New Structural Solutions for Retrofit Easier Access Elevators (EA) and Second Exit Structures (SE)

Case Study: Woodbine Station EA and SE

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AGENDA

1. Project Overview – Woodbine Station EA and SE

2. Elevator E1 Design
   
   2.1 Site Constraints
   
   2.2 Structural Solution – Permanent Shoring
   
   2.3 Permanent Shoring Construction
   
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1. Project Overview - Woodbine Station EA and SE
Woodbine Station - History

➢ Built in 1964 with side platform configuration as part of subway Line 2 (Danforth).

➢ Platform level at 9.4 m (31 ft.) below ground, originally built as a “cut and cover” structure.

➢ Station had one entrance building, and connection was provided through one stair and one escalator to each platform.

➢ Street level bus platform provides an integrated connection for passengers to the subway.
Woodbine Station - Upgrade

➢ Station retrofitted to be compliant with Accessibility for Ontarians with Disabilities Act (AODA) 2005 requirements through addition of:
  ▪ Two elevators - E1 and E2.

➢ Station retrofitted to provide alternate egress in accordance with the 2002 Fire and Life Safety Evacuation Assessment requirements through addition of:
  ▪ Second Exit Stairs from both platforms to street level.
  ▪ Second Exit/Entrance structure building.

➢ Community consultation conducted before start of final design.
New Easy Access Elevators and Second Exit Structures

➢ Design completed in June 2013.

➢ Construction of all stages completed between 2014 to 2017.

Connection to concourse level and Westbound platform level.

Connection to street level, concourse level and Eastbound platform level.
2. Elevator E1 Design

➢ **Main objective:** Locate and build new elevators causing minimal disruption to public and station operations.

Google photo of site (early stage of construction)
➢ Existing roof framing layout allowed for localized removal of roof precast concrete T-beam framing to construct new elevator E1.
2.1 Site Constraints at Elevator E1

➢ Do not affect access to subway station.

➢ Fit new E1 structure within the available 7200 mm (23.6 ft.) width of the roof removal.

➢ Drill caissons tight against existing structure or very close to above grade roof structure.

➢ Not enough space to install a conventional structural system consisting of separate shoring and structural walls.
Station Roof Plan - Caisson layout and roof removal area for elevator E1

Max. 300 mm (1.0 ft.) clearance between roof beams and caissons

Caissons drilled tight against the existing underground structure below

Roof precast T-beams removed within hatched area

Existing station roof precast T-beams not affected

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Caissons drilled tight against
the existing underground
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Existing station roof
precast T-beams not
affected

7200 mm
(23.6 ft.)
2.2 Structural Solution- Permanent Shoring

Permanent tangent caisson wall shoring combined with structural concrete wall

Permanent shoring – for lateral load resistance.

Concrete wall – for support of vertical loads and to provide water tightness.

- 350 mm (14”) wall
- W250 (W10) pile
- 610 mm (2.0 ft.) tangent caisson

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➢ Permanent caisson wall properties:

- Tangent 610 mm (2.0 ft.) diameter concrete drilled caisson.
- Reinforced with W250x80 (W10x54) steel piles.
- Concrete 35 MPa (5000 psi) @ 28 days.
- C1 concrete mix with integral crystalline waterproofing additive.
Steel pile with bond breaker – one face of W pile greased before installation, to allow for easy concrete removal.
2.3 Permanent Shoring Construction

Elevator E1 Construction Milestones:

- Shoring installation (30 tangent piles): 1.5 months; Oct. 2015
- Excavation: 2.5 months; Nov. 2015 to Jan. 2016
- Structure (below grade - concrete): 5.5 months; Feb. - July 2016
- Structure (above grade - steel): 2.5 months; July to Sep. 2016
Caisson Layout Plan at Elevator E1

Outline of underground station structure below

Outline of roof above (after partial removal)
Permanent Shoring Installation

Drilling of caissons beside existing roof
Caisson Drilling
Permanent tangent caisson piles installed tight against the existing station wall.

