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A Design-Assist Approach to Laser Cleaning of Stonework at the Centre Block, Parliament Hill, Ottawa.

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ABSTRACT

The Centre Block (CB) is a Classified Federal Heritage Building housing Canada's Parliament. Nearly a century after opening, it closed in 2019 for rehabilitation. The requirements of the Centre Block Rehabilitation Project (CBRP) include major structural, seismic and security upgrades, while prioritizing the preservation of the building's heritage character and materials. Lessons learned during the rehabilitation of other buildings in the Parliamentary Precinct led to the adoption of an integrated approach to conservation, using "Design Assist" to bring conservation specialists – under contract to the Construction Manager (CM) - directly into a role that combines design and construction activities. The conservation of the exterior stonework forms a major part of the project scope and the chosen "level of clean" must address multiple challenging factors: technical and regulatory conservation requirements; Client/Stakeholder expectations; public perception; construction budget and schedule. The CM team reviewed existing masonry materials reference documentation and testing results, including the nature of the soiling to be removed by laser cleaning. A gap analysis exercise then identified any additional testing requirements. A program of trials was developed whereby every contractor/supplier with previous laser cleaning experience on Parliament Hill carried out three small trials in discreet locations on the CB building. Each contractor supplied three different levels of clean. The processes and outcomes were carefully managed by the Heritage Leads from the Client (Public Service and Procurement Canada), the Consultant (CENTRUS) and the CM (PCL/ED). The Client engaged various project stakeholders and representatives of applicable regulatory bodies to review the results of the trials on site. Testing was carried out to determine changes in surface morphology, colour, and moisture movement properties. Every stage in the process and every decision was evaluated by the collaborative team and rigorously documented. The trials, analysis and reporting fed into the development of specifications and tender documents. The suppliers who carried out trials on site were evaluated and pre-qualified to bid on the larger scope of work. The CBRP's innovative "Design-Assist" project approach encouraged input from craftspeople, equipment suppliers, designers, client(s), the CM, conservators and material scientists, resulting in a genuinely holistic approach to architectural conservation. The design-assist led cleaning trials have contributed to a successful construction phase, with minimal need for variations to scope, budget or schedule.

KEYWORDS

Laser ablation, masonry conservation, stone cleaning, sandstone, gothic architecture, analysis.

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INTRODUCTION

The cleaning of stone buildings may be carried out for aesthetic reasons, for technical conservation reasons, or as part of ongoing maintenance. Historically, the cleaning of historic stonework often involved re-facing or re-tooling, resulting in unwanted or unintended loss of historical material. In recent decades, good conservation practice typically has prevailed, and cleaning work now proceeds by the gentlest available means possible. In Canada, prior to the West Block Project (2012-2017), micro-abrasive cleaning provided the gentlest and most conservative means of cleaning soiled sandstone, but it is now generally agreed amongst building conservation professionals that cleaning by laser is the most appropriate, and gentlest method available.

The conservation of the exterior stonework at CB is a significant and visible component of the overall rehabilitation project. Striking a balance between preserving the building's weathered exterior while ensuring the technical performance of the building envelope requires careful consideration of design parameters, and ongoing qualitative and quantitative analysis. The rehabilitation offers a unique opportunity to remove soiling deposited during an era of heavy industry and high-pollution levels, such as products from coal burning, etc.

The first step in the exterior masonry rehabilitation project has been to establish the desired level of clean for CB. The goal of masonry cleaning is to remove atmospheric soiling and other unwanted surface pollutants from the surface, to reveal the natural weathered patina of the stonework while avoiding 'over-cleaning' that would result in damage and loss of surface material. In 2019, the project heritage teams planned and executed mock-ups on the north face of the building; the results of these mock-ups were incorporated into consultant drawings and specifications for tender. Since 2019, various tenders for masonry conservation and rehabilitation work have been awarded to pre-qualified heritage masonry sub-contractors. This work is ongoing and will continue until the completion of the project. The 2019 mock-ups provide a consistent reference for qualified companies who bid on these scopes of work, which simplifies the bidding process and ensures consistency and a transparent approach to pricing work. Various laser systems have been introduced to the project and with each introduction of new technology, a mock-up has been performed to measure compliance against the 2019 standard.

