RELIEF LINE SOUTH

Appendix 2-3

Subway Design Standards and Construction Methods

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RELIEF LINE
PROJECT ASSESSMENT

Subway Design Standards and Construction Methods

June 2018

RELIEF LINE

TORONTO

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Introduction

Providing additional rapid transit capacity into and within the downtown Toronto area has long been an objective for the City of Toronto. Downtown Toronto is the economic, social, and cultural heart of the Greater Toronto and Hamilton Area (GTHA), and its continued health and vitality is contingent on the provision of efficient and accessible transportation of both people and goods between it and the region.

These services are reaching or exceeding their practical capacity during peak periods. Significant inbound transit capacity deficiencies exist during the morning peak period, particularly on the Yonge Subway south of Bloor and at Bloor-Yonge interchange, and several GO Rail lines, but also on streetcar routes east and west of downtown. With continued growth projected for the City of Toronto and the GTHA, there is an urgent need for improvements. Potential infrastructure, operational, and policy improvements to provide additional transit capacity into and within downtown Toronto have been identified by Metrolinx (within the Regional Transportation Plan), the City of Toronto, and the TTC; however these measures will not on their own be sufficient to address capacity issues during peak periods into the future. As such, there exists a need to examine additional opportunities to enhance rapid transit, particularly into the downtown area.

In response to these issues, and the concern that the planned Yonge North Subway Extension (YNSE) into York Region would exacerbate crowding on the Yonge Subway line, in 2009 Toronto City Council approved a series of motions requesting that Metrolinx prioritize a Relief Line (RL) within its 15-year plan; that Metrolinx prioritize the Relief Line in advance of the YNSE; and that the TTC commence studies to evaluate the merits of the Relief Line.

The purpose of this report is to define the design, operations, and construction assumptions carried through the Relief Line Project Assessment. These assumptions informed the planning process from the identification and evaluation of alternatives through to conceptual design and the identification if impacts and mitigation measures. In general, for the purposes of the TPAP, the Relief Line is assumed to follow standard TTC design standards for station, alignment, and running structure. Further, traditional TTC construction methods are assumed. The following section describes these assumptions in detail.

Subway Design Standards and Construction Methods

TTC Design Standards

Horizontal Alignment

The horizontal alignment of the proposed Relief Line was developed following the existing TTC Design Manual standards for subway infrastructure.

For the purpose of the Relief Line Conceptual Design, the vehicle dimensions and track gauge are assumed to be similar to the existing T-1 vehicles operating on Line 2. The track gauge is 4'-10 7/8", the vehicle width is 10'-3 3/8" and the height is 12' (top of car to bottom of wheel). TTC has not yet committed to a particular configuration for the T-1 replacement fleet (i.e. married pair vs. 6-car or 7-car trainset), with the exception that all cars will be capable of operating under ATC. The T-1 cars on Line 2 were purchased between 1995 and 2001 and are scheduled for replacement in 2026. All replacement vehicles are expected to be received and operational by 2031.

The Relief Line alignment is based on the TTC Design Manual criteria for subway infrastructure and the running structure cross-sections are based on the T-1 series subway vehicle dimensions and dynamic clearances. All proposed alignments are assumed to be underground.

The horizontal alignment of the proposed Relief Line was developed following the existing TTC Design Manual standards for subway infrastructure.

Vertical Alignment

The vertical alignment of the proposed Relief Line was developed following the existing TTC Design Manual standards for subway infrastructure.

The minimum and maximum design parameters used on the vertical alignment are:

1) Minimum gradient at stations and special track structures = 0.3%

2) Maximum gradient along rest of running structure = 3.5%

3) Minimum length of vertical curve: LVC = 60 m

Sight line for signalling will be confirmed during Detailed Design phase of the project.

Stations

Relief Line stations include platforms, station entrances, emergency vent shafts, and connections to other transit services such as SmartTrack stations. Additional features, particularly bus loops and commuter parking facilities were not assumed for the TPAP.

