



**2013 Ontario Region Steel Design Awards**

**Project:** The Canadian Museum for Human Rights

**Category:** Projects Constructed Outside of Ontario

**Submitted by:** Yolles, A CH2M HILL Company

# Canadian Museum for Human Rights

Winnipeg, Manitoba

## Project Team

Owner:	Canadian Museum for Human Rights Susanne Robertson
Architect:	Smith Carter Architects/Antoine Predock Architect PC Grant Van Iderstine/Graham Hogan
Structural Engineer:	Yolles, A CH2M HILL Company Neb Erakovic
General Contractor:	PCL Constructors Canada Inc. Todd Craigen
Steel Detailer:	Walters Inc. Tim Verhey
Steel Erector:	Walters Inc. Tim Verhey

## By the Numbers

- 44 months for structural construction (April 2009 to December 2012)
- 16 months structural steel erection (July 2010 to November 2011)
- 9 years from architectural inception to project completion (2004 to 2013)
- 50m height to top of Cloud Roof
- 100m height to top of Tower of Hope
- 24,500 m<sup>2</sup> total floor space
- 4,500 m<sup>2</sup> of exhibition space
- 5100 metric tones of structural steel and 165,000 bolts
- 800m of pedestrian ramps
- 4000m of masonry shelf angles
- 6000 concrete fasteners, 2500 embedded plates and 2300 concrete insert tie-ins



*“To explore the subject of human rights, with special but not exclusive reference to Canada, in order to enhance the public’s understanding of human rights, to promote respect for others, and to encourage reflection and dialogue.”*

## Museums Act



**Ground-breaking Ceremony December 19th, 2008**  
Canadian Museum for Human Rights

## Structural Innovation at the Centre of our Nation

Located in the geographical centre of Canada at The Forks of the historic Red and Assiniboine Rivers in Winnipeg, MB, the architectural design for the Canadian Museum for Human Rights (CMHR) was selected from an international competition that included 62 submissions from 21 countries. Antoine Predock’s winning design draws inspiration from the natural scenery and open spaces of Canada.

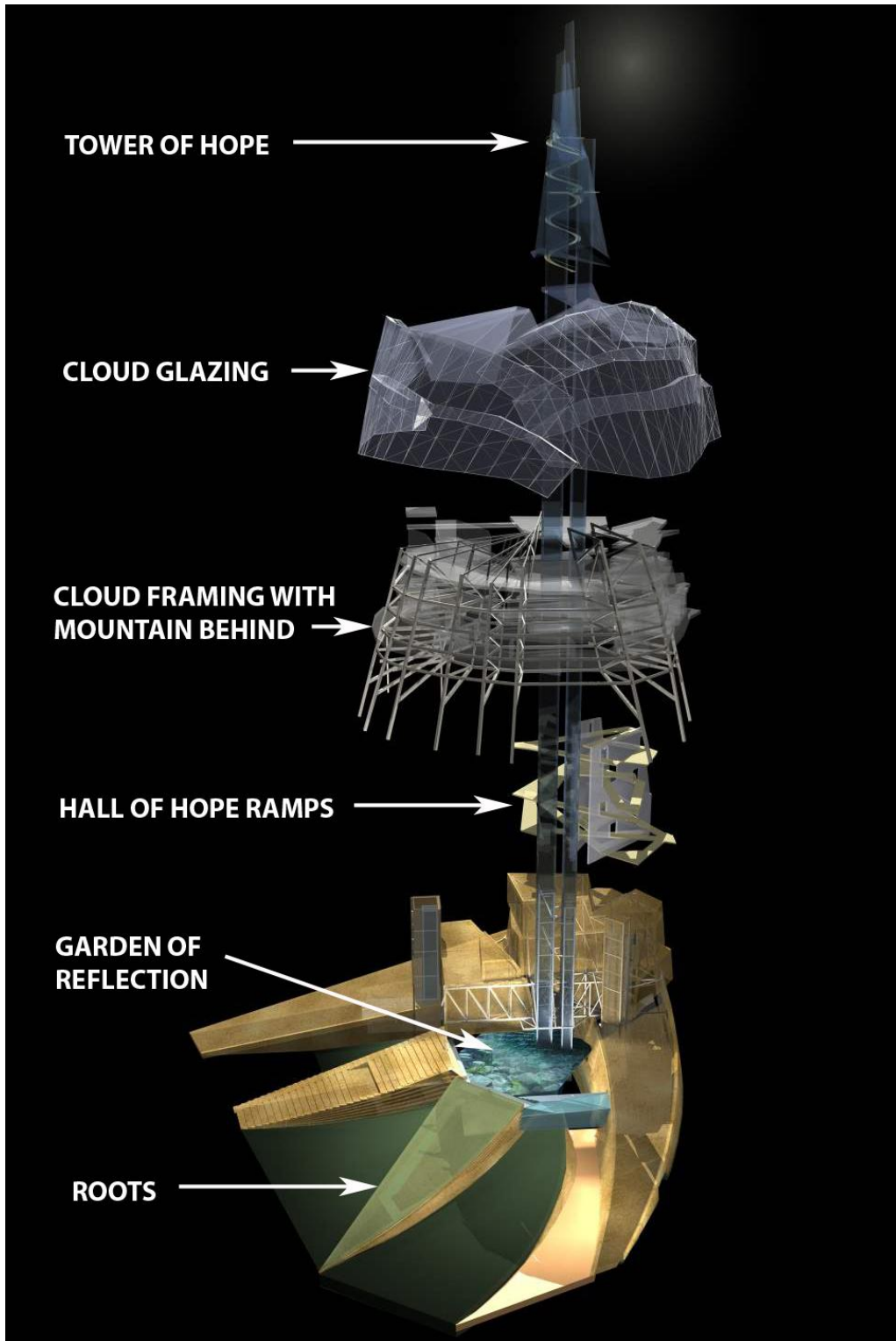
Yolles, A CH2M HILL Company, collaborated closely with the Architects to translate their vision of organic forms into rational structural components tied together to create a unique building structure that is stable and ultimately constructible. The iconic architectural forms used by Predock’s team within CMHR resulted in significant structural complexity including large column free spaces, unconventional