The level of clean determined by the CBRP team is the result of extensive research, analysis, testing (mock-ups) and deliberation among the project's heritage and masonry experts including input from internal project subject matter experts, the Federal Heritage Review Office (FHRO) and the National Capital Commission (NCC). Results from the mock-ups demonstrate that laser technology is effective in removing atmospheric soil from the surface without causing damage to the stone or compromising the architectural detail.

The establishment of the end-state level of clean for the exterior masonry of CB, using design parameters, and exercising heritage due diligence will be further illustrated. Masonry repairs and other aspects of the masonry rehabilitation will not be discussed here.

STONE TYPES AT CENTRE BLOCK

The exterior walls are clad with three principal sandstones: Nepean, Ohio, and Wallace.

Nepean sandstone was obtained locally and used for the rock-faced work (referred to as "snecked" rubble).), and punch-faced or crandalled quoins. All stone faces are pitched by hand, with an average depth of 150 to 200 mm (6 to 8″) in the wall. The face dimensions are typically between 65 and 300 mm (21⁄2 and 12″) in height and from 150 to 410 mm (6 to 16″) in length. Nepean sandstone is no longer available; St. Canut sandstone from Quebec has been used as a replacement stone in recent projects.

Ohio sandstone (also referred to as Berea sandstone) is a buff and pale grey coloured sandstone, from the South Amherst quarries located south of Cleveland, Ohio. It was used for cut stone dressings, carved detail and trim on CB. Ohio sandstone is still available for repair work.

Wallace sandstone is a buff/olive green/grey coloured stone from Nova Scotia, with a subtly-different appearance to Berea. It was used in the construction of the Peace Tower, the interior courts, vent towers, chimneys and penthouses. Wallace sandstone was used at the extreme upper elements as dressed stone (turret caps, parapets, and chimney quoins and caps) and as carved stone (small, decorative gablets found immediately below the roof line). Replacement Wallace stone used on the south façade and other projects was sourced from the quarries at Wallace in Nova Scotia and the stone remains available today.

Examination of Soiling and Investigation of Cleaning Methods

Over the years, different types of cleaning methods have been used on Parliament Hill. Cleaning methods vary depending on the surface area (i.e. flat versus decorative), the type of soil contaminants and how deeply they are embedded in the surface. These methods include (but are not limited to) the following:

- Abrasive cleaning.
- Mechanical cleaning using small hammers and carving chisels, for the removal of surface accretions, such as mortar droppings, tar, and paints.
- Chemical surface cleaning for the removal of paints, metallic stains, adhesives and mastics (etc.)
- Poultices to remove sub-surface staining such as copper or iron.
- Steam-cleaning as a means of removing general loosely attached surface dirt.

It is important to note that sculptural and decorative elements are addressed separately. For these elements, the same methods of cleaning with be evaluated on a case-by-case basis.

Consultation

The approach taken by the project team to define the level of clean for CB has been collaborative, incremental and transparent. Input was provided by the Conservation Management Team—the project's internal heritage review panel—which includes Parliamentary representatives (Senate of Canada, House of Commons, and Library of Parliament subject matter experts), the Canadian Conservation Institute (CCI), the Dominion Sculptor and Heritage Conservation Services (HCS), and PSPC. Representatives from the Federal Heritage Review Office (FHRO) and the National Capital Commission (NCC) also participated in the process due to federal review and approval obligations. Their involvement included in-person review of the site mock-up, and review of the design parameters. Given the importance of the level of clean recommendation to the overall masonry rehabilitation project, it was helpful to engage all parties early in the process to ensure a thorough, objective analysis of results from the mock-ups. This engagement continued until final decisions were made. The goal of this approach is to deliver informed and appropriate recommendations for the end-state level of clean for the exterior masonry of CB.

