Enhancing Durability of Stone Cladding Corrosion Restoration and Repair

By Julie Holmquist

Fig. 1: Stav Street residential building during repairs (image courtesy of Glimmer Industrial Consultation)

Fig. 2: Stav Street residential building after repairs completed (image courtesy of Glimmer Industrial Consultation)

Stone has been a traditional building material in Israel since ancient times. However, according to an engineering presentation given at a January 2018 Construction Convention in Israel,[1] with the development of reinforced concrete and its ability to meet the demand for rapid, cheap construction in the early years of Israel's statehood, concrete and plaster took the stage as the main construction materials from the 1950s and onward. In the 1980s, the use of stone as a decorative element began to be sought after as an architectural sign of prestige. This brought about the popularity of reinforced concrete structures enhanced with stone cladding façades. Today, several cities in Israel, including Jerusalem, require construction plans for residential and public buildings to include stone cladding on part or all of the structure. Unfortunately for building owners, these structures can experience problems with corrosion and failure of cladding anchors, causing stone cladding tiles to loosen and fall.

This article highlights three stone cladding repair projects that incorporated migrating corrosion inhibitors for enhanced durability. Rather than simply repairing and replacing the damaged tiles, allowing the same issues to recur, the inhibitors were applied to mitigate the root problem of corrosion. This is critical considering the difficulty and costliness of such repairs. Compared to total repair cost, migrating corrosion inhibitors typically comprise only a small fraction of the expense, serving as an economical "insurance policy" to minimize the need for future restoration. An estimated two dozen such repairs using migrating corrosion inhibitors have since been performed throughout Israel, providing a more effective repair method for a common problem.

RESTORATION OF STAV STREET RESIDENTIAL

A residential building constructed in Hod Hasharon, Israel, circa 1999, began to have problems with stone cladding tiles detaching and falling off within about five years

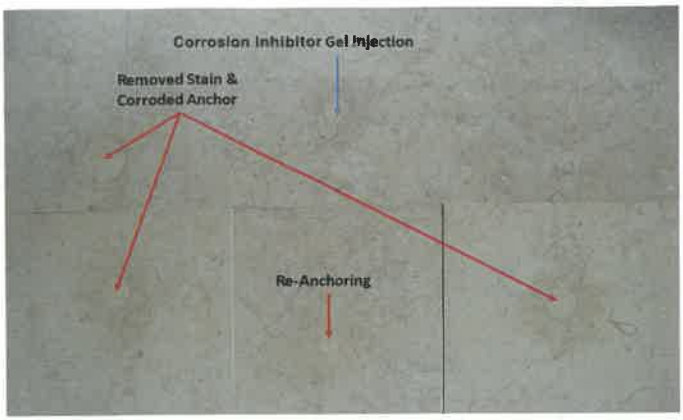

Fig. 3: Portion of Stav Street residential building wall showing locations of inhibitor gel injection, removal of stains and corroded anchors, and re-anchoring of tile (image courtesy of Glimmer Industrial Consultation)

of construction. Corroding reinforcement and cladding anchors were identified as the root problem. Seven years of legal litigation ruled that a gel containing migrating corrosion inhibitors should be injected into the walls as part of the repair work.

The restoration of approximately 270,000 sf (25,000 m^2) of surface area was completed in 2011 at a total cost of over $2 million USD. Once the cracked and loose cladding tiles were removed, corrosion stains and corroded anchors were drilled out of the walls and filled with repair mortar. New screws were used to re-anchor the tiles, and pieces cut from the original cracked tiles were used to cap the holes to minimize change in surface appearance. To inhibit further corrosion, holes were also drilled intermittently throughout the cladding to allow the injection of the corrosion inhibiting gel, designed to release corrosion inhibiting vapors that would work their way through concrete pores and voids behind the tiles to deter corrosion on cladding anchors and reinforcement (Fig. 1, 2, and 3).

Six months after gel injection, testing was performed that confirmed the presence of inhibitor in the concrete. A visual inspection at five years found no new corrosion stains. As of the last review in November 2017, a year after the 5-year inspection, the building repairs were still in good condition, as opposed to an adjacent building where additional work had been required to remove new corrosion stains.

