2004 CONCRETE MIX DESIGN GUIDANCE DOCUMENT

Prepared by the Construction Division of the Texas Department of Transportation for use in conjunction with the 2004 Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges.

Introduction 3
Determining Over-design Value 3
Gather Existing Strength Test Data 3
Determine Over-design Value 6
Mix Design Using ACI 211 7
Trial Batch 8
A. Roles and Responsibilities 8
B. Material Testing Requirements 8
C. Slump Loss Test 8
D. Time Limits for Concrete Delivery 9
E. Central-Mix Concrete Plant Mixing Time 9
F. Volumetric Mixer Uniformity Testing 9
G. Establishing Maximum Water-Cementitious-Material Ratio 10
H. Establishing 7-Day Compressive Strength Target Values 10
Mix Design Review and Approval 12
Testing During Production 13
A. Testing Equipment 13
B. Contractor Testing During Production 13
Contractor Job-Control Testing for Item 360 Concrete Pavement 13
Contractor Schedule Restriction Testing for Item 420 Concrete Structures 14
C. TxDOT Testing During Production 14
TxDOT Job-Control Testing for Item 360 Concrete Pavement 14
TxDOT Split-Sample Verification Testing for Item 360 Concrete Pavement 15
TxDOT Adequacy and Acceptance Testing for Concrete (except pavement) 15
Important Documents and Programs 15

Introduction

This guidance document has been prepared by the Construction Division of the Texas Department of Transportation for use in conjunction with the 2004 Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges.

This document should be used as a reference only and should not supercede specifications, special provisions, plan documents or engineering decisions made by the Engineer.

Determining Over-design Value

Item 360 Concrete Pavement specifies design strengths that include an over-design value of approximately 10%. There is no need to use the following method for determining over-design values for Class P concrete.

For other classes of concrete, in order to ensure that the minimum 28-day design compressive strength values are being met consistently during concrete production, it is necessary for the concrete producer to establish an over-design value based on the production variability of a specific concrete production operation and materials used. The method chosen to accomplish this is a simplified version of ACI 318 and is identical to Table 4 of ASTM C 94, except the over-design values are rounded to the nearest 10 psi. Using this over-design value for mix design and trial batch purposes increases the probability of producing concrete that meets the minimum 28-day design strength to levels approaching 99%. After historical data has been collected, a standard deviation can be calculated and an appropriate over-design value can be selected. This process is described in detail below.

Gather Existing Strength Test Data

Historical 28-day compressive strength data should be used to determine the production variation. The source of data may be from any laboratory accredited by TxDOT, AASHTO, CCRL or from any ACI Field Level II Certified Technician.

It is allowable to use the strengths from multiple designs of a given class of concrete to determine production variation, but this practice will likely result in a higher calculated standard deviation. However, increasing the number of tests may still be beneficial to decreasing the required over-design value as listed in Table 6 of Item 421.

The over-design value determined may be applied to other concrete classes within 1,000 psi. of the specified strength used for the initial determination. Thus, if we are trying to determine the over-design for a Class “C” concrete, with a minimum 28-day compressive strength of 3600 psi, the over-design determined for the Class “C” can also be applied to any class with a 28-day design strength ranging from 2600 psi to 4600 psi. For any mix outside of this range, a separate data set would be used for the over-design determination.

Example Plant Production Data:

Example Ready-Mix Concrete Plant: Data from All Sources

Production Date	Time	Design Name	Design strength requirement	28-day Comp. Str. (psi)
Jan. 1, 2004	6:30 am	C-1	3600	3880
Jan. 1, 2004	9:00 am	C-1	3600	3750
Jan. 1, 2004	4:00 pm	S	4000	4200
Jan. 3, 2004	7:00 am	C-2	3600	3900
Jan. 3, 2004	12:00 pm	C-1	3600	3650
Jan. 4, 2004	9:00 pm	DC	5500	6000
Jan. 5, 2004	7:00 am	C-1	3600	3890
Jan. 5, 2004	3:00 pm	C-1	3600	4000
Jan. 6, 2004	8:00 am	A-State	3000	3100
Jan. 8, 2004	8:00 am	S	4000	4500
Jan. 10, 2004	8:00 am	C-2	3600	3900
Jan. 10, 2004	11:00 am	C-1	3600	3870
Jan. 11, 2004	5:00 pm	C-1	3600	3850
Jan. 12, 2004	7:00 am	C-1	3600	3770
Jan. 15, 2004	7:30 am	C-1	3600	3800
Jan. 16, 2004	9:00 am	C-2	3600	4100
Jan. 17, 2004	10:00 am	C-2	3600	4150
Jan. 20, 2004	6:00 am	C-2	3600	4280
Jan. 20, 2004	4:00 pm	C-1	3600	3900
Jan. 21, 2004	1:00 am	C-2	3600	4290
Jan. 22, 2004	6:00 am	S	4000	4490
Jan. 23, 2004	9:00 am	S	4000	4600
Jan. 26, 2004	2:30 pm	S	4000	4220
Jan. 27, 2004	5:00 am	S	4000	4550
Jan. 28, 2004	9:00 am	C-1	3600	3900
Feb. 2, 2004	11:30 am	C-1	3600	3800
Feb. 3, 2004	4:00 pm	C-1	3600	3770
Feb. 4, 2004	2:00 pm	C-1	3600	3720
Feb. 7, 2004	6:00 am	C-2	3600	4000
Feb. 8, 2004	7:00 am	C-1	3600	3800
Feb. 10, 2004	5:00 am	C-1	3600	3810
Feb. 10, 2004	12:00 pm	S	4000	4390
Feb. 10, 2004	8:00 pm	S	4000	4360
Feb. 11, 2004	2:00 am	S	4000	4400
Feb. 12, 2004	8:00 am	C-1	3600	3900
Feb. 13, 2004	3:30 pm	C-1	3600	3780

Calculate Standard Deviation

Once the appropriate data has been collected, calculate the standard deviation using the following formula:

$$s = \sqrt{\frac{\sum\left(X_i - \overline{X}\right)^2}{(n-1)}}$$

where:

- s = standard deviation, psi
- Xi = individual strength tests, psi
- $\overline{X}$ = average of n strength test results
- n = number of samples used for calculation
- Σ indicates summation

Example Standard Deviation Calculations:

For simplicity and consistency, the use of the Excel program, "Concrete Mix Design and Control Workbook", available from the Construction Division – Materials and Pavements Section, will be used in this example. It is recommended that this program be used by both TxDOT and the Contractor for reporting purposes. The results are shown below:

Example Ready-Mix Class S: Nine (9) test results are too few to calculate a standard deviation, at least fifteen (15) results are needed.

Example Ready-Mix Class A: One (1) test result is too few to calculate a standard deviation, at least fifteen (15) results are needed.

Example Ready-Mix Class DC: One (1) test result is too few to calculate a standard deviation, at least fifteen (15) results are needed.

Example Ready-Mix Class C: Standard Deviation = 162 psi, based on 25 test results

Refer to Figure 1 for a view of the screen from "Concrete Mix Design and Control Workbook" where this value was obtained.