The Heritage Triangle Assessment

The Heritage Triangle includes the Heritage Lead from CENTRUS (the project's prime consultant), the Construction Manager's (CM) Lead Conservation Manager, and the Heritage Lead from PSPC. This group took the comments received from the CMT, the FHRO and NCC under consideration, and conducted a thorough assessment of each of the mock-up samples against a set of variables (design parameters).

At a high-level, these parameters include the following:

- Why clean? The rationale behind the choice to clean in the first place (i.e. material performance and longevity, public expectations, disfigurement of architectural details due to soil).
- The precinct's masonry cleaning history.
- Technical considerations such as quality, cost, and time.
- Philosophical requirements such as the original design intent for CB, harmonization of Parliament Hill buildings, and the importance of the building's patina as a representation of the passage of time.

Examining the mock-up samples using this framework ensured an objective assessment by the Heritage Triangle. The two areas selected (and the range between the two samples) met the design parameters for the masonry cleaning of CB. The recommendation made by the project heritage team leads was endorsed by external authorities, via Review of Intervention (FHRO) and Federal Land Use Design Approval (NCC).

THE ANALYSIS

Atmospheric Soiling and its Effects on the Stone

When planning any historic masonry cleaning project, it is important to understand the nature and composition of the stone substrate and the soiling layers that have deposited on the surface of the stone over the years. The National Research Council (NRC) in Ottawa has extensively tested and analysed the three exterior sandstone types and the soiling associated with each stone type. The CB Conservator Field Report (2019) describes the atmospheric soiling layer on the sandstone of CB as a dirt crust comprised of carbon, sulfur, calcium, gypsum, iron and lead; a combination of the deposition of atmospheric pollution combined with materials inherent in the construction materials themselves. Compositional analysis of surface soiling by Yuan Hu [1]. reveals that the soiling layer obscures the quartz grains of the sandstone and appears to "clog pores". Water is the vehicle for most of the staining matter.

The purpose of cleaning the stone is to remove the crust which is caused by atmospheric soiling. This crust impedes the movement of moisture and associated soluble salts, which can cause an accumulation of recrystallized salts under the surface of the stone (sub-florescence), leading to mechanical damage, surface exfoliation and material loss. Removing the crust will unclog the stone pores, thereby increasing the water vapour transmission properties of the stone so it can 'breathe'. Moisture will always pass through porous material (such as sandstone) which is why it is important for the building to maintain its ability to lose water. Laser cleaning can help achieve this goal. However, over-cleaning must be avoided as the resultant loss of surface material will accelerate damage to the stone.

Nature of soiling on CB's exterior

History of Masonry Cleaning Using Laser Technology on Parliament Hill

The impact of various cleaning technologies used on the Parliament Hill stone types has been studied by past project teams and the NRC. Several types of laser and other cleaning technologies (micro-abrasive, chemical) have been used to clean the sandstone on the Parliament Hill buildings.

Low-pressure micro-abrasive systems were used in the 1990's and early 2000's for the south façade, Peace Tower, Library of Parliament, and West Block pilot projects (north towers and south-east tower). Laser ablation was introduced as an alternative cleaning method in 2012. The West Block project team conducted trials and analysis that showed laser technology to be an effective replacement for abrasive methods (although abrasive cleaning is still used on masonry). Most recently, laser cleaning technology was used to clean the stone on both West Block and East Block as well as the Wellington Wall.

West Block was the first building in Canada to use laser technology for masonry cleaning. The East Block project team were able to make use of lessons learned from the West Block project. In each project case, the level of clean using laser technology was newly considered, in the context of the project and the site, and evaluated using mock-ups. Mock-ups continue to be an important decision-making tool to determine an acceptable level of clean. Mock-ups are also used to guide the preparation of contract documents, establish cost estimates, serve as the reference during the bidding process and become the benchmark reference after contract award. Based on project experience, performance-based specifications that refer to site mock-ups provide the surest way of maintaining a consistent outcome. It is not recommended to prescribe laser power and speed settings in specifications.

