Estimating Compressive Strength with SilverSchmidt

Using the reference curve or regional curve in the SilverSchmidt
Please refer to the document "The SilverSchmidt Reference Curve". This curve may be used for checking uniformity and also for a quick estimate of the in-situ strength. If used for estimating the strength it should be used with some caution. The conversion curve of a rebound hammer is very much dependent on the concrete mixture. The mixtures used to determine this curve are given in the above mentioned document for comparison.

The regional curves, if applicable, are the results of independent tests made concrete mixtures typical to the particular region.

Improving the estimate– working with the standards and guidelines.
The recommended method common to all major standards is to correlate the rebound hammer measurements with destructive tests made on core samples.
Please refer to the following standards and guidelines for details of the requirements for creating such a correlation curve.

EN 13791 (Europe), ASTM C805, ACI 228.1R-03 (North America), JGJ T23-2001 (China)

The resulting data is used either to shift a reference conversion curve or to define a custom curve for that particular mix. Typically the curve is adjusted to provide a safety margin to take into account the various factors, (see below), that may affect the in-situ tests.

For example EN 13791 recommends the use of a lower 10th percentile curve. This means that 90% of the data pairs lie above the curve and only 10% lie below.
ASTM C805 refers to the guideline ACI 228.1R-03. In chapter 6 of this document a simplified method "6.2.4 Alternative method (Carino 1993)" which takes into account the uncertainties of both the rebound method and the destructive testing of the core samples is presented. Again a lower 10th percentile curve is recommended.

Such custom curves, either polynomial or exponential, may be defined in Hammerlink and downloaded onto the SilverSchmidt PC making it the ideal instrument for carrying out such tests. See also the document "Using EXCEL to define the parameters for custom curves in Hammerlink".

Obtaining the rebound value
The European standard EN12504-2 determines the procedure for obtaining a valid rebound number, based on a minimum of 9 impacts and calculating a median.
The North American standard ASTM C805 determines the procedure for obtaining a valid rebound number, based on 10 impacts and calculating a mean.
The Chinese standard JGJ T23-2001 determines the procedure for obtaining a valid rebound number based on 16 impacts and calculating a mean. All of these procedures are pre-programmed into the SilverSchmidt ST/PC and may be selected accordingly.

These standards are based on classical hammers which measure the rebound distance. The SilverSchmidt ST/PC measures the rebound energy coefficient. This deviation from the standard should be mentioned on the test report.

Using the correct form factor
Please refer to the document "Using Form Factors with SilverSchmidt" for information about the correct use of form factors.

proceq

Made in Switzerland ... more than 50 years of know-how you can measure!

Sources of uncertainty
The following factors may affect the determination of the rebound number.

- The concrete mixture (also multiple batches and varied curing conditions)
- The surface condition. (Rough surfaces should be ground smooth)
- The moisture content. (e.g. dry surfaces give higher rebound values)
- Temperature. (Rebound tests should not be carried out on frozen concrete)
- Carbonation (see below)
- Movement of the concrete under test. The concrete should be at least 100mm thick and firmly fixed.
- Direction of test. (Not applicable for the SilverSchmidt ST/PC)
- The presence of rebars. ASTM C805 states that rebound tests should not be carried out above a rebar with less than 20mm (0.75 in) of concrete cover.

Carbonation
Carbonation occurs when carbon dioxide reacts with calcium hydroxide in concrete to form calcium carbonate. The process of carbonation is usually very slow beginning at the outer surface and penetrating into the concrete.
Carbonation forms a hardened layer on the surface and as this layer increases it can lead to a significant over-estimation (possibly as high as 50%) of the compressive strength of the underlying concrete when measuring with a rebound hammer. Therefore it is important to know the thickness of the carbonation layer when carrying out such a measurement.

Either the carbonated layer must be removed before rebound testing, or the rebound test should be carried out before and after removal of the carbonated layer. This allows a correction factor to be considered. A correction factor obtained in this way may be entered into the results in Hammerlink.

Measurement principle
In practice it is very simple to measure the carbonation depth using an indicator solution of phenolphthalein in ethanol. The indicator is simply sprayed onto a fresh fracture surface or core sample.

A non-carbonated layer with a pH of > 9.2 shows purple.
A carbonated layer with a pH < 9.2 shows colourless.

pH < 9.2 colourless (carbonation is present)

pH > 9.2 purple (no carbonation is present)
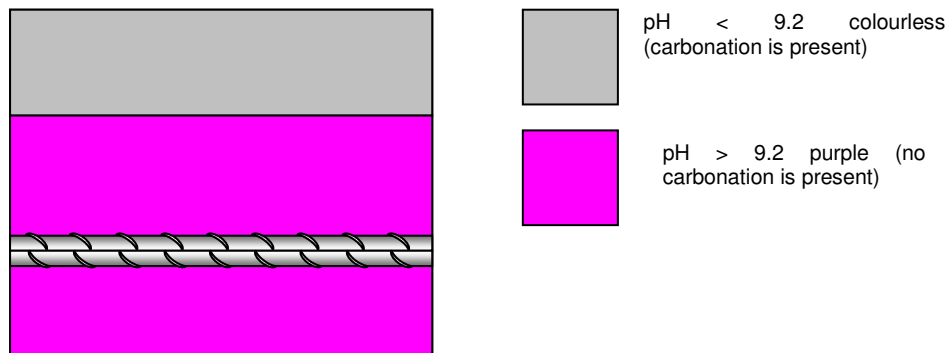
A number of recommendations describe the procedure for carrying out a carbonation test. Two are mentioned here.

- DAfStb: Prüfung von Beton, Empfehlung und Hinweise als Ergänzung zu DIN 1048, Heft 422, Berlin, 1991
- RILEM recommendation CPC 18. Measurement of hardened concrete – Carbonation depth.