load paths, long cantilevers, and highly stressed connection points between steel forms and at concrete walls, all necessitating the use of structural steel.



**Construction Progress, March 13th 2013**  
Antoine Predock Architect PC

The CMHR is generally composed of four base 'Roots' radiating out from a central 'Great Hall' and 'Garden of Reflection' beneath a suspended 'Mountain', 'Cloud' and 'Tower of Hope'. The 50m tall 'Hall of Hope' atrium at the back of the building cuts into the Mountain and Roots like a canyon and houses circulation ramps between galleries. The Roots contain the functional spaces of the museum and are constructed of sloping, segmented, reinforced concrete walls. The Mountain contains the bulk of the exhibition spaces and the Cloud encapsulates office spaces and a large atrium. Projecting above the Cloud roof, the Tower of Hope houses an observation gallery to provide visitors with a stunning view of The Forks, downtown Winnipeg, and the surrounding Prairie. The unique Mountain exhibition galleries, curved Cloud façade, the Tower of Hope spire, the garden of Reflection, and Hall of Hope ramps posed significant design challenges that were ultimately accomplished by innovated use of structural steel framing.



**Assembly of Primary Programmatic Zones**  
Courtesy of Antoine Predock Architect PC





## Design Form Challenges and Structural Steel Solutions

The Mountain consists of an array of five eccentrically stone clad closed steel forms of irregular shape suspended 18 metres above ground floor level. Initially conceived in reinforced concrete, design challenges including highly stressed contact points between forms, large column-free spaces, significant form cantilevers, large openings in walls, sloping walls, eccentricity of stone cladding, and unconventional vertical and horizontal load paths necessitated the use of structural steel framing.



**Erection of the Mountain Diagrid begins in Winter 2010**  
Yolles, A CH2M HILL Company

Each two-storey Mountain wall consists of structural steel W-sections and corner circular hollow sections to form the primary diagrid wall trusses which span significant unsupported distances between concrete walls and steel columns. The diagonal and vertical elements within the diagrid wall trusses are positioned around wall openings to provide direct load paths down to supports, but also transfer lateral loads down the building with composite floor diaphragms distributing those loads across to supporting walls. Parametric sensitivity analyses were conducted to assess the effects of changes in temperature, slab and wall cracking, construction sequencing and staging, and connection fixities. Optimizing the diagrid wall truss member locations, designs, and connections with consideration to these parameters is complicated by the redistributive nature of the stacked diagrids.