Research associated with the projects mentioned above shows that laser technology, when used by appropriately trained, skilled and experienced operatives, provides a safe and effective cleaning method that removes atmospheric soiling from surfaces to allow for improved moisture transmission and continued natural weathering of the stone. It can provide a level of clean that reveals the heritage character of the building's exterior while preserving the stone material into the future.

Literature Review

As part of the due diligence applied to this work, a literature review was conducted by the project team to help inform the proposed level of clean. These sources (historical and contemporary reports) provided insights that were deliberated and applied to the mock-ups. A full list of sources can be provided.

THE HERITAGE CONSERVATION APPROACH

Heritage Character of Centre Block Masonry

The second CB building was designed to sustain and enrich Parliament Hill. Pearson and Marchand accomplished this goal by designing a building that demonstrated a sensitivity to Canada's history, and simultaneously spoke to the country's growing maturity as an independent nation. Informed by the mid-19th century Gothic Revival style of its predecessor, the building's form and uniform massing, choice of exterior materials, varied roofline, and soaring central tower, combine to emulate the design of the original building. In doing so, CB recreated visual unity between the three pavilions and their landscape while simultaneously introducing a new Beaux-Arts formality, clarity, and monumentality to the whole of Parliament Hill.

The CB's exterior stonework plays an important role in this endeavour. The principal stone is Nepean sandstone, chosen to correspond with that of the 19th century buildings, however, it is treated in a different manner. While the pitch-faced, sneck-bond pattern of the neighbouring Blocks is maintained at CB, the dimensional differences between jumpers and specks is less pronounced, resulting in a more orderly appearance. The appearance of order and restraint is further underlined by the even, pale coloration of stone and mortar joints. This orderly treatment emphasizes both the plane of the wall and its load bearing, functional character. While a monochromatic appearance was sought for the exterior, the Nepean sandstone has a subtle colour range that can run from fawn to yellow/ochre and orange, and from light to dark greys. This dappled colouring lends the elevations a lively and weathered look.

The rough-faced Nepean sandstone is offset by finely tooled and dressed Ohio and Wallace sandstones that are used to emphasize drip lines and shadow lines around window frames, and edge architectural elements. Cumulatively, they create a restrained linear pattern across the façades. The skill of the mason is particularly evident in the treatment of these softer sandstones, as illustrated by their smoother finishes and discernable tool marks that run through the main body of the stone and/or define its edges. These softer stones are also intricately carved into representations of flora, fauna, figures, and grotesques.

Preliminary Conservation Goals

The overarching goal for the project, is the conservation of CB's conception as a coherent, three-dimensional composition, or 'total work of art', in which the smallest details support the whole. A related goal is the conservation of the clarity and logic of the CB's Beaux-Arts composition and plan; its spatial, decorative, and material hierarchies; and the quality and richness of its decorative program. All of these qualities can be read on the exterior stonework of the building.

The attributes which characterize the exterior of the building include its rectangular form and uniform massing; as well as the restrained approach to materials and colour on the exterior with its refined exterior sculpture and decorative program. The surface soiling on the exterior stonework at CB negatively impact the appearance of many of the character-defining attributes.

Conservation Approach for Masonry and Level of Clean Considerations

The primary treatment for the exterior masonry of CB is preservation. The Standards and Guidelines for the Conservation of Historic Places in Canada (2010) states that preservation involves 'protecting, maintaining and stabilizing the existing form, material and integrity of an historic place or individual component, while protecting its heritage value'. The heritage value of the exterior form and material of CB will be conserved by adopting a minimal intervention approach which will allow deterioration and stone repairs to be easily discerned. To this end, if used properly, laser technology is a minimally invasive cleaning method that aligns with conservation goals.

