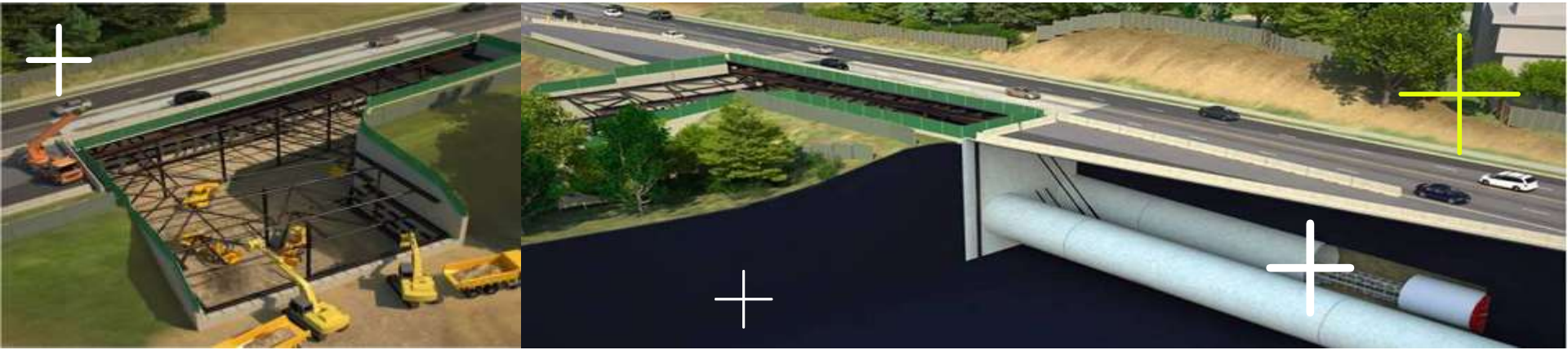
Considérations techniques pour la planification, la conception et la construction d'un projet de transport en commun dans un milieu densément peuplé



Le cas du projet de système léger sur rail Eglinton Scarborough Crosstown

Jean Habimana, ing., PE, Ph. D.

HATCH

Ordre du jour

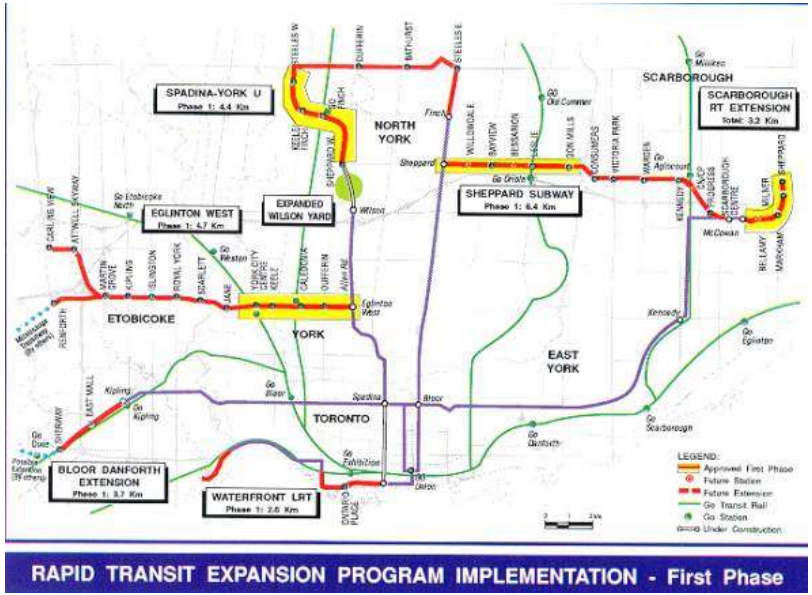
- Historique du projet
- Envergure du programme
- Quelques enjeux de planification, de conception et réalisation

Original image without dividing of Y-U-S via TourByTransit @ http://tourbytransit.com/toronto/images/Toronto-Subway-Map.png

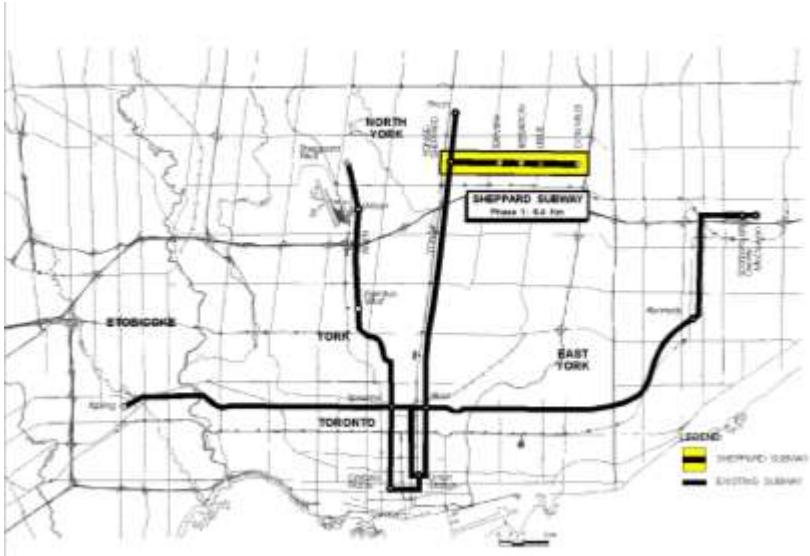
HATCH

Historique du projet

1991 – “*Rapid Transit Expansion*”



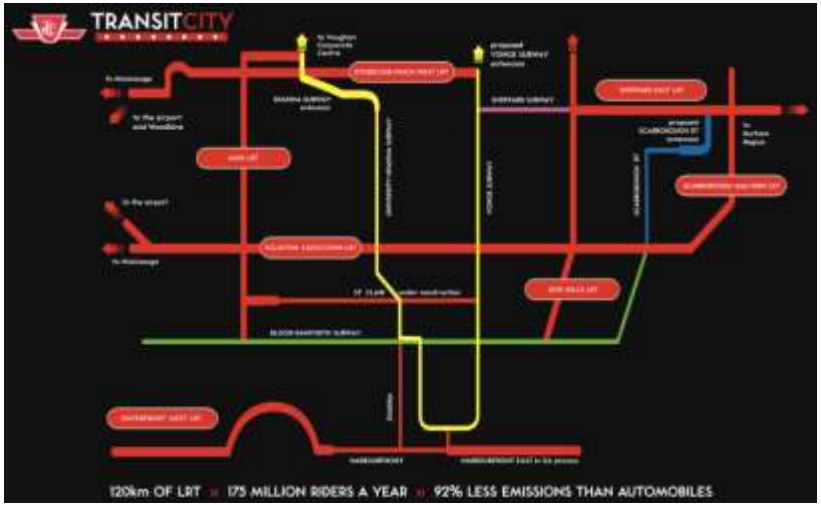
2007 – Prolongement de Sheppard



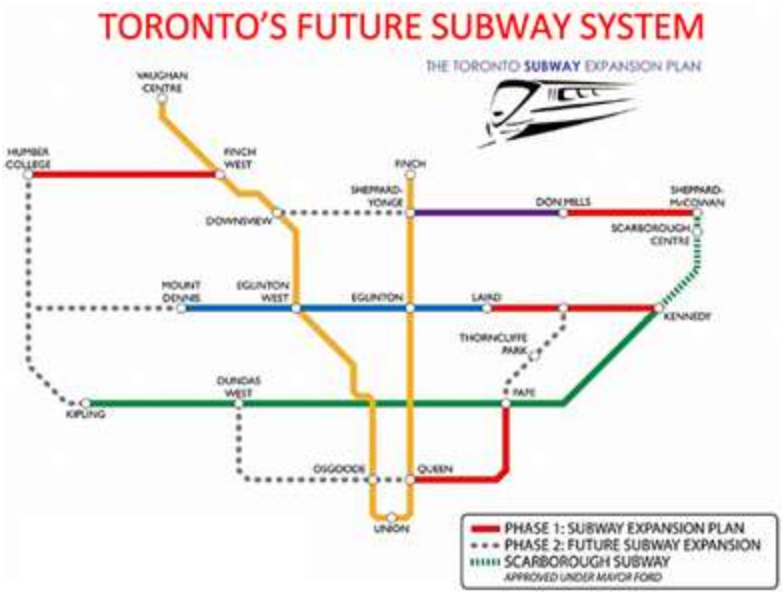
HATCH

Historique du projet

2007 – Transit City



2010 – Transit Expansion

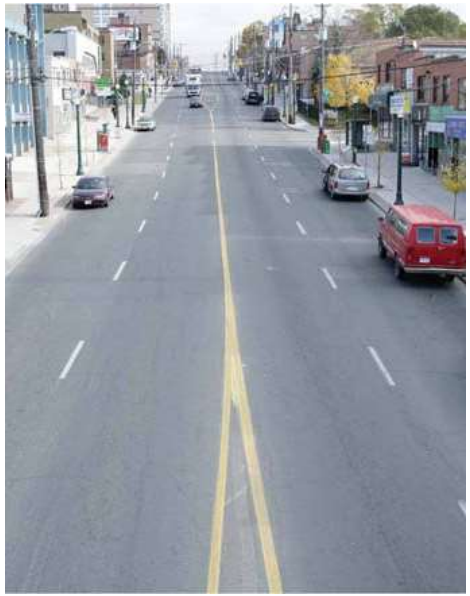


HATCH

Historique du projet

2012 – Accord entre la Ville et Metrolinx

Budget total 8,4 milliards $ (du gouvernement provincial)



