CHAPTER 9
JOB CONTROL SAMPLING AND TESTING

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9 JOB CONTROL SAMPLING AND TESTING

Introduction

In addition to all materials being tested and approved for use, the resulting concrete mixture must be tested to verify that the basic ingredients, when combined, produce concrete having the specified properties and characteristics.

All concrete mixes are tested in the plastic state to determine yield, cementitious material content, density[1], consistency, and uniformity. In addition, certain mixes (such as air-entrained concrete mixes) require tests to verify that the desired special properties are being obtained.

The normal frequency of acceptance sampling and testing is addressed in Chapter 6 of the Construction Manual. Note that the frequencies shown in the tabulation are minimums for average conditions. In actual practice concrete should be tested as often as necessary to verify compliance with specification requirements.

Sampling and testing of the plastic concrete must be performed in accordance with the applicable California Test or ASTM Test methods. Tests normally performed in the field are briefly discussed in the following sections. Complete descriptions and instructions may be found at the following web locations:

California Test Methods: http://www.dot.ca.gov/hq/esc/ctms/

ASTMs: http://onramp.dot.ca.gov/hq/oscnet/
Click on "Field Resources", then select "ASTMs, etc." from the dropdown menu.
Contact the Structure Materials Representative for additional assistance.

The importance of sampling and testing in strict accordance with the applicable procedure cannot be overemphasized. To ensure reliable test results, samples must be taken carefully, and they must be truly representative of the material to be tested. Likewise, all test methods and procedures must be followed explicitly.

[1]Density and Unit Weight are being used interchangeably throughout this chapter.

Sampling Procedure

California Test 539 describes the procedure for obtaining samples of fresh concrete. The following points are emphasized:

- The minimum sample size for compressive strength tests is about 8 gallons. Where appropriate, a smaller volume may be used for other tests.
- Samples for tests to verify compliance with a compressive strength specification should be taken at, or as close as practicable to, the mixer discharge. Samples for tests to determine actual in-place strength at a particular time (such as strength to control prestressing) should be taken at the point of placement in the work.
- When sampling from truck mixers, the sample should be made from portions taken at three or more intervals through the discharge of the entire batch, taking care to avoid the start and end of the discharge. Concrete thus obtained should be remixed with a shovel or trowel before casting test cylinders or performing field concrete tests.
- If water is needed to be added to a truck mixer to adjust slump at the job site, the sample should be taken after the water has been added and the concrete thoroughly remixed. In no case, however, should any water be added beyond the required mix design amount.
- When sampling from forms, the test sample should consist of unvibrated concrete from the same batch taken at several different locations within the forms. Individual portions of the sample should extend deep enough into the mix to assure a representative distribution of the ingredients.
- Field control tests should be made as soon as practicable after the sample is taken.

