Supporting Infrastructure with HDPE Geogrid on the South Fraser Perimeter Road Project with MSE/RSS

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ABSTRACT

This paper will focus on the array of retaining walls and slope systems utilized on this recent 40 km section of new four-lane expressway along the Fraser River in the Province of British Columbia.

The author intends to visually share the diverse applications where the unique advantages of *high-density polyethylene* (*HDPE*) have been utilized specific to this project in the following structures.

- Temporary Preload Walls Constructed Well In Advance of the Prime Construction Works
- Mechanically Stabilized Earth (MSE) Approach Walls
- Two Stage Piled Abutment Walls Involving False Fascia Precast
- Reinforced Soil Slopes (RSS) as Sustainable Green Slopes
- Unique Grade Separations With Uneven Soil Reinforcement Lengths In Steep Terrain
- MSE/RSS Applications At Culvert Structures
- Unique Combination Wall Involving a Load Transfer Platform

"Designing with Geosynthetics" as a soil reinforcement material for bridge supporting structures exists as an acceptable design methodology within the American Association of State Highway and Transportation Officials (AASHTO), as well as the Federal Highway Administration (FHWA).

The use of HDPE geogrid on such projects as the SFPR provides many benefits to stakeholders making decisions on publically funded infrastructure. Benefits associated with the use of HDPE geogrid will be briefly illuminated for the audience with respect to the following design considerations.

- Integration of Sustainable Structures (RSS) as encouraged by our professional associations.
- Advantages of HDPE soil reinforcement in aggressive environments (i.e. Chlorides and pH).

This highway alignment has the additional challenge of poorer bearing soils as it is proximal to the foreshore of the Fraser River and Burns Bog, coupled with the demanding seismic requirements typical of this region. The benefits of HDPE in this design environment will be briefly discussed.

The paper will provide a brief background on design methodology, and the ability to tolerate settlement in poor soils, which ultimately resulted in an improved construction schedule in the overall earthworks program for this project.

1.0 INTRODUCTION

The South Fraser Perimeter Road Project (SFPR), also known as Highway 17, opened to traffic in December of 2013, and employed an array of diverse MSE (Mechanically Stabilized Earth) systems, as well as RSS (Reinforced Soil Slopes) to achieve overall project completion.

This paper will focus on the abundance of diverse retaining wall/slope structures utilized on this project, that specifically utilized high-density polyethylene (HDPE) geogrid as the soil reinforcement elements on this large scale infrastructure project.

Map 1: Courtesy of Fraser Transportation Group

This four lane, 80 km/hour route extends for a distance of 40 kilometers along the south side of Fraser River. As noted in Map 1, it extends from Deltaport Way (S.E.) to Highway 15 (N.W), and provides a key route for commercial truck traffic commuting along highway 17 between the Ferry Terminals, Fraser River Industrial Areas, with connection to highway 15 leading to the USA border.

The initial phase of the project (Fall 2008) involved placement of preload in key areas in order to reduce long term settlements. The original concept was to support the preload fills using large 0.76 x 0.76 x 1.52m concrete blocks with geogrid reinforcement. The project would have required over 10,000 blocks. Such blocks weigh in the order of 2000kg each, and thus not many can be carried on a single truck. However, Nilex teamed up with the successful Contractor (Tyam Construction Ltd.) to allow the use of a geotextile wrapped face in place of the concrete blocks, thus providing a considerable cost and time savings to the project. Additional details of the preload walls are provided in Section 2.

FTG was chosen in 2010 to deliver the final phase of design and construction for the South Fraser Perimeter Road (SFPR), as well as to maintain and operate the section between Deltaport Way and 176 Street for 20 years.

Fraser Transportation Group (FTG) an internationally led company consisted of the following firms:

- ACS Infrastructure Canada Inc.
- Ledcor Industrial/Mining Group Ltd.
- Dragados Canada Inc.
- Ledcor CMI Ltd.
- Belpacific Excavating and Shoring Limited Partnership
- Vancouver Pile Driving Ltd.

This four-lane infrastructure project was officially opened to public traffic in December of 2013.

2.0 TEMPORARY PRELOAD WALLS

The initial Phase 1 works, commenced in the Fall of 2008, with the construction of temporary walls over settlement prone soils typical of many river systems, such as the Fraser River on this project.

