac) must be 100.00 or greater for the production lot to be eligible for positive ADJ (quality initiative) consideration. Use the following formula to determine price adjustment for each production lot, using the established Base Price for the pay item included in the contract:

$$\text{ADJ} = (\text{OLPF} - 100)(\text{Price})/100$$

2 Non-PWL Applications. Positive ADJ (quality initiative) does not apply for non-PWL applications. Each individual QA strength sample test result will be used to determine the PF and ADJ for the respective quantity of concrete that it represents, based on the sampling rate.

The specification limits for non-PWL applications are defined in Tables 2 and 3. Unless otherwise specified in the contract, concrete not conforming to the requirements specified in Tables 2 and 3 is rejectable and subject to further evaluation.

**Table 2: Quality Index Parameter Specification Limits for Non-PWL Applications**

Quality Characteristic	Specification Limits
Air Content of Fresh Concrete (percent)	5.5 – 8.5
Rejection Limit (percent)	<5.0 or >9.0
Conc. Temp. (deg. F)	45 - 90 at time of placement
Slump (max.) (inch)	See footnotes a through l in Table 1004-1 of

	the Standard Specifications for Construction
28-day Compressive Strength (psi)	For LSL see Table 3
Rejection Limit - 28-day Compressive Strength	See Table 3

**Table 3: Quality Index Parameter Specification Limits for 28-Day Compressive Strength (psi) for Non-PWL Applications**

Parameter	Grade of Concrete						
	3000	3500	3500HP	4000	4000HP	4500	4500HP
Lower Specification Limit (psi)	3000	3500	3500	4000	4000	4500	4500
Rejection Limit for an Individual Strength Sample Test Result (psi)	2500	3000	3000	3500	3500	4000	4000

A. Pay Factor Determination for Non-PWL Applications.

(1) Pay Factor for 28-Day Compressive Strength (PFs). If the tested strength does not meet the minimum rejection limit in Table 3, the Engineer will require additional evaluation as described in section e. of this special provision. Use the following formula to determine PFs:

$$PFs = (QA \text{ Test Strength})/LSL$$

(2) Pay Factor for Air Content of Fresh Concrete (PFac). The pay factor for air content of fresh concrete (PFac) will be in accordance with Table 4.

**Table 4: Air Content of Fresh Concrete Pay Factor (PFac) for Non-PWL Applications**

Air Content of Fresh Concrete (percent)	Pay Factor (PFac)
5.5 – 8.5	1.00
5.0 – 5.4	0.50
Below 5.0	Rejection
8.6 – 9.0	0.75
Above 9.0	Rejection

If the air content of fresh concrete is below 5.0 or above 9.0 percent, the Engineer will elect to do one of the following:

(a) Require removal and replacement of the entire quantity of concrete represented by the test with new testing conducted on the replacement concrete and repeat the evaluation procedure.

(b) Allow submittal of a corrective action plan for the Engineer's approval. If the Engineer does not approve the plan for corrective action, subsection d.2.A.(2).(a) will be applied. All costs associated with plan submittal and corrective action under this subsection will be borne by the Contractor.

(3) Overall Lot Pay Factor. Use the following formula to determine the OLPF.

The OLPF cannot exceed 1.00:

$$\text{OLPF} = (0.60 \times \text{PFs}) + (0.40 \times \text{PFac})$$

B. Price Adjustment for Non-PWL Applications. Use the following formula to calculate the price adjustment:

$$\text{ADJ} = (\text{OLPF} - 1) \times (\text{Price})$$

3. Small Incidental Quantities. Positive ADJ (quality initiative) does not apply to small incidental quantities. Price adjustment for 28-day compressive strength deficiencies will be based on test results for the corresponding weekly QA test specimens and the pay factor (PFs) calculated in accordance with the formula defined in subsection d.2.A.(1). Price adjustment is calculated using the following formula, using the pay factor for 28-day compressive strength (PFs) and the established base price for the pay item (Price):

$$(\text{ADJ}) = (\text{PFs} - 1) \times (\text{Price})$$

**e. Evaluation of Rejectable Concrete.** The Engineer will require additional evaluation to decide what further action may be warranted. Results for air content testing of fresh concrete are not eligible for re-evaluation.

If the Engineer determines that non-destructive testing (NDT) is appropriate, this work must be done by the Contractor in the presence of the Engineer within 45 calendar days of concrete placement. All costs associated with this work will be borne by the Contractor. Ensure a complete set of non-destructive tests is conducted (in accordance with the respective standard test method) at a minimum of three randomly selected locations. If NDT is used to estimate the in-situ strength, a calibrated relationship between the project job mix formula (JMF) under evaluation and the NDT apparatus must have been established prior to NDT testing in accordance with its respective standard test method.

