

Concrete Test Procedure

Last Revised: July 19, 2011

Preamble

Why should we do any testing at all? Everything's good enough, right? It will probably be OK, right? 56-day strength is good enough and if that doesn't satisfy, just do it at 117 days, it's good enough, right? After all, we don't want to cost the contractor money. And we don't want to delay the schedule. (from Eng-Tips forum www.eng-tips.com)

Procedure

It should be stipulated that concrete should be supplied using Alternative 1 or Alternative 2. Alternative 1 is a performance based approach where the intent of the concrete design is stipulated. Alternative 2 is a prescriptive method where the actual quantities of the components of the concrete mix are stipulated. This includes cementitious material, aggregate, sand, water, admixtures, etc. Refer to CSA A23.1, Table 5, for the responsibilities of the Owner or Owner's Representative, the Contractor and the Concrete Supplier. Alternative 1 is preferable unless the Owner wants to accept responsibility for the mix design.

The designer is given a fair latitude in specifying the concrete required. CSA A23.1, Table 5, clearly states in the owner obligations, ***“(f) any other properties that might be required to meet the owner’s performance criteria.”***

Concrete mix supplier shall provide a mix design history showing suitability prior to delivering concrete to site. CSA A23.1, Table 5, clearly states in the supplier obligations, ***“(g) at the request of the owner, submit documentation to the satisfaction of the owner, demonstrating that the proposed mix design will achieve the required strength, durability and performance requirements.”*** Concrete mix issues should be discussed and finalised well in advance of construction. It is also a requirement that this 'history' be requested.

Testing shall be undertaken by a certified laboratory and by a certified concrete technician. Provide copies of all certifications and CV's of testing personnel.

The manner of certified testing shall be established and outlined by the testing agency; CSA, ACI, ASTM, AASHTO, etc.

Concrete testing shall be authorised and paid for by the Owner. The concrete testing agency shall review the batch plant facilities and their methods of quality control prior to concrete delivery to site.

The Testing Agency should be responsible to the Owner. The problem with including testing as a 'cash allowance' is that the Testing Agency's client is often the Contractor and not the Owner. In general, concrete testing should be paid for directly by the Owner.

Copies of all test reports shall be forwarded directly to the EOR by the testing agency.

If a test result is outside specification, it shall be reviewed by the EOR and the Owner at the time of the occurrence.

The [Testing Agency | Contractor | EOR] shall be given the authority to reject any material not conforming to specification. The causes and manner for rejection and person(s) responsible should be identified prior to the start of construction.

All parties shall be familiar with the requirements of CSA A23 prior to commencing concrete work. Be familiar with CSA before you have a problem.

Method of sampling and frequency of testing shall be in accordance with A23.1.

A minimum of three cylinders shall be taken for strength tests, one cylinder for seven day strength and two cylinders for twenty-eight day strength. Obtain additional cylinders for testing as required. Seven day strength should be approximately seventy percent of the specified twenty-eight day strength.

Slump tests shall be taken with each set of concrete cylinders taken for strength testing.

Air content tests shall be taken from each load unless a reduced frequency is permitted by the EOR.

Cylinders for strength tests and a slump test shall be taken from at least each third truck, and preferably from each second truck.

A minimum of three cylinders for strength tests, and a slump test shall be taken each day for each different type of concrete mix design.

If large volumes of concrete are being supplied (other than by truck), there should be a minimum of three cylinders taken for strength testing, one air test, and one slump test for each one hundred cubic metres, or part thereof.

Care shall be exercised in protecting the concrete test cylinders from damage. Concrete test cylinders shall be properly cured.

If test results show a large 'scatter' of data, additional testing should be prescribed; this can be qualitatively defined using Standard Deviation.

If superplasticisers are used, they shall be at the direction of the concrete supplier. Testing shall occur prior to the addition of the superplasticiser and after the superplasticiser is properly mixed. The specified slump is the concrete slump prior to the addition of a superplasticiser. The concrete supplier shall provide a pumpable mix if required and if available. Maximum slump with superplasticiser shall not exceed 8".

When possible the superplasticiser should be added at the plant as there is better control and the mix design should indicate that it is a superplasticised mix. If superplasticiser is added to the load on site, you may not be not using the approved mix. In addition, air normally has to be adjusted because the superplasticiser may have an effect on the air content.

Until there is a correlation of the supplied mix and the mix stipulated in the construction documents, the following should be implemented:

The concrete arriving at site should be uniformly mixed.

A '*first test sample*' should be taken from the beginning of the load. This sample is not taken from the normal 10%, 50%, and 90% point of load discharge. This *first test sample* should be representative of the stipulated mix.

This *first test sample* should be taken prior to the addition of superplasticiser.

This *first test sample* of the load should be tested for slump and air.

Superplasticiser can be added to the load as stipulated by the concrete supplier and the load should be properly mixed.

A sample should be taken at the discharge end of the pump that represents the concrete at 10%, 50%, and 90% point of the discharged load.

This '*discharge test sample*' should be tested for slump, air and strength.

After a few loads, if there is a general correlation of slump and air from the *first test sample* and the *discharge test sample*, then the testing of the *first test sample* can be waived by the QA/QC personnel.

Refer to CSA A23.1, Clause 5.2.4.5.1, for information the truck ticket should contain. The 'truck ticket' shall show the following information:

- Ticket serial number,
- Concrete supplier,
- Truck number,
- Mix number,
- Mix description including cement, W/C ratio, strength, slump, aggregate size, etc.,
- Volume of concrete in batch,
- Project, project location, and project number,
- Contractor,
- Date and time truck was charged, and
- Any special instructions including extra water added.