**Shared Node between Mountain Forms**

Yolles, A CH2M HILL Company

Another significant design challenge was that the lower Mountain form cantilevers 16 metres over part of the Garden of Reflection. A disproportionately small 20 metre back span requires the floor diaphragms at the top and bottom levels of this form to act as a horizontal force couple to provide supplemental resistance to overturning of the cantilever. The connection of cantilever to the concrete core walls also proved to be challenging, requiring complex tie-in connections at this material interface. The massive supported weight of stone cladding, heavily loaded exhibition and plant floors, upper Mountain, Cloud roof, and the Tower of Hope require this form to be super elevated at erection to ensure flat floors in the final condition. Extreme loads also require six 500mm x 100mm solid steel plates to be built up to form a solid 500x600 steel diagrid member. The design and construction of this cantilever form proved to be the most challenging aspect of the project.





**Zone of Overlap between Cloud Wings**  
Antoine Predock Architect PC



**Central Atrium Interior**  
Antoine Predock Architect PC

The glazed Cloud encapsulates the large central atrium, the museum offices and the Garden of Reflection. The Cloud curvature is framed with a series of curved 610mm diameter hollow circular steel pipes supported by raking built-up hollow steel columns that span over 30m from the Roots up to the Cloud roof. Balcony-like partial perimeter office floors encircle the atrium at three levels and act as diaphragms to provide lateral stability to the raking columns. Steel framing allows light into the Tower of Hope and practically unobscured panoramic views out. The underlying geometry consists of two overlapping cones discretized into faceted shards of layered glazed panels.



**Long Span Trusses below the Garden of Reflection**  
Antoine Predock Architect PC



**Maintenance Access within the Tower of Hope**  
Antoine Predock Architect PC



The Garden of Reflection, located at the base of the Cloud atrium and Tower of Hope, provided its own structural complexity. To provide a column free space for the dark void of the Great Hall below and to support the Tower of Hope elevator hoist-way, and spiral stair above, a two directional, long spanning, steel truss support system was used. The Garden of Reflection framing, which supports still water reflective pools and Basalt stone seating, floats between surrounding structural components (Hall of Hope walls and adjacent Roots) and sits on sliding bearings to prevent the attraction of significant compatibility forces. Behind the Garden of Reflection, circulation ramps, clad in backlit alabaster stone, link the museum exhibition spaces and fly through the Hall of Hope atrium, a 50m high black concrete canyon. These ramps, which are steel pony trusses up to 25m in length, are highly irregular and susceptible to significant human induced vibrations; steel was the only viable solution for this complex series of pathways. As each ramp is unique in span and supports, a repetitive structural framing system was used to rationalize the fabrication and construction.



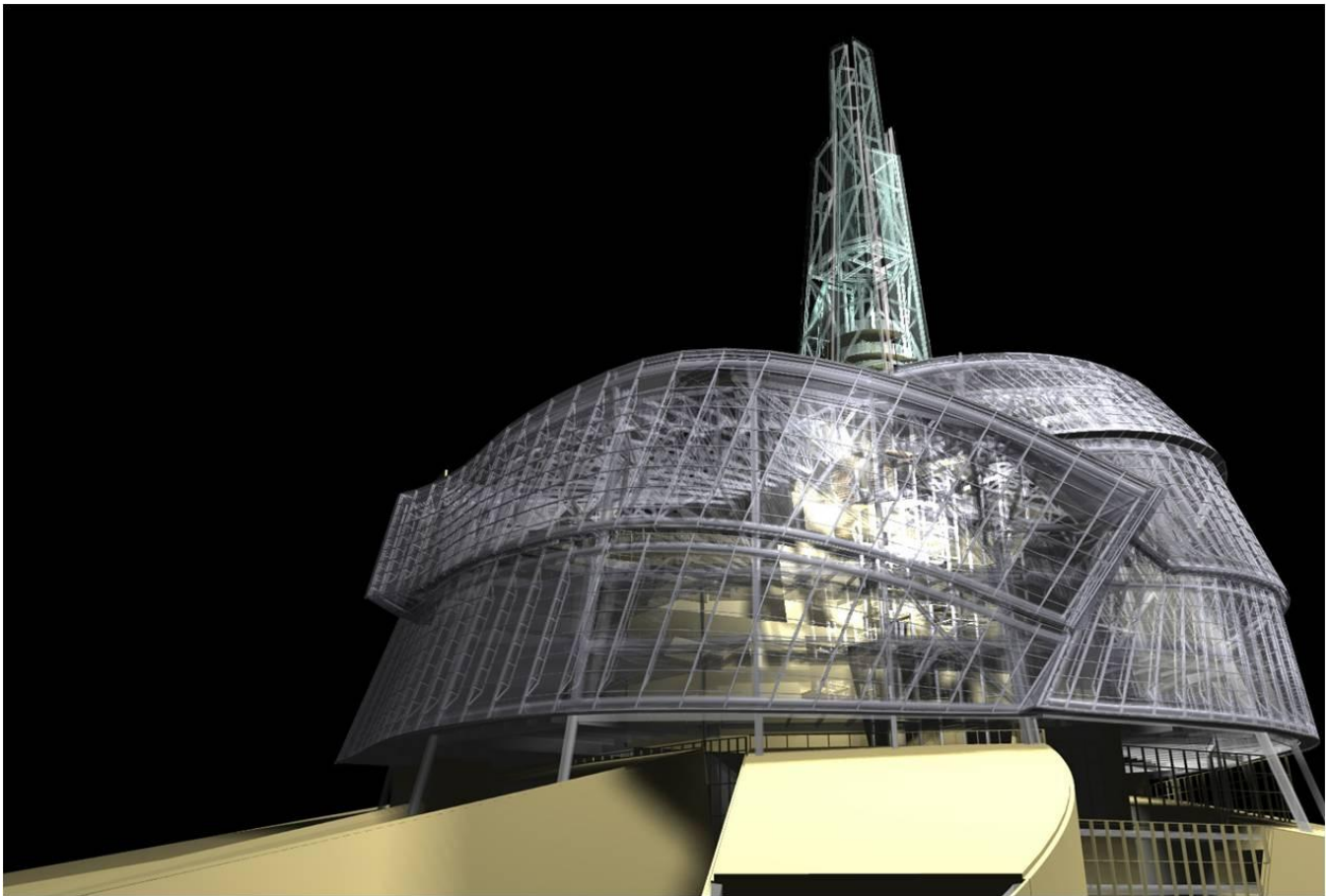
**Hall of Hope Ramps in the process of installing metal deck and concrete**  
Yolles, A CH2M HILL Company



