Kentucky Method 64-314-03
Revised 2/6/03
Supersedes KM 64-314-02
Dated 12/13/01

EVALUATION OF CONCRETE CYLINDER RESULTS

1. SCOPE:

1.1. This method is a procedure for evaluating concrete cylinder strengths and for conducting investigations of in-place concrete. It covers job control procedures, which shall be implemented as soon as sufficient cylinder data becomes available, indicating either low or borderline strength. It also contains an adjustment table for various classes of portland cement concrete determined by cores to have low compressive strength.

1.2. Definition of a Concrete Cylinder Test:

1.2.1. Cylinders for all classes of concrete are taken in sets of two for 6 inch diameter by 12 inch height cylinders (6x12's) and in sets of three for 4 inch diameter by 8 inch height cylinders (4x8's) from a composite sample of concrete. Cylinders are tested and the average is treated as a single test except as provided in 1.2.2.

1.2.2. When a low cylinder result from a set is less than 75 percent of the other, the lower result will be considered invalid and the test value for the set will be the result of the cylinder(s) which tested higher.

2. ACCEPTANCE PROCEDURES:

2.1. When at any time the number of low strength tests for any class of concrete falls between 10 and 20 percent, the prime contractor shall be notified by the Project Engineer that the in-place concrete represented by the low tests is questionable, and that his source should be advised to immediately take action to improve strength.

2.2. When at any time the number of low strength tests for any class exceeds 20 percent of the tests performed after the first 10 tests, all production of that class shall be stopped immediately until the prime contractor provides an acceptable proposal for improving strength. A low test is defined as the average strength of two cylinders obtained from the same sample of concrete which is less than the expected strength as specified.

2.3. When at any time cylinder strengths approach the criteria as hereinafter provided as a basis of requiring investigation of the adequacy of in-place concrete (Section 3) the Project Engineer should review the overall plant and batching operations to determine if batching errors or inconsistent plant operations are in evidence, review materials quality, review sampling techniques and procedures in molding, curing and testing specimens in efforts to detect and eliminate possible causes for low strength results.

Control charts such as the attached example are highly recommended as a means of providing graphic comparison of concrete cylinder strengths to established limits, for indicating trends and in providing information regarding the effects of seasonal changes, changes in materials, changes in concrete operations, etc.

2.4. When at any time cylinder strengths become such that the in-place concrete requires investigation as outlined in Section 3, the Project Engineer should initiate the necessary investigation as outlined in Section 4 as soon as possible to avoid possible delays in final acceptance of the work.

3. CRITERIA FOR REQUIRING IN-PLACE INVESTIGATION OF CONCRETE REPRESENTED BY LOW TESTS:

3.1. Extent of low tests that will require investigation of in-place concrete they represent.

3.1.1. Concrete Classes M1 and M2: As outlined in Subsection 601.03.03 A, Note 11

3.1.2. Concrete Classes AA, AAA, D, D Modified, S, or any other class of concrete with a specified f'_c of greater than 3500 psi: When either an individual test result falls more than 500 psi below f'_c or when the average of any 3 consecutive tests does not equal or exceed 100% of f'_c. (Where only two tests are available and their average does not equal or exceed 95% of f'_c).

3.1.3. Concrete Classes A, A Modified, P, or any other class of concrete with a specified f'_c of 3500 psi: When either an individual test falls below 3000 psi or when the average of any six consecutive tests does not equal or exceed 3500 psi. When less than six tests are available, critical test averages will be as tabulated below.

5 tests - 3465 psi
4 tests - 3395 psi
3 tests - 3290 psi
2 tests - 3150 psi

3.1.4. Concrete Class B: When either an individual test result falls below 2000 psi or when the average of any 6 tests taken in chronological order does not equal or exceed 2500 psi. When less than six tests are available, critical test average will be as tabulated below.

5 tests - 2475 psi
4 tests - 2425 psi
3 tests - 2350 psi
2 tests - 2250 psi

3.2. Low Cylinder results which do not require in-place investigation of the concrete as outlined in Section 3.1 will be considered within reasonable conformity with specifications.

4. PROCEDURE FOR INVESTIGATING IN-PLACE STRENGTH:

4.1. Concrete requiring in-place investigation shall, when possible, be investigated by taking and testing of cores from the concrete represented by each low test. In the case of unusually large pours involving numerous low tests, fewer cores may be obtained as deemed necessary while maintaining sufficient coring frequency to adequately represent the pour. Cores shall be obtained and tested in accordance with AASHTO T 24. Two cores shall be taken to represent each low cylinder test.

4.2. For those cases not allowing the taking of cores due to location or clearance problems, an investigation may consist of rebound hammer comparisons of the suspect concrete with concrete known to be represented by adequate specimens. The rebound hammer readings are used only for verification of the cylinder breaks. If the rebound hammer readings verify the low cylinder strengths, the Department may accept as outlined in Section 4.4.