TECHNICAL NOTES ON LASER CLEANING

Laser cleaning in the conservation of art and objects began in the 1970's. Until recently it had been considered too slow and expensive for use in large-scale architectural conservation applications. The West Block of Parliament Hill was only the second building in North America to be cleaned by laser technology, after the Nickerson Mansion in Chicago. In Europe it is still common to only use lasers to clean decorative and sculptural elements, due to the high cost of laser cleaning compared with other techniques. However, it is expected that laser cleaning will become increasingly popular as the technology becomes more widely available, and more robust and durable for use on construction sites.

The most commonly used technology for the cleaning of stonework on an "industrial scale" is the Nd: YAG laser, with a wavelength of 1064nm. Other types of lasers with different wavelengths are used to clean materials such as oil paintings and paper. Lasers clean stonework through a process of absorption/reflection: the laser wavelength delivers high amounts of energy in very short durations ("pulses"). When in focus (focal length is one of the numerous parameters that define the amount of energy deposited on the surface of the material), the heat is deposited extremely briefly and there is little thermal transfer to the stone beyond the dirt layer. The process of laser irradiation means that the darker material/dirt layer absorbs a large amount of energy and is vaporized (a process known as "ablation"). Once the thermal expansion and ablation of the dirt layer is complete, the lighter material/buff-coloured sandstone in this case, no longer absorbs the energy emitted by the laser and instead reflects it. For this reason, laser cleaning is often referred to as a "self-limiting process". In lower-powered lasers (low wattage), cleaning is achieved through a process known as photo-chemical ablation, where the energy created is sufficient to break bonds between the dirt and the substrate, but no heat is generated. In the case of high-powered lasers (for these mock-ups the range was 100-500watts), cleaning is achieved through photo-thermal ablation, where the energy transfer creates sufficient heat to vaporize dirt.

Studies have shown [2] that cleaning by abrasive means can cause minor surface loss and a rounding of surface particles in stonework, while also depositing micro-particles of abrasive media into stone pores, resulting in a clogging effect [3]. Abrasive cleaning also creates large amounts of silica dust which must be controlled and requires large amounts of water during operation and for clean-up. On the other hand, laser cleaning produces minimal amounts of dust and requires minimal water. It is possible to clean by laser while other activities take place on the same scaffolding (with appropriate protective eyewear and enclosures). Laser cleaning is therefore the current preferred technique for removal of atmospheric soiling from stonework at Parliament Hill.

WHY CLEAN WITH LASER TECHNOLOGY?

The Standards and Guidelines for the Conservation of Historic Places in Canada (2010) state the following:

- "Cleaning masonry [is recommended] only when necessary, to remove heavy soiling or graffiti. The cleaning method should be as gentle as possible to obtain satisfactory results" [4]

- “Cleaning treatments for purely aesthetic purposes should be avoided because they can aggravate and accelerate deterioration” [5]

As stated previously, the primary purpose of laser cleaning the CB sandstone is to remove the atmospheric soiling layer, in order to unclog the stone pores and increase the water vapour transmission properties of the stone. This allows the stone to ‘breathe.’ Laser cleaning does not result in surface loss or in the alteration of surface morphology, according to scientific analysis undertaken by the project’s conservation teams [6]. For these reasons, and for reasons of safety and schedule (permits concurrent activities) it is currently the preferred technique to remove atmospheric soiling from stonework on Parliament Hill.

The level of clean using laser ablation technology can vary considerably; it can be used to remove a fine layer of atmospheric soiling, it can also be used to remove all soiling, without risking the unintended removal of the discernable tool marks or the hand of the maker on cut, carved and sculpted details.

Laser cleaning of sandstone also allows for a more thorough inspection of the masonry by removing surface atmospheric soiling. Conservators can then identify conditions previously obscured by the accumulated soiling so that they can be documented, and the required repairs defined.

Although laser technology is extremely effective in removing atmospheric soiling, it cannot remove all types of soiling; the laser can only interact with the surface, so any staining that penetrates sub-surface cannot be addressed in this way. Other cleaning technologies are used to remove other types of harmful soiling on the stone of CB. Further investigation, testing and mock-ups are conducted as required to assess other cleaning techniques.