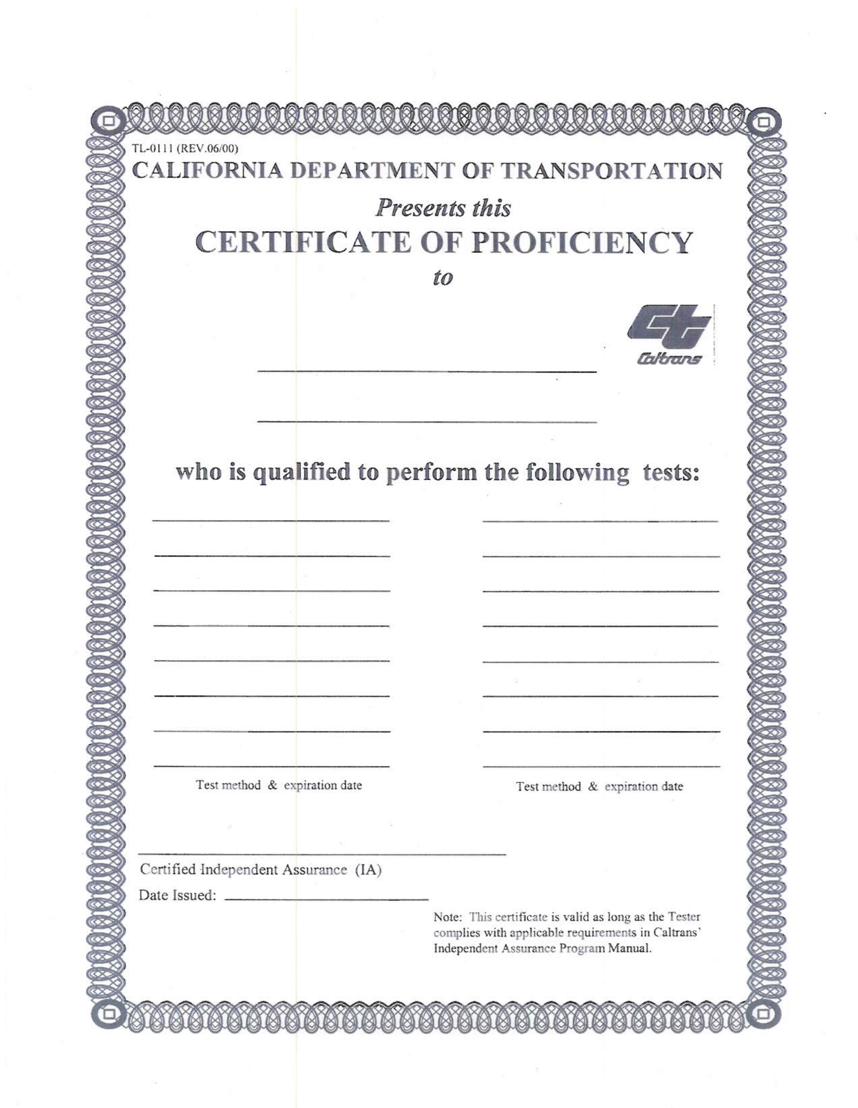
Field Control Tests

Field control tests routinely performed by Caltrans personnel include the unit-weight test, the ball penetration test and the test to determine air content. On rare occasions, a test to determine coarse aggregate proportions may be warranted.

Under current Caltrans policy, all project personnel who perform tests on material being used in the work must possess a valid Form TL-0111, "Tester Certificate of Proficiency" listing the tests the individual is authorized to perform. This form and its applicable requirements may be found in Independent Assurance Manual, Procedures for Accreditation of Laboratories and Qualification of Testers at:

http://www.dot.ca.gov/hq/esc/Translab/ofpm/IA_reports/IAP.htm
Click on IA Program Manual.
Form TL-0111 is reproduced below in Figure 9-1.

Concrete field control tests are briefly discussed in the following sections. The tests are identified by their California Test numbers. A complete description of each test may be found at http://www.dot.ca.gov/hq/esc/ctms/. Table 9-1 provides a list of California Test Methods (CTMs) with comparable ASTM standards. It is recommended that personnel preparing for certification testing use the CTM rather than the comparable ASTM to ensure familiarity with the CTM.



TL-0111 (REV.06/00)

CALIFORNIA DEPARTMENT OF TRANSPORTATION

Presents this

CERTIFICATE OF PROFICIENCY

to

Caltrans

____

____

who is qualified to perform the following tests:

____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________
Test method & expiration date	Test method & expiration date

____

Certified Independent Assurance (IA)

Date Issued: ____________________

Note: This certificate is valid as long as the Tester complies with applicable requirements in Caltrans' Independent Assurance Program Manual.

Figure 9-1. Form TL-0111.

Table 9-1. Applicable California Test Methods and their ASTM Comparable.

California Test Methods	Comparable Test	Description
CTM 504	ASTM C231	Air Content (Pressure Method)
CTM 518	ASTM C138	Test for density, yield and air content (gravimetric)
CTM 529	-------	Proportions of coarse aggregate in fresh concrete
CTM 533	-------	Ball Penetration
CTM 539	ASTM C172	Sampling Fresh Concrete
CTM 540	ASTM C31	Making and Curing Test Cylinders in the field
CTM 543	ASTM C173	Air Content (Volumetric Method)
CTM 556	ASTM C143	Slump of Hydraulic Cement Concrete

Ball Penetration Test (California Test 533)

This test method describes the procedure for determining the consistency of fresh concrete by measuring the depth of penetration of a metal mass into plastic concrete under the force of gravity.

The ball penetration apparatus consists of a 6-inch cylinder with a hemispherical shaped bottom which is machined to a smooth finish. The penetrator is attached to a shaft graduated to measure penetration to the nearest 1/4 inch. The mass of the apparatus (ball, shaft, and handle), exclusive of the yoke, is 30 ± 0.1 pounds.

Lightweight Concrete

A modified ball is used for determining the consistency of fresh lightweight concrete. The modified ball is identical in shape and size to the 30 lb ball, but the mass of the lightweight apparatus (ball, shaft, and handle), exclusive of the yoke, is 20 ± 0.1 pounds.

Calibration

Zero reading is established by placing the ball and the feet of the yoke on a plane surface. The shaft is then adjusted by turning the threaded shaft in the ball penetrator to obtain a zero reading at the top of the sleeve. The locknut at the top of the penetrator is then tightened.

Test Procedure

- The ball penetration test may be made on concrete in a wheelbarrow, buggy, or other container, or after it has been deposited in the forms or on the subgrade. The depth of the concrete above the bottom of the container or reinforcement shall be at least 6 inches for 1-inch maximum size aggregate or smaller, and 8 inches for larger maximum size aggregate.

- The surface of the concrete to be tested is struck off level over an area of about 3 square feet. Do not tamp, vibrate or consolidate the concrete. Screed the minimum amount required to obtain a reasonably level surface. Overworking may flush excess mortar to the surface and cause erroneously high penetration readings.

- Hold the device by the handle; lower it slowly over the prepared area until the feet of the yoke touch the surface of the concrete. Make certain the shaft is in a vertical position and free to slide through the yoke. Gradually lower the ball penetrator into the concrete, maintaining enough restraint on the handle so that penetration is due to the dead load of the ball only and not to any force generated by acceleration of the mass. When the ball comes to rest, release the handle and read the penetration to the nearest 1/4 inch. Penetration of the feet of more than 1/8 inch may indicate that the concrete has been overworked in screeding the surface, or that the yoke is binding on the shaft.

