

2.1. The specified concrete strength f'_c for a new building is 5000 psi. Calculate the required average f_{cr} for the concrete (a) if there are no prior test results for concrete with a compressive strength within 1000 psi of f'_c made with similar materials, (b) if 20 test results for concrete with $f'_c = 5500$ psi made with similar materials produce a sample standard deviation s_s of 560 psi, and (c) if 30 tests with $f'_c = 4500$ psi made with similar materials produce a sample standard deviation s_s of 540 psi.

Solution: $f'_c = 5000$ psi

a) No prior results

$$f_{cr} = f'_c + 1200 \text{ psi} = 5000 + 1200 = 6200 \text{ psi}$$

b) 20 prior tests for concrete with f'_c within 1000 psi of f'_c of the project and $s_s = 560$ psi. From Table 2.1, $k = 1.08$ and ks_s is $1.08 * 560 = 605$ psi.

Because $f'_c = 5000$ psi, use eqs (2.1) and (2.2a)

$$f_{cr} = f'_c + 1.34 ks_s = 5000 + 1.34 * 605 = 5810 \text{ psi}$$

$$f_{cr} = f'_c + 2.33 ks_s - 500 = 5000 + 2.33 * 605 - 500 = 5910 \text{ psi}$$

USE $f_{cr} = 5910$ psi

c) 30 prior tests for concrete with f'_c within 1000 psi of f'_c for the project. $s_s = 590$ psi and k is 1.0.

$$f_{cr} = f'_c + 1.34 s_s = 5000 + 1.34 * 590 = 5790 \text{ psi}$$

$$f_{cr} = f'_c + 2.33 s_s - 500 = 5000 + 2.33 * 590 - 500 = 5870 \text{ psi}$$

USE $f_{cr} = 5790$ psi

COMMENT: in cases b) and c) the f_{cr} would reasonably be taken as 6000 psi.

2.2. Ten consecutive strength tests are available for a new concrete mixture with $f'_c = 4000$ psi: 4830, 4980, 3840, 4370, 4410, 4890, 4450, 3970, 4780, and 4040 psi.

(a) Do the strength results represent concrete of satisfactory quality? Explain your reasoning.

(b) If f_{cr} has been selected based on 30 consecutive test results from an earlier project with a sample standard deviation s_s of 570 psi, must the mixture proportions be adjusted? Explain.

Solution:

a) For $f'_c = 4000$ psi, the strength results indicate satisfactory concrete quality because (1) no individual test is below $f'_c - 500$ psi = 3500 psi, and (2) every arithmetic average of any three consecutive tests equals or exceeds f'_c .

b) For $s_s = 570$ psi, for 30 consecutive tests calculate f_{cr} using equations 2.1 and 2.2a.

$$f_{cr} = f'_c + 1.34 ks_s = 4000 + 1.34 * 1 * 570 = 4760 \text{ psi}$$

$$f_{cr} = f'_c + 2.33 ks_s - 500 = 4000 + 2.33 * 1 * 570 - 500 = 4830 \text{ psi}$$

USE $f_{cr} = 4830$ psi

The average of the above tests is $(4830 + 4980 + 3840 + 4370 + 4410 + 4890 + 4450 + 3970 + 4780 + 4040) / 10 = 4460$

Because the average strength is less than the target strength, the water/cement ratio must be adjusted by adding cement or reducing water to increase the strength. If the water is reduced, a water reducer admixture would be required to maintain workability.

2.3. The specified concrete strength f'_c for the columns in a high-rise building is 12,000 psi. Calculate the required average f'_{cr} for the concrete (*a*) if there are no prior test results for concrete with a compressive strength within 1000 psi of f'_c made with similar materials, (*b*) if 15 test results for concrete with $f'_c = 11,000$ psi made with similar materials produce a sample standard deviation s_s of 930 psi, and (*c*) if 30 tests with $f'_c = 12,000$ made with similar materials produce a sample standard deviation s_s of 950 psi.

Solution: $f'_c = 12000$ psi

a) No prior results

$$f'_{cr} = f'_c + 0.1 f'_c + 700 \text{ psi} = 12000 + 0.1 * 12000 + 700 = 13,900 \text{ psi}$$

b) 15 prior tests for concrete with f'_c within 1000 psi of f'_c of the project and $s_s = 930$ psi. From Table 2.1, $k = 1.16$ and ks_s is $1.16 * 930 = 1079$ psi.

Because $f'_c > 5000$ psi, use eqs (2.1) and (2.2b)

$$f'_{cr} = f'_c + 1.34 ks_s = 12000 + 1.34 * 1079 = 13,450 \text{ psi}$$

$$f'_{cr} = 0.9f'_c + 2.33 ks_s = 0.9 * 12000 + 2.33 * 1079 = 13,310 \text{ psi}$$

USE $f'_{cr} = 13,450$ psi

c) 30 prior tests for concrete with f'_c within 1000 psi of f'_c for the project. $s_s = 950$ psi and k is 1.0.

$$f'_{cr} = f'_c + 1.34 s_s = 12000 + 1.34 * 950 = 13,270 \text{ psi}$$

$$f'_{cr} = 0.9f'_c + 2.33 ks_s = 0.9 * 12000 + 2.33 * 950 = 13,010 \text{ psi}$$

USE $f'_{cr} = 13,270$ psi