

Deep Purple and Rainbow Indicator

Purpose

Deep Purple and **Rainbow Indicator** are used to determine the depth of carbonation in samples of field concrete. Carbonation depth can be used for the following purposes:

- To evaluate the cause of corrosion when conducting corrosion surveys
- To estimate service life where penetration of the carbonation front is critical
- To monitor the effectiveness of procedures for re-alkalization of the cover layer
- To make a rough estimate of concrete strength from the age of concrete and the relative humidity

Principle

The natural alkalinity of cement paste in concrete results in a protective oxide coating on steel reinforcement that prevents the steel from rusting. When carbon dioxide (CO_2) in the air penetrates into concrete, it reacts with the calcium hydroxide (CaOH_2) in the cement paste producing calcium carbonate (CaCO_3). This reaction is called **carbonation**, and it causes the alkalinity of the paste to decrease, that is, the pH decreases below its normal value of about 13. When the pH drops below 9, the protective oxide coating is destroyed and, in the presence of moisture and oxygen, the steel will corrode. Thus measurement of the depth of carbonation is an essential step for corrosion evaluation of a reinforced concrete structure.

To measure the pH of the cement paste, a freshly broken piece of concrete or a newly cut core is sprayed with the indicator, and allowed to dry. The approximate pH of the paste is indicated by colors as illustrated below.

Deep Purple Indicator



Rainbow Indicator



Accuracy

The carbonation front measured with the **Deep Purple Indicator** represents where the cement paste has a pH within the range of 8.5 to 9.5 as shown above.

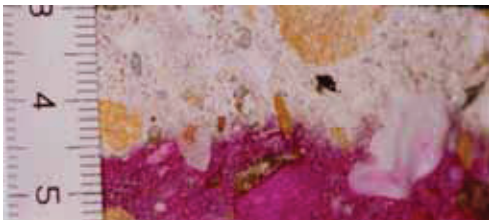
The results of the **Rainbow Indicator** were correlated with the depth of carbonation determined by petrographic thin section analysis for a wide range of concretes with varying slump, with or without calcium chloride or fly-ash, different water-cement ratios, varying degrees of consolidation and different finishing methods. The results were published in:

Campbell, D.H., Sturm, R.D. and Kosmatka, S.H., "Detecting Carbonation," *Concrete Technology Today*, Vol. 12, No. 1, March 1991, Portland Cement Association, USA

The results indicated that the depth of carbonation determined from thin section analysis correlated with the depth where the **Rainbow Indicator** indicated a green color or pH of 9 as shown above.

On normal concrete, the depth of the carbonation front can be determined with an accuracy of $\pm 10\%$ to $\pm 15\%$.

Testing Examples



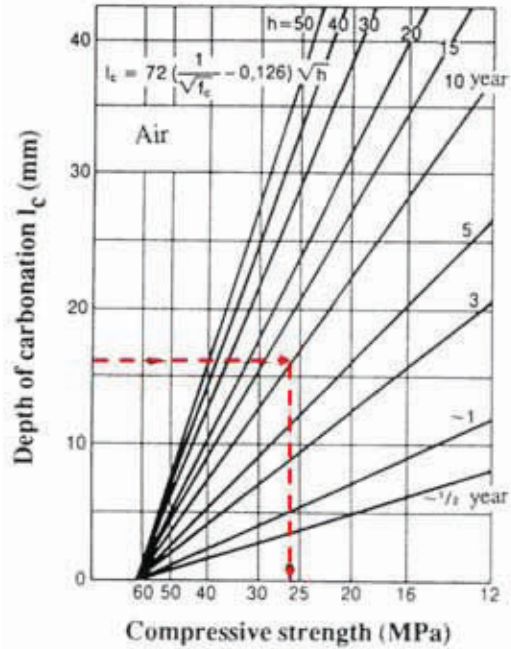
*The depth of carbonation evaluated by the **Deep Purple Indicator**. An average depth of carbonation of 16 mm was measured.*

Deep Purple and Rainbow Indicator



Shown in the photo to the left, the pH profile was evaluated by the **Rainbow Indicator** on a newly cut core. The first 2 to 3 mm from the surface is colored red to yellow indicating a pH of 5 to 7. The green color, corresponding to a pH of 9, is dominant at a depth from 4 mm to 7 mm. A pH higher than 11 is indicated by the blue and purple colors, deeper than 7 mm. Also note that some of the aggregates had a reddish color indicating a pH of 5.

The figure to the right illustrates the approximate relationship between depth of carbonation l_c in mm, the compressive strength f_c in MPa, and the age of the structure h in years for exposure to a 50 % relative humidity. In the example shown, the depth of carbonation was measured to be 16 mm for a 10-year old structure. This implies that the concrete compressive strength is about 25 MPa. Alternatively, the graphs, or the given equation, can be used for service life estimation, where service life is defined as when the carbonation front reaches the depth of the reinforcing steel. As an example, for a cover depth of 25 mm, if the depth of carbonation is 4 mm at the time of testing and the compressive strength is 25 MPa, the carbonation front will reach the steel (an additional penetration of 21 mm), in approximately 22 years. For a relative humidity different from 50 %, a correction factor has to be applied to the graphs.



Average relationships between depth of carbonation, compressive strength, and time of exposure in air at 50 % RH. Source: "The Concrete Book," CTO, Aalborg, Denmark

Ordering Numbers



RI-7000 Deep Purple Indicator
Set of 4 spray bottles, 80 mL each



RI-8000 Rainbow Indicator
Set of 4 spray bottles, 80 mL each

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