

Problem: You are the Field Engineer on a project that is currently underway. The project specification states that the concrete strength is **24MPa** in twenty-eight (28) days. The following data contains the two (2) twenty eight (28) day cylinder test data that was sent to you by the testing laboratory. You need to evaluate this data and determine if the concrete is acceptable according to **ACI 318**.

Test #	Cylinder #1 (MPa)	Cylinder #2 (MPa)
1	28.3	29.8
2	29.8	28.9
3	29.7	29.7
4	30.5	30.2
5	29.0	28.7
6	29.3	26.3
7	26.8	27.9
8	24.6	25.4
9	24.6	22.1
10	26.1	26.1
11	25.4	20.5
12	22.8	25.8
13	23.9	22.1
14	19.1	19.0
15	22.1	24.0

Assumptions

1. Samples are taken on a random basis – concrete was not to be sampled due to appearance, convenience, or other biased criteria.
(ACI 318.5.6.2.2 and ACI 318R. 5.6.2.2)
2. Each set of cylinders come from a different batch of concrete.
(ACI 318.5.6.2.2 and ACI 318R 5.6.2.2)
3. No water was added to the concrete after the samples were taken.
(ACI 318R. 5.6.2.2)
4. Qualified field testing technicians performed the test on the fresh concrete.
(ACI 318.5.6.1)
5. Qualified laboratory technician performed all required laboratory tests.
(ACI 318.5.6.1)

Solution

Step 1

Determine the strength test results (average strength of two tests cylinders from the same batch and tested at 28 days or at test age designed for determination of f'_c . (ACI 318.5.6.2.4)

$$\frac{\text{Cylinder 1} + \text{Cylinder 2}}{2} = \text{strength test results}$$

Therefore,

For strength test #1:

$$\frac{28.3 + 29.8}{2} = 29.0 \text{ MPa}$$

Thus the strength test results are:

Test #	Strength Test Results (MPa)
1	29.0
2	29.3
3	29.7
4	30.3
5	28.8
6	27.8
7	27.3
8	25.0
9	23.4
10	26.1
11	23.0
12	24.3
13	23.0
14	19.0
15	23.0

2. Determine the arithmetic average of any three (3) consecutive strength test results. (ACI 318.5.6.3.3a)

For the first three (3) strength test results –

$$\frac{ST_1 + ST_2 + ST_3}{3} = \text{Arithmetic Average}$$

On our project

$$\frac{29.0 + 29.3 + 29.7}{3} = 29.4 \text{ MPa}$$

Thus, the arithmetic averages are:

Test #	Arithmetic Average (MPa)
1	-
2	-
3	29.4
4	29.8
5	29.6
6	29.0
7	28.0
8	26.7
9	25.2
10	24.8
11	24.1
12	24.4
13	23.4
14	22.1
15	21.7

Step 3. Determine if any strength test results are below $f'_c - 3.5$ MPa for $f'_c \leq 35$ MPa or by more than $0.10f'_c$ when f'_c is more than 35MPa psi.

Since $f'_c = 24$ MPa, inspect the strength test results for:

$$f'_c - 3.5 = 24 - 3.5 = 20.5 \text{ MPa}$$

Strength test result # 14 is the only strength test result below 20.5 MPa (19 MPa)

Notes:

- Only the strength test results (average of 2 cylinders) are to be used **not** the individual cylinders results.
- Test # 9 has one cylinder test result below 24 MPa (22.1 MPa). This does not indicate a problem since the strength test result is 25.2 MPa; this is above 20.5 MPa, thus, the concrete is acceptable.
- Test # 11 has a cylinder test result of 20.5 MPa. The strength test result is 24.1MPa; this is above 20.5 MPa, thus the concrete is acceptable.

Evaluation of results

Determine if either the arithmetic average (calculated in Step 2) is below f'_c or if the strength test result is $f'_c - 3.5$ MPa (calculated in 3), steps must be taken to improve the strength of future concrete placements.

1. The arithmetic average of three consecutive averages are below f'_c (24 MPa) on test numbers 13,14, and 15.
2. Aso, Strength test results below $f'_c - 3.5$ or (20.5 MPa) occurs at test number 14.

Thus on our project, we must improve future concrete placement.

Options of what needs to be done long term and short term:

Long Term

- a. An increase in cementitious materials content
- b. Change in mixture proportions
- c. Reductions in or better control of levels of slump supplied
- d. A reduction in delivery time
- e. Closer control of air content
- f. An improvement in the quality of the testing, including strict compliance with standard test procedures

Short Term

If the strength test result is below $f'_c - 3.5$ MPa, steps must be taken to assure that the load carrying capacity of the structure is not jeopardized

Since concrete placed at the location identified by test number 14 is below $f'_c - 3.5$ or 20.5 MPa. The concrete in this area does not meet the strength criteria and needs to beevaluated.

How to determine what needs to be done to assure that the load carrying capacity is not jeopardized.

- a. Apply judgment as to the significance of the low test result
- c. If further investigation is deemed necessary, consider non-destructive testing
- d. Core area(s) of the concrete where load carrying capacity is significantly reduced in accordance with ASTM C 42.

On our Project:

If we take three (3) cores in the area where the concrete at test location number 14 was placed,

- a. The average strength of the cores must exceed 85% of 24 MPa (20.4 MPa) and,
- b. No single core strength is below 75% of 24 MPa psi (18 MPa).

Note:

Additional core testing is permitted if the core test results are considered erratic.

Resolve the above problem using the following standards for acceptance criteria

1- BS-EN206

2- IS 456:2000