Photo courtesy of Nilex Inc.

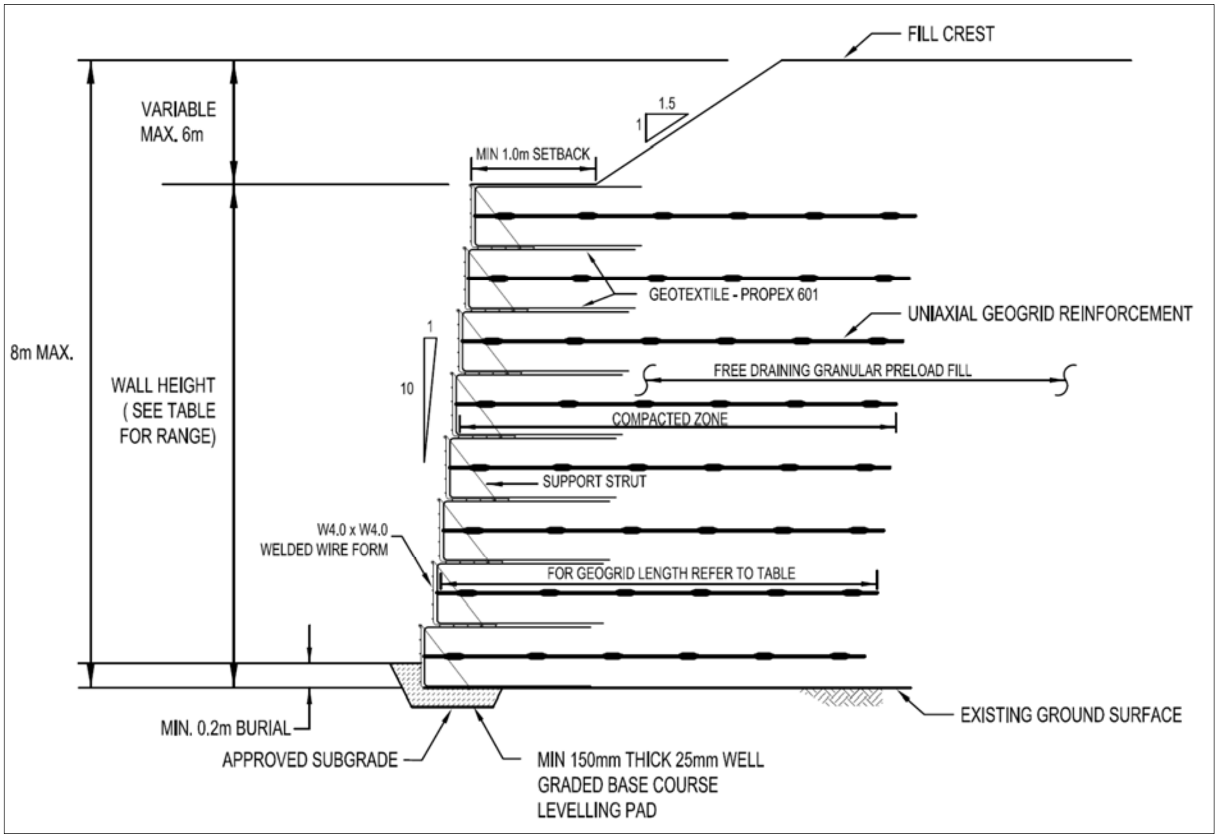
Photo A: Preload Walls Comprised of Welded Wire Facing, Geotextile, and HDPE Soil Reinforcement

Photo A illustrates the early preload walls, which were generally constructed in the vicinity of Tannery Road, Surrey, BC (Map 1).

For those not specifically familiar with MSE systems they are essentially a composite soil system containing planar geogrid reinforcements that are arranged in a horizontal fashion, extending back from the wall facing materials. The soil reinforcements discussed in this paper consist of HDPE geogrids which are contained within a compacted granular soil.

In the case of the SFPR project the majority of backfill materials utilized for both temporary and permanent walls primarily consisted of a river sand backfill material, since it is an economic and locally available backfill commonly utilized on projects in the greater Vancouver Region.