Refer to CSA A23.1, and A23.2-9C for information the testing report should contain. The Concrete Testing Report shall show the following information:

- Concrete testing laboratory
- Test identification number,
- Project, project location and project number
- Location of pour
- Concrete supplier
- Mix number
- Ticket serial number,
- Truck number,
- Date and time truck was charged
- Date and time truck was discharged
- Contractor
- Specified 28 day strength
- Cement Type; GU, GUb, HS, HSb, etc.
- Any additives on site; water, admixtures, etc. and by whom,
- Max aggregate size
- Concrete slump; specified and measured,
- Air content; specified and measured,
- Concrete temperature
- Air temperature

Provision for 7 day and 28 day concrete cylinder strength
Type of mold and size of test cylinders
Manner of fracture and type of fracture if different from a conical fracture (Type 1).
Date and time the concrete was sampled,
Date and time of testing and casting,
Name of person(s) or laboratory undertaking sampling and casting of the cylinders,
Name of person undertaking slump testing,
Name of the laboratory or person undertaking the air content test,
Name and signature of person(s) undertaking cylinder testing
Name & signature of person(s) responsible for the quality of test report,

A procedure shall be established, prior to placing any concrete, for concrete that does not conform to the required mix specifications.

Testing agency shall notify the Contractor and the EOR of any material not conforming to specification at the time this is determined.

Quality control is the Contractor's responsibility. It is using the right mix design, admixtures and procedures to produce quality concrete. Quality assurance is monitoring the Contractor's quality control to ensure the end result is acceptable to the EOR.

The site technician's only role is quality assurance. Specifications generally make the Contractor responsible for the final product.

Water shall not be added on site, except under the direct supervision of the concrete supplier and specifying:

- (a) that the W/C ratio is not exceeded,
- (b) that no more than 60 min has elapsed from the time of batch, and
- (c) that not more than the lesser of 16L/m³ or 10% of the mixing water shall be added.

The maximum time permitted from charging to discharging shall be 2 hours.

If concrete slump is excessive, continued mixing as directed by the concrete supplier up to the maximum discharge time is permitted. An additional concrete slump test shall be taken at discharge.

A procedure shall be established, prior to placing any concrete, for concrete that does not conform to 28 day specified strength. With low compressive test results, it has been my experience that the first thing questioned is the qualification of the technician or the manner they sampled or tested. Was the sample consolidated properly? Were the cylinders picked up too soon or too late? was the transportation method proper i.e. padded? were the cylinders lab cured or field cured? If field cured, is there a suitable curing 'tank' on site?

Unless a good correlation exists for actual strength and Schmidt hammer results, Schmidt hammer shall not be used to confirm concrete strength. If critical then concrete cores should be taken.

For failure of concrete testing refer to CSA A23.1, Clause 4.4.6.6.1 and Clause 4.4.6.7.1. An example of the approach for concrete strength failure is as follows:

Failure of Concrete Tests and Acceptance of Concrete

(from ACI 318 Chapter 5, prepared by Jeff Ehler, P.E.)

ACI Building Code Requirements for Structural Concrete (ACI 318) A strength test is defined as the average strengths of two cylinders tested at 28 days. A strength test is acceptable if BOTH of the following are met:

1. Every arithmetic average of any three consecutive tests (6 cylinders) equals or exceeds f'_c .
2. No individual strength test (average of two cylinders) falls more than 500 psi. below the required strength, f'_c .

If either of the above two requirements are not met, contractor should take steps to increase the average of future concrete tests.

If Item 2 above is not met, then the following should also be followed:

1. With the lower f'_c derived from the strength tests above, the structural engineer should review the design of the affected portion of the structure to determine if the lower f'_c is acceptable. If the lower f'_c is acceptable, then no further efforts are required and the concrete can be accepted. Steps still should be taken by the contractor to increase the compressive strength of the concrete for future mixes.
2. If the lower f'_c is found to be critical to the performance of the structure, then further testing should be performed using drilled core samples.

Core samples should be obtained – three at a time, for each strength test that falls below 500 psi. If the concrete in the structure will be dry under service conditions, cores shall be air dried for 7 days before the test and tested dry. If the concrete in the structure will be more than superficially wet under service conditions, cores shall be immersed in water for at least 40 hours and be tested wet.

The concrete can be accepted if BOTH of the following are met:

1. The average of the three cores is equal to or greater than 85% of f'_c .
2. No single core is less than 75% of f'_c .

For CSA reference see CSA A23.1, Clause 4.4.6.6.2.

If the cores don't meet the required levels the following are all options to consider:

1. Perform a load test of the structure in the area under consideration (per ACI Chapter 20)
2. Provide additional structural framing to strengthen the portion of the affected structure to meet the required load carrying capacity.
3. Accept the concrete if acceptable to the owner.
4. Reject the concrete and remove and replace the portion that is considered below strength.

Contractor Responsibility

If the concrete strength is unacceptably low, it's the Contractor's responsibility to replace it. Any lost time due to replacement is the Contractor's responsibility.

The consequences of low strength should be evaluated. Unless high percentages of reinforcing steel are specified, low strength has little effect on the flexural strength. From a strength vantage, it is mostly shear capacity that is affected by low strength.

From a servicablilty vantage, low strength can have a real impact on durability. Because removal may have an impact on schedule a quick decision to remove may be prescribed. I would suggest that coring for testng be done as soon as low strengths are recorded. The costs of delay could far outweigh the costs for coring and testing. The concrete supplier should be notified at this point of the low test results and that testing has been undertaken in full compliance with the recognized standards and that the material supplied appears to be deficient.