AD-120 RETIREMENT CENTER

The Ad-120 Retirement Center (Fig. 4) was completed in the year 2000. Similar to the Stav Street situation, problems with the stone cladding started to appear only four years after construction. Large voids developed behind the cladding, and corrosion damage on cladding hooks and reinforcement resulted in cladding tiles that cracked, detached, and began to fall off the building. A comprehensive rehabilitation program was developed between 2006 and 2012, and repairs took place in 2013-

Fig. 4: General view of Ad-120 retirement center (image courtesy of Glimmer Industrial Consultation)

2014. The repair encompassed approximately 150,000 sf (12,000 m^2) of surface area at a total cost nearing $2 million USD.

In addition to using stainless steel for the new anchoring system, an important part of the rehabilitation was to deter future corrosion through the use of two forms of migrating corrosion inhibitors. Where void spaces behind the stone tiles needed additional concrete cover, repair mortar admixed with migrating corrosion inhibitors was injected. A gel containing migrating corrosion inhibitors was also injected at periodic spacings along the grout lines to provide protection to cladding anchors and metal reinforcement underlying the surface (Fig. 5 and 6). Holes were capped with cementitious mortar, and grout lines were renewed. A visual survey several years later found no new corrosion damage.

BEN-GURION STREET RESIDENTIAL BUILDING

A residential building (Fig. 7) in Givatayim, Israel, had stone cladding tiles that began to detach and fall off in 2004, about 15 years after construction. Following an initial re-anchoring repair that did not incorporate migrating corrosion inhibitors, tiles continued to fall off and delamination of exposed concrete occurred. Corrosion was identified on both concrete reinforcement and cladding anchors. Corroding rebar was causing expansion beneath the tiles, making them unstable (Fig. 8). Despite the expensive repair completed in 2004, the building was in need of a second repair program in 2014, only 25 years after construction.

This time in 2014, the repair included migrating and vapor corrosion inhibitors to mitigate corrosion on rebar and cladding anchors. As performed at the Ad-120 Retirement Center, migrating corrosion inhibitors were admixed into repair mortars for repair of delaminated concrete. To minimize cosmetic damage to the building, holes were

drilled into the grout lines so that tablets containing vapor corrosion inhibitors could be inserted. Similar to migrating inhibitors, these corrosion inhibitors vaporize and diffuse throughout void spaces (e.g., concrete pores) to provide corrosion protection to embedded metals. The holes were capped and grout lines renewed, leaving the tablets to gradually release corrosion inhibiting vapor for future protection. A migrating corrosion inhibitor surface treatment was applied for additional protection to exposed concrete surfaces on the ground floor, where wet-dry cycles and fertilizer and pesticide application made the environment especially harsh. The repair covered

