CHALLENGES IN PRESERVATION ENGINEERING:
RESTORING A 100-YEAR-OLD
HISTORICAL TERRA COTTA FACADE

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ABSTRACT

Set in the heart of Toronto’s financial district is a 100-year old, 11-story Beaux-Arts designated heritage building named 1 King Street West. The exterior walls at the base of the building are smooth Quebec granite, with glazed speckled terra cotta above. Five years of evaluation and research lead to restoration of the building fabric, including replacement of deteriorated terra cotta and installation of a new copper cornice in 2014-2015.

This paper focuses on lessons learned during the construction phase of the historical restoration of 1 King Street West, with examples of how identification of specific masonry repairs and anchorage scenarios at early stages significantly impact project success.

SPEAKERS

CARLY CONNOR — WSP CANADA INC.

CARLY CONNOR combines an academic background in masonry restoration with experience as both a heritage masonry contractor and consultant to provide a unique perspective on the industry and best practices from all sides of a project. This leads to better anticipation of potential problems and developing innovative solutions. Carly has a bachelor’s in engineering and management and a master’s in applied science (masonry focus).

HANNAH THEVAPALAN — WSP CANADA INC.

HANNAH THEVAPALAN has consulting experience in New York City and Toronto with exposure to new construction projects and heritage restoration. She continues to gain knowledge at both ends of the construction spectrum. Her combination of a bachelor’s in architectural sciences and a master’s in engineering (building science majors) provides her with unique tools to approach challenges in building restoration.
INTRODUCTION

Constructed in 1914 and set in the heart of Toronto’s financial district, 1 King Street West is an Ontario designated heritage property and recently celebrated its centennial. The building was the headquarters of the Toronto Dominion Bank. Darling and Pearson architects were the designers, and Harkness & Oxley were the project’s consulting engineers. The architects were among the leading designers who contributed to the construction of significant buildings across Canada. The 14-story, 150-ft.-tall building is a steel-framed building clad with terra cotta and manufactured by Northwestern Terra Cotta Company.

1 King’s owners, after a lengthy process of evaluation and analysis, committed to proceed with a major repair program to restore the historical façade’s fabric. Despite pre-planning that considered potential design and construction issues, the façade rehabilitation was faced with challenges common to complex restoration projects. This paper discusses highlights of the project from design through construction.

BACKGROUND

1 King Street West is a Beaux-Arts former Toronto Dominion Bank Building set in the heart of downtown Toronto. The original building was constructed in 1914 (Photo 1A) and is now designated under Part IV of the Ontario Heritage Act (Photo 1B), listed by the city of Toronto. A 52-story, high-rise tower was constructed between 2003 and 2005 and is connected to the west elevation of the historic building (Photo 1C). The building complex is now a mixed-use hotel and residential condominium.
The exterior walls at the base of the building are composed of smooth Quebec granite, while the remainder is constructed of glazed, speckled terra cotta (Photo 2 and Figure 1) supported on steel framing and tied back to the structure using a combination of steel hooks, ties, and straps. Canadian Steward Co. Ltd. was the contractor, and the terra cotta was manufactured by Northwestern Terra Cotta Company of Chicago, which also supplied terra cotta to buildings such as Chicago’s Wrigley Building, the Civic Opera House, and the Chicago Theatre. In the peak of terra cotta use in steel-framed buildings following the Industrial Revolution, Northwestern Terra Cotta took the lead in establishing the national standard for specification and detailing, promoting the advancement of the industry.1

The structural framing at the building perimeter included two lines of supporting frames (Figures 2A and 2B): an interior beam to support the floor, and the exterior to support the walls. This was indicative of a shift from the transitional (i.e., hybrid) systems to curtain wall (veneer) systems, where the exterior wall was no longer

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Figure 1 – Typical elevation and wall section (Darling & Pearson Architects, Drawing 120, June 24, 1913).

Photo 2 – Typical wall elevation.

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Figure 2A – Typical floor framing plan (Harkness and Oxley Consulting Engineers, ninth-floor framing plan, Drawing S-145-26, November 1913).

Figure 2B – Typical wall sections (Harkness and Oxley Consulting Engineers, Drawing S-145-25, April 1913).
a load-bearing structural system and thus was intended to act as a barrier and exterior skin only (Photos 3A and 3B).