All proposed Relief Line passenger stations generally have a street entrance, a concourse level and a platform level. The interchange stations (University, Yonge and Pape) have a street entrance, upper concourse level, Line 1 or Line 2 platform levels, lower concourse level(s) and Relief Line platform level.

All passenger stations will be designed in accordance with the TTC Design Manual, AODA and will be fully accessible to persons with disabilities.

Subway Platforms

Stations typically have a “centre platform” configuration in which passengers can board and exit trains via a single platform between the two tracks. The use of centre platforms enables more efficient vertical circulation and cross-platform transfers. It also provides a greater capacity to accommodate surges in traffic flow, especially during service interruptions.

The revenue train vehicle configuration and technology selected for the Relief Line will determine the minimum platform length for the proposed stations.

Platform widths will typically be 10.3 m based on the tunnel track centrelines. Some rooms (such as ancillary rooms and service rooms) are provided at the platform level.

Concourse Levels

The concourse level is located directly above the platform and is connected to the platform through stairs, escalators and an elevator. The interchange stations (University, Yonge and Pape) have multiple concourse levels. The collector’s booth and turnstiles will be located at the concourse level where Proof of Payment (POP) is required beyond that point. Other rooms, such as service rooms, staff rooms and electrical rooms may be located at the concourse level. Exact configurations will be determined during the detailed design phase.

Station Entrances

Station entrances provide access / egress to each station associated with walk-in traffic. The station entrances will be located on street-level and will be equipped with stairs, escalators and an elevator to direct pedestrian traffic to the concourse level where the fare collection is located. Secondary entrances typically comprise of a set of stairs from ground level that connect down to the concourse level. Secondary entrances may include escalators that are dependent on the depth of the station and the proximity to the main entrance.

Ventilation Shafts

Ventilation shafts are to be located throughout the project, particularly at station entrances. Ventilation is incorporated into the stations to balance air pressure within the tunnels and stations and to provide for emergency exhaust and fresh air supply in case of an underground fire.

Running Structure

This section summarizes the Relief Line running structure and access provisions including emergency access points and walkways. It includes descriptions of typical cross-sections for the bored tunnel and box section running structure. For complete details on these requirements, refer to the TTC Design Manual.

Tunnels

The Relief Line will be constructed with an internal tunnel diameter of 5.4 m. A typical cross-section for a tunnel is shown on **Exhibit 1**. The tunnels will be constructed using the twin boring construction method that is effective for difficult ground conditions (sands and clays under high groundwater pressure).

Modern TBMs use a pressurized face at the front of the machine to maintain stability in the ground in front of the TMB.

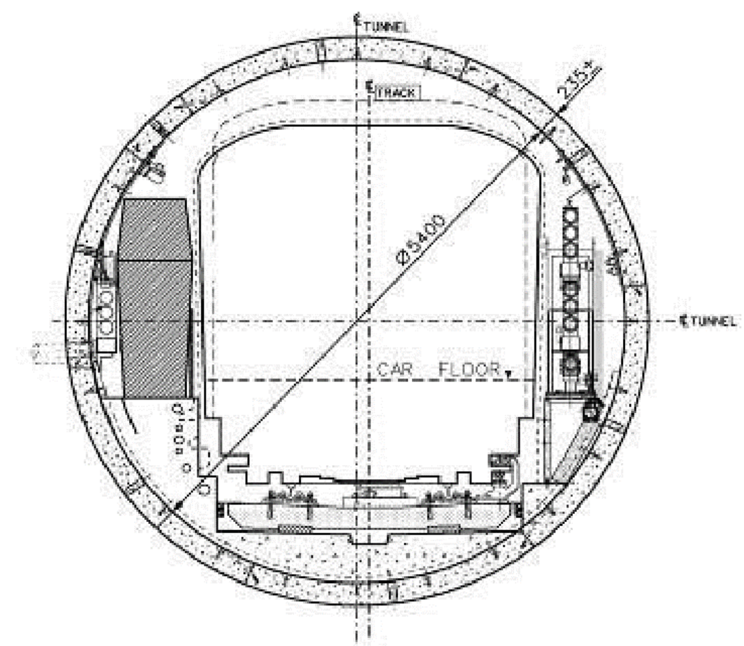

Exhibit 1: Cross-section of bored tunnel

Box Structure

A typical cross-section for a box structure is illustrated on **Exhibit 2**. Box structures are constructed where twin bore is not feasible at cross-overs and tail tracks.