A keen observer may note the settlement which has occurred when looking at the wall on the left hand side of photo A, in the vicinity of the ponded-water at road shoulder. A benefit of using a welded wire facing (WWF) is the flexibility under conditions of settlement as noted above.



Courtesy of Braun Geotechnical Ltd

Figure 1: Typical Section of MSE Preload Wall (Courtesy of Braun Geotechnical Ltd.)

In general, the walls were designed to accommodate upwards of 8m of vertical grade separation as noted in Figure 1.

The walls were founded on a levelling pad comprised of a granular base course which assisted in providing a level surface for the contracting forces in terms of maintaining alignment during the initial placement of wire wall facing elements.

The planar horizontal soil reinforcements were comprised of Tensar® Uniaxial Geogrid Reinforcements, as the prime soil reinforcement. The facing elements were comprised of a black wire facing which consisted of W4.0 × W4.0 welded wire forms, which were also wrapped along the backside of facing with a geotextile wrap, commonly known as a wrapped facing technique within the geotechnical community.

These walls were battered back at 1H: 10V which also provides a measure of comfort, since the final facing orientation of such a wall is not truly known until actual primary consolidation/settlement actually occurs. In other words, attempting to build truly vertical preload walls is not typically suggested by this author when settlement is expected, thereby avoiding a wall system that could lean out after the preconsolidation phase.

3.0 LONG APPROACH WALLS LEADING UP TO TWO STAGE ABUTMENT WALLS

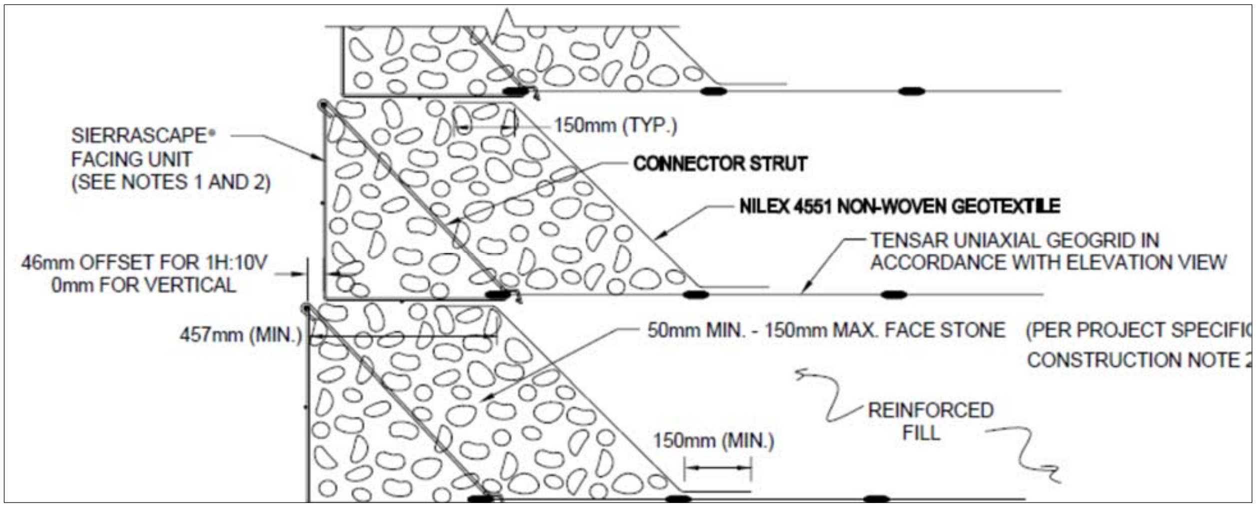
Photo courtesy of Nilex Inc.

Photo B: SierraScape® Galvanized Wire-Faced Walls (Left Hand Side) Leading Up To MSE Bridge Structure

A galvanized wire-faced wall system as observed on the left hand side of Photo B, was utilized on many of the long approach walls leading up to the bridge crossing structures on the SFPR.

This particular wall facing system is illustrated in more detail in Figure 2. It is key to note that this is referred to as a connected wall facing system, whereby the soil reinforcement is attached to the lower facing return by use of a connector strut. This assures full load transfer between the prime soil reinforcement(uniaxial grid), and the wire facing element.