The top of the building was decorated with a highly detailed, internally drained terra cotta cornice and parapet capped with terra cotta ornamental features (Photo 4A). However, archived documents indicate that the cornice and decorative features showed signs of distress and were removed prior to the 1930s. The cornice was replaced with a copper facsimile in the 1930s, with reduced decorative details and also removal of finials at the top of the building (Figure 4B). Further, in 2007, the copper cornice was removed due to deterioration of the supporting structures (Photo 4C), and the building lost its crown completely (Photo 4D).

Under new ownership, building management decided to proceed with a full-scale...
terra cotta repair and restoration program that included reinstatement of the copper cornice. In 2011, we began a series of evaluations and studies to assess and develop options and management strategies to restore the façade to meet the client’s expectations.

**EVALUATION**

An evaluation was authorized to develop a benchmark for future monitoring, maintenance, and restoration. This included identifying potential safety concerns, evaluating the existing condition of the terra cotta façade, developing a repair strategy, and reviewing options for cornice replacement.

**Scope**

The evaluation involved review of available historical documents and drawings from historic archives and a previous condition evaluation report (completed in 1989). These documents established the baseline for the building condition assessment. Select areas of the building were accessed “up close” via a swing stage to review and sound the terra cotta units, to remove select terra cotta units in order to evaluate concealed conditions, and to collect samples for material testing. During the up-close review of the façade, loose materials were removed or stabilized to limit potential hazards to public safety.

Laser scanning of the façade was completed to develop electronic (CAD) elevation drawings. A 100% façade survey was then completed using industrial rope access to document existing conditions (Figures 4A and 4B) and determine quantities of repairs. A thermographic scan of the façade was also carried out to review airtightness and thermal effectiveness of the wall system. The scan showed that there were no major thermal anomalies within the field of the terra cotta.

**Key Findings**

The evaluation revealed that the façade was generally in good condition; however, terra cotta was at risk of further deterioration, primarily at building corners. Previously repaired corner terra cotta units exhibited cracking, which suggested continuing deterioration following the previous repairs.

Widespread hairline cracking and localized spalling were observed on skyward-facing sills, in addition to localized deterioration of terra cotta glazing, which included “coining” and crazing, both conditions that can contribute to increased water entry into the façade and possible dete-
Cornice Option

As noted above, the original terra cotta cornice and subsequent copper cornice were removed from the building. A key part of our evaluation and restoration program was to reinstate the cornice in order to complement the building’s historic fabric. The main goal of the analysis of cornice options was to present feasible designs for cornice replacement while taking into account durability, constructability, and economics. The review and schematic design process involved consultation with an historic preservation architect.

Several material options (terra cotta, metals, and composites) were evaluated, and the profile of the original cornice was also studied. Advantages and disadvantages of the options were presented to the owner. Installing a new terra cotta cornice would have matched the original cornice and remainder of the building; however, it presented challenges regarding drainage, the need for structural reinforcement, constructability, and cost. Metal options considered included lead-coated copper, red copper, and terne-plated stainless steel. Metal options were the least structurally demanding option. Further, lead-coated copper that is workable and durable was presented as a material used regularly in heritage buildings. Composite materials considered included glass-fiber reinforced concrete (GFRC) and fiberglass-reinforced polymers (FRP). The composite options presented the ability to match aesthetics of the existing terra cotta, but their durability and maintenance were questionable. The owner opted to proceed with red copper as the primary fabric of the cornice.

DESIGN

The decision was made to proceed with a full façade repair program that addressed the deterioration of the terra cotta units.

Material testing and analysis of terra cotta samples indicated that the material was durable and in good condition for its age and exposure to Toronto weather conditions. Compressive strength and water absorption of terra cotta was found to be about 10,000 psi and 12% respectively, which is comparable to historic published material data (Figure 5). Lack of visible distress is an indication that the façade was installed with diligence and care.

The existing structural steel frame and anchorage reviewed were in good condition with minimal to moderate corrosion (Photo 5). Terra cotta cracking at building corners was attributed to lack of continuity in steel framing and resultant stress concentrations, further exasperated by lack of expansion joints (vertical and horizontal), which was typical and part of the lessons learned in the transitional building construction.