1. PWL Applications. If the quality index analysis for 28-day compressive strength shows that the RQL has not been met (50 PWL, minimum) for a production lot or the rejection limit for the individual strength sample test result representing the rejected subplot within a production lot has not been achieved (as specified in Table 1), the associated concrete will be rejected.

A. If the results from evaluation of the rejected concrete indicate that the RQL has been met (50 PWL, minimum) for the rejected production lot, or the rejection limit for the individual strength sample test result representing the rejected subplot within a production lot has been achieved, the represented quantity of concrete under evaluation will remain in place and a pay factor for 28-day compressive strength (PFs) of 50.00 will be applied for overall lot pay factor (OLPF) and price adjustment (ADJ) determinations in accordance with subsection d.1 of this special provision.

B. If the results from evaluation of the rejected concrete confirm that the RQL has not been met (50 PWL, minimum) for the rejected production lot, or the rejection limit for the individual strength sample test result represented by the rejected subplot within a production lot has not been achieved, the Engineer will elect to do one of the following:

(1) Require removal and replacement of the entire rejected production lot, or the

individual rejected subplot within a production lot, including new initial tests for quality index analysis conducted in accordance with subsection d.1.A of this special provision.

(2) Allow the Contractor to submit a plan for corrective action, for the Engineer's approval, to address the disposition of the rejected concrete. If the Engineer does not approve the plan for corrective action, subsection e.1.B.(1) will be applied. All costs associated with plan submittal and corrective action under this subsection will be borne by the Contractor.

2. Non-PWL Applications. If the 28-day compressive strength QA test results show that the rejection limit (as specified in Table 3) has not been achieved, the quantity of concrete under evaluation will be rejected and the Engineer will require additional evaluation to decide what further action may be warranted.

Propose an evaluation plan and submit it to the Engineer for approval before proceeding. The results from NDT will be used only to decide what further action is required. This determination will be made by the Engineer, as follows:

A. For non-structural concrete. If no test result from non-destructive testing falls below the lower specification limit (LSL) 28-day compressive strength, the represented quantity of concrete under evaluation will remain in place and a pay factor for 28-day compressive strength (PFs) of 1.00 will be applied for overall lot pay factor (OLPF) and price adjustment (ADJ) determinations will be in accordance with subsection d.2 of this special provision.

B. For structural concrete (including overhead sign foundations). If no test result from non-destructive testing falls below the lower specification limit (LSL), the represented quantity of concrete under evaluation will remain in place and a pay factor for 28-day compressive strength (PFs) of 0.85 will be applied for overall lot pay factor (OLPF) and price adjustment (ADJ) determinations will be in accordance with subsection d.2 of this special provision.

C. If one or more of the non-destructive test results fall below the lower specification limit (LSL) 28-day compressive strength, the Engineer may elect to do one of the following:

(1) Require removal and replacement of the entire rejected quantity of concrete, including new initial tests for quality index analysis conducted in accordance with subsection d.2 of this special provision.

(2) Allow the Contractor to submit a plan for corrective action, for the Engineer's approval, to address the disposition of the rejected concrete. If the Engineer does not approve the plan for corrective action, subsection e.2.C.(1) will be applied. All costs associated with plan submittal and corrective action under this subsection will be borne by the Contractor.

(3) Allow the in-situ quantity of concrete under evaluation to remain in place and a pay factor (PFs) of 0.50 will be applied for overall lot pay factor (OLPF) and price adjustment (ADJ) determinations in accordance with subsection d.2 of this special provision.

**f. Lot Dispute Resolution.**

1. Requirements. Dispute resolution pertains to production lots subject to quality index analysis for PWL applications only. Dispute resolution will not be considered if it is shown that the Contractor QC has not been completed in accordance with the approved QC plan. Failure by the Contractor to maintain the proper curing environment during initial cure will not be the basis for rejection of samples or claims against the Department. If the Contractor does not maintain the proper curing environment for initial cure, the production lot represented by the improperly cured samples are not eligible for dispute resolution. Air content of fresh concrete is not eligible for dispute resolution.

Submit the Contractor's 28-day compressive strength QC test results to the Engineer, accompanied by a signed statement certifying that the QC test results are true and accurate, prior to the Engineer's release of any QA test results for the respective production lot. The 28-day compressive strength QA test results for a production lot of concrete may be eligible for dispute resolution only if criteria below are met. If the Engineer determines, based on the criteria below, that further evaluation is not warranted, the ADJ for the production lot will be based on the Engineer's original 28-day compressive strength QA test results.

