tion of iron oxide around the rebar, which results in the expansion in volume of the corrosion products causing the concrete to spall. This eventually leads to cracking or sections of concrete breaking away from the rebar. It is observed where the iron oxide was building up at the brown/black line.

Another way that corrosion of rebar can cause concrete failure is through carbonation, delamination, or spalling.

The salt slowly permeates the concrete and corrodes the rebar, reducing the thickness of these critical support structures over a period of years. For aging reinforced concrete, the process is decades in the making and is presented in Figure 4.

Figure 5 is a close-up photograph of the rebar inside core sample with thickness loss shown at the top. The corrosion risk was captured early on. Corrosion mitigation and cathodic protection prevented catastrophic failure in this 100-year-old building.

FIGURE 5 Close-up photograph of the rebar inside core sample with thickness loss shown at the top. The corrosion risk was captured early on. Corrosion mitigation and cathodic protection prevented catastrophic failure in a 100-year-old building.

Carbonation

In older concrete structures, carbonation occurs at the exterior surfaces. The process of carbonation will cause the carbonated surface layer to shrink and crack. Cracks from carbonation tend to be shallower than cracks from initial drying shrinkage. Carbonation can be detected by pH measurement.

Synergistic Effects of Carbonation and Chlorides

The chloride content at the carbonation front has reached higher levels than in uncarbonated concrete and can be much higher than the levels measured just below the concrete surface. This increases the risk of corrosion initiation when the carbonation front reaches the reinforcing steel.[1] The decrease in pH of the carbonated concrete also increases the risk of corrosion because the concentration of chlorides necessary to initiate corrosion, i.e., the threshold value, decreases with the pH. This is because the chloroaluminates break down, freeing the bound chlorides as the pH drops.

Conclusion

Corrosion risk assessment of aging concrete structures should include analysis of load conditions for potential cracking, vibrational issues, rebar corrosion, carbonation, and chloride-induced corrosion. It is critical that condition assessment should include both structural engineering as well as corrosion engineering analysis. Structural engineers must therefore work closely with corrosion engineers in this endeavor.

References

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