Case Study - Railway Embankment Widening for CN Rail & GO Transit, Mississauga, Ontario

GEO2010 CALGARY, ALBERTA in the New West

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ABSTRACT
GO Transit, The Greater Toronto Area's commuter rail/bus system is currently undergoing a dramatic expansion in service. A part of this expansion is an improvement in the limited rail service between Hamilton and Toronto, Ontario, some 65 km to the east. In some cases, in order to meet the increased commuter volume demands, it is necessary to add additional tracks to accommodate the existing and future rail traffic. This is certainly the case on the Lakeshore West Line where a third track was only the way to meet demand.

In the Lorne Park area of Mississauga, existing conditions did not provide sufficient room for a number of rail embankments to be widened without the use of an earth retention system. Numerous retaining wall and over-steepened slope options were considered for the seven distinct locations. The ultimate solution was a prototype Mechanically Stabilized Earth (MSE) retaining wall that combined a steel fascia with geosynthetic reinforcement.

This case study will examine the various aspects of this project from the initial stages of design, through the various solution options, to the development of the final solution. With a restricted time schedule and construction constraints, the paper will also detail how those major obstacles were successfully overcome in the completion of this project.

RÉSUMÉ
Le réseau GO, système de trains/autobus de banlieue de la région du Grand Toronto, connaît actuellement une formidable augmentation de service. Cette augmentation consiste notamment à améliorer le service ferroviaire limité entre Hamilton, en Ontario, et Toronto, à quelque 65 km à l'est. Dans certains cas, pour répondre à la demande accrue du nombre de banlieusards, il est nécessaire d'ajouter des voies pour faire face au trafic ferroviaire actuel et futur. C'est sûrement le cas du corridor Lakeshore Ouest où une troisième voie était le seul moyen de répondre à la demande.

Dans la zone de Lorne Park, à Mississauga, les conditions existantes ne laissaient pas assez d'espace pour permettre d'élargir divers talus ferroviaires et de recevoir une troisième voie sans recourir à un système de rétention de sol. On a examiné diverses solutions de murs de retenue et de pentes très inclinées pour les sept endroits distincts. La solution finale a été un prototype de mur de retenue en terre stabilisée mécaniquement, qui combine une bordure en acier et un renforcement géosynthétique.

Cette étude de cas portera sur les divers aspects de ce projet à partir des phases initiales de la conception à l'élaboration de la solution finale, en passant par les diverses solutions envisagées. Compte tenu du calendrier restreint des travaux et des contraintes de construction, le document décrira en outre en détail la manière dont on a vaincu ces obstacles de taille au parachèvement du projet.

1. BACKGROUND

GO Transit is Canada's first and Ontario's only, interregional public transit system, linking the City of Toronto with the surrounding regions of the Greater Toronto Area (GTA). The combined rail and bus transit system first began operating in May of 1967 as a single rail line along the north shore of Lake Ontario. Since that time, ridership has grown to over 54 million passengers a year, travelling an extensive network of train and bus services that has grown into one of North America's premier public transportation systems. In an effort to meet growing demand for more services, GO Transit is currently undertaking an extensive upgrading of its facilities. Included in this expansion is the construction of numerous additional rail lines throughout the existing rail network. A key component of this service expansion is an improvement to the rail service between Hamilton, at the western end of Lake Ontario, and Toronto.

The original rail line that runs through the Lorne Park section of Mississauga was constructed circa 1850, and currently supports the main CN Rail line running from Halifax, Nova Scotia to Chicago, Illinois. In addition to the GO Transit traffic and Via Rail and Amtrak passenger traffic, this line experiences a large volume of containerized freight traffic.

Due to a fixed right-of-way and site geometry, the third line could not be added without employing a series of seven retaining walls.

2. Solutions

The need for some form of earth retention system or systems was obvious from the outset of the project. Typically, these seven walls support a sizeable railway embankment, which in turn supports the tracks. However, in some cases the new track sits virtually on top of the wall.

The project's Consulting Engineer, Hatch Mott Macdonald considered a variety of near vertical retaining wall systems that would provide durability, performance

Figure 1 Proximity of existing track to wall is evident

and comfort to the owner of the tracks, CN Rail. With a long history of use by CN Rail, Armtec's sectional gravity-type retaining wall system was selected as the system of choice for the seven wall locations.

