UK Method

Bibliography (2a - 2b – 2c)

In the UK, the method considered most relevant for assessing the concrete strength in the structure is the determination of the **E**stimated **I**n situ **C**ube **S**trength (EICS) from cores as it exists at the sampling location, without correction for the effect of curing history, age or degree of compaction.

BS EN 13791, together with BS 6089, gives procedures for :

- **Assessing whether concrete conforms to the specification**

This is where cores are taken in order to resolve a dispute over the strength of the concrete supplied

- **Determination of specified in situ strength**

This is undertaken when :

a- There is no information about the concrete or
b- The producer has declared the concrete as nonconforming with respect to compressive strength.

The objective in this case is to find the specified strength based on the mean in situ strength

INDIVIDUAL CORRECTED IN SITU STRENGTH CALCULATION

$$f_{ci,eq} = f_{c,i} * F_{l/d} * F_r * F_m$$

$f_{ci,eq}$: in situ equivalent strength of each concrete core (N/mm^2)

$f_{c,i}$: strength of each core specimen (N/mm^2)

$F_{l/d}$: correction factor for height/diam ratio of core

$$F_{l/d} = \frac{2}{1.5 + \frac{1}{\lambda}}$$

Where λ = l/d

F_r : correction factor for presence of reinforcement bar

$$F_r = 1.0 + 1.5 * \left(\frac{\sum_{i=1}^{n} (\varphi_r * h)}{\varphi_c * l} \right)$$

Where :

φ_r : rebar diam (mm)

h : distance of axis of bar from the nearer end of core (mm)

φ_c : core diam (mm)

l : core height (mm)

F_m : correction factor for cores tested wet or dry or in an unknown condition

(BS EN 13791 – Annex A § A.2.1)

1.0 : tested dry or moisture condition unknown
1.1 : tested wet

SMALL VOLUME UNDER SUSPICION

$$R_t = \frac{f_{m,(n-1)} - f_{situ,lowest}}{f_{m,(n-1)}}$$

R_t : ratio for assessment of individual core results within a group (table 5 of BS 6089:2010).

If R_t exceeds the value of the 2nd column, the core result should be treated as being suspicious or rejected as appropriate

If R_t exceeds the value of the 3nd column, the core result should be rejected

$f_{m,(n-1)}$: mean of other core results ($f_{situ,lowest}$ excluded)

From BS EN 13791 Clause 9, for a small test region with less than 15 valid core results, the region may be deemed to contain concrete with adequate strength if :

$$f_{situ,lowest} \geq 0.85 * (f_{ck,design} - 4)$$

If it doesn't the region tested has failed to meet strength criteria and suggests the concrete has not come from a conforming population. Thus the design assumptions are not valid and the structure should be assessed for structural adequacy by using a reduced strength class or by calculating the in situ specified strength (large volume under suspicion)

Table 5 **Checking the validity of the lowest core result**

No. of cores	Ratio (R_t) above which a low result should be treated as being suspicious	Ratio (R_t) above which a low result should be rejected [A)]
4	0.202	0.298
5	0.158	0.213
6	0.140	0.182
7	0.131	0.167
8	0.125	0.157
9	0.121	0.150
10	0.118	0.146
11	0.115	0.142
12	0.114	0.140
13	0.112	0.137
14	0.111	0.136
15	0.110	0.134
16	0.109	0.133
17	0.108	0.132
18	0.108	0.131
19	0.107	0.130
20	0.107	0.129
21	0.106	0.129
22	0.106	0.128
23	0.106	0.128
24	0.105	0.127
25	0.105	0.127
> 25	0.099	0.118

A) It is rejected from the calculation of the mean strength, but the result might still be valid, e.g. because it represents an area of poor compaction.

NOTE The ratio (R_t) is based on an assumed population standard deviation of 6% of the mean of the other core strengths and "t" values for n – 2 degrees of freedom.

LARGE VOLUME UNDER SUSPICION

When a large volume of concrete is under suspicion as a result of many continuous cube data sets failing to meet the identity test criteria, 15 valid cores results are required. To allow for rejection of any invalid results it is suggested at least 17 cores are taken to.

Same procedure of small volume is to be followed :

$$R_t = \frac{f_{m,(n-1)} - f_{situ,lowest}}{f_{m,(n-1)}}$$

If the result is suspicious but not rejected, the lowest result should be accepted.

If the result is suspicious and rejected, then further investigation needs to be carried out as per BS EN 13791 Clause 9 :

criterion 1 $$f_{m,(n-1)} \geq 0{,}85 * (f_{ck,design} + 1.48 * s)$$

criterion 2 $$f_{situ,lowest} \geq 0{,}85 * (f_{ck,design} - 4)$$

where :

s : standard deviation of (n-1) cores results ($f_{situ,lowest}$ excluded)

The test region may be deemed to contain concrete conforming to the specified strength class if complies with both criterions.

ASSESSMENT OF SPECIFIED IN SITU COMPRESSIVE STRENGTH

BS 6089 Clause 6.2 details the alternative approach to the one given in BS EN 13791 for the determination of specified in situ compressive strength by statistical use of the well-established and accepted t-statistic .

The in situ specified strength is calculated with the formula :

$$f_{ck,situ} = f_{m(n),situ} - (t_{0,05} * s)$$

Where :

$t_{0,05}$: value based on (n-1) degrees of freedom (Table 6 of BS 6089)

s : sample standard deviation

1. large number of core data

if $f_{ck,situ} \leq (f_{situ,lowest} + 4)$ then $f_{ck,situ} = f_{ck,design}$ for the tested area

if $f_{ck,situ} > (f_{situ,lowest} + 4)$ then $f_{situ,lowest} = f_{ck,design}$ for the tested area

2. small number of core data (but > 4)

it is advisable to take a more conservative approach and use a lower core strength for structural calculations, such as :

$f_{situ,lowest} = f_{ck,design}$