# Approach to Evaluate Foundation Reuse

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## Approach to Evaluation Foundation Reuse

**Highway 401 Toronto, Ontario, Canada**


**Morning Session:**

- Ministry of Transportation Ontario's Position on Foundation Reuse
- Site and Project Description
- Overview of the Evaluation Process
- Evaluation Process Step 1) Preliminary Foundation Assessment

**Afternoon Session:**

- Evaluation Process Step 2) Risk Assessment

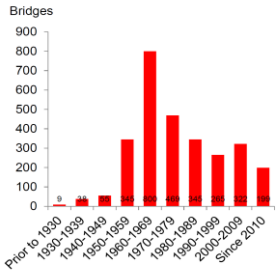


## Ministry of Transportation of Ontario (MTO) Assets

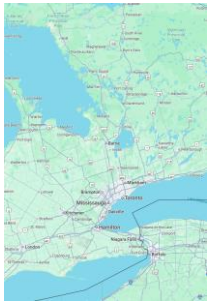
- 17,000 km of highways
- 3,000 bridges
- 5,000 structural culverts
- Total asset value of CAD$100B
- CAD$3B goods and services daily

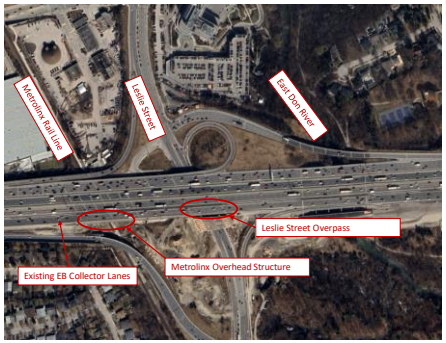


## MTO's Position on Foundation Reuse




## Site Location







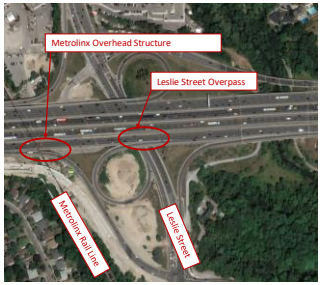

## MTO's Foundation Reuse Evaluation Guideline

**Step 1** Preliminary Foundation Assessment
**Step 2** Risk Analysis
**Step 3** Life Cycle Cost Assessment
**Step 4** Estimation of Remaining Service Life
**Step 5** Environmental and Social Considerations



## Step 1) Preliminary Foundation Assessment

- To assess pile capacity, integrity, and durability
- Preliminary foundation assessment:
  - A. Review of subsurface conditions
  - B. Review of existing foundation design, construction and past performance
  - C. Assessment of geometric compatibility and constructability
  - D. Evaluation of existing pile capacity
  - E. Evaluation of existing pile integrity and durability






## A) Review of Subsurface Conditions

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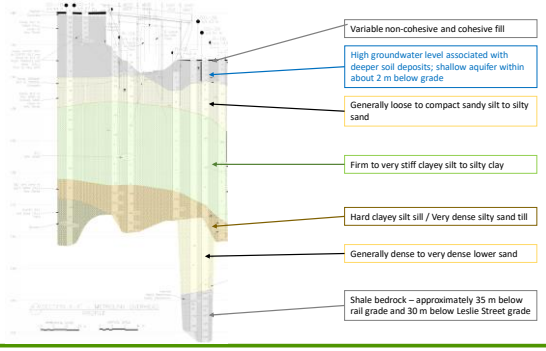





## B) Review of Existing Foundation Design, Construction and Past Performance


| Proposed Structure* | Existing Foundation Element | Foundation Type | Approximate Underside of Pile Cap / Pile Cut-Off Elevation (m) | Approximate Depth** (m) | Approximate Pile Spacing*** (m) |
|---|---|---|---|---|---|
| EB Express Metrolinx Overhead | West Pier (Bent 420) | HP 310×79 steel H-piles (2 rows of 7 piles; 7 piles are vertical and 7 piles are battered at 1:6) | 139.1 / 139.4 | 18 | 3.3 (N-S) 2.4 (E-W) |
| | East Pier (Bent 421) | HP 310×79 steel H-piles (2 rows of 7 piles; 7 piles are vertical and 7 piles are battered at 1:6) | 139.1 / 139.4 | 18 | 3.3 (N-S) 2.4 (E-W) |
| EB Express Leslie Street Overpass | West Pier (Bent 431) | HP 310×79 steel H-piles (2 rows of 9 piles; 9 piles are vertical and 9 piles are battered at 1:6) | 134.7 / 135.0 | 20 | 3.4 (N-S) 2.4 (E-W) |
| | Centre Pier (Bent 432) | HP 310×79 steel H-piles (2 rows of 9 piles; 9 piles are vertical and 9 piles are battered at 1:6) | 134.9 / 135.1 | 20 | 3.3 (N-S) 2.4 (E-W) |
| | East Pier (Bent 433) | HP 310×79 steel H-piles (2 rows of 9 piles, battered at 1:6) | 135.0 / 135.3 | 21 | 3.2 (N-S) 2.4 (E-W) |

* For clarity, these proposed Highway 401 EB Express structures are planned to be within the same footprint / alignment of the current (as of September 2024) EB Collector structures.
** The approximate pile depths at Bent 420 and 421 were estimated to extend 1 m into the very dense till, as shown on Contract Drawings D5622-5) and the pile depths at Bent 431 to 433 were obtained from Table 5-1 of GEOCRES 30M14-328.
*** Spacing measured from centre of pile to centre of pile in North-South (N-S) direction and East-West (E-W) direction.