- Take a minimum of three individual readings for each penetration determination. Individual readings shall be at least 9 inches between centers. The minimum horizontal distance from the centerline of the handle to the nearest edge of the level surface on which the test is made shall be 6 inches. The reported penetration shall be the average of the first three successive readings, which agree within 1/2 inch of penetration.

Report the average of the three readings as penetration in "___ inches of penetration." To ensure such accurate results, keep in mind that accuracy is impaired if the surface of the ball is roughened by scratches, dents, or adhering mortar. It should be cleaned carefully after each test and always kept in the carrying case when not in use to prevent damage.

Density Of Fresh Concrete (California Test 518)

Section 90 of Standard Specifications requires the cementitious material content of a concrete mixture to be determined in accordance with California Test 518. This test, previously referred to as Unit Weight test, could be used to determine the true cementitious material content of a given batch of concrete when the actual batch weights are known. Based on the test results, batches may need to be adjusted in order to be in compliance with cementitious material content requirements.

In this test method a sample of concrete with known volume is taken and weighed. The density is then calculated in lb/yd^3 as the ratio of the weight to volume of the sample. From the calculated density and the known total batch weight provided in the batch ticket, in pounds, the volume of the batch is determined from the following formula:

$$S \text{ (volume in yd}^3\text{)} = \text{total batch weight/density}$$

The total weight of cementitious material is also provided by the batch ticket. Therefore, cementitious material content (CC), expressed in lb/yd^3, could then be calculated as follows:

$$CC = \frac{\text{(total weight of cementitious materials, lbs)}}{S}$$

When performing the density test, field personnel should keep in mind that the test does not check batching accuracy. The test procedure assumes that scale weights shown on the batch ticket are correct.

Though the Standards do not allow pay deduction for insufficient cementitious material content based solely on California Test 518, they do require the Contractor to make adjustments on subsequent loads based on the test results. This test can also be an indicator of adequacy of proportioning operations as changes in proportioning can lead to changes in density. An example might be where the water content of a stockpile is underestimated resulting in both more sand and water than called for by design. This will lower the unit weight as water and sand are the lightest ingredients even with the right cementitious content.

The OSC work sheet (Form DS-OS C68), facilitates the unit weight and cementitious material content calculations. Bridge Construction Memo 100-2.0, Control of Cement Content[2] in Concrete, provides filled-in examples of this worksheet along with a more detailed explanation of the procedure involved in making the required calculations.

[2] 2010 Standard Specifications use "cementitious" materials.

Air Content by Pressure Method (California Test 504)

This test describes the method used to determine the air content of fluid concrete by the pressure method using a commercial air meter. The meter, shown in Figure 9-2, operates on the principle of equalizing a known volume of air at a known pressure in a sealed air chamber with the unknown volume of air in the concrete sample, the dial on the pressure gauge being calibrated in terms of percent air for the observed pressure at which equalization takes place.

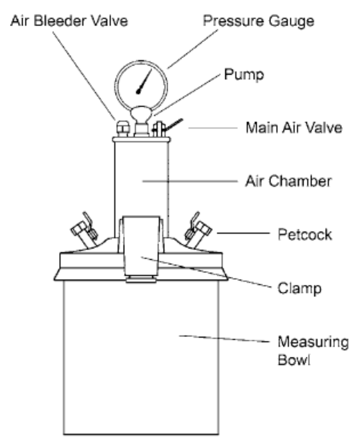


Figure 9-2. Apparatus for Air Content Test by Pressure Method.
(Ref. ASTM C231/C231M – 09b)

An air meter consists of a base unit and a cover containing a pressure chamber. In making the test, the base unit, which is essentially a metal container, is filled with fresh concrete. The concrete is placed into the container and rodded following the same procedure as used when casting concrete test cylinders.

After rodding, the concrete is struck off to the level of the top of the container with a flat bar or other suitable tool, and the top of the container is wiped clean to ensure a tight seal when the cover is clamped into place.

The cover is clamped in place with the petcocks open. Depending on the air meter type, either a funnel or syringe is used to add water in the space between the top of the concrete and the bottom of the cover unit. Water is added through one petcock until all air is expelled through the opposite petcock. Air is then pumped into the pressure chamber until the gauge reaches the initial pressure line. The gauge is allowed to stabilize, the petcocks are closed and the air is released into the base section, thus compressing the concrete in the base.

Since the initial pressure and volume are known, the drop in gauge pressure is directly related to the compressibility of the concrete, which in turn is a function of the amount of air in the concrete mixture. The more air there is in the fresh concrete, the more compression of the mass; hence the greater will be the corresponding drop in gauge pressure. The gauge is calibrated so that the drop in gauge pressure is shown as an increase in air content, which permits direct reading of the percent of air in the mix.

Air meters are precision instruments and should be treated as such. They should be handled with care, and in particular, they should be cleaned thoroughly after each use.

Air Content by Volumetric Method (California Test 543)

Use of a pressure-type air meter to determine the air content of a concrete mixture as described in the preceding section is not applicable to lightweight concrete. This is the case because the porosity of the lightweight aggregate permits water to penetrate the particles when pressure is applied to the concrete mass, thus causing an incorrect (too high) reading on the air gauge.

The volumetric-type air meter used in California Test 543 does not depend on air pressure; consequently, it is not sensitive to aggregate porosity and can be used with lightweight concrete.