Eglinton Crosstown

- 25 km
  - 10 km de voies souterraines
  - 8 km en surface
  - 1 km de voie surélevée
  - 6 km de conversion en SLR
- 12 stations souterraines
- 12 gares en surface

HATCH

Contexte du projet (2012)

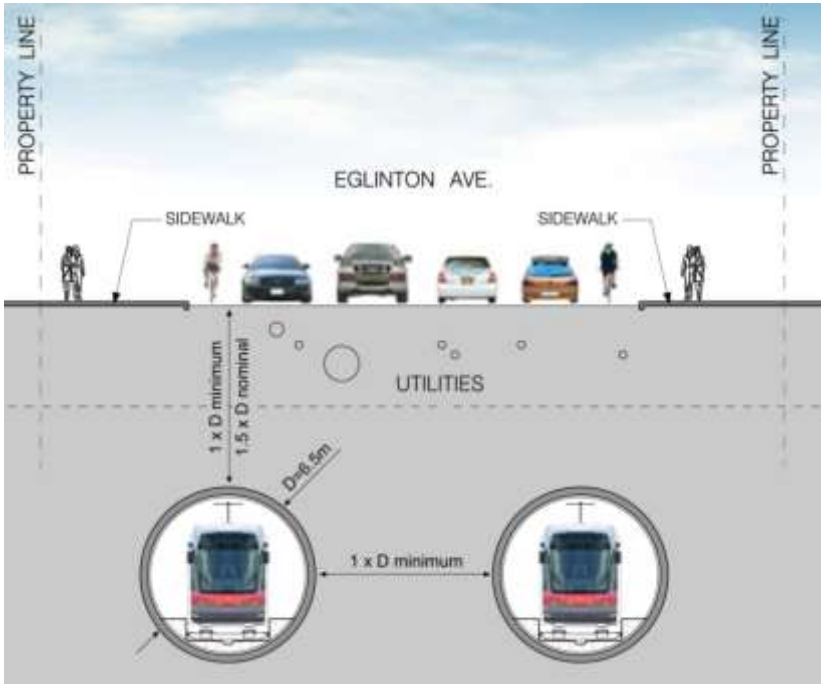
- Préachat (déjà attribué)
  - 4 tunneliers
  - Voussoirs préfabriqués
  - Trains
- Mode traditionnel
  - Puits de lancement
  - Excavation des tunnels
- Financement innovant (PPP)
  - Stations
  - Exploitation
  - Systèmes

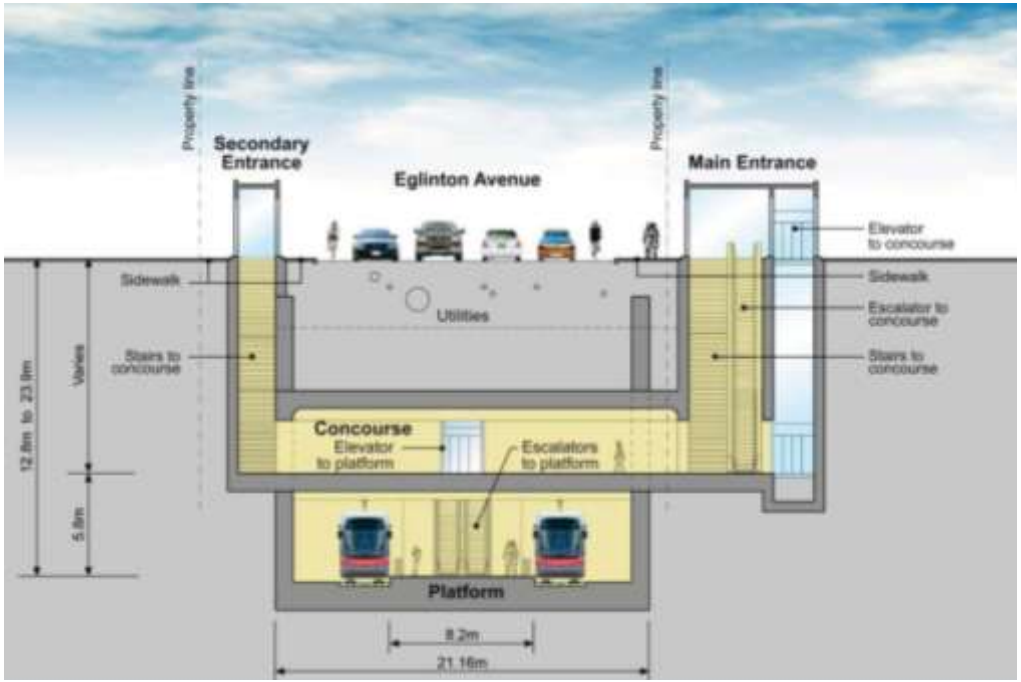
HATCH

Excavation à ciel ouvert

HATCH

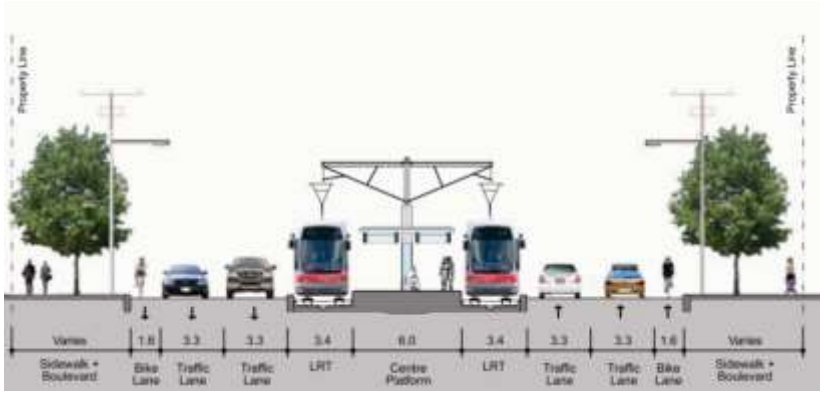
Établir la profondeur du tunnel

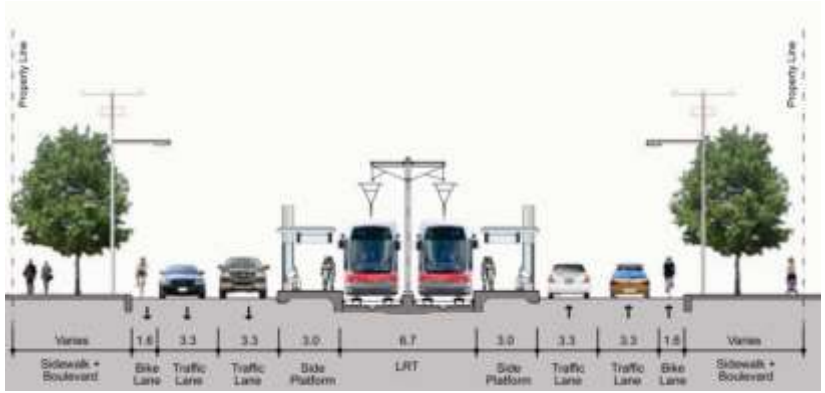




HATCH

Configuration en surface





HATCH

Approche utilisée pour atteindre les objectifs de Metrolinx

- Basée sur notre expérience antérieure et les pratiques actuelles
- Rencontrer les échéanciers (2020)
- Finir les travaux des tunnels pour l'excavation des stations et l'installation des équipements
- 4 nouveaux tunneliers ont été commandés
- Phasage des travaux pour maximiser la performance des tunneliers et leur entretien (tronçons de 3 km jugés optimaux)

HATCH

Contrat en préachat

- Tunneliers
  - Contrat attribué à Lovat (Caterpillar) en juillet 2010
  - 4 tunneliers
  - Fournis aux entrepreneurs avec une garantie de performance
  - Coût: 62 M$
- Voussoirs
  - Contrat attribué à Monroe
  - Système de contrôle de qualité
  - Coût: 80 M$
- Trains
  - Contrat attribué à Bombardier en juin 2010
  - Coût: 770 M$

HATCH

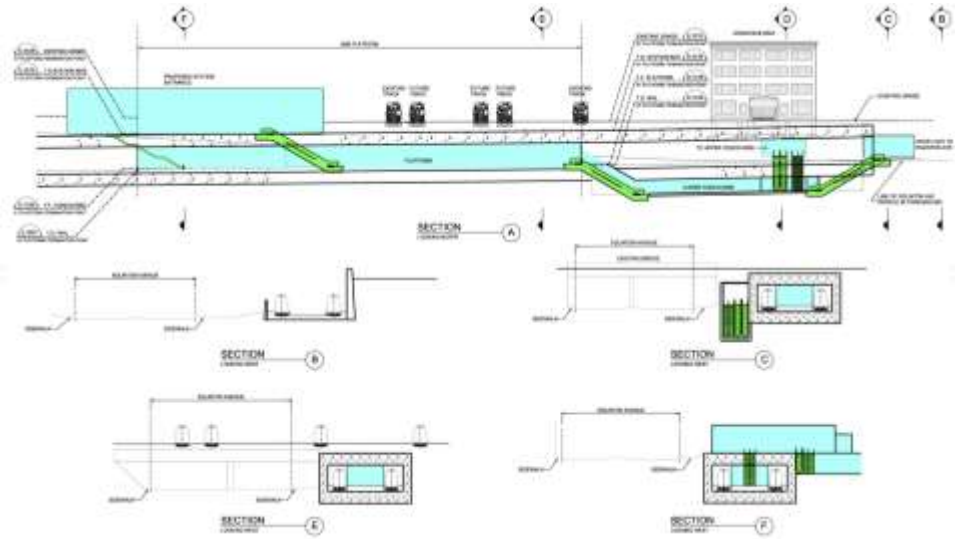
Contrat en mode traditionnel

- Puits de lancement à Keele
  - Excavation et support temporaire
  - Attribué au consortium (Kenaiden/Obayashi)
- Excavation des tunnels Ouest
  - Deux tunnels jumeaux
  - 1 sortie d'urgence
  - Galeries de connections tous les 380 m
  - Attribué à Obayashi/Kenaiden/Kenny
  - Coût: 283 M$
- Excavation tunnels est
  - Deux tunnels jumeaux
  - 2 sorties d'urgence
  - Galeries de connections tous les 380 m
  - Attribué à Aecon/Dragados
  - Coût: 177 M$

