Marble Conservation at the Dominion Public Building, Hamilton, Ontario

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Abstract

This paper discusses the conservation treatment of marble cladding on the walls of the great postal hall of the Dominion Public Building in Hamilton. The original bond between the marble cladding and its terra cotta backup wall had been plaster of Paris adhesive. Scanning the surface with a miniature but high-powered radar antenna that had recently been developed provided conservators with a map showing the precise location, shape, and size of every patch of plaster adhesive. This non-destructive investigative technique made it possible to repair the bond where it had failed (either between the marble and plaster of Paris or between the plaster of Paris and terra cotta, or both) with very little disruption to the original building fabric. Also discussed is the additional mechanical connection that was established as a backup to the adhesive for each marble slab.

Modern Classicism became the preferred mode for urban federal architecture during the 1930's. The Dominion Public Building (by Hutton and Souter Architects, erected in Hamilton by the federal government between 1935 and 1937), was one of the "...large 'dominion buildings' that were built in many cities across the country to accommodate government offices, using funds released under the Public Works Construction Act."[1]

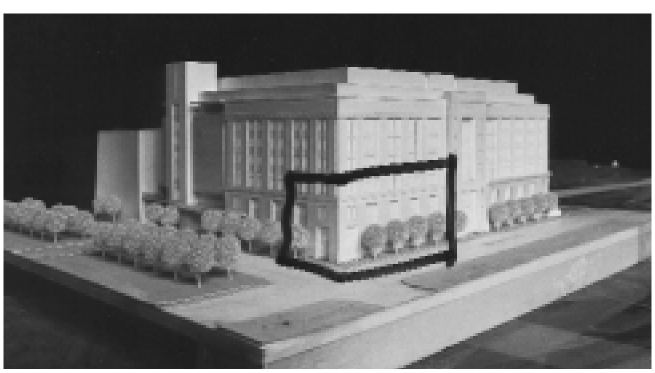

Figure 1. Architects' Model DPB 1935. Subject room marked.

The building housed the central post office, customs' officialdom, and all other federal government offices in the city of Hamilton until the 1980's, when it was declared redundant and sold to the Ontario Realty Corporation. On their behalf, Norr Partnership Architects thoroughly renovated the building between 1997 and 1999, and added considerable space. UMA Engineering and Martin Weaver Conservation Consultant were engaged to assess the building and report on the requirements from a conservation perspective. The original building envelope, the great postal hall, and the main elevator lobby were preserved in this adaptive re-use scheme. The building is currently used as Provincial Courts.

Description of subject rooms as found

The postal hall was a long, narrow room with a proportionately high ceiling. One side wall was pierced by large high windows to the street, while the other was lined with bronze-framed wickets used for the dispensing of stamps and other over-the-counter postal services. Three great electric chandeliers hung from the coffered plaster ceiling. Massive glass-topped bronze desks were provided for the convenience of patrons wishing to address letters. There was a large ceramic-tiled map of the young Dominion of Canada above the stamp windows. Two marble-tiled telephone booths were provided for public use. In all, it was a room designed to impress and engender confidence.

Figure 2. Postal hall of the Dominion Public Building is clad floor-to-ceiling in marble.

The postal hall and the adjoining elevator lobby were both tiled from floor to ceiling with marble panels. Intended to simulate ashlar, the panels were 38 cm (15 in.) high and were cut randomly up to 1.3 m (52 in.) in length. A 5-cm-high (2-in.) contrasting second marble type (to simulate the mortar joint) divided the larger courses. This material was of random length, up to 2.4 m (8 ft.). The actual grout joint between marble tiles was always less than 0.5 cm (3/16 in.).

The problem

In 1996, Martin Weaver was asked to form an opinion about the condition and stability of the marble cladding. The survey was necessary because:

a) there had been greatly increased vibration from truck traffic along two facing streets;
b) large swings in humidity and temperature in the building during the heating season had caused great stress on the type of connection used in the 1930's installation;[2]
c) there had recently been a significant increase in vibration within the building structure caused by the use of a motorized track-driven front-end loader and other demolition equipment on the floor above the subject rooms during the demolition phase of the current renovations.[3]

From temporary scaffolding, Weaver thoroughly sounded each of the 1200 panels for the quality of its connection to its substrate and mapped the results on his as-found notes. He concluded that the connection of a very substantial percentage of the slabs had suffered at least somewhat over time, and most decidedly over the recent past (during renovation and demolition and during the 5-year period when the building was closed to the public and minimally maintained).