Site constraints and economics played large roles in determining which type of wall system was employed. There was no direct street access for the contractor and all access to the various wall locations was achieved via access roads located parallel and adjacent to the track. The clearance between the proposed third track centerline and the property line, varied from 7 metres to 21 metres. In the case of the larger offsets from the track, the walls were invariably located in relatively deep creek valleys. These site constraints made the gravity wall, which ships to site in a very compact knocked-down state, an ideal solution.

Figure 2 One of the true Bin-Walls during assembly

However, after initially attempting to make the steel gravity retaining walls work throughout the project, it was determined after contract award, that a Mechanically Stabilized Earth (MSE) type of retaining wall would be much easier to construct and therefore more cost effective. Mechanically Stabilized Earth retaining walls typically use geosynthetic (geogrid) or metallic tiebacks to provide reinforcement to the granular soil behind the wall face. MSE wall fascias vary from precast concrete block to welded wire mesh and geocell confinement systems. After much consultation between the owner, contractor, consultant and retaining wall supplier, it was agreed that a combination of two true sectional gravity-type retaining walls and five MSE walls would be constructed. The MSE walls would utilize geogrids as the soil reinforcement and Bin-Wall® as the wall fascia.

The two gravity retaining walls were relatively short and low in height with a maximum length of 39m (13 bins) and a maximum height of 2.1m. The construction of these two walls was possible as these walls retained embankments that would have intruded onto the new track as opposed to the remaining five walls which supported the track embankment.

The five MSE walls had a maximum length of 283m (93 bins) and maximum height of 6.6m. Two of the walls had large drainage pipes penetrating the fascia on a skew.

3. Design

Bin-Wall gravity retaining walls are just as the name suggests, open bottom, steel bins. Manufactured for the most part from galvanized, corrugated steel sheets, these 3m wide modular walls quickly bolt together in the field and are then infilled with free draining granular backfill material. There are six standard bin depths which vary with the live and dead loading conditions and wall height. The walls are designed to resist the overturning and sliding forces typical of a gravity wall system.
In this MSE wall, a steel fascia is employed, but the remaining three sides of the steel bin are replaced with horizontal layers of uni-axial geogrid reinforcement. To the best knowledge of the authors, this is the first time that

this fascia has been combined with geogrid soil reinforcement to create a hybrid retaining wall system. With the exception of the geogrid, all of the components used in the fascia, and the geogrid/fascia connection are standard sectional gravity-type retaining wall components. The vertical spacing of the various geogrid layers utilizes the standard wall system Spacer and Stringer spacing of 406mm. The required embedment length of the geogrid varied with the wall height and loading conditions.

For ease of construction and quality verification, requirements for the reinforcement were kept relatively simple. Only one model (strength) of uni-axial geogrid (Miragrid 3XT) and only three geogrid embedment (tieback) lengths were employed on the project. Similar to a towel on a towel rack, the fascia to geogrid connection was accomplished via a simple wrapping of the geogrid about a Stringer Stiffener which was bolted to the back of the fascia columns.

Figure 3 Non-typical bracing of wall fascia

The uni-axial geogrid used on this project has a published Long Term Design Strength of 28kN/m (per GRI GG-4(b)). The Long Term Design Strength of a geogrid is comparable to the working strength of steel. The Ultimate Strength of the geogrid is reduced for various factors including creep and potential construction damage. These reduction factors are based on the properties of the geogrid polymer (i.e. polyester or polyethylene) and extensive laboratory testing. Uni-axial simply means that the geogrid has a functional strength in one direction only. As these open mesh geogrids are specifically developed for uni-axial reinforcement applications such as retaining walls, over-steepened slopes and embankments on weak foundation soils, they are very economical versus bi-axial (functional strength in two directions) geogrids of similar strengths. All of the geogrid installed on this project was manufactured by TC Mirafi of Pendergrass, Georgia. These uni-axial geogrids are manufactured from high tenacity polyester yarns and coated with PVC for additional protection and dimensional stability.

The design of the various retaining walls was carried out using the proprietary software, MSEW. This is an interactive software program for the design and analysis of mechanically stabilized earth walls. It follows the design guidelines of AASHTO98/Demo 82, AASHTO02/FHWA-NHI-00-043, AASHTO07, or NCMA97/98. For the purposes of this project, wall analysis was run using both AASHTO and NCMA deign methodologies with the more conservative design being selected. Design live loads were based on AREMA (American Railway Engineering and Maintenance-of-Way Association) Cooper E90 loading conditions.