The volumetric-type air meter consists of a base unit and a top unit. The base unit is filled with concrete, following the same procedure as described for the pressure method. The top unit, which is essentially a hollow chamber, is clamped in place and the chamber filled with water. The air meter is then inverted and agitated. After the water and concrete are thoroughly mixed, the meter is placed in a tilted position and rolled and/or rocked to further agitate the mixture. This action removes air from the concrete, and the air thus released rises to a calibrated gauge in the neck at the top of the chamber. After all air appears to have escaped from the concrete, agitation is stopped and the meter is placed in an upright position and allowed to stand for several minutes. This allows any remaining air to rise to the surface of the water in the top chamber. The volume of air displaced from the concrete is read directly on the gauge at the top of the upper section of the air meter.

While volumetric type air meters can be used with any concrete, California Test 543 takes much longer and is dependent on the skill of the technician to a much greater extent than California Test 504. Accordingly, the volumetric method is used only with lightweight concrete.

Proportion of Coarse Aggregate (California Test 529)

This test is used to check the effectiveness of concrete mixing equipment by measuring the uniformity of distribution of coarse aggregate in freshly-mixed concrete. The test, which is sometimes referred to as the "uniformity" test or the "washout" test, may be warranted to verify mixer compliance with contract requirements if visual inspection reveals a non-uniform mix or if it is suspected that a mixer is not functioning properly.

Depending on minor variation in procedure, the test method describes three procedures which may be used. In essence, however, each procedure compares the weight of coarse aggregate in two samples taken from separate portions of a batch of concrete or a truck mixer load. The samples are wet-sieved until all material finer than the No. 4 sieve has been removed. The free water is then drained, the retained aggregate weighed, and the proportion of aggregate in the sample (lb/yd^3) is calculated. As a standard of uniformity, Section 90 of Standard Specifications limits the variation in the amount of coarse aggregate to 170 lb/yd^3, as determined from the weight of aggregate in the two samples. It should be noted that this test is not commonly performed.

Tests for Compressive Strength (California Test 521)

Compressive strength requirements are covered in Standard Specifications Section 90. The compressive strength of concrete will be determined from test cylinders that have been fabricated from concrete sampled in conformance with the requirements of California Test 539. The results of this test method are used for determination of compliance with specifications and as a basis for quality control of concrete proportioning, mixing, and placing operations; control for evaluating effectiveness of admixtures; and similar uses.

A nominal Design compressive strength will be specified for all structure concrete, and occasionally for other highly stressed structural elements as well. Historically, minimum design compressive strength was measured at 28 days. With the addition of Supplementary Cementitious Materials (SCMs) and the resulting slow down in concrete strength gain, the design compressive strength may be measured over 42 days or longer. This period will be determined in the mix design review process. Additionally, the specifications prohibit the start of certain construction operations, such as removing falsework and placing backfill material against retaining walls and bridge abutments, until a minimum compressive strength (usually less than the minimum design strength) is obtained.

Since construction operations often depend on the time needed for concrete to reach a specified strength, sufficient information must be available to predict the rate of strength gain. It is good practice early in the project to cast extra test cylinders and have them broken at 7, 10, 14 and 28-day intervals. Using the strength-time curve thus developed, fairly accurate predictions of strength gain are possible.

Number of Test Cylinders

Each compressive strength test requires 2 cylinders taken from the same batch or load of concrete, and the test result is the average strength of the 2 cylinders.

Frequency of Sampling

Sampling frequency will be per Section 6 of the Construction Manual, or as required for acceptance for a specific contract. Where knowledge of early strength is required and at other times where engineering judgment indicates a need, test cylinders may be cast at more frequent intervals.

For concrete designated by compressive strength, the specifications provide that no single compressive strength test shall represent more than 300 cubic yards.

Making and Handling Test Specimens (California Test 540)

This test covers the procedure for casting, handling and curing concrete compressive test specimens. The test method procedures are self-explanatory, and generally are well-understood by field personnel. However, since large quantities of concrete are accepted on the basis of compressive strength test results, it is imperative that the test cylinders are cast, handled and stored in exact accordance with the test method. Therefore, the test method should be reviewed periodically to ensure that all required procedures are being followed.

Department policy requires a penetration test and a unit weight test (to determine the cementitious material content) for each batch or truckload of concrete from which cylinders for strength tests are fabricated. When air-entrained concrete is being used, an air content test is required as well.

Proper care needs to be taken when casting the cylinders. Pictures included in Figure 9-3 are examples of cylinders that were poorly cast, making them unusable for strength testing.

(a) Cylinder Cast with Rock Pockets.

(b) Cylinder Not Filled Properly.

(c) Cylinder Poorly Cast.

(d) Foreign Objects Left in the Cylinder.

(e) Cylinder Top Not level.

Figure 9-3. Examples of Improperly Cast Concrete Cylinders.

After fabrication, the test cylinders should be taken to their field-curing location as soon as practical. Precautions are necessary when moving the cylinders from the site to the curing location to prevent vibration which might result in segregation within the cylinder mold. The curing location should be on a firm level surface, free from vibration and protected from any disturbance during the field-curing period.