## C) Assessment of Geometric Compatibility and Constructability

| Span Arrangement Option | Foundation Option | Comments and Risks |
|---|---|---|
| Maintain current pier locations | Reuse existing steel H-piles with no enhancement/ augmentation | Greatest risk re: capacity, integrity and durability of piles |
| | Existing piles provide partial capacity and new foundations are added to augment geotechnical and structural capacity | Would require work near active rail and heavily-travelled road, but eliminates risks re: integrity and durability. Could incorporate H-piles following removal of pile cap, or drilled shafts or micropiles could be constructed through pile cap if necessary. Pile conflicts could occur. |
| | Existing piles are not reused and are cut off (not extracted), and replaced with new foundations | New foundations may consist of driven piles or drilled shafts. |
| Modify pier locations | New deep foundations in new pier footprints | Existing centre pier location at Leslie Street cannot be modified and would require reconstruction at existing location. |



## D) Evaluation of Capacity of Existing Piles

- Geotechnical resistance calculated based on subsurface model and existing pile details
- Structural engineers assessed total vertical forces acting on existing piers
- Existing piles will provide sufficient axial geotechnical resistance for proposed structure loading

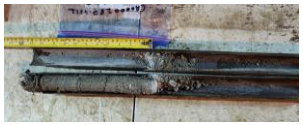
**Assessment of Geotechnical Resistances to Structural Loading Requirements**

| Proposed Structure | Foundation Element | Foundation Type | Factored Vertical Force Per Pier (Per Pile) | Factored Geotechnical Resistance per pile | % of Factored Geotechnical Resistance Required for Structural Support |
|---|---|---|---|---|---|
| EB Express Metrolinx Overhead (Existing EB Collector) | Piers at Bent 420 and 421 | HP 310×79 H-piles (14 piles per pier, 7 vertical and 7 battered) | 11,900 kN (850 kN) | 1,300 kN to 1,400 kN | 65% |
| EB Express Leslie Street Overpass (Existing EB Collector) | Piers at Bent 431 to 433 | HP 310×79 H-piles (18 piles, 9 vertical and 9 battered) | 10,680 kN (594 kN) | 1,300 kN to 1,400 kN | 46% |

## E) Evaluation of Integrity and Durability of Existing Piles

**Soil and Groundwater Corrosion Assessment**

- "non-corrosive to severe corrosiveness" compared to:
  - MTO Gravity Pipe Design Guidelines, 2014
  - Caltrans Corrosion Guidelines, Version 3.2
- Soil corrosivity categorization differs depending on which criteria are used
- These guidelines are a simplified qualitative ranking, and do not consider:
  - Microbiological activity
  - External sources (e.g., stray current)
  - Use of de-icing salts
  - Presence of coal, peat/organics, landfill materials, etc.
  - Macro-cell effects





## E) Evaluation of Integrity and Durability of Existing Piles


**Steel Corrosion Assessment**

- Demolition of former ramp bridge, also constructed in 1960s, allowed exposure and extraction of pile sections from above/near the groundwater level
- Pile segments underwent visual examination before and after pressure washing, ultrasonic thickness readings, and tensile testing by a specialist corrosion testing firm



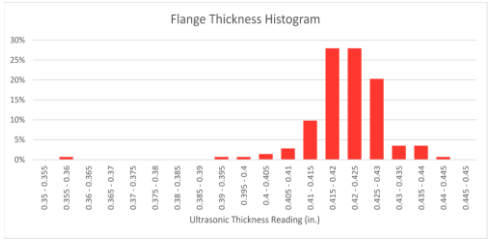
## E) Evaluation of Integrity and Durability of Existing Piles

**Steel Corrosion Assessment**

- Soils rated "non-corrosive" to "severe corrosiveness"
- Corrosion protection barrier coating noted to have "long since failed".
- Corrosion at two elevations.
- Some heavy localized pitting
- Considered to be in "good shape"



## E) Evaluation of Integrity and Durability of Existing Piles




**Steel Corrosion Assessment**

- Ultrasonic thickness measurements considered most applicable for assessing corrosion rate.
- Average remaining wall thickness within 95% confidence was 0.403 inches (representing ~7% section loss).

## E) Evaluation of Integrity and Durability of Existing Piles

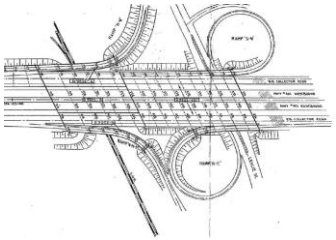
**Steel Corrosion Assessment**

- Upper bound corrosion rate of 1.08 mpy based on:
  - Ultrasonic thickness measurements
  - Assumed original thickness 0.435 inches
  - Assumed 30-year life of original barrier coating
  - 59 years of service from pile installation to extraction
- Remaining steel pile section in an additional 50 years and 75 years was estimated to be about 0.350 inches (20% wall thickness loss) and 0.322 inches (26% wall thickness loss), respectively.



## Conclusion of Step 1) Preliminary Foundation Assessment

- Sufficient axial geotechnical resistance for the structural loading conditions
- Sufficient remaining service life and pile section loss is not likely to compromise the piles
- Reuse of the existing piles is feasible.





## Thank you

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