In his "Preliminary Report and Recommendations for the Stabilization and Conservation of Limestone Exterior Masonry and Interior Marblework and Decorative Finishes of the New Provincial Courthouse in the Old Dominion Building, Hamilton, Ontario" (dated July 28, 1995), Weaver made the following recommendations:

> *For the consolidation/re-attachment of the marblework I recommend a method which was developed for "blind injection" for the consolidation and conservation of decorative plasterwork. The method was fist* (sic) *invented by Morgan Phillips, an architectural conservator now living in New York State* (now deceased). *Working subsequently on the conservation problems of Quebec's National Assembly building with Professor Ian Hodkinson at Queen's University, I developed an improved version of the formula using acrylic resins and a strange material called fluid petroleum coke.*
>
> *The new formula was successfully applied for the conservation of the very large plaster ceiling of the Salon Bleu of the National Assembly Building in Quebec. The specifications for the complete operation are given below.*
>
> *The work must be meticulously carried out and I would recommend that it be done by a conservator... or a conservation firm that has experience of the technique - such as Rod Stewart of Port Hope, Ontario.*

For more information, see also *The Conservation of the Ceiling of the Legislative Assembly Chamber of the National Assembly of the Province of Quebec, Canada* (a paper by Ian S. Hodkinson and Martin E. Weaver that was given to the 1980 Conference of the International Institute for Conservation, Vienna, Austria).

Clearly there needed to be a conservation plan applied to the marble cladding in any part of the building where it was to be retained. Historic Plaster Conservation Services (HPCS) was asked to develop and execute the marble conservation plan.

Objectives

The mandate of HPCS in this project was to devise a cost-effective and minimally intrusive method of achieving secure adhesion of the marble to its terra cotta speed-block substrate. The method had to meet the following objectives:

a) adhesion was to be achieved without the removal of the marble;
b) consolidation of the many broken stones in the band courses and elsewhere was to be achieved and verified with the stones in situ;
c) verification that the adhesion met the standard requirements was to be carried out as the work progressed.

The requirement to develop a program that would not require the removal of panels meant that a non-destructive investigation technique was required to explore the quality of the inner connections within the wall system.

Description of wall system

A 38-cm by 1.3-m (15- by 52-in.) block in the postal hall was typically connected with up to eight patches of plaster of Paris and two copper wires, one at each end.

In some cases the blocks had been set in place with the surplus plaster of Paris trimmed off the edges where it squeezed out (this had been accomplished by laying up the wall one block at a time, so to speak).

In other cases a line of blocks had been prepared and the squeezed-out surplus plaster of Paris left in place to serve as adhesive for the next adjoining block. This would have required very fast well-organized work to keep ahead of the fast-setting plaster of Paris. Unfortunately this method of laying a line of blocks seldom provided a strong bond.

Additional security had been provided by mechanically fastening each block to the substrate. The system consisted of malleable copper wire, cast with plaster of Paris into slots in the edges of the marble. These wires were then bonded to the terra cotta surface with more plaster of Paris during installation.

Given that the general failures of the adhesive were seen just as often at the terra cotta/plaster matrix as at the marble/plaster matrix, it was assumed that many or most of these mechanical connections had failed.

Excelsior, which had arrived on site as a packing material for the marble slabs, had sometimes been used as a filler material in the space between the marble and terra cotta. The intention seems to have been to prevent the plaster of Paris from slumping or indeed falling to the floor when the production line block laying was attempted. No excelsior was found in areas where blocks had been laid up individually and trimmed of excess plaster of Paris. The porous and dry nature of the excelsior probably had a speed-up effect on the plaster of Paris, further contributing to its poor bond.

There were four different conditions of attachment (detachment) present throughout the site:

a) marble was attached securely to plaster of Paris, and plaster of Paris was attached securely to terra cotta (this is the ideal situation as built);
b) marble was attached to plaster of Paris but plaster of Paris was detached from terra cotta;
c) marble was detached from plaster of Paris but plaster of Paris was securely attached to terra cotta;
d) plaster of Paris was detached from both marble and terra cotta (in this case the plaster of Paris was usually held in place only by friction of its two outside surfaces).