Owing to the Prairie climate, it was anticipated that the structure could experience temperature differentials of at least thirty degrees Celsius prior to enclosing the building. As expansion joints were not possible within the building due to the need for continuous diaphragms to resist wind loads and to hold sloping, cantilevered and unbalanced parts of the building together, locking the various steel components of the structure into the supporting concrete walls during construction would result in unacceptably high thermal restraint forces and potential damage. Temporary steel slip connections and slab separation strips were used to disconnect selected structural components during construction with temporary bracing introduced to maintain stability until the building was enclosed.

## Building Information Modeling – 3D Visualization and Information Sharing

By now the advantages and disadvantages of Building Information Modelling (BIM) are well documented in the building construction industry but at the time of CMHR design initiation it was a relatively new technology that forced a cultural change to the design consultant teams. For the complex three dimensionally curved and sloping geometric forms of this building Yolles developed a sophisticated workflow to capitalize on the best aspects of several software programs more common to the industrial, automotive and aircraft industries. Starting with CATIA in 2004 and moving to a full REVIT model in 2008, these building models were utilized as contract documents along with conventional 2D drawings. Various components of the building such as the Mountain, Cloud, and Tower of Hope were broken out and individually translated from design concept into structural components that were manipulated back into the master BIM geometric model. Ultimately the benefits of BIM were realized in excellent 3D visualization, sharing of information for coordination, and clear contract documentation. BIM was clearly the best tool to manage the structural complexity of this building.



**Trade Model Coordination**  
Antoine Predock Architect PC

## Lasting Impression

Structural steel is used to overcome numerous design and construction challenges for the architecturally complex CMHR superstructure including the stacked forms of the Mountain, rationalized geometry of the Cloud and Tower of Hope, the Garden of Reflection, and the long span Hall of Hope ramps. BIM was successfully used to model and document the building structure with various software used to analysis and design advanced, rational, geometric solutions for each structural component. Steel was the only feasible material of choice to satisfy the challenges posed by this architectural vision and the resulting magnificent building will be a true testament to the importance that Canada, as a nation, places on human rights.