Under the current specifications, all test cylinders for concrete designated by compressive strength, other than steam-cured concrete, and all test cylinders taken to verify strength prior to applying loads or stresses, are to be cured by Method 1 as described in California Test 540. If a precast concrete member is steam cured, the compressive strength of the concrete will be determined from test cylinders that have been handled and stored in conformance with Method 3 of California Test 540.

California Test Method 540 also includes a second method for curing concrete cylinders. Method 2 was developed to evaluate in-place concrete strength prior to applying loads and is particularly suited to situations where concrete temperature could be well below 65°F. In 1988 it was decided to eliminate cylinder curing by Method 2 in furtherance of simplification efforts to the Standard Specifications. The basis for this decision was the assumption that most in-place concrete strengths would not be overestimated from cylinders cured by the room temperature water-bath method (Method 1) since most concrete initially cures with an internal temperature of more than 70°F.

For most climates in the State this assumption holds true; rarely would one experience conditions where the initial internal concrete temperatures fall below 65°F. For certain climatic conditions where Method 1 curing may not be appropriate for determining the load carrying capacity, and certain applications, such as cast-in-place segmental construction, the engineer may choose to cure the cylinders in accordance with Method 2. As a rule of thumb, if the ambient temperature falls below 50°F, the potential exists for the concrete temperature to remain low enough to affect the rate of strength gain. Field engineers should always make sure that sound engineering is practiced and that the contract stipulations are respected. At times, contract-testing requirements may need to be modified to comply with sound engineering.

Identification of Test Cylinders

Test cylinders are marked in accordance with a uniform system of identification. Under this system, each cylinder is marked with the contract number, a sample identification number, and the date cast. The sample identification number is a series of digits separated by dashes to indicate the method of field curing, the age at which the cylinder is to be tested, the cylinder number of the pair which is to be tested, and optional job coding. (Use of a flow pen to mark each cylinder is recommended.)

Note the following cylinder identification example:

Contract	03-100844
Sample No.	1 - 28 - 2/2 - - -
Date Cast	08/01/09

In the example, the first digit of the sample number indicates that Method 1 curing procedure was used. The second group of two digits (28) indicates that the cylinder is to be tested at 28 days. The third entry (2/2) indicates that it is the No. 2 cylinder of a two-cylinder test group. The remaining spaces may be used for any desired job coding consisting of number, letters, or a combination of both.

Shipping Test Cylinders

Each pair of cylinders is shipped to the lab for testing in a cardboard carton specifically designed for this purpose, as seen in Figure 9-4. These cartons may be obtained from District supplies.

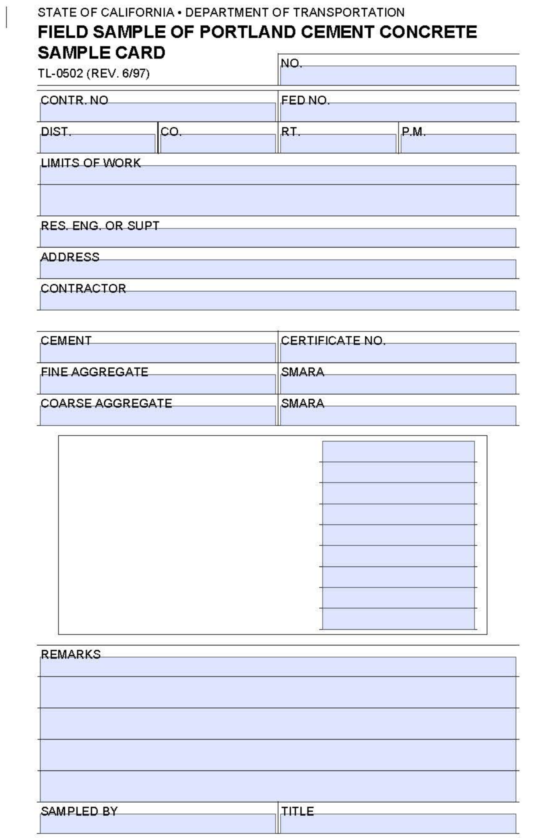
Figure 9-4. Shipping Test Cylinders.

When submitted for testing, all test cylinders are accompanied by a sample identification card, which is Standard Form TL-502. For easy reference, Form TL-502 is reproduced in Figure 9-5. Only one identification card is needed for each pair of cylinders shipped in the same carton.

This form is generally self-explanatory; however, care must be taken to ensure that all entries are completed and that the information entered is correct.

When completing the card, note the following:

- Under source of aggregates indicate the deposit from which they were obtained, such as “Kaiser-Radum”, or “Chevreau-Bear River”, and not the batch plant.
- Enter the sample identification number, noting that the card covers two test cylinders. (For the example in the previous section, the sample number entry would read: 1-28-1/2 & 2/2 to indicate that the information on the card covers both test cylinders.)
- In the space designated, show the total weight of water used per weight of cementitious material in the mix based on actual weights -- not design weights.
- Show the mix design number or other entry to identify the type of concrete on the first line of the “Remarks” section.
- Use the “Remarks” section to give any special instructions to the lab, such as a request for test results by telephone. (If this service is desired, show the phone number and the name of the person to receive the results.)
- Under “Remarks” show if the unit weight of the hardened concrete cylinder(s) is required. The laboratory will not furnish unit weight data unless it is requested.