There could be all or any combination of the four detachment conditions described above on any given block. In addition, it was assumed that a large proportion of the mechanical fastening had failed.

The root causes of failure

1. The marble work in the postal hall took place long after the rough interior speed-block partitions had been erected. Therefore, an accumulation of construction dust built up on the interior partition walls between the time they were built and the time they were tiled.

2. The marble slabs arrived from Italy by ship in wooden crates packed in excelsior. The polishing rouge (the final polishing medium that gives the final smooth glossy finish to a stone) is customarily not removed at the polishing works; rather it is left on the stone as a protection against other contaminants and dust.

3. These two conditions (i.e. dust on the substrate and rouge on the marble surface) require that the work site have a large free-flowing supply of clean water for rinsing and cleaning stones and substrate prior to installation.

4. In the 1930's, the marble trades in Hamilton were dominated by the Italian immigrant community that had established itself there after the turn of the century. Scots immigrants who had preceded them in the previous century dominated construction management and masonry trades. It is unlikely that there would have been many bilingual Scots/Italian foremen and trades workers at the time this building was erected because in Hamilton (as elsewhere in the Dominion) these immigrant communities remained cultural solitudes in isolation. Communication perforce was not easy on the site.

5. Picture, if you can, pails of freezing cold water being delivered to men working on rickety scaffolding for the purpose of giving the marble slabs a final rinse. The subject stone would be stood up on end and wiped from top to bottom with a soaking wet rag. [Imagine doing this in winter in a virtually unheated building!] It is likely the top of the slab would get the best rinse while the bottom would be very much less 'clean'. Now imagine the same right-handed worker performing the same action repeatedly (consistency is an essential element of good trade practice) with each stone along a particular lift of slabs. The result is that along any given line of individually laid slabs, the right-hand sides typically had far better attachment than the left-hand sides. [And this is exactly what we observed.]

6. To give this picture some rhythm, now imagine the delivery to the work station of 'about-to-set-up' plaster of Paris adhesive setting the pace of work. It is not surprising that bonding became inferior as we rose from the floor as this was further from the mixing point of the plaster of Paris. [This was also observed.]

7. In the locations we could inspect because slabs had been removed, failure between marble and plaster invariably involved polishing rouge left on the marble surface and not integrated into the plaster adhesive. Similarly, at the terra cotta surface the contaminant was construction dust.

Therefore, any in situ re-attachment would have to consolidate these two contaminants into the adhesive system.

Simulated mortar joints

The dark brown bands that simulated mortar joints in the postal hall (reported to be of *rosso antico* marble) were extremely fragile. Fissures and cracks were plainly evident in any given section. The material, which is of uniform dimension throughout the hall, had simply been cut to length from a random-length inventory brought to the site on wooden frames similar to geological core sample frames. If this material was dislodged from its present setting, a great percentage of it would crumble and suffer irreparable damage. These bands were typically bonded along their entire length with plaster of Paris, much of which had failed. Sounding was not necessary to establish that much of the body of this marble had also failed. In addition, it was clearly evident that most if not all of it would be lost if it was removed from its present location in any normal construction site manner.

Therefore, an in situ conservation method using a medium that would be suitable for the consolidation of fractured marble was needed.

Non-destructive investigation (NDI)

Sounding with a rubber mallet is a time-honoured method for identifying the existence of fractures within structures, but precision (finding the exact location of fractures) requires techniques beyond the sensitivity of sounding.

Three NDI approaches were explored[4] for this project: impact echo, ultrasound, and ground penetrating radar.

Impact echo and ultrasound were both able to tell us something about the conditions within the wall. Unfortunately, however, they only gave information about the immediate location of the test and they both required that the test subject, in this case the marble wall cladding, be smeared with petroleum jelly for better pickup by the transducers they use to gather data. Either of these systems would have been far too expensive and would have put the marble surface in some danger when removing the jelly.