The evaluation revealed that there was widespread sealant deterioration at subsequent vertical joints that was created at an earlier date, including debonding, hardening, and splitting. Mortar appeared to be cracked and debonded from terra cotta, which can lead to increased water ingress into the façade. Accelerated deterioration of mortar may have been caused by the lack of flashing at horizontal projections.

Based on the findings and repair strategies presented to the owner, a short-term repair program was implemented in 2012, followed by a longer-term restoration program, which was initiated in 2014.
potential risks, thus maintaining property standards, improving durability of the façade, extending its useful life, and reinstating the cornice, thereby deferring future maintenance. The scope of work included replacement of severely cracked and spalled terra cotta units, which accounted for less than 2% of total units on the building. The repair program also included terra cotta repair, localized stabilization of isolated units, repointing of all mortar joints, and reglazing of cracks and patch repairs.

A key to the project’s success was availability of quality terra cotta. Prior to bid and tender, Boston Valley Terra Cotta (BVTC) was selected to supply new units for the project, given that they are a leading manufacturer of custom architectural terra cotta and are located within two hours of the project site. BVTC worked with the design team during the design phase and also during restoration to assist with a full survey of the façade, creating shop drawings and setting elevation drawings for replacement units, which can be a time-consuming process that, if deferred, could impact the construction schedule.

Steel repairs were anticipated as part of the scope once terra cotta units were removed. At building corners, the shelf angle support structure was known to be discontinuous, which required modification (Figure 6) to the existing framing system. Additionally, any exposed steel was to be cleaned and coated.

Cornice design development considered feasible changes to the dimensions, level of detail, and profile. The original terra cotta cornice provided poor drainage, with embedded drainpipes through building interiors, which increased long-term risk of the system. The new reduced-profile 24-oz. red copper cornice with positive slope provided a more effective drainage and a lower-cost solution. A higher level of ornamentation from the first (1930s) copper cornice was introduced in the new design. Full-size mock-ups were prepared in a shop and reviewed for approval.

The outcome was a reduced cornice profile (Figures 7A, 7B, and Photo 6) that was economical and met Toronto Heritage Preservation Services’ approval. The existing steel structure and cornice framing were modified to incorporate a new galvanized steel support frame (Photos 7A and 7B). The building’s 12th-floor terra cotta braided band course and windowsills were to be
flashed with corrugated 24-oz. copper to protect the terra cotta units (Photo 7C).

Project logistics, access, and phasing of the project were considered, presented, and discussed with the clients to solicit their input. The client’s preferred choice was to allow the contractor full access to all façades to complete the project as quickly as possible. However, in the end, it was agreed that project logistics and phasing options are best left to the contractors.

RESTORATION
To tackle a project of this magnitude with the planning and precision required to properly execute the work, only preferred prequalified trades were invited to bid for the project. The successful bidder was selected following a thorough interview process to confirm that the scope and magnitude of the project were fully comprehended.

Limen Group, a major national restoration contractor, was selected as the contractor who portrayed enthusiasm and presented the most competitive pricing and most aggressive schedule. Heather & Little Limited (H&L), who assisted with cornice mock-up, was also retained as a subcontractor to perform all copper restoration work.

The aggressive schedule set by the contractor proved to be optimistic, as the project experienced numerous obstacles and delays. 1 King Street West is located at one of the busiest intersection in Toronto. As such, pedestrian and vehicle access had to be maintained at all times, with public safety being paramount. Delays were experienced at the front end of the project due to site logistics and the high level of involvement with the city officials to erect a scaffold for access to the building façade. Due to this lost time, the project team rushed to meet imposed deadlines. The push to follow the original schedule put a strain on the project team and the client. Given the multifunctional use of the property as a hotel and a condominium, as well as a prime destination for conferences, weddings, and large events, the owner required that target dates for completion of work and scaffold removal be met in order to satisfy their clients’ expectations.

Additional scheduling delays were realized due to escalation of repair quantities. Once the building was fully accessed, we extended some of the terra cotta repair scope and the quantity of terra cotta replacement units to perform a comprehensive restoration. Review and approval of shop drawings by the contractor also became a hurdle in proceeding with production. Given the required lead time for the production of terra cotta units (measuring, shop drawings, production, drying time, inspection, shipping, etc.), identifying an additional unit requiring replacement in a timely manner became critical.