STATE OF CALIFORNIA • DEPARTMENT OF TRANSPORTATION
FIELD SAMPLE OF PORTLAND CEMENT CONCRETE SAMPLE CARD
TL-0502 (REV. 6/97)

NO.
CONTR. NO
FED NO.
DIST.
CO.
RT.
P.M.
LIMITS OF WORK
RES. ENG. OR SUPT
ADDRESS
CONTRACTOR
CEMENT
CERTIFICATE NO.
FINE AGGREGATE
SMARA
COARSE AGGREGATE
SMARA
REMARKS
SAMPLED BY
TITLE

Figure 9-5. Form TL-502 Field Sample of Portland Cement Concrete.

Cylinders may be shipped or delivered either to the Main Transportation Laboratory (Translab) in Sacramento or to the district lab where available, whichever is more convenient. Test cylinders should be shipped within the time period specified in California Test 540, using the least expensive means that will get them to the lab in time for testing on the required date.

Reporting Test Results

The lab uses Form TL-507 to keep a permanent record of all concrete test cylinders received and tested. Form TL-507 contains enough space to record the results of several different tests made for a particular job. A Form TL-507 is initiated whenever test specimens are received by the lab. The sample number, the date on which the test will be made and the age at testing are entered in the first three columns on the master copy of the form. When a test cylinder is broken, the strength of the concrete is entered in the fourth column. Test results are reported by means of a photocopy of the master form.

Note that the sample shipment card (Form DH-TL-502) for the particular cylinder tested will be reproduced on the right side of the report form.

Safety

Safety should be a primary consideration when sampling and molding the test cylinders. Transit-mix trucks, particularly when they are backing, swinging concrete buckets and similar concrete construction equipment can present a danger in unguarded moments, and they deserve special alertness. Molding the test cylinders requires close attention to detail and, in the interest of safety, should always be done away from the construction area.

These safety precautions should also be followed when making the unit weight and air content tests, which are done in conjunction with molding concrete test cylinders.

Concrete Pour Records

To ensure uniformity as well as facilitate and streamline record keeping, Structure Construction has developed a series of forms which are used to record and report certain information pertaining to concrete used in structure construction. These forms are shown in the following tabulation:

Form No.	Description	Purpose
DS-OS C71	Aggregate Grading Chart	Used to plot aggregate grading.
DS-OS C70 A&B	Concrete Mix Design	Used to check contractor's mix design.
DS-OS C72	Field Record for Concrete Pours	Used by concrete inspector to record pour data.
DS-C73	Concrete Pour Record	Used to summarize and record data for each concrete pour.

These forms may be accessed on Bridge Construction Records and Procedures Manual located on Structure Construction's web page at:

http://onramp.dot.ca.gov/hq/oscnet/sc_manuals/crp/vol_1/crp016.htm

and on the Structure Construction forms page at:

http://onramp.dot.ca.gov/hq/oscnet/downloads/forms.htm.

Please note that on the latter page, forms for aggregate grading and mix design checks are contained in an Excel spreadsheet named "concrete.xls".

Form DS-OS C72 was developed to facilitate recording of test data and other pertinent information by the concrete pour inspector. Note, however, that the use of this particular form is optional and is at the engineer's discretion. Alternatively, any suitable method of record keeping may be used provided all required information is preserved.

Following completion of the concrete pour, any information needed from truck delivery tickets should be entered on Form DS-OS C72, if this form is used, and the completed form (or the alternative record), the vendor's certificate, and the delivery tickets should be stapled together and filed by pour number in a suitable box or holder.

Form DS-C73 is the permanent record of the concrete pour. It is prepared from information previously recorded on Form DS-OS C72, or from an alternative field record-keeping source. When completing Form DS-C73, it is very important to substantiate all waste. Waste due to form variation should be estimated on an attached calculation sheet. Waste outside the forms (concrete that is spilled, left-over, rejected, etc.) must be described and estimated as accurately as possible. See the example form shown in Figure 9-6. For instructions on use of Form DS-C73 as an estimate document, refer to Bridge Construction Memo 4-5.8.

Caltrans

Department of Transportation
CONCRETE POUR RECORD
DS-C73 (Rev. 5-2-77)

File Category | Item Number | This Bridge | Bridge Identification

Sheet No. 48 - (34-0006R)

Job Stamp
04-01202L4
04-SF, Ala-80-1.6/2.7
New SFOBB East Span

Bridge Name: *Oakland Touch Down* Bridge Number:
Item No. and Description: *102 Structural Concrete*
Date: *8/15/2008* Mix Design No.: *M 418 1283* Cert. of Compliance No.: *17830*
Pour Location: *23 L Abutment*
Admixture Used:
Air Entraining Agent: Amount: Air Required:
Pour Inspected By: *Mahmoud K.* Samples Taken By: *Sami Daouk*
Sample Numbers:

Time	Load Number	Barge Number	Air Temp C	Conc. Temp C		Average Readings Slump (inches)	% Air	Tested By
12:30 PM	8		64'	80'		41-/4"		Sami Daouk

Remarks:

Waste Outside Forms - Explain:

Waste Inside Forms - Substantiate:

Plan Pay Quant.-This Item-This Br. ______ m^3
Due to CCO's ______
Final Pay Quant.-This Item-This Br. ______
Quant. Prev. Paid-This Item-This Br. ______
Total Quant. To Date-This Item-This Br. ______

Quantity Delivered: 138.0 M^3
Quantity Returned: 1.5 M^3
Waste in forms: 0.0 M^3
Waste Outside Forms: 0.0 M^3
Net =Pay Quant.
This Pour: 136.5 M^3
Sheet No.
Line No.
Date: 8/15/2008

Pour Record Info Entered By: *Sami Daouk*

Figure 9-6. Completed Form DS-C73 Concrete Pour Record.