4.3. When using the rebound hammer, please observe the following rules:

4.3.1. Concrete to be compared should have approximately the same age and moisture condition and the surface finish should be the same. Also, the direction of impact must be the same.

4.3.2. Heavy textured, soft, or surfaces with loose mortar or masonry coatings shall be ground smooth with the abrasive stone prior to taking the readings.

4.3.3. Distribute a copy of the results to the Central Lab project files and to the District Materials Engineer.

4.4. Latex or Low Slump concrete overlays will not require coring. Upon satisfactory completion of an in-place investigation for an overlay, indicating failing but adequate strength, the Department may accept the overlay in accordance with Section 105.04 of the Kentucky Standard Specifications for Road and Bridge Construction by making a change order to document the basis of acceptance based on the following adjustments.

Average Cylinder strength - % of f'_c	% of overlay unit bid price to be paid
98 - 100	100
90 - 97	95
85 - 89	90
80 - 84	85
75 - 79	75
Below 75	Remove and Replace

5.0. CORE STRENGTH EVALUATION:

5.1. Classes M1 and M2: The Department may accept the concrete in accordance with the Schedule for Adjusted Payment for Class M Strength Deficiency as stated in Section 601.05.

5.2. All other classes:

5.2.1. The concrete strength investigated by cores per paragraph 4.1 shall be considered structurally adequate when the average of the two cores meet or exceed 90% of the specified f'_c for that class of concrete and may be accepted per paragraph 5.2.3

5.2.2. When the core strength does not meet 90% of f'_c, a design analysis shall be made to determine whether the actual concrete strength is adequate for the actual design stresses plus an adequate safety factor. If the concrete strength is not adequate, it shall be removed or sufficiently reinforced as may be required by the Department's engineers to meet that requirement.

5.2.3. When the core strength fails to meet contract requirements but is determined to have an adequate strength per paragraphs 5.2.1 or 5.2.2, the

Department may accept the concrete in accordance with Section 105.04 of the Kentucky Standard Specifications for Road and Bridge Construction by making a change order to document the basis of acceptance based upon the following adjustments.

Average Core strength - % of f'_c	% of delivered cost of the concrete to be deducted *
98 – 100	0
90 – 97	25
85 – 89	50
80 – 84	75
75 – 79	100

* Deduction to be applied against Contract unit bid price.

5.2.4. At the contractor's option, areas deficient in strength may be removed and replaced at no cost to the Department when the strength has been determined to be adequate but not meeting the specifications.

APPROVED _____

Director
Division of Materials

DATE _____2/6/03_____

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Attachments

Km31403.doc

SAMPLE CONTROL CHART FOR AA CONCRETE

KM 64-314-03

CYL NO.	Mpa	PSI
1	31.44	4560
2	31.16	4520
3	31.02	4500
4	30.89	4480
5	30.06	4360
6	30.13	4370
7	30.34	4400
8	30.61	4440
9	29.79	4320
10	29.58	4290
11	27.99	4060
12	26.75	3880
13	26.48	3840
14	27.30	3960
15	27.99	4060
16	29.51	4280
17	31.86	4620
18	32.13	4660
19	32.96	4780
20	30.48	4420
21	29.51	4280
22	26.55	3850
23	27.44	3980
24	28.41	4120
25	25.17	3650
26	27.44	3980
27	29.51	4280
28	31.77	4600
29	32.27	4680
30	32.27	4680
31	33.65	4880
32	34.20	4960
33	31.86	4620
34	30.34	4400
35	28.41	4120

COMPRESSIVE STRENGTH IN (MPa) (PSI)

3447
(5000)

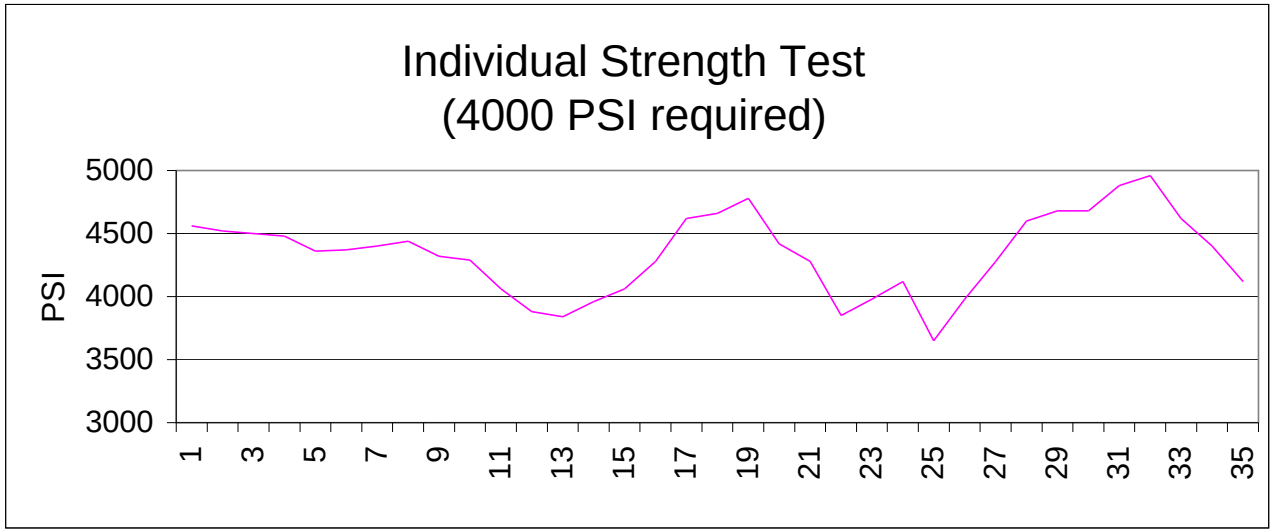
2758
(4000)

