Seismic upgrading of the structure to comply with BC Building Code requirements

The seismic upgrade will be achieved by isolating the Great Hall from the ground and the adjoining Museum structure. The main floor slabs will be suspended on base isolators located in a new crawlspace below. Isolation of the Great Hall will impact the connecting elements between the Great Hall and adjoining building. These will include the floor, walls, and roof assemblies. During severe seismic events, up to 12 inches of differential movement is projected to occur between the base isolated Great Hall and the adjoining structure. Movement joint cover plates will be incorporated at the junction of slabs. These plates will respond to a seismic event by either decreasing or increasing the planned movement gap. The metal plates will be cast with嵌套, maintaining the integrity of the adjacent coverings in the entire Museum and allowing for unimpeded traffic over the separated slabs.

In addition, to accommodate the seismic upgrade work, the glass walls facing the landscape will need to be removed and replaced with tempered laminated glass. The glass supporting system will be replicated to maintain the transparency of the existing system. The anticipated movement at the glass walls connecting to the adjoining non-isolated structures will be achieved by incorporating laminated glass panels that will hinge out of the way. The design objective is to minimize changes to the existing glass wall assembly and detailing and to not endanger occupants during a potential seismic event.

The columns at the entry to the O’Brien Gallery will be removed and replaced with a new column located approximately 12 inches away from the glass enlargement wall. New foundation to roof to allow for the anticipated movement during a seismic event. A portion of the low roof of the O’Brien Gallery entry will be demolished and rebuilt with a combination of precast concrete beams and structural steel decking. This portion of the low roof is part of the Great Hall structural system and will be isolated from the rest of the O’Brien Gallery roof and the adjoining concrete gun emplacement wall. Furthermore, the vertical and horizontal movement joints between the O’Brien Gallery and the low roof entry will be expressed with dark bronze metal plates that will be hinged. The existing entry doors to the O’Brien Gallery will be hinged. The existing entry doors to the O’Brien Gallery will be replaced with a sliding glass door.

Skylight replacement and upgrading

The cascading vaulted single-glazed acrylic skylights forming the roof of the Great Hall will be replaced by vaulted double-glazed sealed units, maintaining the existing OUCH shape, lighting, and requirements. New pre-action sprinkler cabinets will be installed in the existing mechanical room located above the Koerner Gallery, the new pre-action sprinkler cabinets will be installed in the existing mechanical room located above the Koerner Gallery, and the track lighting within the U structure which provides general lighting to the Great Hall and highlights to exhibits will be replaced with new LED light strips. Lighting for special events in the Great Hall will also be incorporated within the tracks. Additional lighting opportunities for exhibits will be incorporated by means of electrical power outlets in the floor. All lighting will be computer controlled. New recessed lighting in the exterior concrete pads will create a soft wash at the base of the columns.

Enhanced fire suppression upgrades

This project includes the addition of a pre-action sprinkler system with concealed heads to the entire area east of the Great Hall and to the unpartitioned portion of the transverse corridor as it intersects with the main entrance ramp. A new pre-action sprinkler cabinet will be installed in the existing mechanical room located above the Koerner Gallery, an enhanced detection system will be installed in the Great Hall. A new electrical and storage room will be located on top of the burner shell/courtyard adjacent to the south-east end of the Great Hall.

Roll-down shading

The Great Hall has considerable heat gain and glare issues from the low western afternoon sun. This problem is magnified during large gathering events and performances. To mitigate this problem, roll-down blinds will be incorporated into the west glass façade.

Additional museum upgrades

Seismic upgrades at the main entrance concrete frames will be achieved by introducing a thin structural steel frame mounted at top of the new skylight. The steel frame will follow the curvature of the skylights and be inset one foot from the edges to minimize the visual impact.

Main entry lighting located at the stair and roof structures will be converted to LEDs. In addition, the vaulted acrylic skylights beyond the Great Hall will all be replaced with vaulted-double-glazed sealed units. The specifications will be the same as the Great Hall.