Trial Batches

When concrete has a compressive strength greater than 3,600 psi, the Standard Specifications require the concrete materials, mix proportions, and mixing equipment and procedures to be prequalified based on certified test data or trial batch reports by the contractor. In most cases, the concrete will be prequalified by trial batches.

Compliance with prequalification requirements is the contractor's responsibility. This means the contractor must make all arrangements for producing the trial batch, and must arrange for a testing firm to sample the concrete and make the appropriate tests. All tests must be performed in accordance with California Test methods or the comparable ASTM test methods.

In accordance with Structure Construction policy, the structure's engineer should witness sampling of trial batch concrete, molding of the test cylinders, and all field tests. The engineer may elect to sample trial batch concrete and make test cylinders for testing in the Translab or district materials lab.

Concrete Compressive Strength by Maturity Method

An alternative method of estimating concrete strength is by the use of Maturity Method. This method is based on the principle that concrete properties are directly related to its age and temperature history. Furthermore, it is assumed that samples of a concrete mixture of the same maturity will have similar strengths even though they may have different age and temperature combinations. Maturity Method concept is described in more detail in Chapter 1 of this manual. The advantage of the maturity method is that it uses the actual temperature profile of the concrete in the structure to estimate its in-place strength.

It should be noted that determination of concrete compressive strength by Maturity Method does not apply to all projects. Use of this method would be based on its cost effectiveness and relative complexity or special circumstances of the project.

ASTM C1074 defines Maturity Method as a technique for estimating concrete strength that is based on the assumption that samples of a given concrete mixture attain equal strengths if they attain equal values of maturity index. Maturity index of concrete is a function of its temperature history and age and is used to estimate its strength development based on a pre-determined relationship developed from lab tests for that mixture.

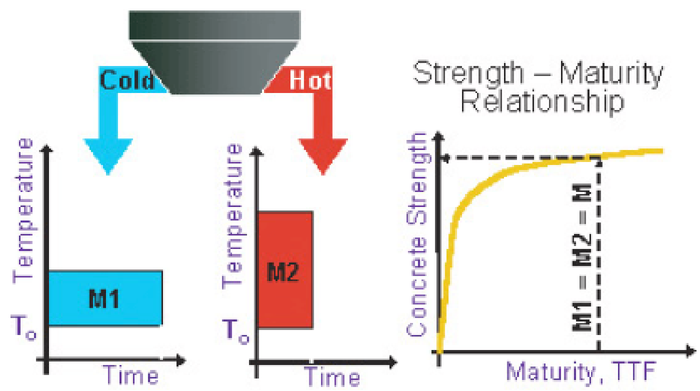


Figure 9-7. Concrete Maturity and Strength[3].

ASTM C1074 provides the procedure for estimating concrete strength using this method. Two types of maturity functions are described in the standard. One is the Nurse-Saul function that assumes a linear relationship between rate of strength development and temperature. Using this method the maturity index is expressed as temperature-time factor (TTF) from the product of temperature and time in °F-hours or °F-days. The accuracy of the Nurse-Saul prediction breaks down when there are wide ranges of curing temperatures, but its accuracy is considered adequate for most applications. Figure 9-7 provides a graphic depiction of the maturity concept. The figure shows that two concrete specimens, with different curing histories, would reach the same strength as long as their TTFs, M1, and M2 are equal.

In the second method, the Arrhenius function assumes that the rate of strength development follows an exponential relationship with temperature. The maturity index is expressed in terms of an "Equivalent Age" at a reference temperature. Actual age is typically normalized to an equivalent age at 68°F or 73°F. The Arrhenius function is considered to be more scientifically accurate although the Nurse-Saul function is more commonly used due to its simplicity.

It should be noted that, like any other test method, there are limitations for accuracy of the maturity method. These include:

- Concrete used in the structure must be representative of the one used to establish the maturity index. Changes in concrete mix design, like cementitious materials, aggregates, air content and w/c ratio could lead to erroneous estimates of concrete strength;

[3] http://www.fhwa.dot.gov/pavement/pccp/pubs/06004/index.cfm

- It does not account for humidity conditions during the curing stage and/or high early age temperatures, and

- It is assumed that concrete is placed, consolidated and cured properly. Additionally, continued cement hydration is assumed by providing adequate curing conditions.

It is a good practice to periodically verify that the established maturity-strength relationships for the specific concrete are still valid by alternative verification methods such as cast-in-place cylinders. Field-molded cylinders instrumented with maturity instruments could also be tested at early ages to serve as another verification method.

Commercial maturity devices are capable of continuous measurement of concrete temperature and calculating maturity index. The technology allows numerous locations to be monitored simultaneously. It is important to select a rugged system with uninterruptable data collection capabilities.