For a permanent wall application such as required on this public highway project, a facing stone, more commonly known as rock-fill, is placed immediately behind the facing cage. The use of rock-fill behind such a facing system affords for easier installation, as well as better overall alignment of the final facing system. The facing stone is separated from the structural backfill (river sand in this case), by the use of a non-woven geotextile separator (Nilex 4551).



Courtesy of Braun Geotechnical Ltd.

Figure 2: Typical Section, Galvanized Wire Wall c/w Facing Stone, Geotextile, HDPE Soil Reinforcement

The allowable long term design strengths utilized for this wall were determined by taking the ultimate HDPE grid strength(T ultimate), and dividing it by appropriate factors of safety, more commonly known as reduction factors(RF). The following equation below is the common method suggested for determining allowable design strengths when HDPE geogrid is employed on design structures.

T allowable = T ultimate / (RF creep x RF aging/durability x RF installation damage)

- T ult, Ultimate Tensile Strength
- RF cr Reduction Factor for creep of the polymer
- RF d Reduction Factor for aging or durability (chemical and biological degradation)
- RF id Reduction Factor for installation damage

Geogrid Type	Tult kN/m	RFcr	RFid	RFd	Tal kN/m	Ci
UX1100MSE	58	2.58	1.10	1.10	18.6	0.8
UX1400MSE	70	2.58	1.10	1.10	22.4	0.8
UX1500MSE	114	2.58	1.10	1.10	36.5	0.8
BX1100/BX1120	19.0	3.60	1.20	1.10	4.0	0.9

Courtesy of Braun Geotechnical Ltd.

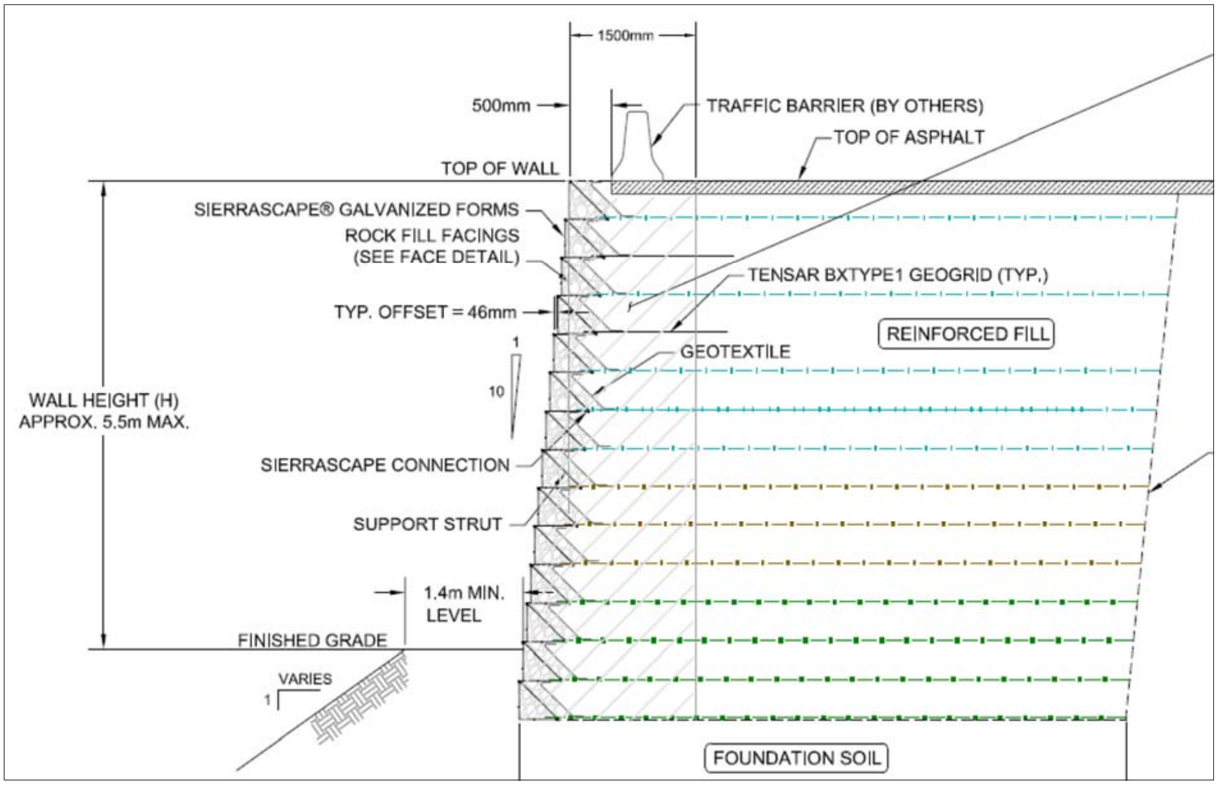
Table 1: Geogrid Strength Parameters and Reduction Factors

