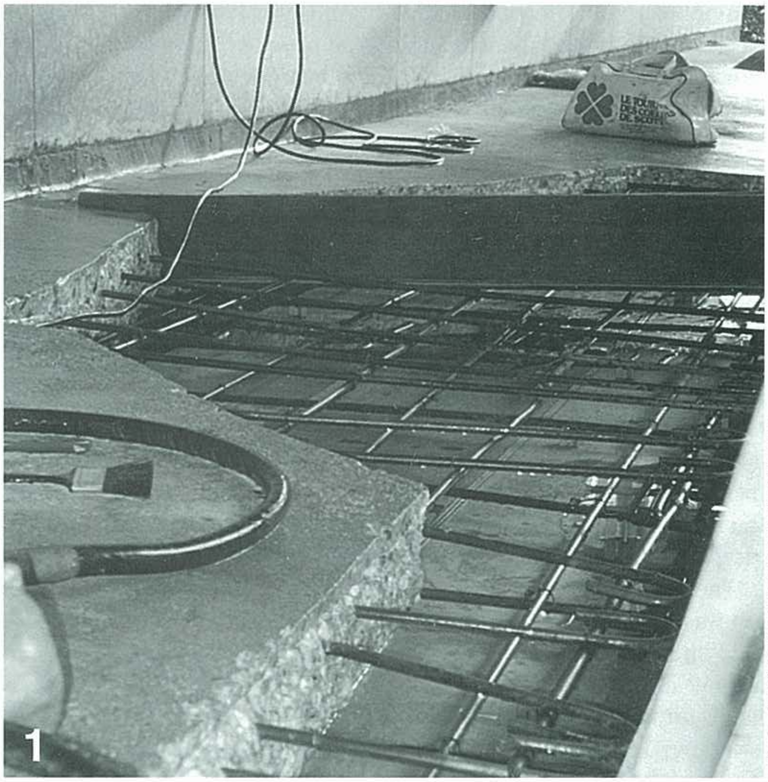
Repair Of Poured Concrete

by Susan D. Turner

Concrete has been a building material forever, correct? Actually, the material as we know it today was developed in England around the 1820s as a mixture of Portland cement, sand and water in varying proportions. Over time, other materials have been added to it—colourant, air entrainment, and setting agents. Concrete became especially popular with Bauhaus architects in the 1920s and then through the 1950s when it was widely exploited in Modern architecture as an "honest" material.



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Level of deterioration, near the perimeter and gutter.

What causes the deterioration of concrete? Aside from problems brought about by structural failure, there are several mechanisms responsible for deterioration: freeze/thaw cycling, attacks by sulphates or salts and carbonation. These mechanisms occur naturally or are man-made. The susceptibility of concrete depends on its composition and its relationship to the ground or weather.

Mechanisms Responsible For Deterioration

Freeze/thaw cycling occurs as the weather alternates between very cold (freezing) weather and warmer (thawing) weather. Concrete is porous and absorbs moisture through rain or by contact with wet soil. As water enters concrete and freezes, it expands. Air entrainment can supply tiny, discontinuous air bubbles to concrete, which then makes room for water to expand. In earlier periods, concrete was produced without air entrainment, resulting in fractures. When this occurs, more water enters the concrete causing ice to form, which in turn causes more fractures.

Sulphate attack is caused by the chemical reaction between minerals carried by the soil and groundwater and sub-surface concrete. This results in a breakdown of the cement paste and the subsequent crumbling of the concrete. Current building methods employ sulphate-resistant concrete to prevent this problem.

Salt attack is generally a man-made problem stemming from the use of salts to melt ice on roadways. This salt is carried by the melt-water to concrete structures where it attacks the steel reinforcing rods, causing them to rust. Rust being greater in volume than the original steel, it expands and fractures the concrete. This process is called rust jacking. Damp salt air in marine environments produces similar effects.

Carbonation of concrete is caused by carbon dioxide which can be airborne in smog or water-borne in acid rain. Carbon dioxide, in the presence of water, reacts with the chemical composition of the concrete, causing minute cracks and crazing on the surface. While the damage may not be significant at first, the problem escalates when combined with freeze/thaw cycling. Carbonation is a man-made problem associated with air quality and generally only affects the exterior of the building.