Any project that involves the replacement
of a large number of masonry units is specifically governed by the pattern and location of the units to be replaced (Figure 8 and Photo 8). The pattern of replacement units governs required shoring, installation constraints, and anchorage requirements—just to name a few. For large openings where many units have been removed, units must be installed from the bottom, working towards the top to properly support the new units. If terra cotta units are not delivered in a specific order, site crews may experience great fluctuations in workload with times when they are unable to progress with further installations, even with a positive inventory of units on-site. This situation directly results in a delay towards the end of the schedule, making planning during the ordering and delivery of terra cotta units critical to avoid this backlog and inefficiency. Terra cotta setting drawings (Photo 8) must be analyzed and utilized to their full extent to identify any critical scenarios that may have delivery or installation constraints.

In the terra cotta replacement project at 1 King Street West, setting drawings were not efficiently used to plan and identify the specific and unique terra cotta anchor- age scenarios. During original construction, terra cotta was often built from the bottom up (Photo 3), frequently utilizing interlocking elements between units to provide the required lateral anchorage and support that the units require. When such a unit requires replacement, the constraints of the surrounding units require that a new anchorage scenario be developed. Additionally, anchorage to secure units to steel supports can be installed with ease when the

*Figure 8 – Terra cotta setting drawing, partial elevation (area noted was most severely distressed area) (BVTC, Setting Drawing Priority 2, 1KS-S-2.E, March 5, 2015).*

*Photo 8 – Newly received terra cotta unit inspection prior to installation.*
walls are wide open, similar to original construction (Photos 9A and 9B). When access to install anchorage to the existing wall is limited (Photo 9C and 9D), each scenario must be analyzed; and often, a unique design must be developed for each case. At 1 King, new anchorage scenarios needed to be developed for isolated units, headers, cartouche shields, balustrades, and units in series.

As is often the case with existing structures, backup wall conditions are not the same throughout the building, nor do they always match original design details. In limited cases, existing steel was supplemented by extending shelf angle horizontal legs to provide additional support for the new terra cotta.

Additionally, the existing steel angles greatly impacted installation of terra cotta units at select locations where the profile of the terra cotta unit had to be modified to fit around the protruding angles. It was surprising that the overall extent of remedial repairs to the existing steel was less than what we anticipated. In addition to the repairs mentioned above, addressing corrosion was typically limited to cleaning and coating of exposed steel frames.

Given the heritage designation of the property, matching of repairs (color, texture, etc.) to the original material was a priority, with repair of existing materials preferred over replacement wherever possible. Repair products and tech-
niques used were compatible with existing materials and sympathetic to the heritage nature of the building façade. Crews working on the project were outstanding and highly skilled in their execution of the repairs.

CONCLUSION

The terra cotta façade of 1 King Street West is an exemplar demonstrating advancement of the terra cotta industry and construction of transitional masonry buildings in 1914. The relatively minimal level of deterioration is a testament to the quality of the terra cotta used, the original design details, and the workmanship implemented to execute the work. A century later, extensive research and preplanning efforts led to restoration of this heritage façade. Attention to detail, including selection and coordination of the project team, was part of the effort to make the project a success. The construction team was faced with challenges including increased scope of work, scheduling, and the need for trade/supplier coordination. In all, the project was completed several months behind schedule. However, care was taken by the trades to perform their work to a high standard in a similar fashion to the pride taken by the original masons on the building. The overall lessons learned from the restoration were that a phased approach to execution and performing the work over two years could have been more beneficial. This would require breaking up the project and performing the work on a representative portion of the building during year one, including terra cotta documentation and fabrication. This would allow ironing out site challenges for a more efficient approach to project delivery.

REFERENCES


Project Team

Owner – TSCC 1703 c/o Y.L. Hendler Ltd.
Heritage Architect – McGillivray Architect Consulting Engineers – WSP Canada Inc. (formerly Halsall Associates)
Existing Documentation Support – Vertical Access
Restoration Contractor – Limen Group Ltd.
Terra Cotta Supplier – Boston Valley
Terra Cotta Sheet Metal Subcontractor – Heather & Little Ltd.