EVALUATING THE EFFECTIVENESS OF LASER TECHNOLOGY

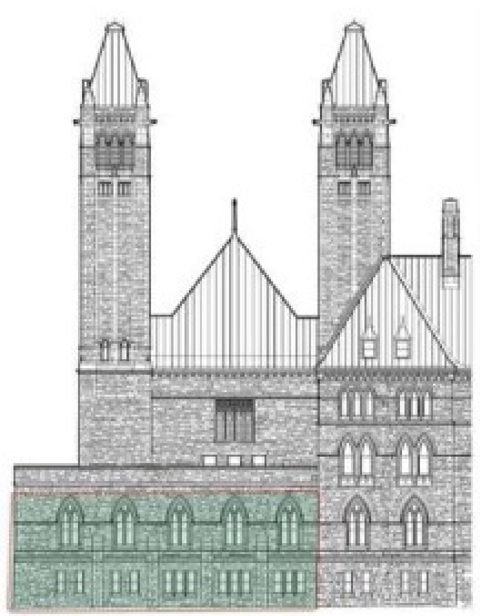
The goal of the recommended level of clean using laser technology at CB is to strike a balance between removing atmospheric soiling to improve stone performance/avoid surface deterioration and preserving the original appearance of CB's façade. The following considerations guide the level of clean discussions during project development and construction to preserve heritage character:

- Reveal visual unity and harmony between the three pavilions.
- Conserve monumentality, formality, and gravitas of CB.
- Conserve the visual evidence of orderly layering of the stone in a wall treatment that emphasizes both the wall plane and its load bearing functional character.
- Respect the range of Nepean sandstone colouring and reveal the variation in pitch-faced and tooled finishes.
- Respect the range of the smooth-dressed Ohio and Wallace sandstone that frames architectural elements.
- Preserve evidence of the skill of the mason in cutting and carving architectural stonework (rough faced Nepean) and dressed, tooled surfaces of Ohio and Wallace sandstone.
- Protect evidence of the skill of the carver and iconographic intent in the carved stone.
- Respect the role of weathering and patina to highlight dappled and muted colour variation of the stones in the monochromatic formal appearance of the exterior.

LEVEL OF CLEAN MOCK-UPS USING LASER TECHNOLOGY

The head conservator with the CM’s team planned and organized laser cleaning mock-ups, following project-wide discussions regarding level of clean, in 2018. All contractors and service suppliers with Parliament Hill experience were invited to participate and outcomes were documented by the CM Heritage

Team. Four masonry conservation contractors agreed to perform mock-ups on site at the end of October 2019. The east end of the north elevation of CB was chosen as the mock-up area because it had relatively even dirt deposits, mostly the result of atmospheric soiling. The area was divided into four bays with each contractor given one bay to do their work. The mock-ups were conducted on different types of stone (Nepean and Berea) and exposure (flat wall sections, sills and string courses) to test the effectiveness of the methods and technology (see photos below). Each company was required to follow best conservation practices as outlined in the Standards and Guidelines (section 4.5.3) as discussed above, and including carrying out masonry cleaning tests after it has been determined that a specific cleaning method is appropriate. The work is documented in a Conservator's Field Report, and a report was prepared by the Construction Manager which includes all the technical notes on laser cleaning with a description of the mock-ups. It outlines the results, conclusions, and next steps [7]. Results are shown below.