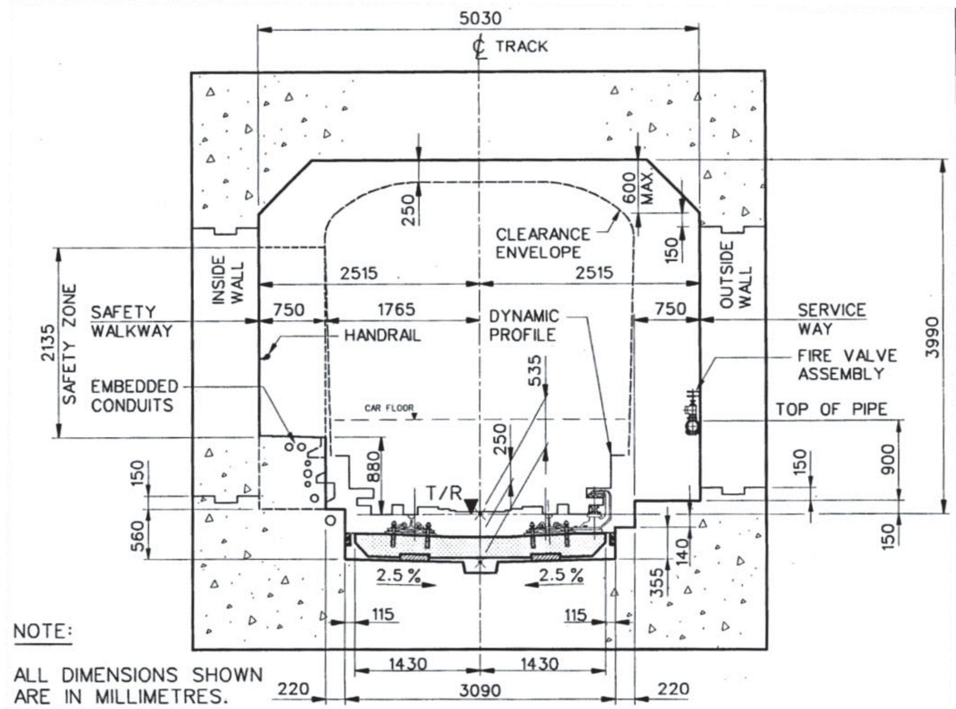

Exhibit 2: Typical Single Box Section – Double Tie, Tangent Track (Source: TTC DM–0205-01)

Walkways

Safety walkways will be provided in all new tunnels for the Relief Line. A walkway system will consist of a safety walkway and a service-way between stations. The safety walkway will be located on the left of the track-ways for operations in the normal direction of travel, and will provide direct connections to the centre platform stations. The walkways will be elevated and the service-way will be near track level.

The Emergency Exit Buildings (EEBs) track-way access will be centred between the northbound and southbound tunnels.

The safety walkway will support the emergency evacuation of a train in a tunnel and provide an access path to track-way installed equipment for maintenance personnel. During subsequent design phases, the design should be optimized so that zero-clearance areas for workers at track level are not created.

Drainage

The entirety of the Relief Line will exhibit a longitudinal gradient of at least 0.3% to ensure adequate run-off, via the standard drainage provisions described in the TTC Design Manual.

Track Support Structure

The track will be laid upon noise and vibration isolated double ties, with the exception of the special trackwork areas. Floating slab support structures with noise and vibration isolation will be constructed in the special trackwork areas with direct rail fixation to the slabs.