Conservation of Cultural Importance

A key question throughout the design process is how to complete the necessary upgrades while at the same time maintaining the cultural importance of the Great Hall. Working with a heritage consultant, several conservation principles outlined in the August 2017 Statement of Significance have been identified in reference to the Great Hall. These conservation principles have and continue to guide the Great Hall upgrades and are as follows:

• Retain in original locations the measured Northeast Coast First Nations carvings specifically consistent with the sequence of spaces.
• Preserve the characteristic elements of the Great Hall’s concrete and glass endowments.
• Maintain the original materials palette of the spaces; maintain the original simple detailing that uses concrete, glass, curved skylights, bridging between concrete stepped concrete beams, and wall-to-wall carpet; new material to match original material.
• Preserve the views of the building’s stepped concrete frames and window walls of the Great Hall.

• Maintain the evergreen tree screening of the building portions that flank the concrete frame elements of the Great Hall.

PROJECT SCOPE

This project entails upgrading the following elements of the Museum of Anthropology’s Great Hall:

- Skylight replacement and upgrading
- Roll-down shading
- Additional museum upgrades
- Conservation of Cultural Importance
- Museum of Anthropology Great Hall Upgrades

MUSEUM OF ANTHROPOLOGY GREAT HALL UPGRADES

THE UNIVERSITY OF BRITISH COLUMBIA

n i c k  m i l k o v i c h  a r c h i t e c t s  i n c
The Great Hall concrete structure is visible throughout the space and creates the expressive architectural form. The deceptively simple beam and column system is in fact a two-way spanning roof diaphragm supported on large columns and the adjacent roof of the Museum. The main structure is made up of the following elements:

1. Precast channel beams - The precast channels are upside down "U" shaped beams that span the long direction of the Great Hall. They were built in sections, lifted into place, and post-tensioned together.

2. Cast-in-place link beams - The link beams weave between the precast channels to provide critical two-way action of the roof system. These link beams also tie the channels together forming a rigid diaphragm at the roof, meaning that during an earthquake the frames largely move together as one, rather than moving as individual frames.

3. Precast columns - Two precast columns support each channel beam. The existing drawings show 1'-8" wide x 6'-0" long solid precast concrete columns (see Fig 2, top). Site investigations have revealed that the columns are actually hollow and prestressed precast concrete columns (see Fig 2, bottom). This change was not documented and greatly affects the seismic performance of the existing structure. The hollow columns are supported on small pad foundations below grade.

4. Support beam/wall - Vertical support to the two-way spanning Great Hall roof beams is also provided by the reinforced concrete structure of the adjacent main building of the Museum.

5. Sun Envelopment and Barrier Shell - The Museum was constructed in 1975 on remnants of a 1939 military battery. Parts of the barrier shell structure are visible in the Great Hall.

Seismic Performance of Existing Structure
As originally designed (with solid concrete columns), the Great Hall would have about 25% of the capacity to resist seismic loads that is required according to the 2018 BC Building Code. In addition to our own analysis, UBC had engaged Arup to take on a campus-wide seismic assessment that included a review of the Museum of Anthropology. Arup found that in all 11 earthquake simulations they ran, their model of the Great Hall collapsed early in the earthquake. Arup had completed their analysis before the concrete columns were discovered to be hollow (see illustration below), so their model did not account for this additional weakness. The main collapse mechanism of the Hall appears to be caused by the flexibility of the columns combined with the rigidity of the roof. The Great Hall roof is rigidly tied back to the main building by the link beams. While the flexible columns want to sway in an earthquake, the frames largely move together as one, rather than moving as individual frames.

Upgrade Options
The design team explored a number of strategies for the seismic upgrade of the Great Hall, these include:

- Add shearwalls or braces. Additional walls or braces to stiffen the Hall would be visible and disruptive to the openness of the space. This was judged to be an unacceptable solution from an architectural and heritage standpoint.

- Strengthen the roof structure with fibre reinforced polymer (FRP). Wrapping the columns with FRP would help strengthen the columns, however the roof structure would still require substantial upgrading at the link beams. The FRP would hide the concrete finish and thus is not an acceptable solution from an architectural and heritage standpoint.

- Base isolate the existing structure and installing isolators below the columns with new footings and a new suspended floor slab. With this approach, we would still need to reinforce the roof, however these upgrades and the base isolation below grade would have been largely concealed from view. This was the design approach we took until we learned that the existing columns were hollow.