HATCH

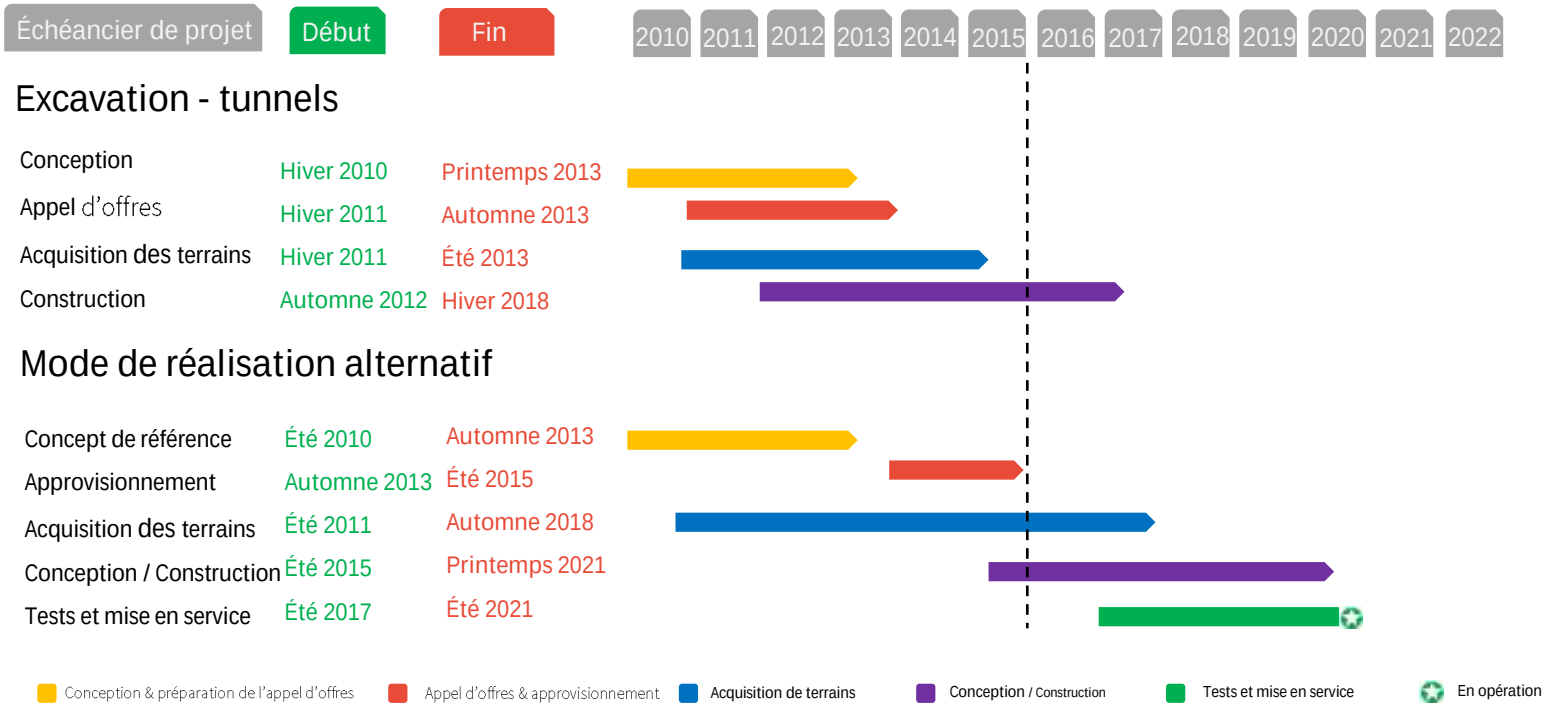
Concept de référence pour le contrat PPP

- Envergure
  - 12 stations souterraines (la conception de 6 stations est déjà complétée)
  - Tous les travaux de surface dont 12 gares en surface
  - Ponts et garage d'entretien et de stockage
  - Tous les systèmes
  - Entretien des infrastructures et des trains pour 30 ans
- Consortium SNC-Lavalin, AECON, ACS Infrastructure et EllisDon en novembre 2015
- Coût: 9,1 G$
- À compléter en 2021



HATCH

Le contrat PPP



HATCH

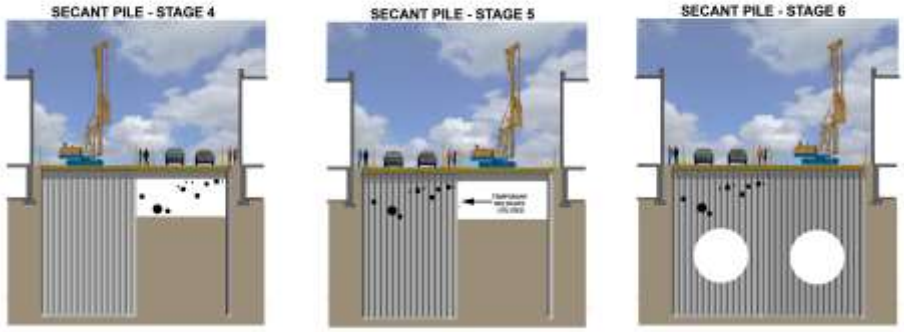
Quelques aspects de conception

- Caractériser les conditions géologiques
- Minimiser les impacts sur les riverains
- Protéger les infrastructures existantes
- Identifier les obstructions

HATCH

Expérience précédente d'utilisation de murs sécants pour construire les murs de têtes

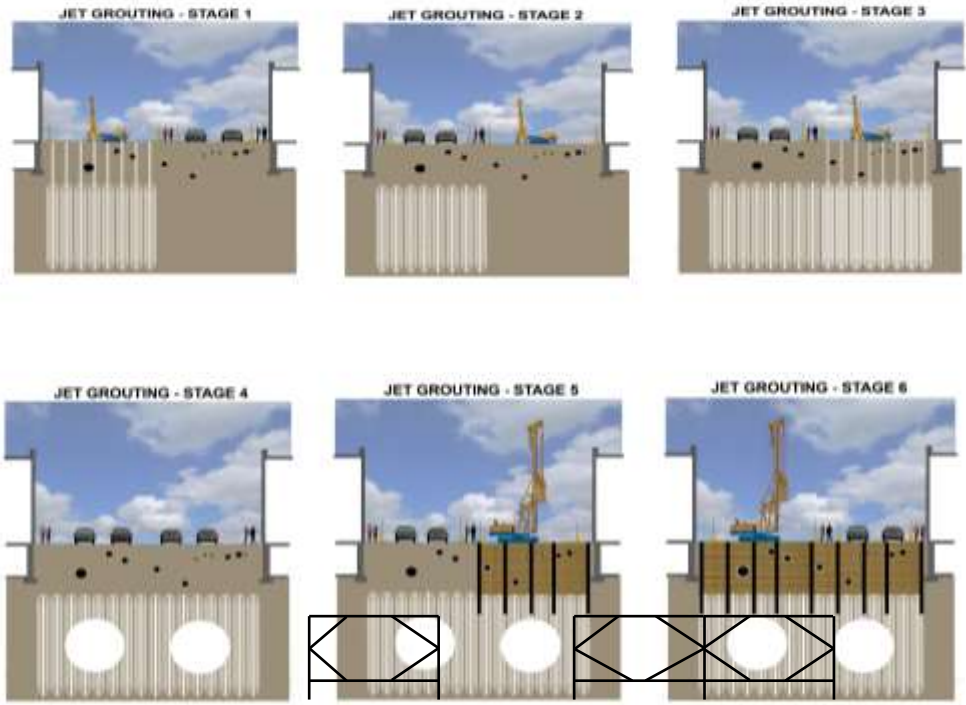
- Relocaliser les réseaux des utilités publiques
- Plaintes des riverains
- Impact sur la circulation
- Impact sur les coûts
- Impact sur l'échéancier



HATCH

Utilisation de la technique « *Jet Grouting* » pour construire les murs de têtes

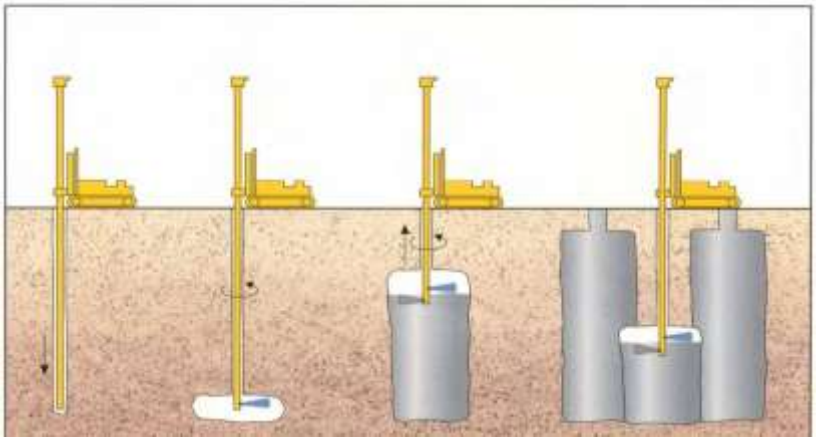
- Aucune relocalisation des réseaux des utilités publiques
- Réduction des plaintes des riverains
- Réduction d'impact sur la circulation
- Réduction d'impact sur les coûts
- Réduction d'impact sur l'échéancier