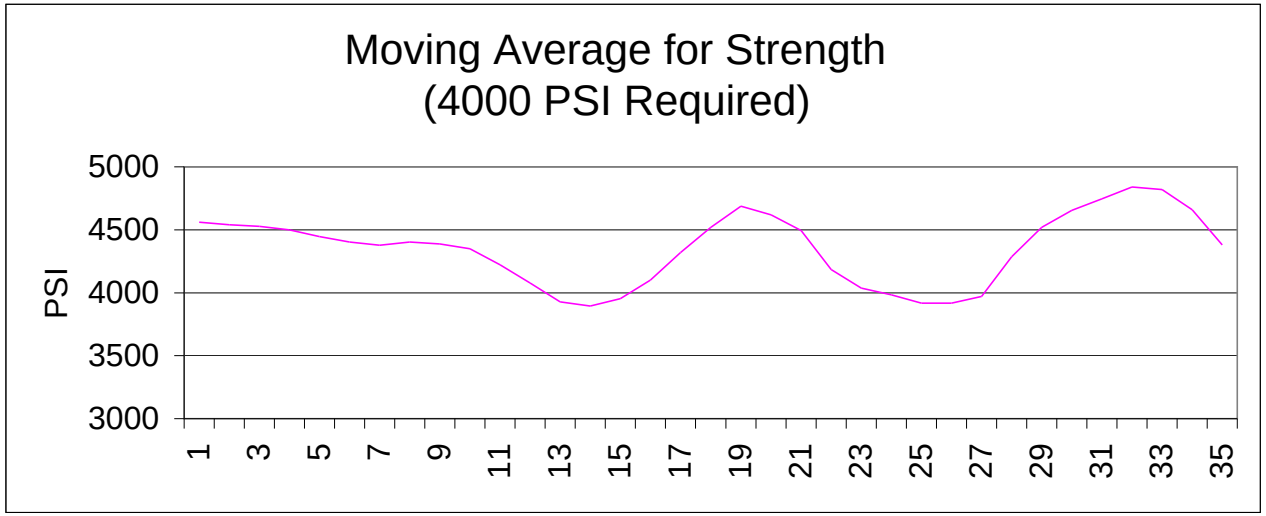
2068
(3000)

3447
(5000)

2758
(4000)

Cylinder No.	PSI
1	4560
2	4520
3	4500
4	4480
5	4360
6	4370
7	4400
8	4440
9	4320
10	4290
11	4060
12	3880
13	3840
14	3960
15	4060
16	4280
17	4620
18	4660
19	4780
20	4420
21	4280
22	3850
23	3980
24	4120
25	3650
26	3980
27	4280
28	4600
29	4680
30	4680
31	4880
32	4960
33	4620
34	4400
35	4120





Cylinder No.	PSI		Cylinder No	PSI
1	4560	4560	1	4560
2	4520	4540	2	4540
3	4500	4527	3	4527
4	4480	4500	4	4500
5	4360	4447	5	4447
6	4370	4403	6	4403
7	4400	4377	7	4377
8	4440	4403	8	4403
9	4320	4387	9	4387
10	4290	4350	10	4350
11	4060	4223	11	4223
12	3880	4077	12	4077
13	3840	3927	13	3927
14	3960	3893	14	3893
15	4060	3953	15	3953
16	4280	4100	16	4100
17	4620	4320	17	4320
18	4660	4520	18	4520
19	4780	4687	19	4687
20	4420	4620	20	4620
21	4280	4493	21	4493
22	3850	4183	22	4183
23	3980	4037	23	4037
24	4120	3983	24	3983
25	3650	3917	25	3917
26	3980	3917	26	3917
27	4280	3970	27	3970
28	4600	4287	28	4287
29	4680	4520	29	4520
30	4680	4653	30	4653
31	4880	4747	31	4747
32	4960	4840	32	4840
33	4620	4820	33	4820
34	4400	4660	34	4660
35	4120	4380	35	4380