E1 Concourse Level Plan

E1 Platform Level Plan

Connect to E2 elevator and WB platform

Connect to EB platform
Excavation of E1 Area and Wall Surface Preparation

- Excavation along existing wall exposed old shoring piles.
- Face of caissons shaved to expose steel piles as excavation progressed down.
Existing Shoring along Station Wall

➢ No interference with old shoring pile.

New shoring piles installed tight against existing station wall.
Excavation Shoring - Section

Shoring along existing wall also serves as underpinning for existing passageway.

Underside of existing station structure (concourse level)

Street Level
Wood lagging installed where existing pile was removed
Excavation and Shoring at Elevator E1 - Steel Piles Exposed
Excavation – Elevator E1
Dewatering at the base of the elevator pit
Connection of Permanent Shoring to Interior Concrete Wall

- Connection between each W pile and concrete wall reinforcing through welded strap anchors.
- Strap anchor spacing 450 mm (18") along full height of each W pile.
Strap Anchors and Wall Reinforcement
Connection of Permanent Shoring to Base Slab

30M (#10) U - bars welded to W piles
Connection of Permanent Shoring to Concourse Level Slab

Epoxy grouted stainless steel dowels and strap anchors provide support and load transfer.
Dowelling – Concourse Slab
Connection of Permanent Shoring at Street Level Slab

W piles encased in slab and strap anchors provide lateral support and load transfer.
Street Level – Shoring Piles with Welded Straps
Street Level Slab Reinforcement
Concrete column infill provided in locations where the old shoring piles were removed.
Additional protection against water ingress:

Cementitious crystalline waterproofing applied to interior surface of structure.
Elevator E1 Shaft - before cementitious waterproofing application

Elevator E1 Shaft - with cementitious crystalline waterproofing
Installation of Structural Steel for Elevator E1

Steel framing tie-in at station roof
2.4 Structural Solution- Connection to Existing Structure

Main Objective: Design and construct access openings to existing subway platforms with minimal disruptions to passengers and requiring minimal modifications to the existing station structure.

➢ Locate opening in the existing station wall as to have minimal impact on the structure.

➢ Avoid the need for shoring existing structure from the platform level.

Solution:

➢ Design new structure to support existing structure through structural dowelling.

➢ Cut opening in existing wall after new structure is completed and is capable of supporting load transfer and redistribution.

➢ Used for both SE and EA retrofits.
Platform Level – New Openings in Existing Walls for EA and SE

Openings cut for connection to SE after new structure is completed

Openings cut for connection to Elevators after new structure is completed

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Connection Design

➢ Tributary load from existing structure redistributes and transfers into dowels and new beam.

Existing wall removed from inside the new structure without affecting existing platform.
Base Slab Connection between Existing and New Structure
Concourse Level Connection between Existing and New Structure

New beam designed to carry tributary loads from both new and existing structure.

Stainless steel dowels epoxy grouted into existing wall.
Concourse Level Connection Dowels between Existing and New Structure
Connection to Existing Structure

Conditions:

➢ Geotechnical conditions must be favorable.

➢ Differential settlement between existing and new structures has to be minimal.
  ➢ Soil at this project site: Clear compact fine sand.

➢ Existing station box structure must have adequate reserve capacity to allow for load redistribution.

➢ Existing concrete members are in good condition.

➢ New opening has to be minimum 1.0 m (3 ft.) away from any contraction joints.

➢ Width of opening limited to maximum 3.5 m (11.5 ft.).

➢ The new structure must be completed before the existing wall of the station box is removed.
WOODBINE STATION BEFORE RETROFIT
WOODBINE STATION- AFTER RETROFIT
3.0 Conclusions

➢ Use project specific structural solutions.
  ▪ For SE and EA projects there is no “one solution fits all”.

➢ Size and location of new openings, connections and modifications to existing station structure was driven by structural solutions to control cost and reduce inconvenience to customers.
  ▪ Involve structural engineers early at planning stage.

➢ Use of permanent shoring as structural system is acceptable when:
  ▪ Existing conditions do not allow for use of conventional structural system.
  ▪ Geotechnical conditions are favorable and underground water levels are at or below base slab of structure.

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Thank you!

Any questions?

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