HATCH

Technique de « *Jet Grouting* »

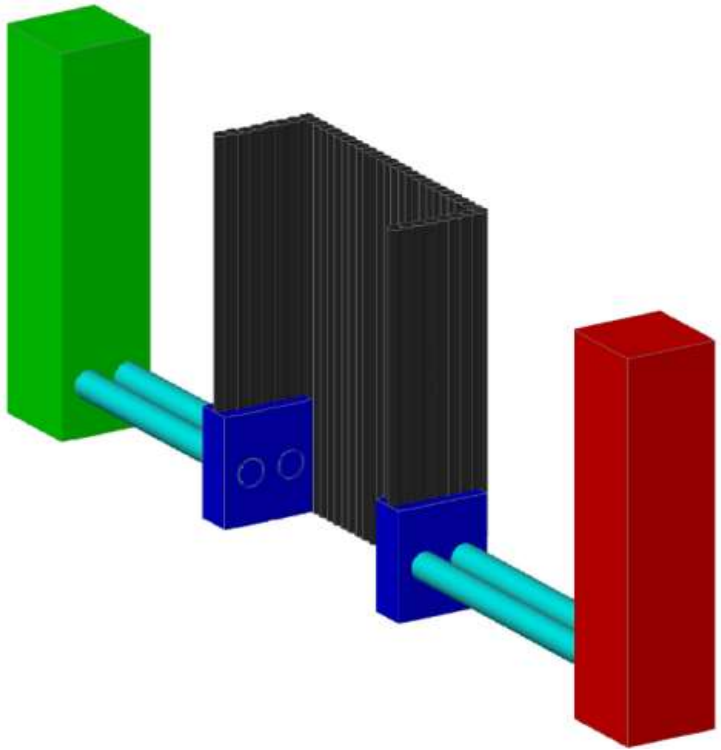
Technique utilisée pour la consolidation des sols et l'assèchement des puits profonds



HATCH

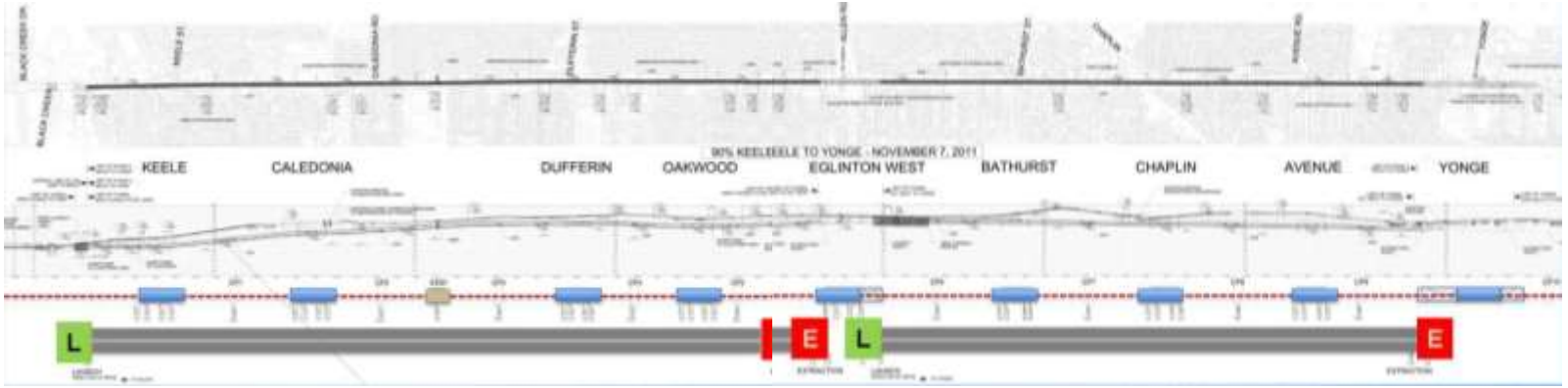
Contrats de construction des tunnels

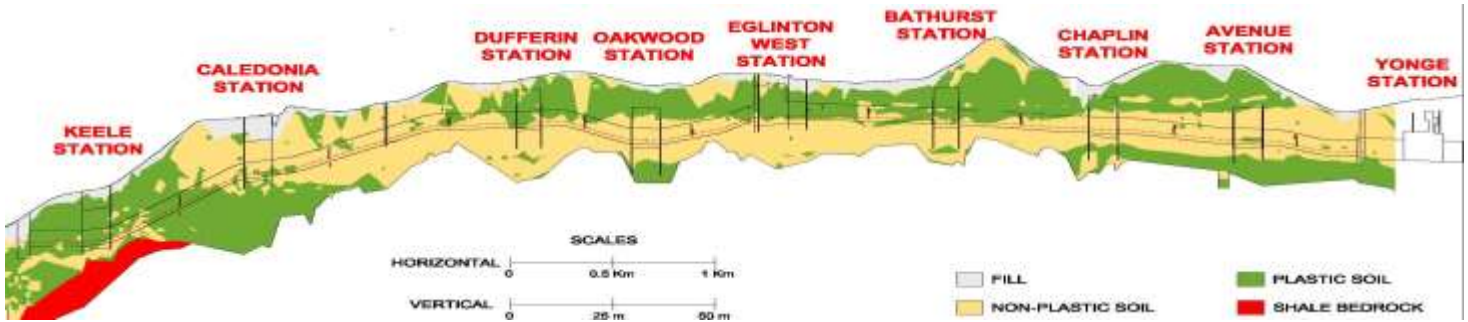
- Contrat Ouest
  - Tunnels jumeaux du puits de lancement jusqu'à la station Yon
- Contrat Est
  - Tunnels jumeaux du la station Do Mills à la station Yonge
- Inclus les puits de lancement et d'extraction, excluant le puits de lancement ouest
- Sorties d'urgence et galeries de connexions
- Murs de têtes pour l'excavation des stations