- Rebuild the Great Hall as is, with no base isolation. Without base isolation or drastically changing the member dimensions, we would not be able to achieve the strength and stiffness that the system would need to prevent likely collapse in a significant earthquake. This option was judged to impact the architectural character of the space too much. In addition, there would be extensive upgrades required to the channel beams, and the hollow columns would very likely also require replacement, making this option unacceptable from multiple points of view.

- Wrap the existing structure with fibre reinforced polymer (FRP). Wrapping the columns with FRP would help strengthen the columns, however the roof structure would still require substantial upgrading at the link beams. The FRP would hide the concrete finish and thus is not an acceptable solution from an architectural and heritage standpoint.

- Base isolate the existing superstructure. This would involve sharing the existing structure and installing isolators below the columns with new footings and a new suspended floor slab. With this approach, we would still need to reinforce the roof, however these upgrades and the base isolation below grade would have been largely concealed from view. This was the design approach we took until we learned that the existing columns were hollow.

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Base isolation is a common technology in Japan and New Zealand and is often used in high seismic zones when the building or contents are culturally or economically significant. A base isolated building will exceed the life-safety performance level and often will meet post-disaster or low-damage performance levels, offering more protection to the building and contents than most other structural systems.

Isolation is achieved by placing the structure on rubber or sliding bearings. As the ground shakes with high acceleration, the building on the isolators moves with higher displacement and lower acceleration. Base isolation reduces the loads on the structure by allowing the isolators to take up most of the flex.

The best chance at protecting the architecture, the occupants, and the building’s priceless contents is to rebuild the Great Hall on a base-isolated slab. Together with the architect, the Working Committee, and other stakeholders, the guiding principles for the current design have been developed as follows:

1. Carefully demolish the existing Great Hall completely including all foundations and the concrete support beam against the main building. Provide shoring for the adjacent main building structure that is supported by the structure of the Great Hall.

2. Rebuild the superstructure dimensionally identical to the existing Great Hall structure. The structural system above grade will be largely the same, with precast channel beams, precast columns, and cast-in-place link beams. A rebuild means that we can provide a substantially stronger and stiffer system by using high-strength concrete and adequate reinforcement.

3. A concrete suspended slab supported on isolators will become the Great Hall floor structure with a 300 – 350mm movement “moat” (see Fig 5) around it, including at the interface between the Great Hall and the main building. At the building exterior, the movement moat will be covered by river rock and will not be visible. There will be a crawl space below the Great Hall slab to access the isolators.

4. Provide a movement joint at the Great Hall roof between the main building and the new concrete support beam (see Figure 6). The movement joint will be almost entirely concealed from view from within the Great Hall except for a continuous horizontal joint along the concrete wall at the elevation of the underside of the support beam.

5. Replace the concrete suspended slab and beams connecting the Great Hall to the roof of the O’Brian Gallery with a lightweight and flexible structural steel and metal deck system connected to the Great Hall and separated from the O’Brian roof with a movement joint.

6. All skylights and glazing at the interface between the Great Hall and the main building or O’Brian Gallery will be detailed to allow movement in an earthquake.

Structural Design Approach

The best chance at protecting the architecture, the occupants, and the building’s priceless contents is to rebuild the Great Hall on a base-isolated slab.
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All measurements must be checked on the drawings by the contractor.

This drawing is not to be used for construction purposes unless countersigned.

MUSEUM OF ANTHROPOLOGY
GREAT HALL
ANTHROPOLOGY AND SOCIOLOGY BUILDING
ISABEL MACINNES HALL
CLIFF EDGE 2003
PARKING
YOSEF WOSK REFLECTING POOL
ANNE WESBROOK HALL
MARY MURRIN HALL
INTERNATIONAL HOUSE
LIU INSTITUTE
APPROX. TOP OF CLIFF (65.0 m)
APPROX. TOP OF CLIFF (69.0 m)
APPROX. T. O. CLIFF (70.0 m)
CLIFF TOP
CLIFF EDGE 2003
APPROX. TOP OF CLIFF (66.0 m)
APPROX. TOP OF CLIFF (62.5 m)
PROPERTY / BOUNDARY LINE BETWEEN UBC - MOA AND METRO VANCOUVER (PACIFIC SPIRIT PARK)
PROPERTY / BOUNDARY LINE BETWEEN UBC - MOA AND METRO VANCOUVER (PACIFIC SPIRIT PARK)