Ground penetrating radar (GPR) was the third option. GPR has been widely used with large-sized antennas for the investigation of concrete slabs, roadbeds, and even graveyards, but it is the miniaturization of radar antennas by a Canadian company (Geophysics GPR International Inc.) that made this technique useful. The important development here is that the 1-GHz radar antenna is about the size of a videocassette. This antenna is ideal for walls, typically requiring high resolution and a shallow depth of penetration.[5]

A technician passes the radar antenna along the wall surface and in so doing generates a real-time representation of the interference the radio frequency meets as it penetrates the wall and returns to the antenna. This interference is displayed on a monitor, and the collected data are analysed. The technician then interprets the wave patterns as locations of adhesive behind the marble cladding and marks them on the wall surface with a water-soluble marking pen. With this information (the location and size of the adhesive plaster patches behind the surface) the task then becomes one of devising a good means of addressing the conditions found.

Consistency of trades is a pleasure to appreciate

After a few days of scanning, interpreting, and marking patches on the wall surface, patterns began to appear and a consistency of approach became evident. [An uncanny feeling of being in the presence of the long ago deceased worker laying up this marble is all part of the appreciation of workmanship. Clearly a skilled worker had taken a consistent approach to the same task performed under the same circumstances repeatedly over time. These workers would have understood innately, as we do in the late 20th century, that repetition enhances productivity.] We

Figure 3. Technician passes 1-GHz antenna across the wall surface.

Figure 4. Data are collected and displayed on a monitor for interpretation. With practice, a technician can interpret the wave patterns.

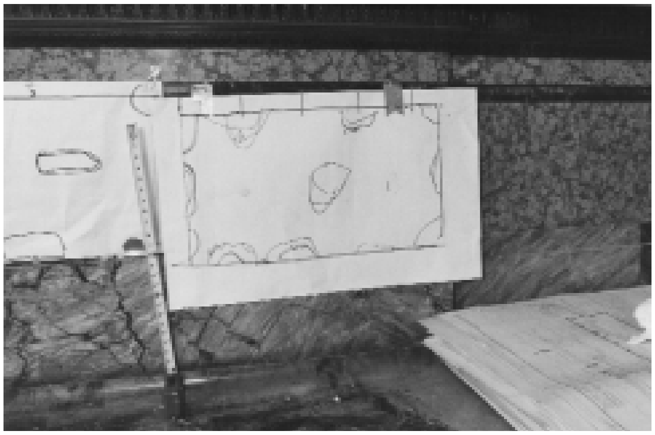

Figure 5. In our blind test, the technician made these marks on newsprint taped to the marble surface.

Figure 6. Once the test indicated that the procedure located the plaster adhesive patches with 90% accuracy, the survey continued.

found that most long slabs had three patches along the top edge, one on each end (over the wires), and one or two along the bottom edge. Any plaster in the middle seemed to have been put in at random and was of little consequence. It was probably placed there to cut down on possible vibration of longer slabs.

This observation did not lead us to cease the scanning exercise. In fact, it became even more interesting when the technician started marking locations inconsistent with the previously observed pattern.

What were we to make of a series of slabs along a line that seemed to have a consistent stream of plaster of Paris on all four sides but that vibrated 'to beat the band' when sounded? The answer, as it turned out, was the skilled tradesman's worst nightmare—speed-up.

In some locations where the opportunity presented itself, the decision had been taken to lay up a long line of slabs simultaneously. Cardboard shims had been placed along the top edge of previously laid slabs over a 6.1-m (20-ft.) section of wall. About-to-be-laid slabs had been washed down and leaned from the scaffold planks against the previously laid up marble. A line had been chalked along the future top edge of marble, and great splashes of plaster of Paris trawled onto the substrate along the line and along the top edge of the previously laid slabs. The slabs had been set in place one after another, then adjusted for final fit and shim thickness.

The problem inherent in this approach would have appeared when the final setting and end shimming were attempted. The workers would have placed 6.1 m (20 ft.) of slabs and then returned to the first one to fine-tune its location. But any movement after the immediate freeze that occurs when plaster of Paris is applied to a dry, dusty surface would have caused immediate and undetectable reduction in the quality of its bond.

In many cases where this line approach was taken, the only adhesive that was actually working was the incidental surplus that got squeezed into place with the setting of the next adjacent slab. The fine-tuning had disturbed the intended adhesive at the critical time of setting up.

[It is pure speculation on my part, but I wonder how site conflicts, trade practice differences (the line technique is perfectly acceptable and common in masonry applications), and inter-trade/cultural rivalry might have contributed to this problem.]