HATCH

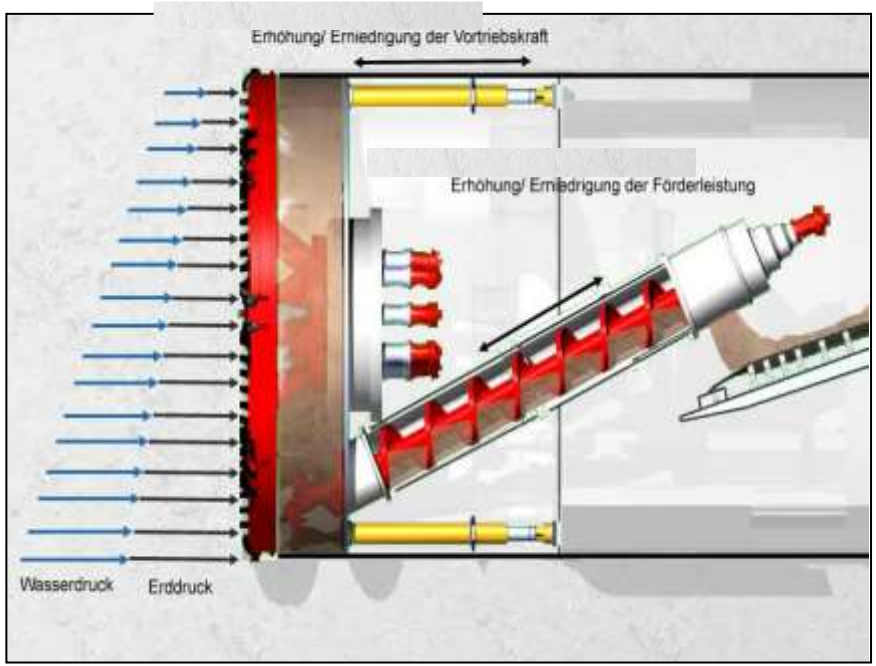
Premier contrat de tunnels

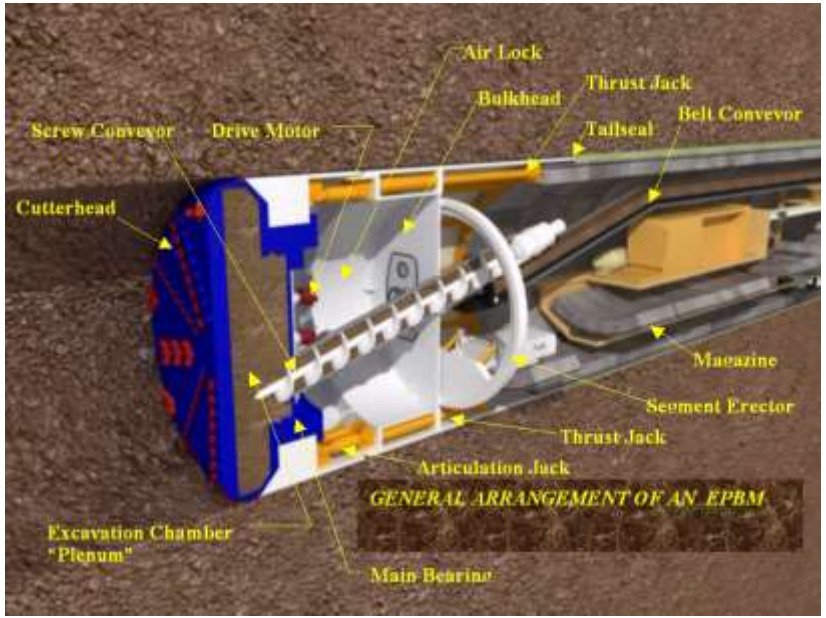




HATCH

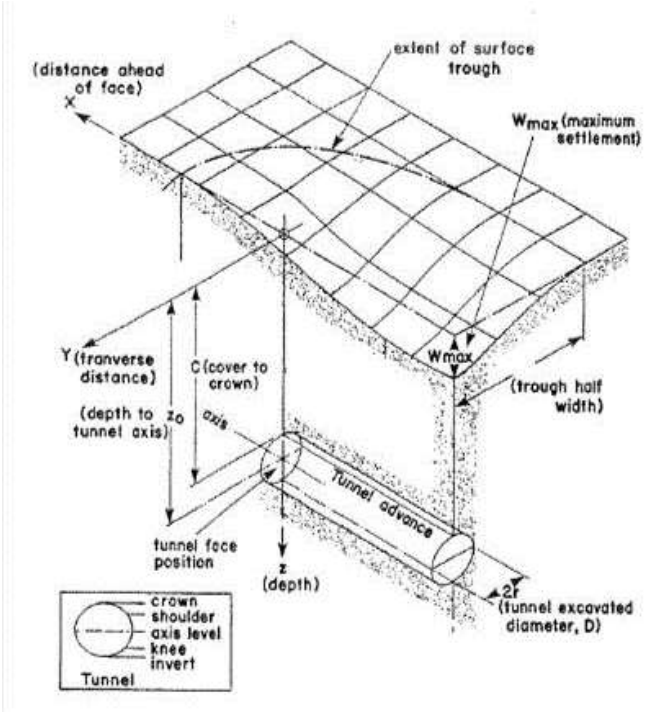
Tunneliers à pression de boue

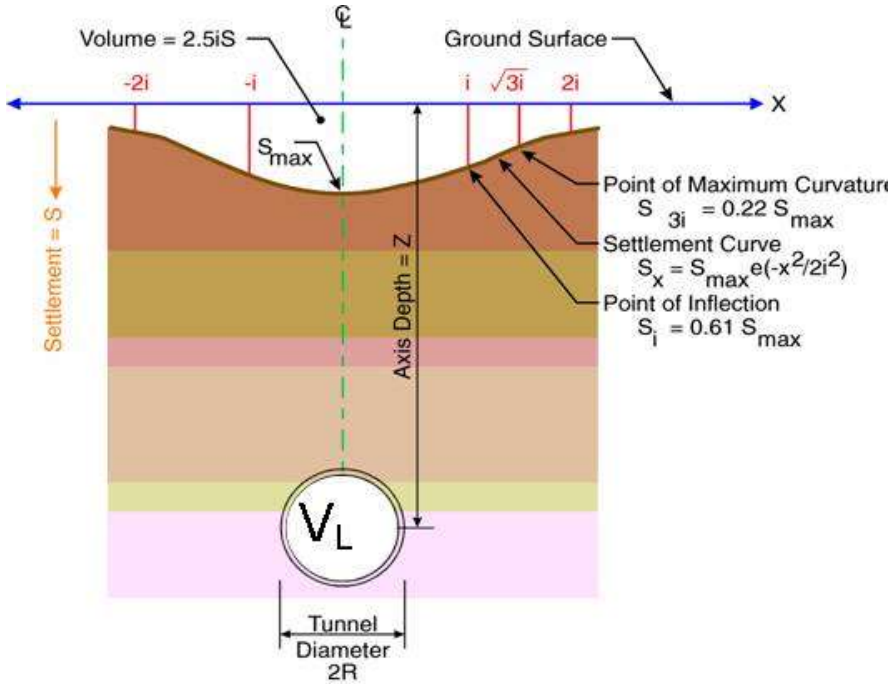




HATCH

Affaissement causé par le creusement des tunnels





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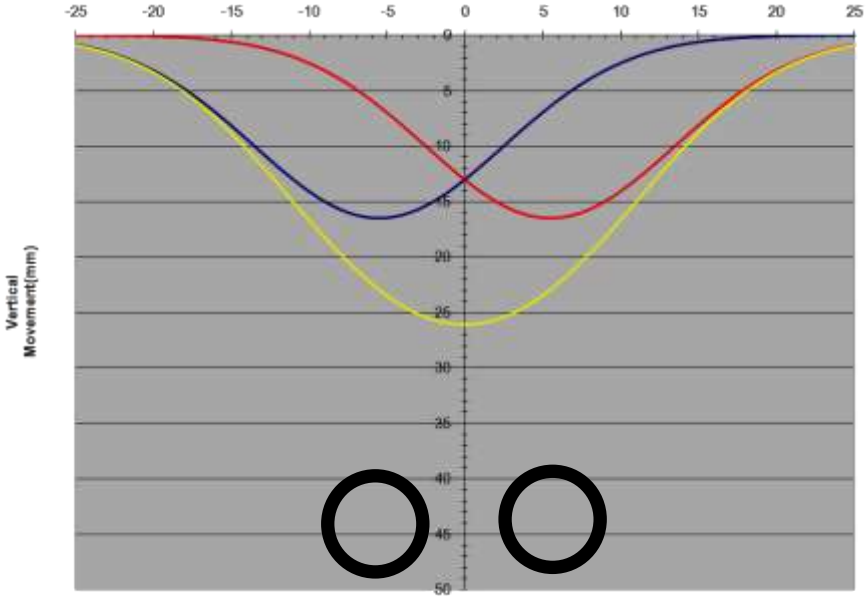
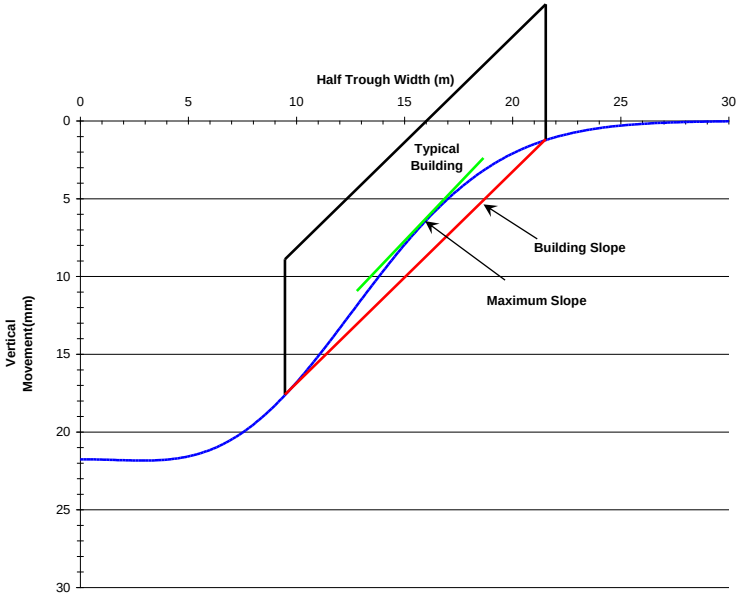
Impact d’affaissement sur les structures existantes





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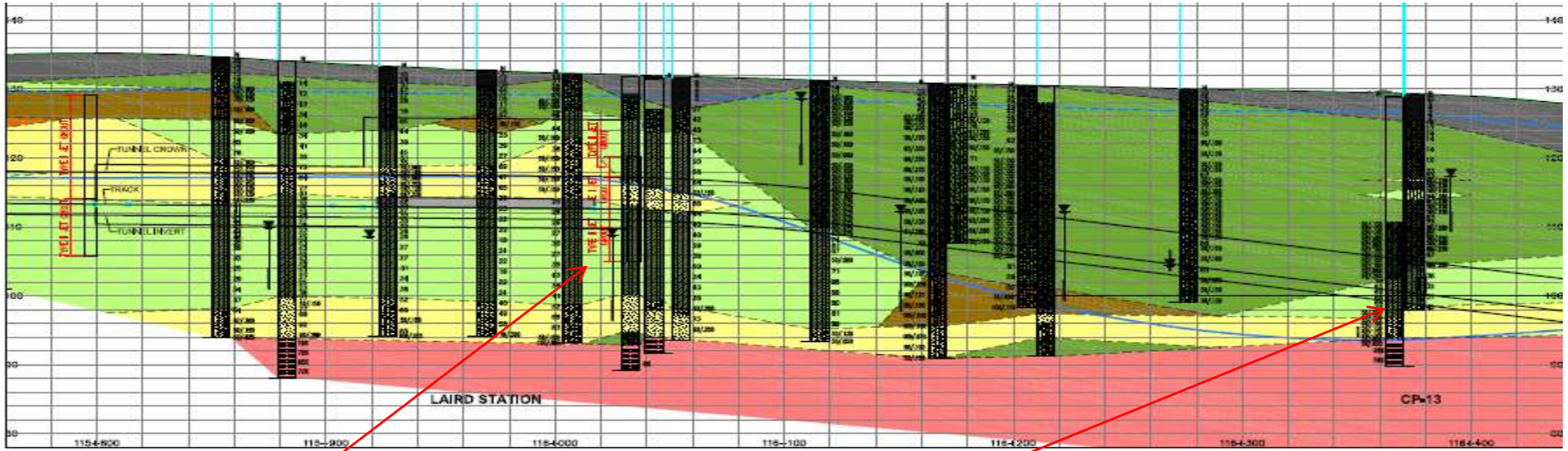
Conditions géologiques



