theDELTAadvantage

DESIGN TOPICS FOR PRECASTERS

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Understanding Required Average Concrete Strength

By Ronald E. Thornton, PE

The structural design of a particular concrete product calls for 4000psi concrete. This, according to ACI, is the Minimum Design Strength or Specified Strength and is designated f'c, (pronounced f-prime-c). Unless otherwise specified, this strength must be met when tested for compressive strength at the age of 28 days.

If we could assure that every batch of concrete would test at exactly 4000psi at 28 days, then there would be no need to overdesign the mix other than to perhaps accelerate the curing process. Unfortunately, making concrete is not an exact science. There are many variables in constituent materials and also within the batching process that can result in significant strength variations from test to test.

Because of this variation, the average of all tests must be something greater that the specified minimum in order to assure that, statistically, no more than 1 test in 100 falls below the minimum. This statistical average is called the Required Average Strength or f_{cr}. f_{cr} can be determined by statistical analysis provided there is a history of at least 30 test results on the same mix. The term standard deviation represents the degree of variation in test results and is computed by the formula:

$$s = [\sum(X-\bar{X})^2/(n-1)]^{1/2}$$

Where: s = standard deviation, psi
$\underline{X}$ = individual strength tests, psi
X = average of n strength tests, psi
n = number of consecutive tests

The required average strength is then determined by the greater of:

$$f_{cr} = f'c + 1.34s$$

or $$f_{cr} = f'c + 2.33s - 500$$

For a standard deviation of say 500psi, the required average strength of a 4000psi mix would be 4670psi.

Table 5.3.1.2 of ACI318 contains modification factors if the number of available test results is less than 30 but greater than 14. Fewer results make the statistical analysis less reliable. Therefore, if there are less than 15 tests to analyze, then fcr is determined from Table 5.3.2.2, which states that for:

f'c < 3000psi,	fcr = f'c + 1000
f'c = 3000 – 5000psi,	fcr = f'c + 1200
f'c >5000psi,	fcr = f'c + 1400

The above calculations can be done quite simply with the use of a spreadsheet such as Excel or Quatro Pro, or there are commercially available software programs that can perform these analyses for you. The key to remember is that by keeping track of your test results and taking steps to minimize the amount of variation in your concrete test results, you can reduce the required average strength of your mix designs and possibly save some money in the process.

Tips to Reduce Strength Test Variation

Here are a few things you can do to minimize the standard deviation of test results:

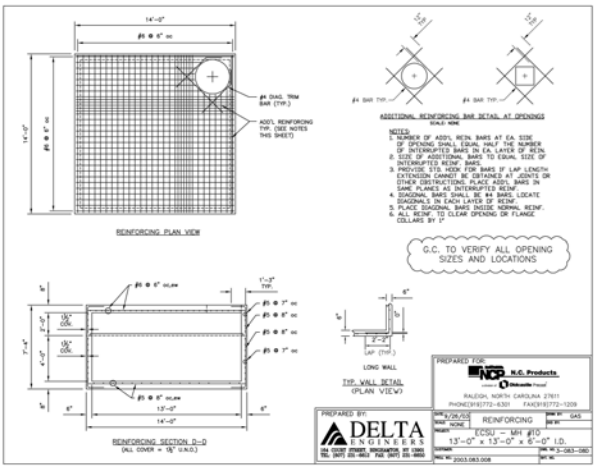
- Use the same brand and type of cement
- Choose aggregates of consistent gradation and cleanliness.
- Control aggregate moisture and adjust mix accordingly
- Carefully follow prescribed test methods and provide a consistent curing environment.
- Assure accurate measurement of materials and calibrate plant-measuring devices as recommended.

Look for us in Atlanta

Delta will again be participating at the MCPX, which will take place in Atlanta, Ga. On February 5 – 8. Ron Thornton will be moderating at round table discussion on blueprint reading on Friday from 10AM until noon and will be teaching a course titled "Testing Concrete: Taking it to the Next Level" from 7:30AM – 8:45AM on Saturday. Ron presented this program in Salt Lake City last year. Our booth this year is #1706 where we will continue to demonstrate our popular DP_Vault program. Hope to see you there.

Featured Project

Central Utility Plant – Phase I
Owner: Elizabeth City State University, NC
Produced by: NC Products, Raleigh, NC
Structural Design and Shop Drawings: Delta Engineers



Send us your project photos to be featured here

This project consisted of 11 precast steam manholes ranging in size from 12’ x 12’ x 7 to 13’-8” x 15’ x 7’ ID. Each unit was designed for HS20 loading with the water table at grade and detailed by Delta to show all reinforcing and pipe penetrations.