By sounding the wall in the precise known locations of adhesive, we could determine if a break in this specific adhesion had occurred. If it had, we were left to determine if the break was between the plaster and marble, or between the plaster and terra cotta, or both.

To do this, we drilled a 0.3-cm ($^1/_8$-in.) hole through the grout joint to the depth of the marble (i.e. just to the plaster surface). This could be determined by checking the drill bit for plaster dust. If the break had occurred between the marble and plaster, we were now intersecting it. Into this hole we gently pumped a wash of methanol using a lab

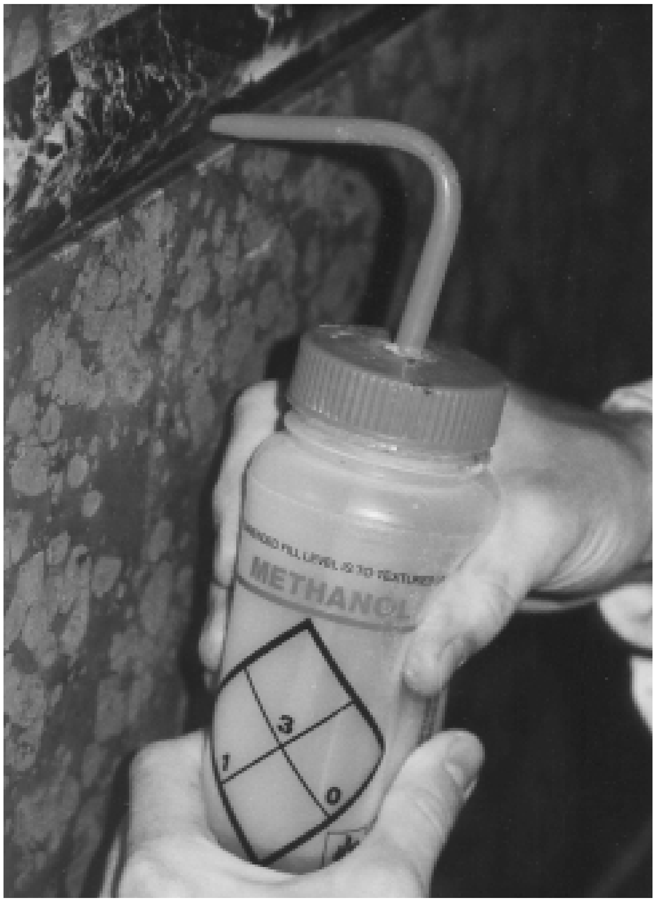

Figure 7. Methanol rinse being applied.

squeeze bottle. This rinsed out or dislodged any polishing rouge on the face of the marble. If the material streamed back out of the hole as quickly as it was delivered, we determined that there was probably no void to be found at this depth in this location. Several attempts were made along the grout line at this depth before it was considered sound. Because we knew that there had been a rattle here when this spot was sounded, we therefore could conclude that the break was to be found at the next level (i.e. between the plaster and the terra cotta).

In the case that the methanol was absorbed freely into a void (and this was readily noticeable with some experience), we concluded that we had discovered a break at the connection between the marble and the plaster. The treatment for this type of break is described below.

1. Continue to rinse the void with methanol until all the plaster face is wet and the contaminating rouge is dislodged or loosened. Some material may appear in the grout joint immediately below the subject location and this could be the result of saturation of the plaster or of the methanol wash simply running around the plaster at the surface. Experience indicated that when the material ran out immediately it was from surface run-off, whereas if run-out occurred after continued application there had been penetration. The total volume of methanol required for a typical treatment should not exceed 227 mL (8 oz.). [Note here that methanol has no harmful effects on the plaster of Paris and evaporates cleanly from it, but water as a wash agent would have a detrimental effect.][6]

2. Using the same tools, inject a dilute (20%) methanol/Rhoplex solution and observe its absorption. If the pre-wetting has been successful, the Rhoplex will be delivered throughout the break; it will consolidate the contaminant rouge and create the necessary bond. Repeat the injection twice, using 50% and then 100% Rhoplex. [A word about adhesives: The material selected for repairing the bonds addressed in this project is Rohm and Haas Rhoplex MC76. Rhoplex is a pure acrylic emulsion that can be diluted with methanol, thickened both chemically and with fillers. It is thixotropic (which means we can cause it to enter very fine spaces), non-toxic, water-soluble, and removable with toluene even when fully coalesced.][7]

3. Mark the spot for testing.

4. After a treatment is carried out at the first level (marble/plaster), let it coalesce and then re-sound the connection to determine if treatment at the second level (plaster/terra cotta) is necessary. [Suppose that the first break has been treated, coalescence has occurred, and re-sounding indicates continued vibration; we must therefore conclude that the break is between both materials and the plaster of Paris.]