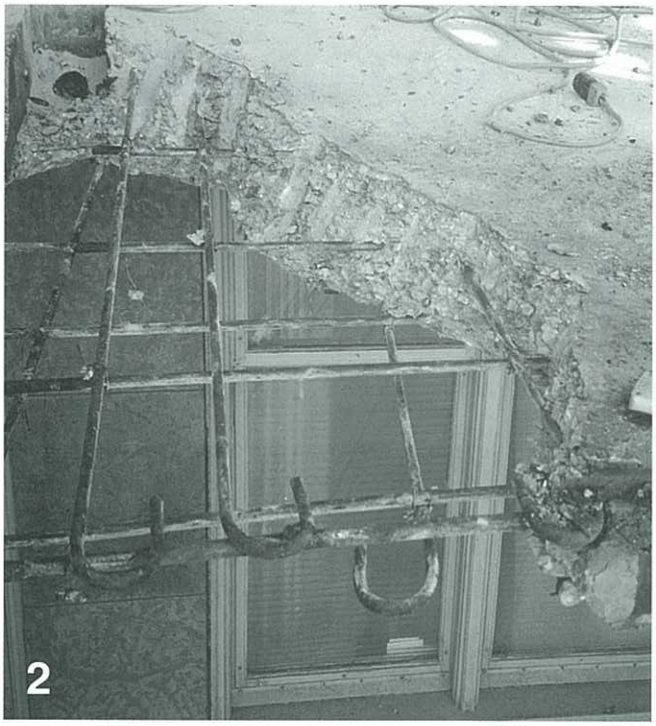
A Case Study: The Winnipeg Clinic

Horizontal concrete sunshades on this building were initially subject to sulphate attack. Although Winnipeg is not known for acid rain or smog, the building is adjacent to a major bus route where buses spew fumes upward through vertically mounted exhaust pipes—good news for pedestrians and cyclists, but bad news for buildings. Over time, carbon dioxide in the fumes builds up on the building, mixes with rain, and causes a chemical reaction which damages the surface of the concrete.

In addition, the waterproofing membrane, composed of a tar-and-gravel roof system, was not maintained. The concrete is basically flat and was designed to shed water via through-wall drains. But, as these became blocked, water was trapped on top of the roofing which infiltrated the deteriorated membrane, causing it to debond and expose the concrete to water. Since the sunshades are on the south and west sides of the building, the exposure created a lot of thawing by day, even when temperatures hovered at -5°C. At night, the temperature dropped, and the melt-water froze. This cycling caused more and more deterioration. As moisture penetrated deeper, it corroded the reinforcing steel (Figure 1).

There were two ways to address the problem. The cheapest was to remove the sunshades. This decision would have had dire repercussions, ranging from a total character change in the clinic's appearance to an increase in heating loads for the building due to additional thermal gain at the windows. Luckily, the client was sensitive to the unique aesthetic of the building and opted for repair. This entailed removing unsound concrete, which in some cases involved up to 75% of the area (Figure 2). Where the reinforcing was only slightly rusted, it was sandblasted and retained. In heavily deteriorated areas, the steel was cut away and new pieces dowelled into the remaining sound concrete. The edge of the slab was formed to match the existing profile, and new concrete was poured.

Once the concrete was in place, the top surface was waterproofed with a two-ply modified bitumen roofing system which was similar in appearance to the original built-up roofing, but thinner. It was also more conducive to be used as flashing around the perimeter, thus preventing the water from seeping around the edges and into the concrete. The drain holes were cleaned out and checked for flow and the slopes on the top surface of the sunshades were improved to hasten drainage. Finally, to minimize the difference in appearance between the old and new concrete, a breathable sealer was applied to the soffit (underside) for an even look. Where possible, the original hammered metal fascias were retained and reinstalled.



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Unsound concrete removed, rusted reinforcing steel.

Conclusion

It is better to repair a feature on a heritage building than to remove it. As concrete is a very plastic material, new material can be patched into the original with relative ease. Where appearance is critical, test concrete mixes can be refined to match the original, thereby making the patches undetectable.

Application of sealers to concrete is popular. Sometimes they are used to improve water-shedding capacity, or for an anti-graffitti coating. They should be applied only after research is conducted to find the appropriate product. Some sealers are "breathable"; i.e., they keep water from entering, but let water vapour out. If a non-breathable coating is applied to the surface, moisture within the building becomes trapped and can freeze. This is the beginning of the end. As the freeze/thaw cycle takes over, it breaks down the substrate over time.

It is very important in "modern heritage" buildings to assess any change in appearance that even a breathable coating can bring. If the appearance of the concrete is a distinctive element, a poorly chosen sealer can detract from the building. It is best to consult an architect or engineer who is knowledgeable in coatings and sealers before choosing one for your building.

References:

Weaver, Martin. *Conserving Buildings: A Guide to Techniques and Materials*. New York: John Wiley and Sons, 1993.

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