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Tech Hotline

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Sto Protective Coatings and Concrete Carbonation

Protective coatings are an effective way to retard carbonation of portland cement concrete and extend the service life of concrete structures. The carbonation process is complex, and the terms used to evaluate the effectiveness of coatings against carbonation can be confusing. This Tech Hotline presents some simplified explanations for use when selecting protective coatings for concrete where carbonation is a concern.

The Carbonation Process and Its Effects

Carbonation is the reaction of calcium hydroxide ($Ca(OH)_2$) in hydrated cement paste with atmospheric carbon dioxide (CO_2) to form calcium carbonate ($CaCO_3$). Carbonation results in a lowering of the pH of the concrete, which results in diminished corrosion protection for embedded steel reinforcement.

Carbonation progresses into the concrete mass from exposed surfaces over time. The rate at which carbonation occurs in concrete depends on the quality of the concrete and the atmospheric conditions to which the concrete is exposed. Dense, high quality concrete is not as permeable to air and CO_2 as poor quality concrete. Therefore high quality concrete will carbonate at a slower rate than poor quality concrete under the same conditions.

Protective Coatings

Organic coatings have been proven to be effective in reducing the rate of carbonation because they can be much less permeable to CO_2 than the concrete itself. The coatings seal the surface pores of the concrete with a material that the CO_2 cannot pass through easily, thus slowing the carbonation reaction. This is particularly important in structures where insufficient concrete cover is provided for embedded steel reinforcement, or where poor quality concrete allows a rapid rate of carbonation.

The effectiveness of a coating as a carbonation retarder is evaluated using laboratory methods to measure how easily CO_2 diffuses through the coating. A test cup is prepared by placing the coating over a CO_2 absorbent material. The cup is placed in a CO_2 rich environment, which tends to drive the CO_2 through the coating into the absorbent material. As the cup absorbs CO_2 it gains weight. The rate at which it gains weight is used to calculate a *CO_2 diffusion resistance rate:* μCO_2. The diffusion resistance rate multiplied by the coating thickness (meters) gives the *diffusion resistance* of the coating: S_D (meters). Dipl.-Ing. Robert Engelfried and Prof. Dr.–Ing. H. Klopfer of the University of Dortmund, Germany, developed the test method and its interpretation.

By definition, concrete with no coating has $S_D = 0$ m. Since a coating has diffusion resistance (μCO_2) and thickness, S_D can be calculated for the coating.

Example:

For a coating with:
μCO_2 = 900,000
Thickness = 200 micrometers (8 mils)
$\mathbf{S}_D$ = 900,000 x 0.0002 m = 180 m

We can see from the example that higher $\mathbf{S}_D$ values indicate increased resistance to carbonation. Engelfried and Klopfer established that an $\mathbf{S}_D$ > 50 m is required for a coating to be considered a carbonation retarder. (1) The larger the $\mathbf{S}_D$ value, the slower the rate of carbon dioxide diffusion into the concrete and the slower the rate of carbonation.

One can see that the $\mathbf{S}_D$ value is influenced by both the carbon dioxide diffusion rate (μCO_2) and the thickness of the coating.

Sto Protective Coatings

Sto Corp. contracted with the University of Dortmund to measure the carbon dioxide diffusion rate (μCO_2) and CO_2 diffusion resistance ($\mathbf{S}_D$) of various Sto coatings. Test results are presented for the dry mil thicknesses recommended by Sto Corp. for the various coatings. The results of the testing are summarized below:

Coating	Thickness (dry mils)	CO_2 Diffusion Resistance Rate, "μCO_2"	CO_2 Diffusion Resistance "$\mathbf{S}_D$" (meters)
StoCoat™ Acryl	7	1,160,000	174
StoLastic Smooth	11	496,000	144
StoSilco® Lastic	11	491,000	142
StoCoat™ Acryl Plus	8	1,400,000	200
StoCoat™ Acryl Medium	17	317,000	140

Reference:

[1] Engelfried, R., "State-of-the-art of Concrete Refurbishment Measures within Europe, especially in Germany", Presentation to International Concrete Repair Institute Annual Meeting, October 1996, pp. 7-9.