Location of mock-ups carried out on north façade of building

Proponent No.1: Mock-ups of West Block contractor and laser for assessment on CB

Proponent No.2: Mock-ups by Wellington Wall contractor for assessment on CB

Proponent No.3: Mock-ups with Wellington Wall laser for assessment on CB

Proponent No.4: Mock-ups of East Block and Canada Four Corners contractor and laser for assessment on CB

The following two samples were considered to meet the project design parameters:

Proponent No.1: West Block contractor and laser, selected by team, and considered acceptable level of clean

Proponent No.4: East Block and Canada Four Corners contractor and laser, selected by team, and considered acceptable level of clean

FURTHER SCIENTIFIC ANALYSIS

The process of cleaning by laser is extremely sensitive and relies on the separation of soiling matter and substrate (historic stonework), by exploiting each material's differing energy absorption characteristics. As such, at the request of PSPC, the CM Heritage team planned and carried out laboratory testing of laser-cleaned stone samples, to confirm that the site trials had successfully identified the optimum settings for laser-cleaning without inadvertently causing damage to the stone. For the purposes of this summary, the optimum settings can be described as a balance that aims to achieve "maximum retention of historic patina AND maximum removal of surface soiling".

For context, prior to the use of lasers at Parliament Hill, micro-abrasion was the preferred method for removing atmospheric soiling from sandstones. Micro-abrasion, even if performed with great skill, carries a risk of loss of patina and historic surfaces (these losses might not be discernible to the human eye, but any loss of case-hardened surface patina can risk accelerated weathering of fresh stone surfaces). The aim of laboratory analysis of laser-cleaned sandstone was to determine if the act of laser cleaning also creates a risk of material loss (even if at a microscopic level).

The CB team opted not to compare laser cleaning with other cleaning methods (given that the other buildings on Parliament Hill had been cleaned with laser technology, a return to micro-abrasion was considered unlikely), and focused solely on the effect of laser radiation energy on the building's stone surfaces. In particular, the team was keen to learn to what degree laser cleaning can cause surface colour change. In the team's experience, and based on a review of the available literature, it is not unusual to see a yellowish appearance on white marble after laser cleaning, for example.

Laser technology continues to advance, and a variety of laser systems have been used during the project. There are various laser parameters that must be set, including Frequency (kHz), Duration (ns) and Scan Speed (mm/s). These settings relate to each other to create the peak/optimal power for the intended use. The successful settings vary with each system, but all systems successfully used at Parliament Hill share the same wavelength of 1064nm; this appears to be the most effective for removal of soiling from sandstone. The experience of the project stone conservators was key in determining optimum settings.

Testing

Capital Conservation Services (CCS), the design-assist masonry conservators for the rehabilitation, operating on behalf of PCL/ED, were responsible for quality control services throughout the laboratory process, and oversaw the preparation of the samples. Two samples were procured for the three main sandstones used in the construction of CB: Nepean, Berea and Wallace. During site trials, the successful outcome was determined according to qualitative analysis only. Using the system settings determined by the on-site trials (power, pulse frequency, scan frequency and speed, pulse duration and fluence), the CM Heritage team devised a proposal for laboratory testing of laser cleaned sandstones, to be carried out by Highbridge Materials Consulting, New York, as follows:

- One test to evaluate/calculate any colour changes between stone surfaces cleaned with laser.
- A second test to determine any effect of the removal of the extensive black surface crust on elements of the CB exterior stone on its ability to absorb/desorb and transmit moisture.
- A third test to assess any apparent changes to surface morphology, if any, of the process of laser ablation on each stone type.

RESULTS

Colorimetry testing

Colorimetry consists in measuring the degree of perceptibility of colour change before and after treatment. According to the values recorded by Highbridge, the colour difference between samples of Berea sandstone treated by lasers is generally below 2, meaning that the visual impact of the laser treatment on the stone is barely perceptible.

Water Vapour Transmission and permeance testing

Water Vapour Transmission (WVT) testing [8] is commonly carried out to define the permeability of stones and mortars in building conservation, and to determine the compatibility of proposed treatments and interventions, and replacement materials. Carbon crusts (dark-coloured atmospheric soiling surface layers, such as those found at Parliament Hill) can block the pores of the underlying stone and mortar, resulting in sub-surface deterioration due to the stone's inability to "breathe", or expel moisture. The removal of the black surface crust from historic stone masonry is a common treatment and a typical primary justification for cleaning stonework, beyond any aesthetic considerations. Highbridge measured the WVT rate on 3 distinct surfaces: freshly quarried, cleaned and soiled, to evaluate the impact of laser radiation on the CB stone types. The WVT testing was carried out according to ASTM E96/E96M-16. The freshly quarried Berea sandstone had the highest WVT value. Soiled Berea sandstone had the lowest WVT value and results showed an increase in WVT after cleaning. In the case of Berea sandstone, the outcome of the testing supports the technical justification for the removal of the black surface crust and highlights the benefits of careful cleaning. The Nepean sandstone shows generally the same behaviour whether soiled or clean. The Wallace sandstone result show minimal difference between clean and soiled samples.