Embedded Conduit

Power supplies and communications cabling will be embedded in the walkways and invert of the tunnel structures during construction of the subway. Cables to be embedded include:

- Emergency trip;
- EAS telephones or other telephoned;
- UPS to wayside mini-substations/load centres for tunnel lighting and utility outlets;
- Fibre optic cables;
- Power supply cables to select stations;
- SCADA cables; and
- Power for tunnel pump stations

Emergency Exists and Cross Passages

Emergency Exits

In accordance with NFPA 130, emergency egress from the tunnel shall be provided throughout the underground system so that the distance to an exit shall not be greater than 381 m. Therefore the maximum distance from emergency exit to emergency exit or emergency exit to station shall be 762 metres.

These structures extend from the underground tunnels to above grade and are designed to provide an emergency exit for passengers and an emergency access for firefighting crews. They can also provide emergency ventilation and secondary power sources.

Cross Passages

NFPA 130 allow the use of cross passages in lieu of emergency exit stairways provided they are fire separated from the trainways with 1 ½ hour fire-rated doors and they are located at a maximum distance of 244 m between cross passages, and between cross passages and stations or portals.

Traction Power

Traction power will be supplied at 600V DC (nominal voltage level) from traction power substations located at passenger stations and at standalone facilities along the line. The substations are sized assuming two 1500 kW rectifiers with a provision for a third rectifier branch. The power is distributed to the trains by way of the third rail power distribution system. The substations will supply each station with 600VAC power supply through a set of pad mounted step-down power transformers. The supply scheme will be redundant and will have spare capacity such that it would be possible to replace major electrical components without curtailing station operation and without major shutdown periods. Power redundancy will be provided to all of the major downstream power equipment to meet latest TTC design standards and regulations. Substations are sited at a spacing of approximately 2.0 km, not exceeding 2.5 km apart (per TTC DM-0804-01). Substations are located during the conceptual design phase to account for their property impacts; however, substation spacing will be confirmed during later design phases via a verifiable computer simulation based load flow analysis.

AC Power
Medium voltage power supply will be provided to each of the substations from local hydro overhead or underground network. The exact power supply arrangement and requirements will be finalized with hydro during design stage and will consider power authority access guidelines and incoming service isolation details.

Essential Power
Emergency Power and Uninterruptible Power Supply requirements are outlined in TTC DM-0701-04. In summary, Uninterruptible Power Supplies (UPS) will be provided at each station. The UPS system will provide a minimum of 90 minutes of battery power at full load for life safety and essential services within the station, substation, and underground running structure. The UPS supply scheme will be fully redundant and will include level of redundancy for batteries and UPS system itself.

Tunnel Ventilation
As per the requirements of NFPA-130, an Emergency Ventilation System will be provided. The system will be designed to provide a tenable environment along the path of egress from a fire incident in enclosed stations and enclosed trainways and to provide continuous ventilation during maintenance operations when fumes are being generated. In addition, the system helps to moderate the piston effect at stations even when not actively engaged.

The ventilation system is comprised of ventilation structures and fan rooms at ends of stations and at the ends of tail tracks. Fans are designed to work in concert with each other to push or pull the air as required. In a fire event at a station or between stations in either of the twin tunnel, the fans on either side of the event will work in conjunction with the other to control the migration of smoke and maintain a tenable egress path away from the event.

The ventilation system is centrally controlled from the Transit Control Centre using a SCADA System. In addition, local control is also provided from the Central Alarm and Control Facility (CACF) located near the attended entrance at each station for that specific station, as well the ventilation equipment at the adjacent stations to provide the ventilation system required set up for the station and the adjacent tunnels.

Drainage and Pumping Stations
The entirety of the Relief Line will exhibit a longitudinal gradient of at least 0.3% to ensure adequate run-off, via the standard drainage provisions described in the TTC Design Manual.

A detailed analysis of the drainage and pumping systems should be reviewed during the detail design stage.

Method of Construction
The Relief Line will be constructed following TTC standard practice of construction, involving twin bore TBMs with box structure (open cut) at tail tracks, special track works, and stations. Mining is considered under special circumstances. This assumption was carried through the purposes of the evaluation of alternatives, as well as through the conceptual design stage and impacts assessment.