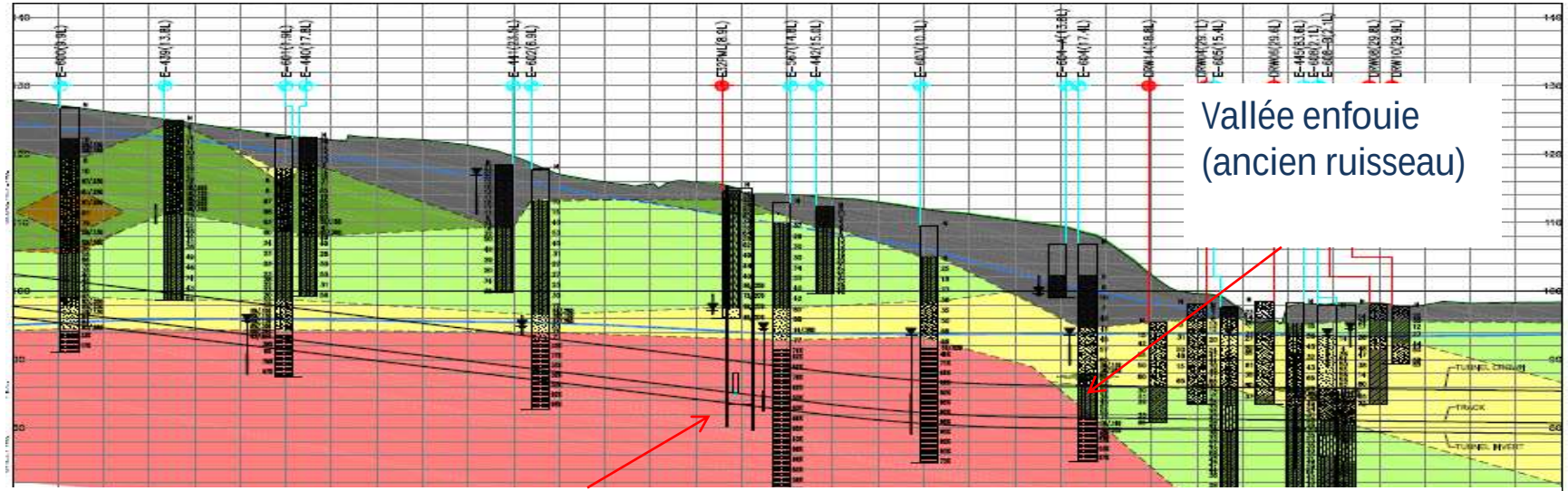
- "*Jet Grouting*" aux murs de tête
  - Injection type I (matériaux non plastiques ou très tendres)
  - Injection type II (sols durs ou plastiques)

CP13

- Excavation manuelle
- Pas de venue d'eau
- Roc peu profond aux stations Laird, Don River et Don Mills

HATCH

Conditions géologiques : conditions mixtes



EEB - 4

- Aucun pompage d'eau dans les sols à cause de la présence de contaminants à ne pas **déplacer**
- Enfoncer les murs sécants jusqu'au roc avec encastrement d'au moins 3 m

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Structures typiques

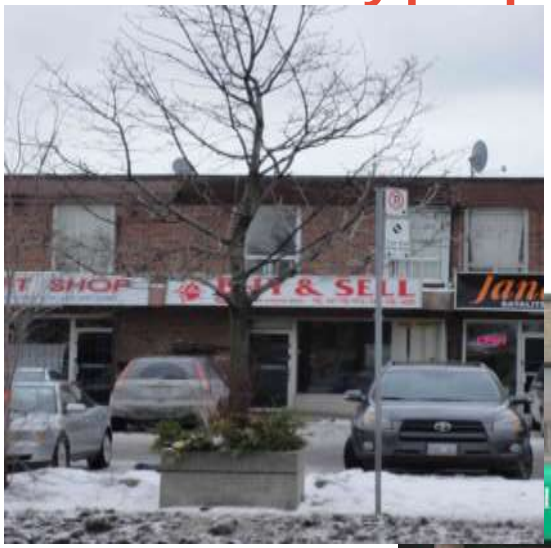
HATCH

Structures typiques

Structures typiques

HATCH

Structures typiques



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Inventaire des structures existantes

ECLE 1-1: Eglinton Crosstown LRT Twin Tunnel
Building Inventory / General Assessment

Hatch Mott MacDonald

Description/Name: Apartment, Stores
Street No.: 158 Street No. Qual.:
Street Name: EGLINTON AVE W
Unit No.:

Surveyed By: Shrestha, Kedar
Checked By: Maki, Peter
Approximate Station: 112+745
No. of Storeys: 7

Occupancy Type
Single Family Residential ☐ Hospital ☐ Church ☐
Multi Family Residential ☑ Offices ☐ Cultural ☐
Commercial ☑ Garage ☐ School ☐
Warehouse ☐ Service Station ☐ Other ☐

NBCC Major Occupancy Classification
NBCC 2005, Vol. 2, Division B, A-3.1.2.1.(1)
Group C, Group E

Structural Framing Material ☐ Assumed ☐ Observed ☑ Verified By Drawings
Brick/Masonry ○ Concrete ◉ Other ○
Steel ○ Wood ○ Unknown ○

Principal Structural Frame System ☐ Assumed ☐ Observed ☑ Verified By Drawings
Shear Wall ○ Moment Frame ◉ Unknown ○
Braced Frame ○ Other ○

Foundation System ☐ Assumed ☐ Observed ☑ Verified By Drawings
Spread Footing ◉ Mat ○ Other ○
Drilled Caissons ○ Piles ○ Unknown ○

Basement ☐ Assumed ☐ Observed ☑ Verified By Drawings
Yes ◉ No ○ No. of Basement Level: 4

Elevators ☐ Assumed ☐ Observed ☑ Verified By Drawings
Yes ◉ No ○

Building Façade (Cladding) ☐ Assumed ☑ Observed ☐ Verified By Drawings
Brick/Masonry ☑ Wood ☐ Glass ☐
Steel ☐ Ornamental Iron ☐ Historical ☐
Concrete/PC Panels ☑ Stone/Marble ☐ Other ☐

Visual Exterior Damage * Noted By: Shrestha, Kedar Date: 17-Nov-10
Minor/Cosmetic ○ Moderate ○
Major ○ Not Observed ◉

Visual Structural Damage *
Minor ○ Moderate ○
Major ○ Not Observed ◉

Observed Overall Building Condition *
Excellent ○ Good ◉
Fair ○ Poor ○

Building Plans Source Reference No.:
City Records ◉ Property Owner ○
TTC ○

Building Plans Condition
Excellent ○ Good ○
Fair ○ Poor ○

Comments - Damage Description

*) These are preliminary observations on the noted date only and are subject to confirmation during pre-construction survey.

Description/Name: Apartment, Stores
Street No.: 158 Street No. Qual.:
Street Name: EGLINTON AVE W
Unit No.:

Photograph Date: 17-Nov-10 Photograph By: Sabhanayagam, Mat

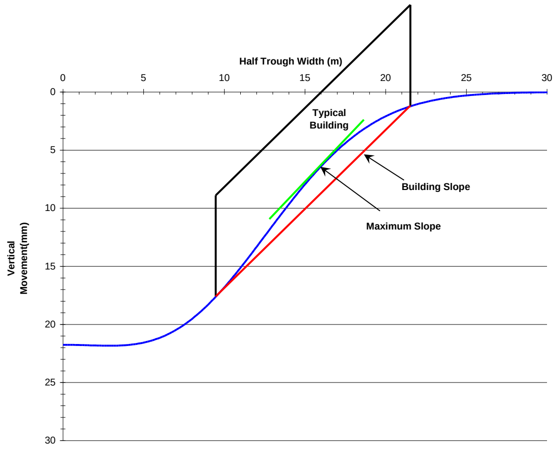
Photo 1

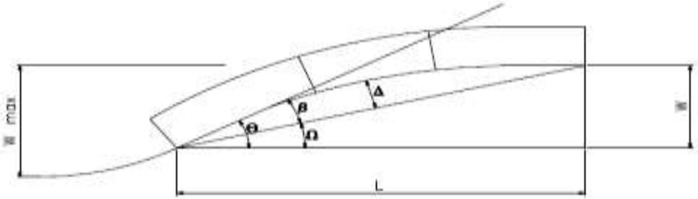
Photograph Date: 17-Nov-10 Photograph By: Sabhanayagam, Mat