On this specific approach wall allowable geogrid strengths ranging from 18 to 36 kN/m of lineal wall facing were utilized for design purposes.

The coefficient of interaction Ci, is dependent on the type of compacted backfill utilized, and provides a measure of how effectively the geogrid strength is mobilized relative to the strength properties of the backfill. In this instance a Ci of 0.8 was utilized, which is generally consistent with a sand type backfill.

Figure 3 illustrates the overall arrangement of the wire faced approach wall, traffic barrier, as well as the arrangement of uniaxial geogrid spaced vertically at intervals of 457 mm(equal to wire facing/cage height).

It is key to note for this particular wall that a horizontal bench at 1.4 m wide is observed at the lower portion of the wall. When the terrain is not flat lying in front of an MSE wall, a common approach is to provide a horizontal bench/berm to enhance the overall wall stability and improve the foundation bearing conditions below and in front of the wall, from a geotechnical perspective.



Courtesy of Braun Geotechnical Ltd.
Figure 3: Typical Section of Longitudinal Approach Wall Leading up to Bridge Structure

4.0 TWO STAGE ABUTMENT WALLS WITH FALSE FASCIA PRECAST FACING

On the overall project a total of 7 bridge structures were completed on settlement prone soils with a Two Stage MSE wall construction technique.

For readers not intimately familiar with two-stage construction the general approach is as follows:

A 1st stage wall is initially erected, which is comprised of a wire faced wall, with HDPE geogrid reinforcement, which allowed the contractor (FTG Constructors) to continue with the earthworks bridge approach fill placement, while the 1st stage wall undergoes settlement, under construction.

Photo courtesy of Nilex Inc.
Photo C: North Abutment at Structure 8225, 1st Stage Wire Wall Earthworks Proceeding, February 2013

The first stage wall is under construction in Photo C(right side), as work proceeds on the bridge deck as noted in this photo.

This first stage wall is then allowed to settle under conditions of loading and time for initial preconsolidation of the soils to occur. One benefit of using a flexible wire-facing wall is that it can accommodate differential settlement generally in the range of 1/50, with no adverse effects to the wall facing system.

It was noted by this author during site visits that the wire facing had experienced relative settlement(observable at front face) of up to approximately 500mm(at the center of abutment faces). With lessor settlement occurring to the outer wing wall extents, with lessor fill loading due to the slope embankment fill edges.

After primary consolidation was completed the installation of a 2nd stage facing, which is effectively a false-fascia precast panel was placed in front of the 1st stage wall, as noted in the following early installation Photo D1.

On this project the initial consolidation of the approach fills behind the wire faced walls took in the range of 18 months to occur, dependent on the specific structure, location, and extent of settlement prone soils.