It should also be noted that the Maturity Method is not intended to replace the standard cylinder break method. However, in conjunction with other non-destructive testing methods it can replace field-cured cylinder testing to improve decision making for important construction activities. It can also be a vital quality control and quality assurance method.

Sampling and Testing of Self-Consolidating Concrete

Self-Consolidating Concrete (SCC) is highly flowable, non-segregating concrete that can flow into place, fill the formwork and encapsulate the reinforcement without any mechanical consolidation. Properties and characteristics of this concrete have been addressed elsewhere in this manual.

Testing of fresh SCC is performed to measure the following:

- Flowability and/or filling ability
- Stability and resistance to segregation (both static and dynamic)
- Passing ability (blocking potential)
- Self leveling (if required)

Note that typical fresh concrete tests such as air content, concrete temperature and density are also needed and addressed earlier in this chapter. During the mixture development stage of SCC, more testing may be needed than in the field for quality control (QC) purposes.

Slump-Flow Test (ASTM C1611)

This test method is used to monitor the consistency of fresh, unhardened self-consolidating concrete and its unconfined flow potential. In this test the mean diameter of the spread of fresh concrete is measured using a conventional slump cone, see Figure 9-8. The test method is considered applicable to SCC having coarse aggregate up to 1 inch in size.

Figure 9-8. Slump Flow Test of SCC.

In addition to spread, ASTM C1611 also provides Relative Viscosity (T_{20}) and a Visual Stability Index (VSI). T_{20} is defined as the time taken for the concrete to reach a spread diameter of 20 inches from the moment the slump cone is lifted up and is a measure of the viscosity of the SCC. T_{20} typically ranges between 2 and 10 seconds for SCC.

The resistance to segregation is estimated through a VSI. The VSI is established based on whether bleed water is observed at the leading edge of the spreading concrete, or if aggregates pile at the center. VSI values range from zero for "highly stable" to three for "unacceptable stability." The test method includes an appendix that provides non-mandatory visual rating criteria to estimate the VSI.

Static Segregation Test (ASTM C1610)

ASTM C1610 is primarily used during the development phase of the SCC mixture. However, it is briefly discussed here in case a need for field application arises. The test method uses a 1/8-inch diameter cylinder filled with SCC and compares the amount of coarse aggregates in the top and bottom sections of the cylinder, when washed over No. 4 sieve, after a 15-minute wait time. A Segregation Index (SI), defined as percent difference in coarse aggregate mass between the top and bottom sections of the cylinder is calculated and compared to the allowable limit, normally 15%.

Passing Ability Test (J-Ring, ASTM C1621)

This test method measures the spread of SCC through reinforcing steel. The test utilizes a J-Ring in combination with a mold. The J-Ring test, shown in Figure 9-9, is a variation to the slump flow, where a simulated rebar cage is placed around the slump cone. The difference between the slump flow and J-Ring flow is an indication of the passing ability of the concrete. A difference less than 1 inch indicates good passing ability and a difference greater than 2 inches indicates poor passing ability. This test method is limited to self-consolidating concrete with nominal maximum size of aggregate of up to 1 inch.

The orientation of the mold for the J-Ring test and for the slump flow test without the J-Ring shall be the same. (Although the ASTM test specifications allow either orientation for the testing, the slump flow test, ASTM C 1611, and the J-Ring test, ASTM C 1621, must agree within 2 inches. Inconsistent orientation of the slump cone could result in a test failure.)

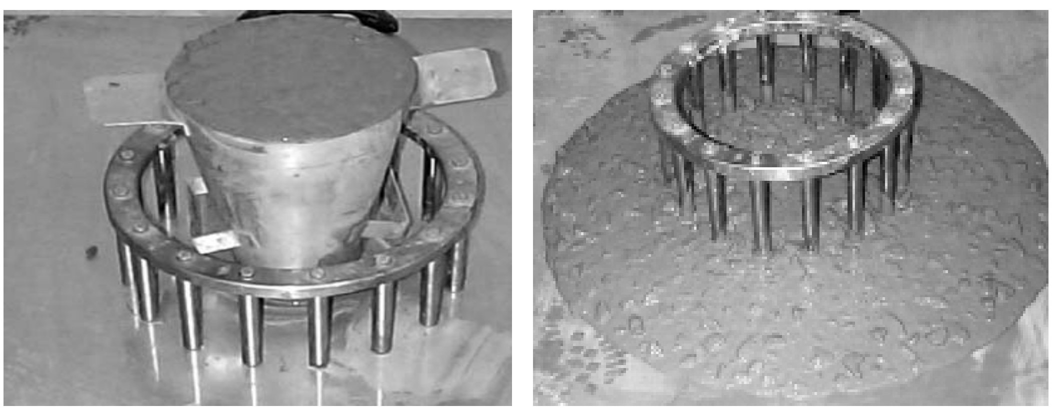


Figure 9-9. J-Ring Test (Ref. ASTM C1621).

References:

- Guide to non-destructive testing of concrete, FHWA, publication No. FHWA-SA-97-105, September 1997

- FHWA Technical Brief: www.fhwa.dot.gov/pavement/pccp/pubs/06004/index.cfm

- National Ready Mix Concrete Association CIP-39, “Maturity methods to estimate concrete strength”