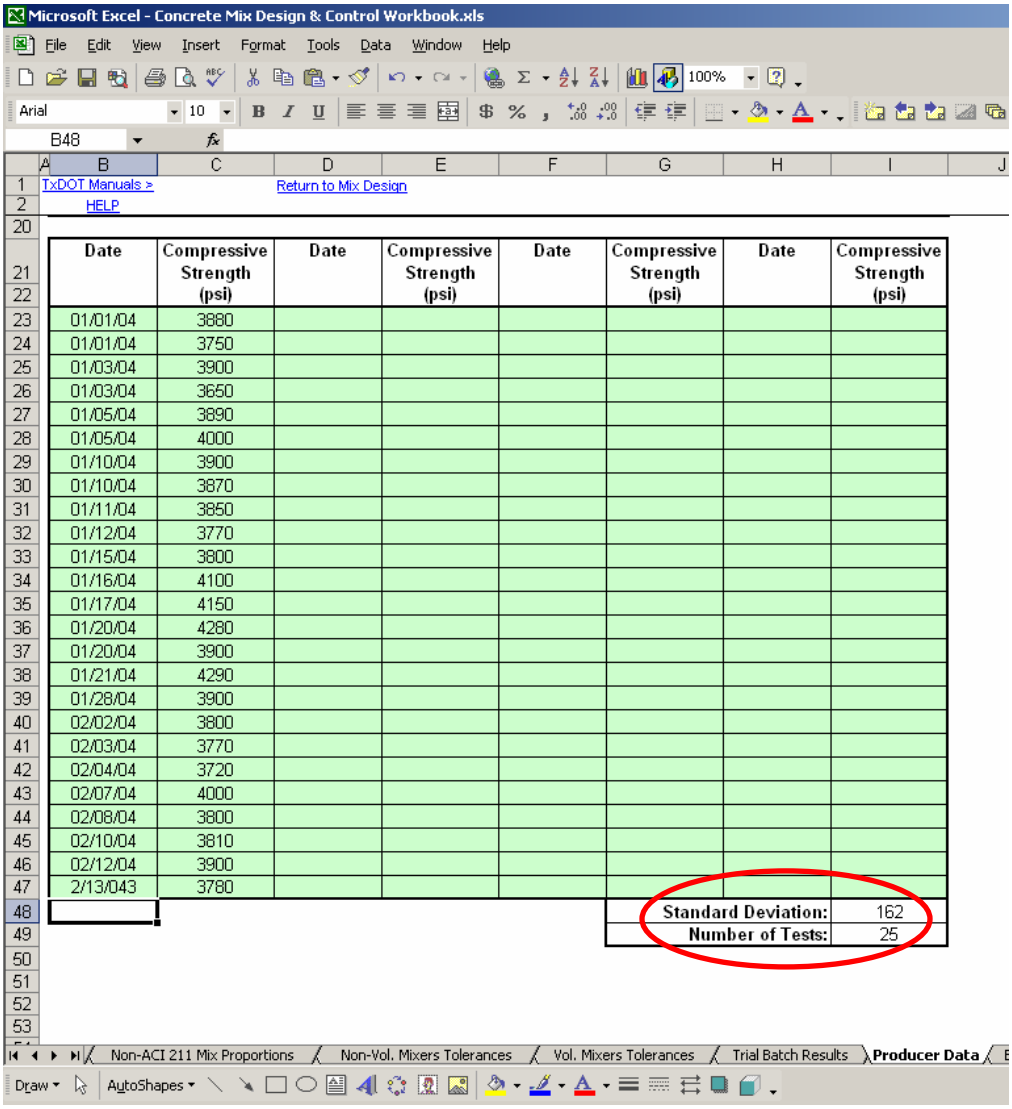


Figure 1: Mix Design and Control Workbook, Producer Data

Determine Over-design Value

Once the standard deviation has been calculated, refer to Table 6 in Item 421 to select the appropriate over-design value. The values for standard deviation shown in Table 6 with bold print are inclusive of the range of standard deviations greater than the value to the left. For example, the circled value shown below includes ranges of standard deviations from 301 to 400 psi. Thus, if the calculated standard deviation from historical data was 340 psi, selection of the over-design amount would be from the column under the "400" heading.

Table 6: Over Design to Meet Compressive Strength Requirements

No. of Tests	Standard Deviation, psi				
	300	**400**	**500**	**600**	**700**

From the previously calculated standard deviation for Example Ready-Mix, the over-design values for the following classes of concrete would be as follows:

Class S: of data points = 9; standard deviation = not applicable;
Since the 28-d design strength for Class "S" is within 1,000 psi of the Class "C" design strength (4000 psi – 3600 psi = 400 psi), use the same over-design value determined for the Class "C"
Over-design = 430 psi

Class A: # of data points = 1; standard deviation = not applicable;
Since the 28-d design strength for Class "A" is within 1,000 psi of the Class "C" design strength (3600 psi – 3000 psi = 600 psi), use the same over-design value determined for the Class "C"
Over-design = 430 psi

Class DC: # of data points = 1; standard deviation = not applicable;
Since the 28-d design strength for Class "DC" is not within 1,000 psi of the Class "C" design strength (5500 psi – 3600 psi = 1900 psi), Item 421 Table 6 footnote 3 requires the use of an over-design value of 1400 psi.