Photo 2

HATCH

Évaluation d’impact: niveau 1 - Empirique





ECLE 1-1: Eglinton Crosstown LRT Twin Tunnel

Level 1 Impact Prediction due to Tunnelling

Hatch Mott MacDonald

Building Address	Description	Approximate Stationing	No. of Storeys	Depths of Tunnel Springline		Offset from Alignment Centreline (m)	Volume Loss (%)	K	Burland et al (1977)				Boscardin and Cording (1989)			Recommended Mitigations and Comments *
									Maximum Settlement Beneath Building Foundation (mm)	Maximum Slope (x10-3)	Predicted Damage Assessment		Angular Distortion β (x10-3)	Horizontal Strain εL (x10-3)	Predicted Damage Assessment	
				m BGS	m USF						Settlement Criterion	Slope Criterion				
250 EGLINTON AVE W	Win-Bar Insurance Building	113+490	3	20.99	19.289 99900 81797	12.6	0.6	0.4	5.8	0.824	Negligible or Very Slight	Negligible or Very Slight	0.386	0.230	Negligible	GMM + BMM + PED
							0.6	0.6	6.0	0.480	Negligible or Very Slight	Negligible or Very Slight	0.187	0.194	Negligible	
							1	0.4	11.7	1.648	Negligible or Very Slight	Negligible or Very Slight	0.777	0.460	Very Slight	
							1	0.6	12.0	0.960	Negligible or Very Slight	Negligible or Very Slight	0.394	0.388	Negligible	
211 EGLINTON AVE W	Apartments	113+555	3	19.05	16.349 99923 70605	12.9	0.5	0.4	5.4	1.021	Negligible or Very Slight	Negligible or Very Slight	0.552	0.207	Negligible	GMM + BMM + PED
							0.5	0.6	6.2	0.627	Negligible or Very Slight	Negligible or Very Slight	0.306	0.252	Negligible	
							1	0.4	10.8	2.042	Negligible or Very Slight	Slight	1.104	0.613	Slight	
							1	0.6	12.3	1.255	Slight	Negligible or Very Slight	0.612	0.504	Very Slight	
166 EASTBOURNE AVE	Apartments	113+685	3	18.56	16.359 99946 59424	10.2	0.5	0.4	5.3	1.059	Negligible or Very Slight	Negligible or Very Slight	0.562	0.323	Negligible	GMM + BMM + PED
							0.5	0.6	6.1	0.602	Negligible or Very Slight	Negligible or Very Slight	0.318	0.260	Negligible	
							1	0.4	10.5	2.117	Negligible or Very Slight	Slight	1.125	0.647	Slight	
							1	0.6	12.3	1.306	Slight	Negligible or Very Slight	0.636	0.527	Very Slight	
151 EGLINTON AVE W	Toronto Independent High School	113+715	4	15.15	11.349 99923 70605	13.4	0.6	0.3	1.3	0.903	Negligible or Very Slight	Negligible or Very Slight	0.672	0.571	Very Slight	GMM + BMM + PEC Level 2 Structural Analysis Recommended
							0.6	0.5	5.1	1.345	Negligible or Very Slight	Negligible or Very Slight	0.890	0.597	Slight	
							1.2	0.3	2.6	1.906	Negligible or Very Slight	Negligible or Very Slight	1.344	1.142	Slight	
							1.2	0.5	10.2	2.689	Negligible or Very Slight	Slight	1.798	1.196	Moderate to Severe	
137 EGLINTON AVE W	Apartment	113+730	3	15.15	13.949 99980 92651	13.5	0.6	0.3	3.1	1.397	Negligible or Very Slight	Negligible or Very Slight	0.765	0.592	Slight	GMM + BMM + PEC Level 2 Structural Analysis Recommended
							0.6	0.5	6.2	1.076	Negligible or Very Slight	Negligible or Very Slight	0.542	0.403	Very Slight	
							1.2	0.3	6.1	2.794	Negligible or Very Slight	Slight	1.538	1.164	Moderate to Severe	
							1.2	0.5	12.4	2.157	Slight	Slight	1.384	0.905	Slight	

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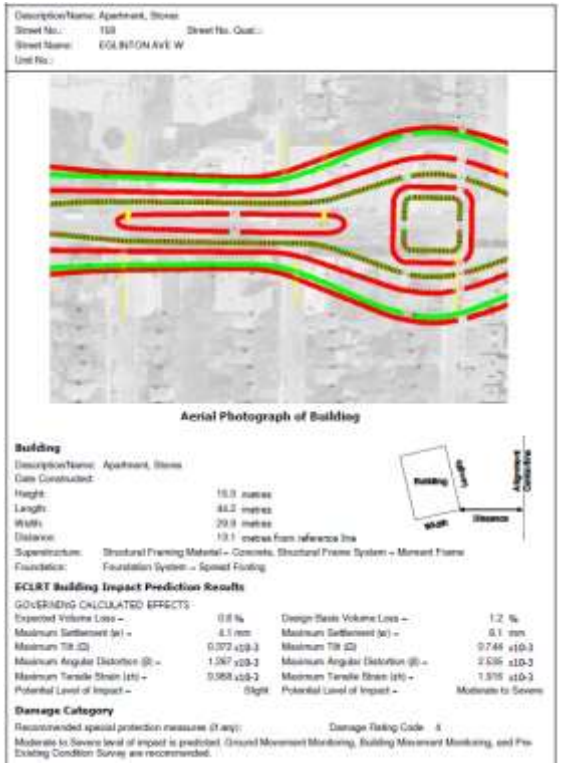
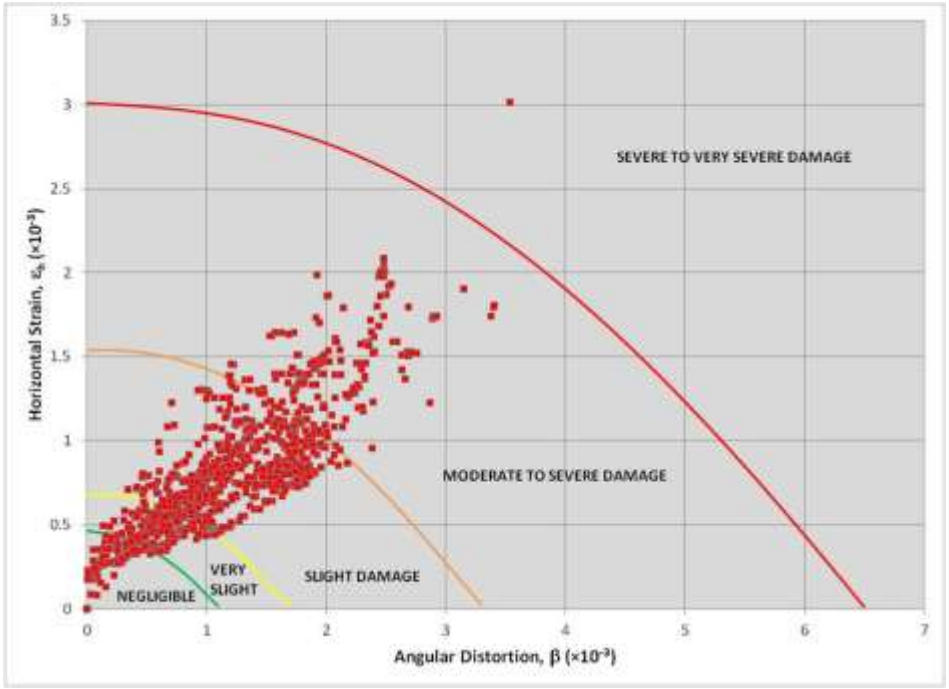
Résultat de l’évaluation d’impact: niveau 1





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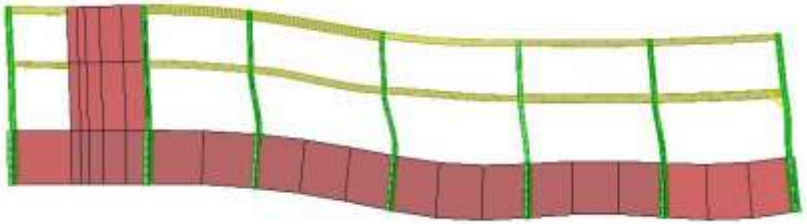
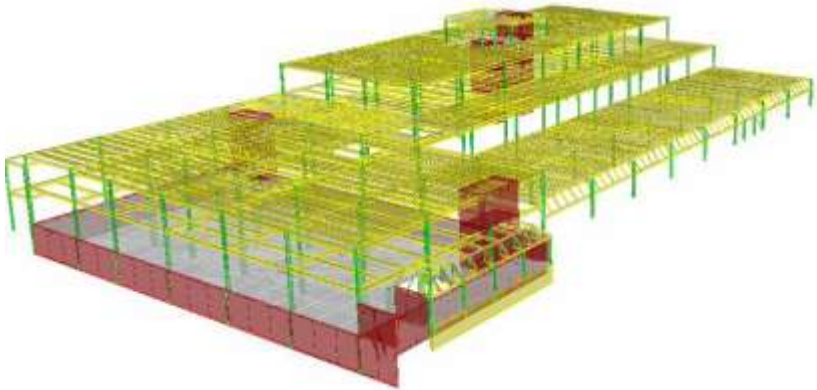
Évaluation d’impact niveau 2 – Modélisation numérique





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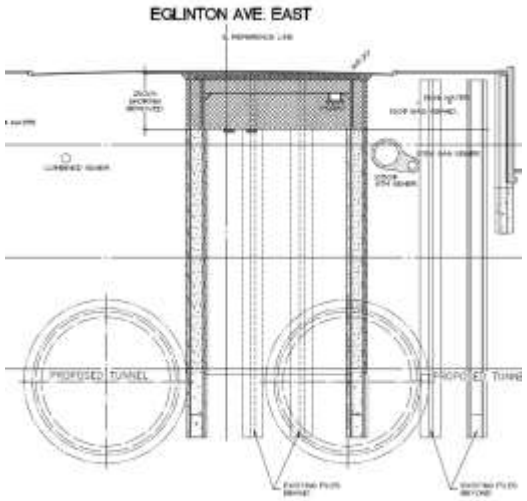
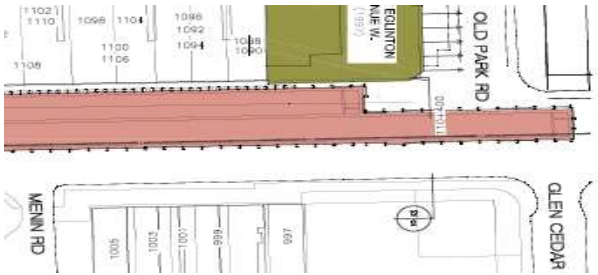
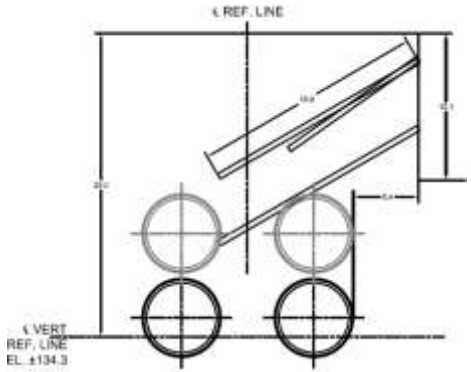
Obstructions (piles abandonnées, ancrages)







RECORDS SHOW TIEBACK ANCHORS ENCROACH ONTO EGLINTON AVE.