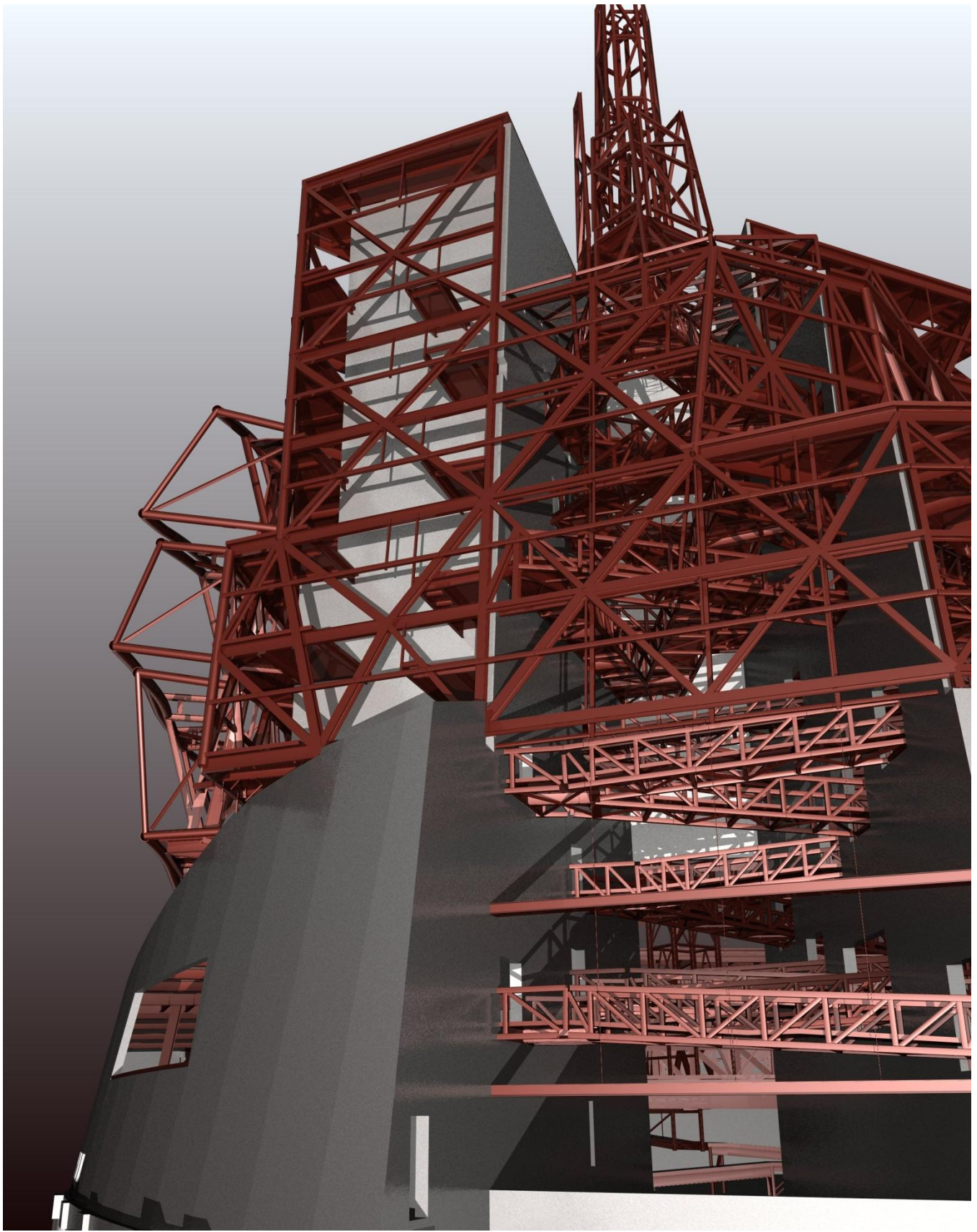
**Construction Progress, Winter 2012**  
Antoine Predock Architect PC





*“The Canadian Museum for Human Rights is rooted in humanity, making visible in the architecture the fundamental commonality of humankind—a symbolic apparition of ice, clouds and stone set in a field of sweet grass. Carved into the earth and dissolving into the sky on the Winnipeg horizon, the abstract ephemeral wings of a white dove embrace a mythic stone mountain of 450 million year old Tyndall limestone in the creation of a unifying and timeless landmark for all nations and cultures of the world.”*

Antoine Predock



**Revit Structure Model Screenshot**  
Yolles, A CH2M HILL Company





**Shared Node between Mountain Forms**  
Yolles, A CH2M HILL Company





**Erection of Continuous Ramps thru Hall of Hope Concrete Walls**  
Yolles, A CH2M HILL Company





**Steel Erection Progress, July 2011**

PCL Constructors Canada Ltd.