SITE PLAN
1:500
17005
A1.0

LEGEND:
TEMPORARY ACCESS ROAD WITH HOARDING
NEW SKYLIGHTS
EXISTING CONCRETE TO BE REPLACED
NEW STORAGE AND ELECTRON / TRUE-CORE ROOM

MUSEUM OF ANTHROPOLOGY
LOADING
1 GREAT HALL MAIN LEVEL PLAN

LEGEND:
- NEW STORAGE AND ELECTRICAL / TELECOMM. ROOM
- EXISTING CONCRETE TO BE REPLACED
- MOVEMENT JOINT

1:100
Understanding an Iconic Landscape Design
Approach to Protection and Restoration

Protection of an Iconic Landscape Design
The role of the landscape architecture team is to assist in the protection and restoration of site vegetation, topography, features, and elements impacted by construction activities. Drawings and documents detailing protection and restoration strategies are in development.

Working collaboratively with the consultant team and Musqueam Nation, strategies will continue to evolve for the retention and enhancement of an iconic landscape that responds to the architecture, as well as spirit of place, history, diverse cultures, ecology, and landscape aesthetics and function.

Vegetation, surface materials, and site elements will be carefully protected during construction. Restoration and rehabilitation strategies will be informed on a case-by-case basis and established before construction commences.

Landscape Conservation and Restoration
The guiding rationale for landscape conservation is to retain the significance of the existing designed landscape while allowing for adaptation and revitalization — a need to consider new land uses and standards for accessibility, sustainability, biodiversity, and rehabilitation.

Specific measures will be undertaken to restore the landscape following construction— including the repair, replacement, and restoration of landform, surfaces, and vegetation. Planning for any additional / replacement planting required will be developed in consultation with stakeholders and partners. Landscape conservation and restoration necessitates land stewardship in partnership with Musqueam Nation, upon whose ancestral homeland the Museum of Anthropology is located.

Documentation of Landscape and Place
Site walks and consultations with landscape architect Cornelia Hahn Oberlander, Museum of Anthropology representatives, architects Nick Milkovich and Anne Gingras, and representatives of the Musqueam Nation have taken place, with emphasis on the cultural significance and history of the land.

A comparative inventory of the planting history between 1973 and 2018, and a planting matrix of native and culturally significant species on Musqueam traditional territory, have been completed.

Detailed photographic and topographic surveys form a catalogue of information about the site; photographs, notes and drawings, together with retained samples of site materials, are part of this documentation. Detailed documentation reflects the philosophy that recording should be an integral part of the conservation process of places of significance. This process will assist in developing a record and understanding of the techniques and technologies used to construct the original landscape and the changes made to the landscape post-1973.

During the construction process, impacts on the landscape will be carefully documented and recorded to assist with the repair and restoration of the landscape and to provide a record of the works for future reference.

Process of Careful Site Documentation. Photos representative of existing conditions in site areas potentially impacted by construction.
Protecting an Iconic Landscape

**Critical Areas to be Protected During Construction**

Plan showing site area potentially impacted by Great Hall seismic and envelope upgrade construction activities, and key landscape protection measures.

Scale 1:400

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**Legend**

- **C1** Proposed Areas where Construction will Impact the Landscape. Protection and restoration will be undertaken.
- **C2** Important Site Access Road
- **C3** Proposed Site Access Road
- **C4** Proposed Site Access Road

**Specially-Protected Landscape and Site Elements**

- **L1** Shell Beach
- **L2** Culturally Significant Site Elements
- **L3** Tree species and stand that are locally significant
- **L4** Native plant species
- **L5** Native plant species

**Specially-Protected Vegetation**

- **V1** Protection of Trees and Vegetation

**Landscape Elements, Art, and Artifacts Temporarily Removed and Stored**

- **T1** Cornwallis Harbour
- **T2** Cornwallis Harbour
- **T3** Cornwallis Harbour

**Landscape Elements to be Reinstated Following Construction**

- **P1** Cornwallis Harbour

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*Museum of Anthropology*
Restoring an Iconic Landscape

Critical Areas to be Restored After Construction

Plan showing key landscape restoration work to be undertaken following seismic and envelope upgrade construction activities for the Great Hall.