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

$f'_{cr} = f'_c + 1200$ psi = 5000+1200= 6200 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 psi

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

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

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

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

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

$$f'_{cr} = 0.9f'_c + 2.33\, ks_s = 0.9*12000 + 2.33*1709 = 13,310 \text{ psi}$$

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