Class C: # of data points = 25; standard deviation = 162;
From Table 6 → over-design = 430 psi

Refer to Figure 2 for a view of the screen from "Concrete Mix Design and Control Workbook" where this value was obtained.

SELECTING TARGET STRENGTH

Minimum 28-day compressive strength based on class of concrete		f'_c min. =	3600	psi
Specified minimum 28-day compressive strength		f'_c min. =		psi
Maximum of preceding 2 rows		f'_c* =	3600	psi
Producer's standard deviation (index of producer's precision), S		S =		psi
Producer's standard deviation from inputted data, S	Producer Data	S =	162	psi
Number of tests of a concrete mixture used to estimate S				
Number of tests from inputted data			25	
Over design amount, A		A =	430	psi
Mix design target strength, $f'_{cr} = f'_c$* + A		f'_{cr} =	4030	psi

Figure 2: Mix Design and Control Workbook, Mix Design, Selecting Target Strength

It is advantageous to both the concrete producer and TxDOT to use as many data points as possible, so that the over-design amount is accurately estimated. Concretes with strengths higher than necessary are not only more expensive but may also be more prone to cracking and other unwanted behavior.

Mix Design Using ACI 211

There are many excellent programs that aid in the design of concrete mixtures following ACI 211.1 Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete. The Materials and Pavements Section of the Construction Division has created an Excel program to perform a design based on ACI 211, as well as calculate a producer's standard deviation and required over-design, record

trial batch information, and calculate 7-day target strengths. Please contact the Rigid Pavements and Concrete Materials Branch at 512.506.5850 to obtain a copy of the "Concrete Mix Design and Control Workbook".

Concrete intended for use in a mass placement has additional design challenges to ensure the mass placement will not exceed central core temperatures of 160°F or differential temperatures of 35°F. In addition to the reference provided in Item 420 to assist in developing an approved plan to achieve the temperature requirements, research funded by TxDOT has developed a software program to perform predictions of heat characteristics based on mass placement geometry, concrete mix ingredients, curing conditions and predicted ambient conditions. Contact the Rigid Pavements and Concrete Materials Branch at (512) 506-5858 to learn more about Concrete Works©.

Trial Batch

A. Roles and Responsibilities

For projects using the 2004 TxDOT Specifications, the Contractor is responsible for:

- Providing the concrete design (with over-design)
- performing all preliminary trial batching and testing to substantiate the proposed mix design;
- performing all testing of the final trial batch with ACI-certified testing personnel;
- providing the Engineer the option of witnessing the final trial batch and all testing of the trial batch;
- establishing the 7-day target value for all concrete; and
- establishing the strength-maturity relationship, if the Contractor has elected to use maturity for schedule restriction testing or early-opening.

B. Material Testing Requirements

The trial batch must be at least 50% of the mixer's rated capacity. The Contractor will perform the following tests with certified personnel:

- air content (Tex-414-A or Tex-416-A)
- slump (Tex-415-A)
- 3 sets of strength specimens; only compressive strength testing (Tex-418-A) will be used unless otherwise specified or shown on the plans. If flexural strength testing has been specified or shown on the plans, perform flexural strength testing (Tex-448-A).
- if desired, strength-maturity testing (Tex-426-A)

C. Slump Loss Test

For the 2004 Specification Book for Item 416 Drilled Shaft Foundations, if the casing is to be pulled or when concrete is to be placed underwater or under slurry, the Contractor must perform a slump loss test in accordance with Tex-430-A to ensure the concrete will maintain a slump of at least 4 inches throughout the entire anticipated time of concrete placement. It is not required to perform the slump loss test during trial batching, although

it might be efficient to do so if the temperature of the concrete at the time of placement will not exceed the concrete temperature at the start of the slump loss test by more 10°F.