5. Using the same hole, drill in the grout line through the plaster to the surface of the terra cotta and treat it in the same manner as the first break. The contaminant found here and either rinsed away or contained is general construction site dust that should have been washed off the substrate at the time of the installation.

7. Inspect after coalescence by sounding and pull testing.

Using this method, HPCS treated several thousand damaged plaster adhesive locations and successfully established a sound reconnection between the marble cladding and its substrate.

Mechanical fastening

It is always advisable when connecting heavy things to walls and ceilings in public spaces to provide a mechanical connection in addition to whatever adhesive might be present.

In the case of the marble cladding, the original mechanical adhesive was wholly inadequate because it only connected the marble to the face of the terra cotta with the same

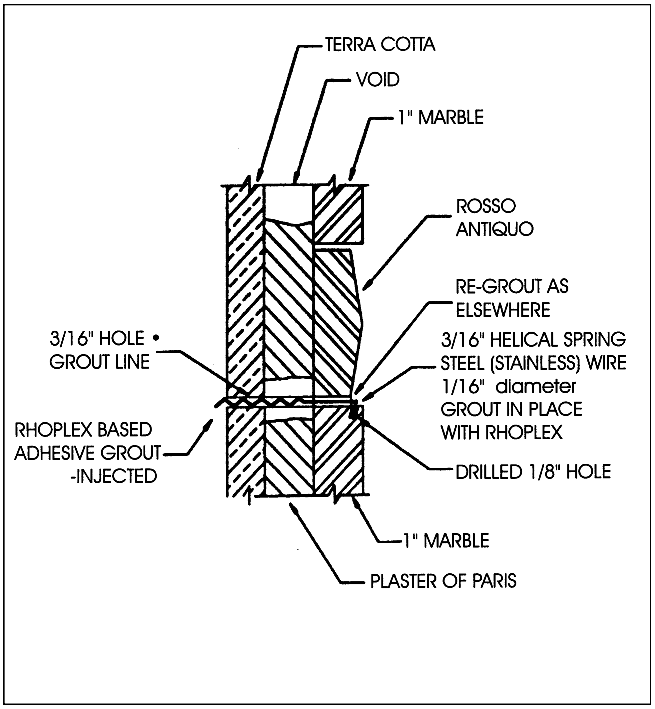

Figure 8. Cross section of marble cladding and wall showing mechanical connection.

Figure 9. A 0.08-cm (1/32-in.) hole drilled at 45° to accept the tail of the mechanical fastener.

plaster of Paris adhesive that had already been seen to fail in so many locations. It was determined that three wire fasteners per average tile would be required.

Our approach was to drill three 0.5-cm (3/16-in.) holes through the grout into or through the terra cotta. Along the top edge, two holes were located 15 cm (6 in.) from each end of each tile. Along the bottom edge, one hole was drilled in the centre of each slab. Some of these holes went through plaster and some went through a void (between the marble and terra cotta) and on into the terra cotta.

A second set of holes, 0.08 cm (1/32 in.) in diameter, was drilled 1.25 cm (1/2 in.) deep at a 45° angle into the edge of the tile in line with each of these holes. A custom-made helical stainless steal wire spring with a long straight tail was inserted into these holes.[8] The tail end was site cut to length and sharply bent for insertion.

The end of the helix was filled with plasticine to prevent the adhesive from running out. The hole was pre-wetted with methanol, a 50% Rhoplex/methanol mixture, and then, while still wet, injected with a filled adhesive[9] down the centre.

These fasteners were very discreet once placed, but occasionally a glint of reflection from the stainless wire was noticed. This was hidden with a dab of grout-coloured acrylic paint applied with a toothpick. Three thousand such fasteners were used on the project.

