

MP 711.03.26  
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WEST VIRGINIA DEPARTMENT OF TRANSPORTATION  
DIVISION OF HIGHWAYS  
MATERIALS CONTROL, SOILS AND TESTING DIVISION  
MATERIALS PROCEDURE

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MAINTAINING SPECIFIED LEVEL OF STRENGTH  
IN PORTLAND CEMENT CONCRETE

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- 1.0 PURPOSE
- 1.1 The purpose of this procedure is to set forth a method of adjusting the cement content of portland cement concrete so that a reasonable conformance with the specified level of strength may be assured.
- 2.0 SCOPE
- 2.1 The procedure shall apply to all classes of concrete except pavement concrete (pavement concrete may also be treated in the manner specified herein providing the Contractor has a suitable means of verifying the minimum 28-day design strength, and providing a copy of the plan for verifying the strength is submitted to and is approved by the Engineer).
- 3.0 PROCEDURE
- 3.1 Initial Cement Requirement
- 3.1.1 "Initial Cement Requirement" is the cement requirements determined by formal laboratory design methods such as MP 711.03.23 or other suitable and approved methods.
- 3.2 Reevaluating Cement Requirement
- 3.2.1 A concrete mix design referred to herein means a combination of particular source and type of materials and a cement factor which satisfies the requirement of the governing specification, said combination of materials and cement factor being formulated for the express purpose satisfying the requirement of a particular class of concrete specified for the work. The

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cement factor in a particular mix design may be changed without invalidating the design. If source or type of materials in a mix design are changed, however, the mix design is changed and two or more mix designs would result there from. Strength data which represents two cement factors in one mix design may be processed collectively in the derivation of statistical parameters, average and standard deviation, for example, if it is felt that such a treatment does not significantly affect the statistics.

3.2.2 For the various classes of concrete which are designed in conformance with MP 711.03.23, the first re-evaluation of cement requirement shall be made after at least ten pieces of strength data are available to evaluate the adequacy of the mix design. Thereafter, a re-evaluation of cement requirement shall be made at monthly intervals at which time, the evaluation shall be based on the strength data developed during the preceding two months or on the last ten pieces of data developed, whichever is greater.

3.3 Method of Evaluating Cement Requirement

3.3.1 The cement requirement for all classes of concrete governed by this procedure shall be the quantity necessary to maintain the strength of the concrete in the range of the Design Strength ( $f'_c$ ) plus  $K_1$  standard deviations and the Design Strength ( $f'_c$ ) plus  $K_2$  standard deviations ( $f'_c + K_1\sigma < \bar{X} < f'_c + K_2\sigma$ ). The average ( $\bar{X}$ ) and the standard deviation ( $\sigma$ ) shall be calculated using the strength data developed during the previous two months or the last ten pieces of strength data, whichever is greater.

3.3.2 If the strength of concrete can be maintained at a level which is equal to or greater than the Design Strength plus  $K_2$  standard deviations ( $f'_c + K_2\sigma < \bar{X}$ ), then the cement factor which causes this level of strength to be developed may be reduced as indicated in Article 3.3.4.3 except that in no instance shall the cement factor be reduced below a level of the target specified cement factor less 28kg of cement per cubic meter.

3.3.3 - If the strength of the concrete is maintained below the level of the Design Strength plus  $K_1$  standard deviations,  $\bar{X} < (f'_c + K_1\sigma)$ , then the cement factor which causes this level of strength to be developed shall be increased as indicated in Article 3.3.4.2.

3.3.4 The relationship between the level of concrete strength (considered to be the average of all data developed during the preceding two months or the average of the last ten pieces of strength data, whichever is greater, and represented by  $\bar{X}$ ), and the action which must be taken regarding the cement factor is as follows:

3.3.4.1 If the average strength is maintained at a level between the Design Strength plus  $K_1$  standard deviations and the Design Strength plus  $K_2$  standard deviations  $\{(f'_c + K_1\sigma) < \bar{X} < (f'_c + K_2\sigma)\}$  the cement factor shall be continued without change.

3.3.4.2 If the average strength falls below the Design Strength, plus  $K_1$  standard deviations  $\{\bar{X} < (f'_c + K_1\sigma)\}$  the cement factor shall be increased in accordance with the following formula:

$$C_i = \frac{(f'_c + K_1\sigma) - \bar{X}}{1.4}$$

Where  $C_i$  = Number of 14kg increments of cement increase per cubic meter, rounded up to a whole number.

$f'_c$  = Design Strength

$K_1$  = Factor from Table 1.

$\sigma$  = Standard Deviation

$\bar{X}$  = Average Strength

3.3.4.3 If the average strength falls above the Design Strength plus  $K_2$  standard deviations  $\{\bar{X} > (f'_c + K_2\sigma)\}$  the cement factor may be decreased in accordance with the following formula:

$$C_d = \frac{\bar{X} - (f'_c + K_1\sigma)}{1.4}$$

Where  $C_d$  = Number of 14kg increments of cement decreases per cubic meter, rounded to the nearest whole number.

3.4 Reporting

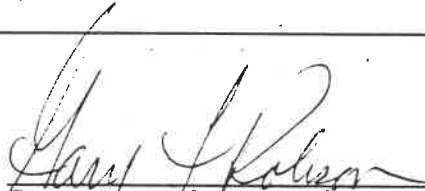
3.4.1 Once each month, the Materials Control, Soils and Testing Division will publish a list of concrete producers (Commercial Suppliers and/or Contractors) with classes of concrete and their corresponding cement factor determined in conformance with this MP.

3.5 Reevaluating Concrete Mix Design

3.5.1 A concrete mix design which is approved for a particular project will remain valid to the extent that it satisfies the requirement for that particular project for its duration.

3.5.2 A concrete mix design which is developed in conformance with MP 711.03.23 and maintained for a period of one year, during which time fewer than ten pieces of strength data are developed to evaluate the adequacy of the mix design, shall become invalid after which time, it will not be approved for use on State projects. It is the Contractor's responsibility to make adjustments to the design mix as necessary to maintain in the concrete proper placability, workability, finishability, yield, air content, and other requirements of the governing specification. The Contractor should be especially aware of the responsibility when he changes the cement factor in conformance with this procedure.

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ATTACHMENT

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ATTACHMENT 1

TABLE 1  
VALUES OF "K" FACTORS

NUMBER OF PIECES OF DATA	$K_1$	$K_2$
10	1.604	3.615
11	1.588	3.510
12	1.576	3.429
13	1.565	3.365
14	1.557	3.313
15	1.549	3.270
16	1.543	3.233
17	1.538	3.202
18	1.533	3.175
19	1.528	3.151
20	1.525	3.130
21	1.521	3.112
22	1.518	3.096
23	1.515	3.081
24	1.513	3.067
25	1.511	3.055
26	1.508	3.044
27	1.507	3.034
28	1.505	3.024
29	1.503	3.016
30	1.501	3.008
Above 30	1.500	3.000