D. Time Limits for Concrete Delivery

The 2004 Item 420 Concrete Structures requires the mix design to be revised as necessary for hot weather or other conditions that contribute to quick setting of the concrete.

Item 420 also allows the transporting time limits to be exceeded if the Contractor submits a plan for the Engineer's approval that demonstrates the time limitations can be extended without any detrimental effects OR the use of additional water.

The 2004 Item 360 Concrete Pavement allows the transporting time limits to be exceeded if the Contractor can demonstrate the concrete can be properly placed, consolidated, and finished without the use of additional water.

Although not required, it might be beneficial for the Contractor to perform testing with retarding-type concrete chemical admixtures during trial batching to substantiate the potential for increased transportation and placement time.

Tests such as Tex-440-A, Initial Time of Set of Fresh Concrete and Tex-430-A, Slump Loss of Hydraulic Cement Concrete could be used to demonstrate the feasibility of extending the time limits, provided the concrete temperature does not vary greatly from the demonstration to actual delivery conditions.

E. Central-Mix Concrete Plant Mixing Time

Although it is not required to be performed during a trial batch, testing to reduce the minimum required mixing time could be performed during a trial batch. If the Contractor wants to reduce the minimum mixing time required by the specification, Tex-472-A must be performed by the Contractor to substantiate uniformity of mixing.

F. Volumetric Mixer Uniformity Testing

Although it is not required to be performed during a trial batch, testing to verify mixer performance according to Tex-472-A could be performed during a trial batch. Although Item 421 requires that volumetric mixers comply with ASTM C 685 (which requires the producer to perform calibration and mixer efficiency tests every 6 months), the Construction Division strongly urges that verification of the uniformity of the concrete be performed during trial batching and during the course of work.

G. Establishing Maximum Water-Cementitious-Material Ratio

Once a mixture design has been submitted and substantiated by trial batching, the water-cementitious-material ratio of the design becomes the maximum allowable at any time during production, even if it is lower than the maximum water-cementitious-material ratio specified in Table 5 of Item 421. This is discussed on page 532 of Item 421, where the specification states, "When this [leave-out] water is added, do not exceed the mix design water-cementitious-material ratio."

H. Establishing 7-Day Compressive Strength Target Values

7-day target strengths provide the Contractor with expeditious test results of concrete strength while allowing pozzolans, which effect early-age strength, to be incorporated into concrete mixes without adversely affecting the progress of work.

Item 360 Concrete Pavement lists 7-day job-control strength values. There is no need to use the following procedure to establish a 7-day strength value unless a lower 7-day job-control strength is desired for mixes that have been proven to meet the 28-day minimum design strength, including the over-design already contained in Item 360. If this the is case, Tex-427-A details the procedure for correlating 28-day strengths to 7-day strengths.

For concrete other than Class P, establish 7-day target values for structural and non-structural concrete, as defined in Table 5 of Item 421.

7-day target values should be established as part of the trial batching; if trial batches are waived by the Engineer, establish the 7-day target value from the first day's production.

Make and cure 3 sets of cylinders according to Tex-447-A. At 7-days test one set and at 28-days test a second set of cylinders according to Tex-418-A[1]. The formula as shown in Item 421 to calculate the 7-day target strength is as follows:

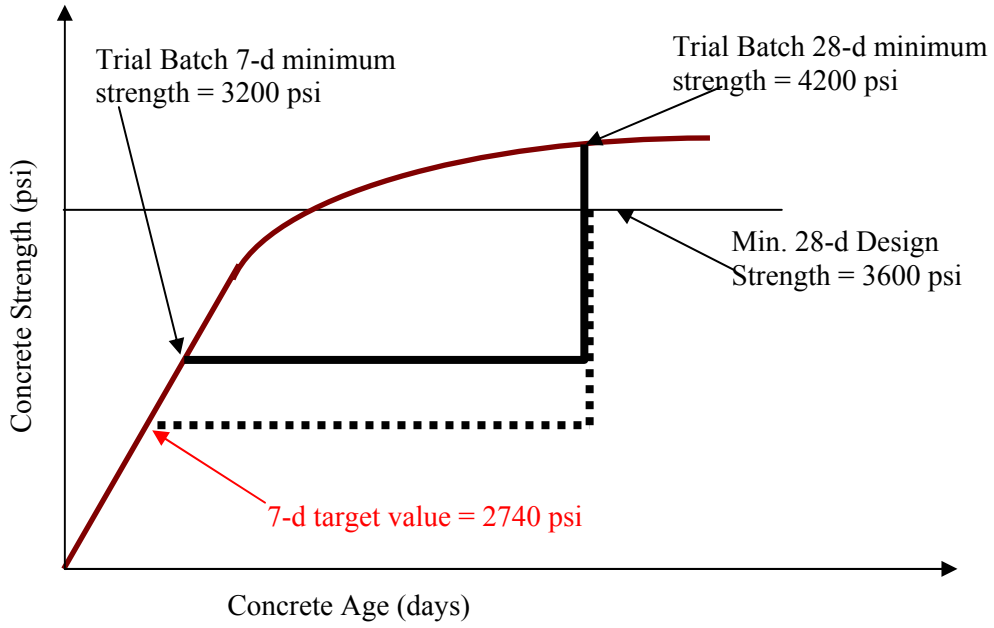
$$\text{Target value} = \text{Minimum design strength} \times \frac{\text{7-day average trial batch strength}}{\text{28-day average trial batch strength}}$$

[1] The third set of cylinders may be broken at any age that is of interest to the Contractor, such as ages that would correspond to the Contractor's "Schedule Restriction Testing" as described in Item 420. A fourth set of cylinders will need to be submitted to the Materials and Pavements Section when the concrete contains silica fume.

For example, if a Class C mix produced by "Example Ready Mix", with a minimum design strength of 3600 psi, had an average 7-day trial batch strength of 3200 psi and 28-day average trial batch strength of 4200 psi[2], the 7-day target value would be calculated as follows:

$$\text{7-day target value} = 3600 \times \frac{3200}{4200}$$
$$= 2743, \text{ when rounded to the nearest 10 psi}$$
$$= 2740 \text{ psi}$$

A graphical representation of this calculation can be shown as follows:



These test results can be recorded and calculated as shown in Figure 3 by using the "Concrete Mix Design and Control Workbook" available from the Rigid Pavements and Concrete Materials Branch of the Construction Division.

[2] Note that this Class C concrete has a 28-day trial batch strength that exceeds the minimum 28-day design strength PLUS the overdesign value for this class of concrete produced by this concrete producer. If this were not the case, there would be no point in calculating the 7-day target value, as the trial batch would not be approved.

COMPRESSIVE STRENGTH

Min. 28-Day Design Strength: 4030 psi

Test Method Tex-418-A

Cylinder Number	Age	Diameter of Cylinder (inches)	Length of Cylinder (inches)	Length to Diameter Ratio	Max Load (Lbs.)	Fracture Type	Correction Factor	Compressive Strength (psi)	Compressive Strength (avg) (psi)
1	7-Day	4.0	8.0	2.00	39,250	Cone	1	3120	3200
2		4.0	8.0	2.00	41,250	Shear	1	3280	
3	28-Day	4.0	8.0	2.00	54,500	Shear	1	4340	4200
4		4.0	8.0	2.00	51,000	Cone & Shear	1	4060	
								Target Value:	
								Target Value:	
								7-Day Target Value:	2740

Mix Design | Matl Properties | Mix Proportions | Non-ACI 211 Mix Proportions | Non-Vol. Mixers Tolerances | Vol. Mixers Tolerances | **Trial Batch Results**

Figure 3: Mix Design and Control Workbook, Trial Batch Results, Compressive Strength

Mix Design Review and Approval

The Contractor furnishes mix designs using ACI 211 or other approved procedures for the classes of concrete required. TxDOT reviews the submitted mix designs. The following items are to be reviewed:

- Are all materials (aggregates, water, cement, fly ash, admixtures, etc.) used approved by TxDOT, either through CST-M&P approved lists or by project-specific testing and approval?
- Is the correct coarse aggregate grade used (including a recent sieve analysis)?
- Does the coarse aggregate meet quality requirements for tests not on the AQMP, such as Tex-413-A, Tex-406-A, and Tex-401-A?
- Does the fine aggregate quality requirements for tests not on the AQMP, such as Tex-413-A, Tex-408-A, Tex-401-A, Tex-402-A, Tex-203-F, and Tex-612-J (only for concrete subject to direct traffic)?
- Does the design remain below the maximum water-to-cement ratio specified in Table 5?
- Has the maximum (unless otherwise specified or approved) limit of 700 lb. of cementitious material per cubic yard been adhered to?
- Have the correct targets for air entrainment and slump been used?
- Has the correct mix design option been applied, depending on concrete class, cement content and sulfate resistance requirements?
- Has the correct over-design value been applied to the target strengths?
- If trial batching was performed, was TxDOT notified and allowed to witness?
- Have minimum strengths (including over-design) been achieved?
- Has a 7-day target value been established, if necessary?
- If silica fume was used, was 1 set of cylinders sent to CST-M&P to ensure adequate mixing?
- If the Contractor will be using the maturity method (Tex-426-A), was a proper strength-maturity relationship developed?
- Does all equipment for the production and/or transport of concrete have current certifications or inspections?

- Do all volumetric mixers have current uniformity test data meeting the requirements of Tex-472-A?
- If the concrete is for Item 416, where "casing is to be pulled or when concrete is to be placed underwater or under slurry," will a slump loss test (Tex-430-A) be performed prior to beginning work?
- If the concrete is for Item 420 Mass Placements, has a plan been submitted and approved for temperature control?

Testing During Production

A. Testing Equipment

Unless otherwise shown on the plans or specified, the Contractor will furnish and maintain:

- test molds
- curing facilities (complete with temperature control to maintain the required curing temperature of 60°F to 80°F, as well as a recording thermometer or a min/max thermometer)
- maturity meters, if used
- wheelbarrow or other acceptable container, and
- strength testing equipment to test for the appropriate strength test

This equipment, as required by test method or specification, is the Contractor's responsibility to calibrate and maintain.

B. Contractor Testing During Production

Refer to the governing specification item for required actions. In general, TxDOT will perform all acceptance testing; the Contractor may be required to perform job-control testing for Item 360 and may elect to perform schedule restriction testing as described in Item 420. Contractor personnel performing testing must be either ACI-certified or qualified by a TxDOT-recognized equivalent testing program. All personnel performing maturity testing must be qualified by a training program recognized by TxDOT.

<u>Contractor Job-Control Testing for Item 360 Concrete Pavement</u>

Unless otherwise shown on the plans, the Contractor will perform all fresh and hardened concrete testing at the following frequencies:

- Check the first few concrete loads for slump, air and temperature on start-up production days
- Strength: Prepare one set (2 specimens) of strength specimens on the first day of production and for each 3,000 sq. yd. or fraction thereof of concrete pavement thereafter. Prepare at least one set of strength specimens for each day of paving. Unless otherwise shown on the plans or permitted by the Engineer, job-control strength testing will be with 7-day strength specimens.
- Perform slump, air and temperature tests each time strength specimens are made. Temperature tests should also be performed more often to

ensure that the concrete is consistently within temperature requirements.

- Maturity testing may only be used to estimate concrete pavement strength for early opening to traffic. Maturity testing for early opening may be disallowed by a plan note.

Contractor Schedule Restriction Testing for Item 420 Concrete Structures

Unless otherwise shown on the plans, the Contractor may choose to perform testing on structural classes of concrete (identified in Table 5 of Item 421 by footnote 5) to address the schedule restrictions defined in Item 420. The schedule restriction testing (SRT) will be based on cylinders cured under the same condition as the structure.

When approved by the Engineer, maturity testing (Tex-426-A) may be used to estimate the in-situ strength, but verification cylinders are still required for removal of structurally critical formwork or falsework, or for steel stressing or other safety-related operations.