Testing

Full coalescence of Rhoplex MC 76 takes place within 30 days. Testing was carried out using a suction device (the type used for carrying sheets of glass) and a mechanical spring scale. More than 91 kg (200 lbs.)

Figure 10. A filled adhesive is applied by injection through the centre of the helix to bond the stainless to the terra cotta. Once set, the straight end is fitted into the angle hole and a drop of Rhoplex placed to hold it.

Figure 11. Stainless helical spring is inserted. Note the tail is formed to fit the hole being drilled in Figure 9.

pull was applied to 20 randomly selected locations in the hall. None failed.

For interest sake, the same test was applied to a section of marble cladding that had been removed and re-applied using modern purpose-made construction adhesives over a similar terra cotta tile base. Adhesion failed at 22.7 kg (50 lbs.) pull.

Conclusions

1. Ground penetrating radar is a useful technique for determining conditions within some complex wall structures.

2. Detached marble cladding can be preserved in historic buildings in situ with minimal intervention.[10]

Endnotes

1. Kalman, H. *A History of Canadian Architecture Vol. 2*. Toronto: Oxford University Press, 1994, 760 pp.

2. Despite what is often claimed and intended by building custodial staff and their managers, buildings are very seldom maintained at an even and suitable temperature/humidity condition during prolonged periods of vacancy. Without the occupant to complain when the environment changes radically, the custodian has little notification that extremes are even occurring. In the Dominion Public Building case, the temperature of the wall near the ceiling could easily have dropped below freezing without the monitoring device at floor level registering the change.

3. Until one sees and feels such demolition activity first hand, it is hard to believe that it would ever be permitted inside a building that is being preserved in part for its architectural significance. It is as if the left hand doesn't know or agree with what the right hand is doing.

4. Hamilton is a centre of heavy industry in Ontario and as such is the home of the Non Destructive Examination Institute of Canada; Managing Director Doug Marshal kindly assisted HPCS by setting up trials of both impact echo and ultrasonic examination systems.

5. Senior Geophysicist Milan Situm of Geophysics GPR International Inc. carried out mapping of the plaster adhesive behind the marble tiles. Georadar uses a radar technology to obtain a continuous profile of the subsurface. The basic principle is to send an electromagnetic impulse into the surface. This pulse will travel through the material and reflect off boundaries of differing dielectric constants. A reflected pulse returns to the surface and is recorded by a receiver. Typical examples of boundaries include air/water; water/earth; earth/metal; and differing earth materials. Using that company's unique hand-held antenna connected to a computer he was able to record scanned transmission data directly on the marble surface.

6. Methanol is a WHMIS Class B-2 flammable liquid, and a WHMIS Class D 1-A Very Toxic substance. Safety precautions include protective clothing, air quality management, and fire prevention. Refer to the Material Safety Data Sheet available from any supplier before use.

7. Morgan Phillips discusses Rhoplex as a consolidant in *APT Bulletin* XII, 2 (1980), p. 37.

8. Custom springs for this application were fabricated by Bohne Spring, 60 Coronet Road, Toronto, Ontario.

9. The filled adhesive used was a mixture of Rhoplex, lime, micro-balloons, and fluid petroleum coke, thickened to a gel state with Acrysol ASE 60.

10. Historic Plaster Conservation Services Limited Web site (www.historicplaster.com) contains further information about this project.

Résumé

Restauration des marbres à l'édifice public Dominion, à Hamilton, en Ontario

Cet article examine le traitement de conservation du revêtement de marbre sur les murs de la grande salle postale de l'édifice public Dominion à Hamilton. Le liant d'origine entre le revêtement de marbre et le mur de support en terra-cotta était un adhésif au plâtre de Paris. Le balayage de la surface avec une antenne radar miniature mais très puissante, récemment mise au point, a fourni aux restaurateurs une carte montrant l'emplacement précis, la forme et la dimension de chaque plaque d'adhésif au plâtre. Cette technique de repérage non destructive a permis de réparer le liant là où il avait cédé (soit entre le marbre et le plâtre de Paris, soit entre le plâtre de Paris et la terra-cotta, ou les deux), avec très peu de perturbations de l'édifice même. Une fixation mécanique supplémentaire mise en place comme système de réserve pour chacune des plaques de marbre est également expliquée.