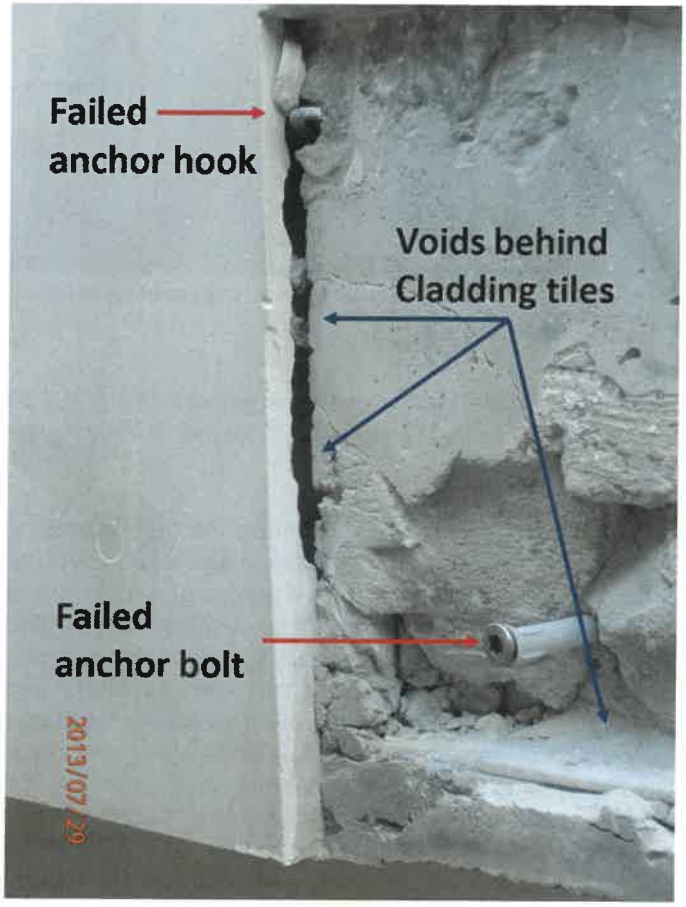

Fig. 5: Ad-120 retirement center wall showing failed anchor hook and voids behind cladding tiles where migrating corrosion inhibitors were injected in gel and/or repair mortar form (image courtesy of Glimmer Industrial Consultation)

Fig. 6: Locations of migrating corrosion inhibitor gel injection in grout lines at wall of Ad-120 retirement center (image courtesy of Glimmer Industrial Consultation)

Fig. 7: Ben-Gurion Street residential building during repairs (image courtesy of Glimmer Industrial Consultation)

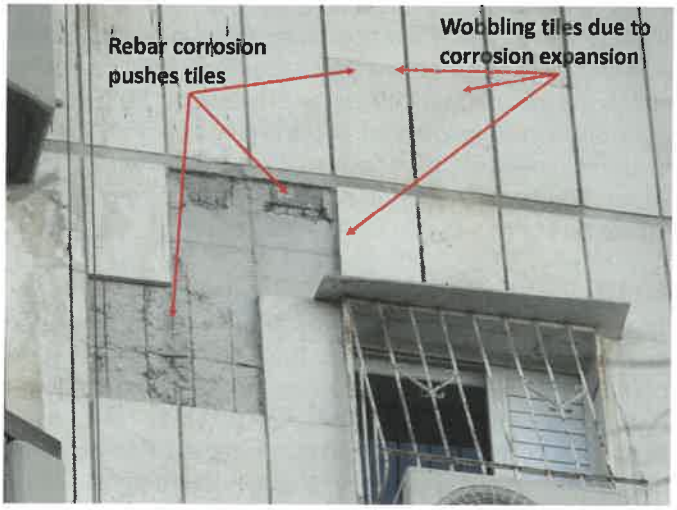

Fig. 8: Ben-Gurion Street building wall showing rebar corrosion behind tiles that led to tile detachment and failure (image courtesy of Glimmer Industrial Consultation)

approximately 270,000 sf (25,000 m²) of surface area at a total cost of over $2 million USD.

SUMMARY

These repairs offer a new outlook on a recurring problem for stone clad concrete structures in Israel. Given the costliness and complexity of stone cladding restoration, migrating corrosion inhibitors provide a practical and economical solution for extending the service life of repairs by addressing the root problem at a fraction of the total repair cost. The Stav Street Residential building project has already shown better performance than the structure's initial construction durability and is doing better than a nearby untreated structure with recurring corrosion problems. Since migrating corrosion inhibitors can be applied to existing structures with minimal damage to cosmetic appearance as an added bonus, the use of this method on approximately two dozen similar repair projects will provide additional data for future monitoring.

ACKNOWLEDGEMENT

Special thanks to Hadar Halperin Shoshany of Glimmer Industrial Consultation for providing images and additional details on these projects.

REFERENCES

1. Carol Wechsler, *Restoration of A Stone Structure Over Time,* Wechsler Engineers, presentation at Construction Convention, Israel, January 10, 2018.

Julie Holmquist is Marketing Content Writer at Cortec Corporation. She has three and a half years of experience in the corrosion control industry and has written for numerous publications on the topic of corrosion inhibitors for reinforced concrete structures. She holds a B.A. degree from the University of Northwestern, Saint Paul, MN.