**Tower of Hope Structural Steel Erection Completed**  
Yolles, A CH2M HILL Company





**Scaffolding to install Cloud Glazing System**  
Yoiles, A CH2M HILL Company



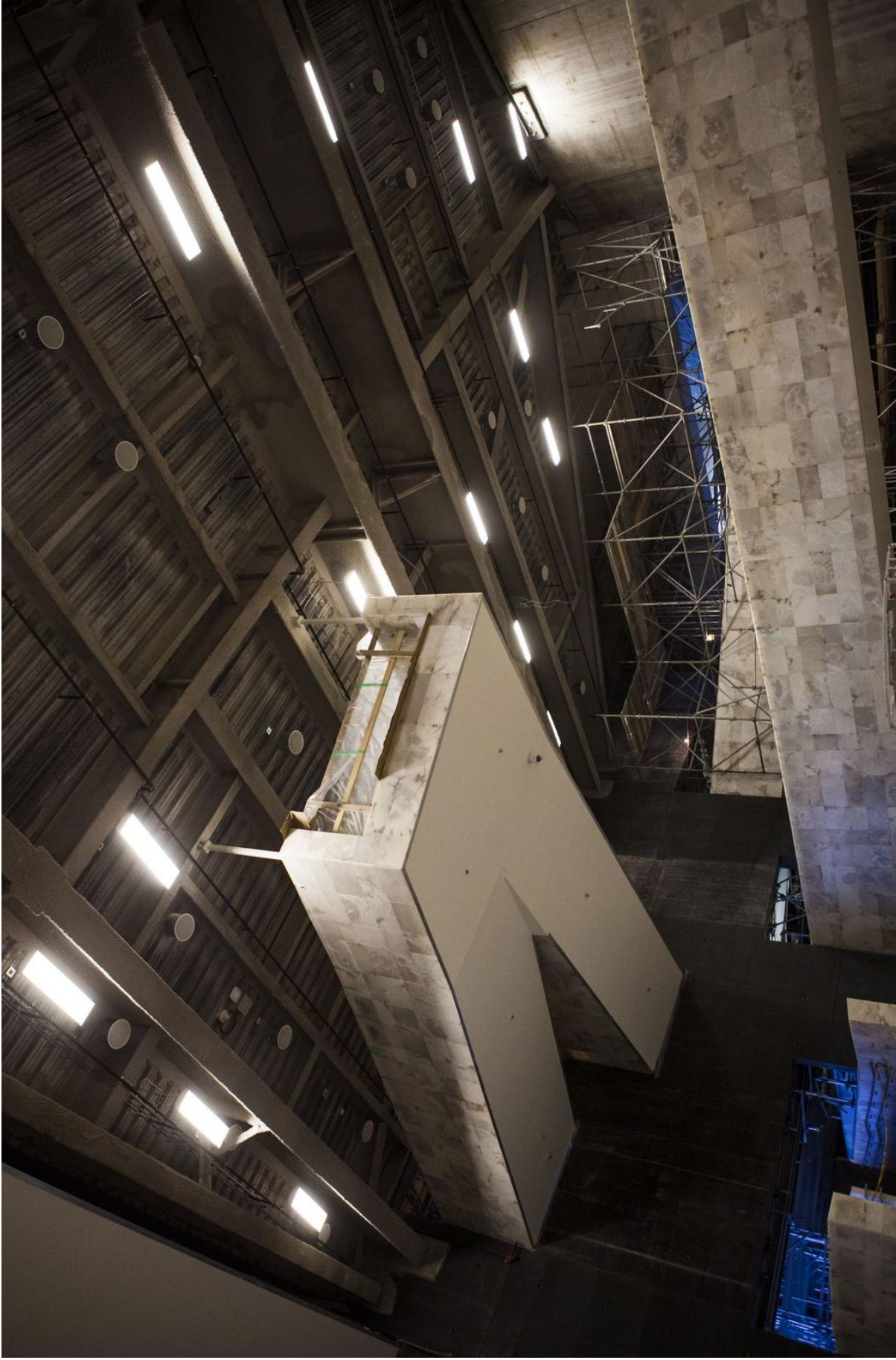


**Atrium Elevators and Cloud Roof**  
Antoine Predock Architect PC



**Hall of Hope Ramps Clad in translucent Alabster**  
The Canadian Museum for Human Rights





**Hall of Hope Ramps within Gallery Space**  
The Canadian Museum for Human Rights





**Museum Exterior, March 2013**  
The Canadian Museum for Human Rights