A. The request for dispute resolution testing was submitted by the Contractor in writing within 2 working days of receipt of the results of the quality index analysis for the production lot.

B. Complete records and reports for all QC tests and inspections as described in subsection 1002.03.C of the Standard Specifications for Construction, including documentation of what action was taken to correct deficient concrete, along with sufficient information and production lot identification to allow the test results to be correlated with the items of work represented, were submitted to the Engineer within 24 hours after the date covered by the records and reports.

C. QC sampling and testing procedures were conducted in the same manner as the Department's QA sampling and testing procedures.

D. The Contractor's QC and Department's QA 28-day compressive strength test specimen for the production lot in dispute are the same nominal size (either 6-inch by 12-inch or 4-inch by 8-inch).

E. The pay factor for 28-day compressive strength (PFs), as re-calculated by the Engineer using the Contractor's QC test results, is greater than that determined by the Engineer using the QA test results.

F. Each subplot within the respective production lot under dispute is represented by complete QC test results.

G. The QC sampling and testing for the production lot in dispute was conducted by a Michigan Concrete Association (MCA) certified Michigan Concrete Technician Level I or II.

H. A current and complete QC plan, for the appropriate items of work, was submitted and approved by the Engineer prior to start of related work.

I. The QC sampling and testing was performed on the same production lot of concrete as the Department's QA sampling and testing, and all associated QC records include the appropriate production lot identification number that coincides with the Engineer's QA production lot identification number.

J. The corresponding Contractor QC and Department QA 28-day compressive strength test specimens for the production lot in dispute were properly secured during initial curing in the curing facility provided and maintained by the Contractor.

K. The QC test results and documentation for aggregate gradation, slump, air content, temperature, and density (unit weight) of the fresh concrete were complete and within specification requirements.

L. The appropriate corrective action was taken in the event QC action limits were exceeded, as described in the QC plan.

M. QC suspension limits for the associated production lot of concrete were not exceeded.

2. Schedule. If the Engineer determines, based on the above criteria, that lot dispute resolution is warranted, the following schedule and testing process will be initiated.

A. The Engineer will document receipt of the request for dispute resolution and will deliver the dispute resolution samples along with the appropriate sample identification submittal forms to the MDOT Construction Field Services (CFS) Central Laboratory for testing within 3 working day of the receipt of the request.

B. The Department's CFS Central laboratory will test all dispute resolution test specimens within 2 working days of their receipt.

C. The MDOT CFS Central laboratory will return the dispute resolution test results to the Engineer within 10 working days from receipt of the dispute resolution samples.

3. Testing Process.

A. All lot dispute resolution samples will be tested for the production lot under dispute resolution.

B. All dispute resolution test results will replace their respective original QA test results.

C. The PFs for the production lot under dispute will be recalculated using the compressive strength test results from the dispute resolution test specimens.

D. If the recalculated lot PFs is less than or equal to the original corresponding PFs, the costs for dispute resolution sample testing will be borne by the Contractor.

E. If the recalculated lot PFs is greater than the original corresponding PFs, the costs for dispute resolution sample testing will be borne by the Department.

F. The OLPF will then be recalculated using the PFs from the compressive strength

dispute resolution test results and the original corresponding PFac.

**g. Measurement and Payment.** Any positive price adjustment payment made in connection with this special provision will use the following pay item:

<b>Pay Item</b>	<b>Pay Unit</b>
Conc Quality Initiative .....	Dollar

**Conc Quality Initiative** is a budgeted amount established in the contract to cover the potential positive ADJ for the pay items associated with the PWL application only. **Conc Quality Initiative** does not apply to the pay items associated with non-PWL applications.

If a price adjustment is made for reasons included in this special provision, that adjustment will be made using the base price established for the specific item. If a contract unit price requires adjustment for other reasons not described in this special provision, the adjustments will be made using the original unit price and the adjustments will be cumulative.

Separate payment will not be made for providing, implementing, and maintaining an effective QC program. All costs associated with this work will be included in the applicable unit prices for the concrete items. Failure by the Contractor to maintain the proper curing environment during initial cure will not be basis for claim against the Department.

All costs associated with providing, locating, relocating, maintaining, and securing the adequate number of portable initial curing facilities for both the QC and QA strength test specimens will be included in the applicable unit prices for the concrete items. No additional payment will be permitted. The Contractor is responsible for damage, theft, subsequent replacement, and removal after completion of the work for each curing facility used on the project.