RECORDS SUGGEST RAKERS / NO TIEBACK ANCHORS ENCROACH ONTO EGLINTON AVE.

SMALL RESIDENTIAL, COMMERCIAL OR OLDER STRUCTURES WITH SHALLOW FOUNDATION WITH NOT TIEBACK EXPECTED

PROPOSED STRUCTURE (POTENTIAL FOR PRESENCE OF TIEBACK ANCHORS)

POTENTIAL FOR PRESENCE OF TIEBACK ANCHORS

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1/28/2015 20:02

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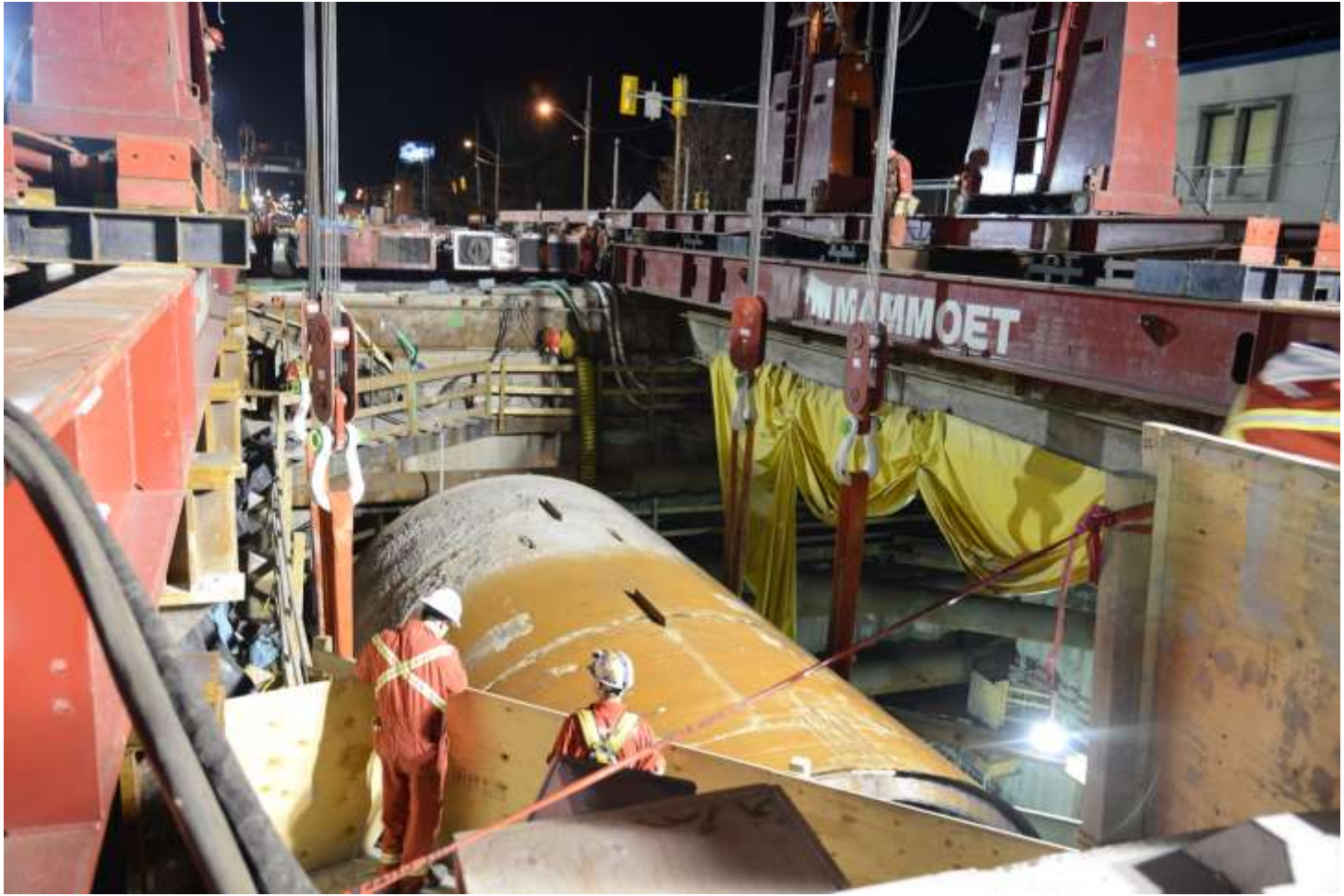

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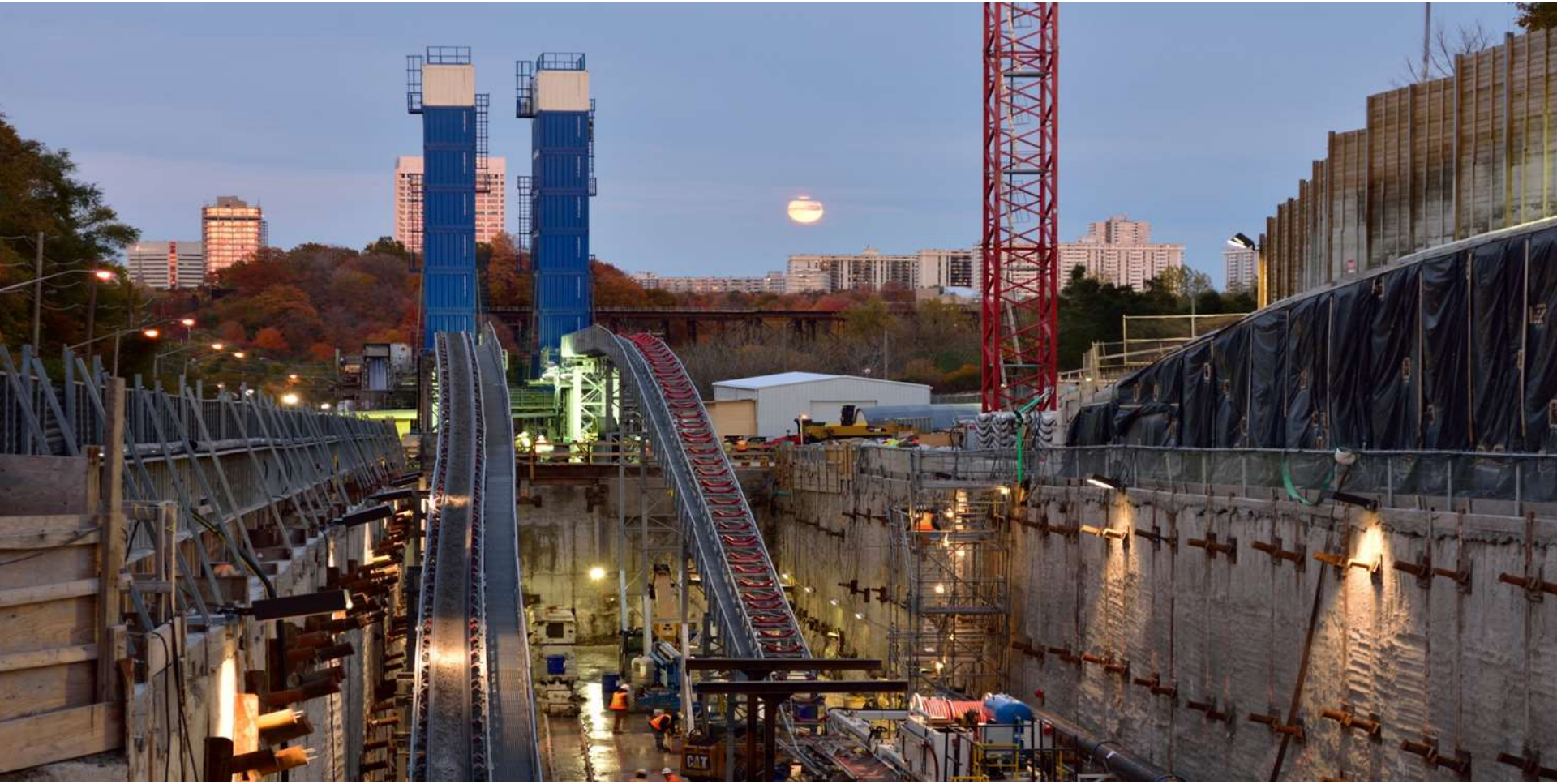

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Merci.

Pour plus d’information,
visitez le site www.hatch.ca.

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