Microscopy [9]

Highbridge performed Scanning Electron Microscopy (SEM) and Backscattered Electron (BSE) imaging in an effort to detect changes in surface morphology caused by the application of laser energy to the surface of the stones. Findings showed that laser cleaning effectively removes the soiling layer wherever there is any measurable soiling to be observed. Highbridge also attempted to identify any mechanical damage to the surface of the stone that could be attributed to the laser cleaning process. No before-and-after differences could be observed in any of the 27 specimens provided for study.

CONCLUSIONS

Cleaning the exterior masonry of CB is an essential step in the conservation and rehabilitation of the building. The recommended end-state level of clean is based on extensive assessments and lessons learned from cleaning East Block and West Block using laser technology. The proposed recommendation is grounded in a conservation approach that respects heritage character and addresses the technical aspects of the work involved in cleaning historic masonry to improve its performance. The mock-ups tested the effectiveness of laser technology in safely removing atmospheric soil from surfaces without causing damage to the stone and its decorative elements. Scientific analysis carried out by professional laboratories further demonstrates this.

Each stage in the process of determining level of clean was evaluated by a collaborative project team and rigorously documented. The trials, analysis and reporting fed into the development of specifications and tender documents. The suppliers who carried out trials on site were evaluated and pre-qualified to bid on the larger scope of work.

The CBRP's design assist framework has ensured expert input from craftspeople, equipment suppliers, designers, client(s), the CM, conservators and material scientists, resulting in a genuinely holistic approach. The design-assist led cleaning trials have contributed to a successful roll out of implementation, with minimal need for variations to scope, budget or schedule. The project team has also been able to proceed with work confidently, knowing that laser ablation currently is the safest and most feasible method for removal of atmospheric soiling on architectural sandstone. At the time of writing, the entire north façade and parts of the east and west facades have been successfully cleaned using laser technology; the work proceeds according to the parameters and standards developed and defined by the collaborative project team and supported by design-assist conservators – as described in this paper. In the coming years, lessons learned from this project will continue to inform work carried out in the Parliamentary Precinct and beyond.

REFERENCES

[1] Hu, Yuan (2018). Characterization the Laser Cleaning Effects on Sandstone from the Canadian Parliament Building, Queen's University, Kingston, Ontario, Canada

[2] Characterization of the Laser Cleaning Effects of Sandstone from the Canadian Parliament Buildings, Yuan Hu, Graduate Thesis, Queen's University, 2018

[3] Documentation of On-Site Laser Cleaning Tests Performed on Sandstone Samples from the West Block, Parliament Hill, Conservation Solutions Inc., 2012

[4] The Standards and Guidelines for the Conservation of Historic Places in Canada (2010) 81468-parks-s+g-eng-web2.pdf page 225

[5] The Standards and Guidelines for the Conservation of Historic Places in Canada (2010) 81468-parks-s+g-eng-web2.pdf page 223

[6] Highbridge (2021). Centre Block Laser Cleaning Studies, SL1590-01, SL1590-02, and SL1590-03

[7] Edgar, David (2022). Laboratory Analysis of Centre Block Laser Cleaned Stone Samples: Summary. PCL-ED, Ottawa, Ontario, Canada

[8] Highbridge Water Vapor Transmissivity Testing Report, Report No. SL1590-02

[9] Highbridge Scanning Electron Microscopy Report, Report No. SL1590-03