SRT frequency is at least 1 set of strength specimens for each element cast each day. It would be prudent to make more than 1 set of specimens, in the event that the first set does not achieve the expected strength when tested. Refer to Item 420 for the minimum strengths required for the various work activities.

The Contractor must provide the Engineer the opportunity to witness all SRT operations and must report all test results to the Engineer.

If the Contractor chooses not to perform SRT, the Engineer's 7-day strength specimens will be used for schedule restriction determinations. The Engineer may require SRT when concrete is placed in cold weather or may require additional time after the Engineer's 7-day strength tests to account for field curing conditions. If the concrete was placed in cold weather, the Engineer's 7-day lab-cured specimen may overestimate the actual strength of the in-place concrete.

C. TxDOT Testing During Production

Refer to the Guide Schedule for Minimum Testing. Refer to the plans to verify who will perform job-control testing for Item 360. Refer to Item 6 for any material quality issues not covered in Items 360, 420, 421, etc.

TxDOT Job-Control Testing for Item 360 Concrete Pavement

If the Contractor is performing job-control testing, TxDOT will verify the Contractor's results as described below for split-sample verification testing.

If Contractor job-control testing has been waived by the plans, TxDOT will use the same frequency as listed above in "Contractor Job-Control Testing for Item 360 Concrete Pavement".

TxDOT Split-Sample Verification Testing for Item 360 Concrete Pavement
When the Contractor is performing job-control testing, TxDOT will test for strength, slump, air and temperature at a rate of 1 for every 10 Contractor tests. This 1-per-10 test will be a split sample with the Contractor. Table 1 in Item 360 lists the allowable differences between the Contractor's and TxDOT's split sample testing. Results outside these limits require investigation and corrective action.

TxDOT Adequacy and Acceptance Testing for Concrete (except pavement)
TxDOT will perform all acceptance testing at the frequencies shown in the Guide Schedule and listed as follows:

- Structural Concrete
  - For every 60 cu. yd. of concrete (or fraction thereof) per class per day, TxDOT will make, at a minimum, 2 sets of 2 strength specimens. One set will be tested at 7-days, and if the average does not meet or exceed the 7-day target value, the remaining set will be tested at 28-days to determine acceptance of that 60 cu. yd. or fraction thereof. If the 7-day test meets the 7-day target strength, the 28-day specimens will be tested at a rate of at least every 180 cu. yd.
  - Slump, air and temperature will be tested whenever strength specimens are made (every 60. cu. yd. of concrete or fraction thereof per class per day).
- Non-Structural Concrete
  - For every 180 cu. yd. of concrete per class, TxDOT will make one set of 2 strength specimens to be tested at 7-days and compared to the established 7-day target strength to determine acceptance.
  - For all non-structural concrete except Class B or unless otherwise shown on the plans, perform one air test whenever strength specimens are made.

Important Documents and Programs

The following are necessary supporting documents for the production, placement, testing and acceptance of concrete for use on TxDOT projects.

- A hard copy of the 2004 Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges can be purchased from TxDOT's Publication Sales Office
  - http://www.dot.state.tx.us/GSD/pubs/despubs.htm
  - Telephone: (512) 465-3016
- An electronic version of the 2004 Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges can be downloaded at no charge from:
  - http://www.dot.state.tx.us/business/specifications.htm, and selecting "2004 English Specifications Book"
- TxDOT's Manual of Testing Procedures is located on the internet at:
  - http://www.dot.state.tx.us/business/materials.htm, and selecting "Manual of Testing Procedures." This manual may be updated as

often as every three months, and it is imperative that the most current test methods are being used.

- TxDOT personnel should refer to the "Guide Schedule for Sampling and Testing" for a written version of the established minimum sampling and testing frequencies. It may be found at:
  - http://www.dot.state.tx.us/business/materials.htm, and selecting "Guide Schedule for Sampling and Testing"
- The computer programs discussed in this guidance document may be obtained by contacting the Rigid Pavements and Concrete Materials Branch of the Construction Division at (512) 506-5850.