Installation of these geogrids is very simple. Unroll the geogrid and cut to the combined embedment length + wrap length (if applicable) specified. Orient the grid such that the tensile strength direction (roll direction) is perpendicular to the wall face. Tension the product slightly in order to remove any slack. Commence the backfilling operation.

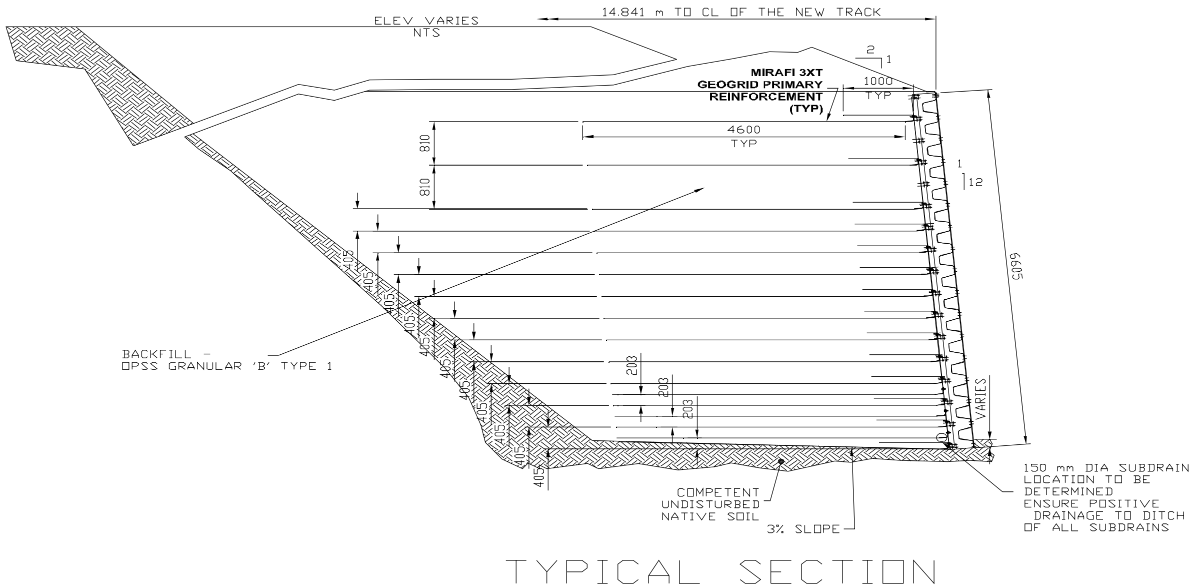

Figure 4 Typical Wall Cross-section

4. Construction

Construction of a wall started at one end on a well compacted granular base. The initial components to be erected were two columns and a fascia stringer which connected the columns. After aligning the above for line, grade and batter, the assembly was temporarily braced in position. At that point, a third column and corresponding stringer were erected. Once the first two layers of stringers and corresponding geogrid and backfill were placed and compacted, bracing was no longer required. Backfill was either placed and spread via an excavator or was pushed into place via small bulldozer. The backfill material was specified as an Ontario Provincial Standard Specification (OPSS) 1010 Granular B Type 1, compacted to 95% Standard Proctor Dry Density. Material conforming to this specification is generally an unprocessed, 75mm minus granular.
Due to site constraints, the supply of backfill to the site was often the biggest bottleneck to productivity. The flow of trucks was limited by the need to back-up long distances alongside the track to the various dump sites and was further limited by the high volume of rail traffic. In the interest of safety, whenever a train passed the site, all large construction equipment activity was temporarily halted. The general construction sequence was to erect and backfill a wall two or three stringers high, for the full length of the wall. This allowed construction efficiencies with regards to placement and compaction of the backfill. The balance of the wall would be constructed in a similar fashion.

Figure 5 Wrapped connection for geogrid reinforcement

5. Summary

Construction was successfully carried out through the winter of 2009, despite low temperatures, precipitation and severely restricted construction time due to the volume of rail traffic.

This wall (segmental steel fascia + geogrid reinforcement) was a prototype wall system that was developed out of necessity from two pre-existing and highly successful retaining wall systems. The knocked-down aspect of the wall components makes them ideal for shipping, assembly and construction in highly restricted sites such adjacent to rail lines.

Figure 6 Backfilling operation over geogrid

Figure 7 Completed Retaining Wall