STRUCTURES DATA SHEET 5
Carbonation of Concrete

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Carbonation is a particularly important form of deterioration. Strangely enough carbonation gives concrete the immediate positive effects of increased; compressive strength, modulus of elasticity, surface hardness, and resistance to frost and sulphate attack. More importantly, it reduces the alkalinity of the concrete which leads to the corrosion of the reinforcing steel. The increased volume of the resulting corroded steel results in internal stresses, spalling and delamination, and the ultimate reduction of the structure's capacity.

Calcium hydroxide, $Ca(OH)^2$, is formed during cement hydration, and because of the high alkalinity of calcium hydroxide, the presence of calcium hydroxide will ensure a high pH-value in the concrete. The pH-value is roughly constant, as long as calcium hydroxide is present, no matter the content of calcium hydroxide.

Phenolphthalein reaction on carbonated concrete

During the carbonation process, calcium hydroxide reacts with carbon dioxide, CO^2, from the atmosphere. When all calcium hydroxide in an area has reacted, the pH-value in the area decreases. If two types of concrete have different initial contents of calcium hydroxide, the one with the lowest content will be most sensitive to carbonation, because the carbonation front will travel faster. This means the initial content of calcium hydroxide in hardened concrete expresses a kind of carbonation potential. The carbonation process also causes bound chlorides to be released which produces a higher concentration of soluble chloride immediately in front of the carbonation zone.

Testing is undertaken by applying a phenolphthalein solution to a freshly fractured or freshly cut surface of concrete, noncarbonated areas turn red or purple while carbonated areas remain colourless. The phenolphthalein indicator when observed against hardened paste changes colour at a pH of 9.0 to 9.5. The pH of good quality noncarbonated concrete without admixtures is usually greater than 12.5.

Carbonation is understood to be time-dependent. However, Figure 1 indicates that for this sample size carbonation damage cannot be predicted based on age of the structure. While there were no marked trends in carbonation depth vs. building orientation for any individual city, carbonation generally tended to be greatest on the south side and least on the north side.

The presence of carbon dioxide from vehicle exhaust corresponded to levels of carbonation, thus carbonation rates were found to be higher at the bottom of high-rise structures than at higher elevations. An exception to this finding occurred at one site where high levels of carbonation were thought to be caused by the presence of a rooftop exhaust fan.

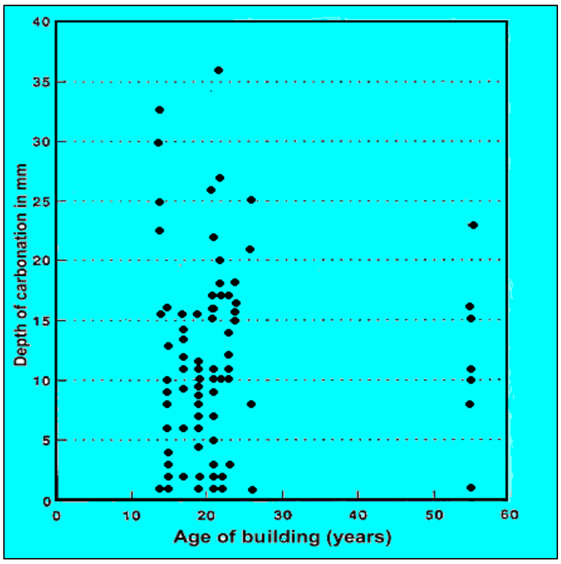

Figure 1 – Depth of carbonation v age of concrete

References:

BS 1881: Part 201: 1988 – Testing Concrete, Methods for analysis of hardened Concrete
BRE Information Sheet: 1981 - IP6/81

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