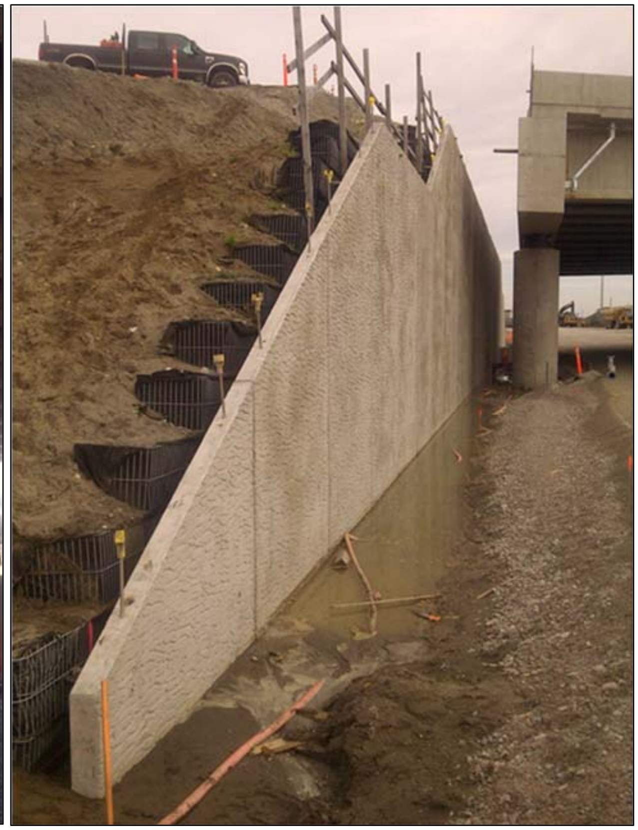



Photo courtesy of Nilex Inc.

Photo D1: Initial Precast Panel Install (2nd Stage) Photo D2: Panel Install at Wing wall, Sept 2013

4.1 GEOTECHNICAL HIGHLIGHTS

In reference to the two stage abutment walls illustrated in photos D1/D2 a brief summary of the geotechnical conditions is outlined below.

The soils at this site consist of surficial sand and some gravel fills underlain by layers of silty clay and clayey silt with trace of organics and a thin layer of peat; these, in turn, were underlain by layers of compact to dense sand interlayered with silt.

Soils under abutment areas were improved using stone columns to minimize liquefaction potential of the sandy soils; preload surcharge varying from 1 m to 2 m was placed on top of the MSE walls to minimize post-construction settlements.

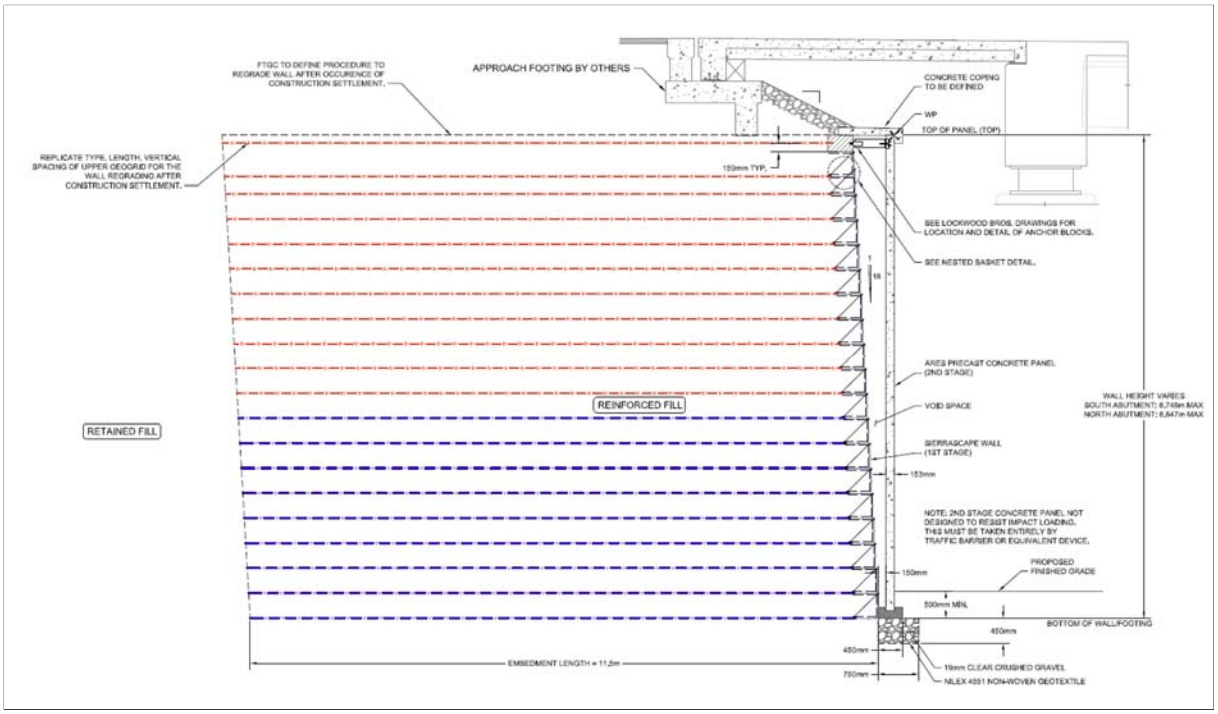
Settlements after completion of the pre-consolidation were in the range of 900 mm to 1500 mm at the abutment areas. Estimated long term post-construction settlements were estimated to be of the order of 50 mmm to 150 mm at the end of 20 years.

Surface peak ground accelerations were in the range of 0.22g to 0.25 g for return periods between 475-yr and 2,475-yr.

The MSE walls were designed with a minimum L/H ratio (geogrid reinforcement length to exposed wall height) of 1.1 in order to achieve minimum factors of safety for global stability of under static and seismic conditions.

The bridge deck on this specific structure was founded on pile supported piers/columns placed in front of the MSE walls. The approach slabs were founded on shallow footings sitting on top of the MSE walls, applying a serviceability bearing pressure of 130 kPa.

As the wall face area(1st/2nd stage) was under the same influence/effect of preload during the pre-consolidation phase, predicted differential settlement between the precast panel (false fascia) and the 1st stage (wire wall) was considered negligible.



Courtesy of Tensar® International

Figure 4: Typical Section Completed Two Stage Wall Illustrating 1st Stage(Wire Face) and 2nd Stage(Precast)

This particular two stage structure was unique on this project, that it did not contain vertical pile elements within the 1st stage mass, since bridge deck support was provide by columns in front of the MSE wall system.

4.2 PRECAST ELEMENTS

The false fascia panel was placed within a 450 mm wide footing containing a keyway recess to receive the base of precast panel. The top of precast panel was connected by mechanical hardware, to a dead-man/anchor block placed in behind the 1st stage wire wall during the initial earthworks phase. The anchor block was cast in such a way, that HDPE soil reinforcement (top grid in Figure 4) could also be established as a contributing primary reinforcement element.

Design and supply of the precast/pre-stressed fascia panels consisted of the following items:

- Architectural (STONE GROUND FRACTURED GRANITE FINISH) for all 7 structures.
- 330 precast anchor blocks placed behind the 1st stage wall facing(Stage 1).
- 336 false fascia panels(Stage 2) consisting of 230 different structural panels required.
- Typical panels: 0.155m thick × 2.98m wide x up to 9m high
- Wall face area of 4792 M2.

Precise co-ordination was required between all stakeholders (FTG CONSTRUCTORS, NILEX INC., SEA-JAE BUILDERS LTD, LOCKWOOD BROS. CONCRETE PRODUCTS) at all stages of the work.

At the early design phase, expected settlement of the 1st stage wall required determination, such that anchor blocks to later facilitate 2nd stage precast panel attachment, could be placed at the time of 1st stage construction.

Total and differential construction/long-term settlements, often occurring within the same structure, necessitated the following considerations leading up to precast fabrication as indicated below:

- At 1st stage construction, the supply and location of anchor blocks c/w anchors, required exacting coordination between the precast fabricator and field crew.

- After primary consolidation, but prior to precast panel production, an exact survey of each anchor location was required for final precast fabrication.

- With a number of unique panels required, there was rigid control on all production scheduling, quality control, and installation co-ordination.

- Panel design and connections needed to be flexible to accommodate significant differential settlement of the walls, as well as design in a high seismic zone, and ease of connection in the field.

The completed two stage wall structure is observed in the following photo E. The top of wall treatment consisted of a wider coping, which was termed a coping-closure-slab as can be seen in this photo viewing angle. A wider coping was essentially needed to cover the horizontal distance from the front face of false fascia precast panel, to allow the coping to continue over and atop the 1st stage MSE wall.

Photo courtesy of Nilex Inc.
Photo E: Completed Two Stage MSE Wall, Highway 17 over Highway 99, Structure 8225, August 2014

Key Benefits With Two Stage Construction

A key advantage in this system approach is that in many instances when soil and design conditions permit, the 1st stage approach allows for the immediate advancement of road approach fills over settlement prone soils. On this project the rate of approach fill placement, was carefully monitored by the geotechnical engineers, due to the unique challenges of building on poor soil areas such as this one.

Once primary consolidation was completed, the placement of full-height false fascia panels occurred rapidly with abutment and wing-walls on this specific structure being installed in the range of approximately one week.

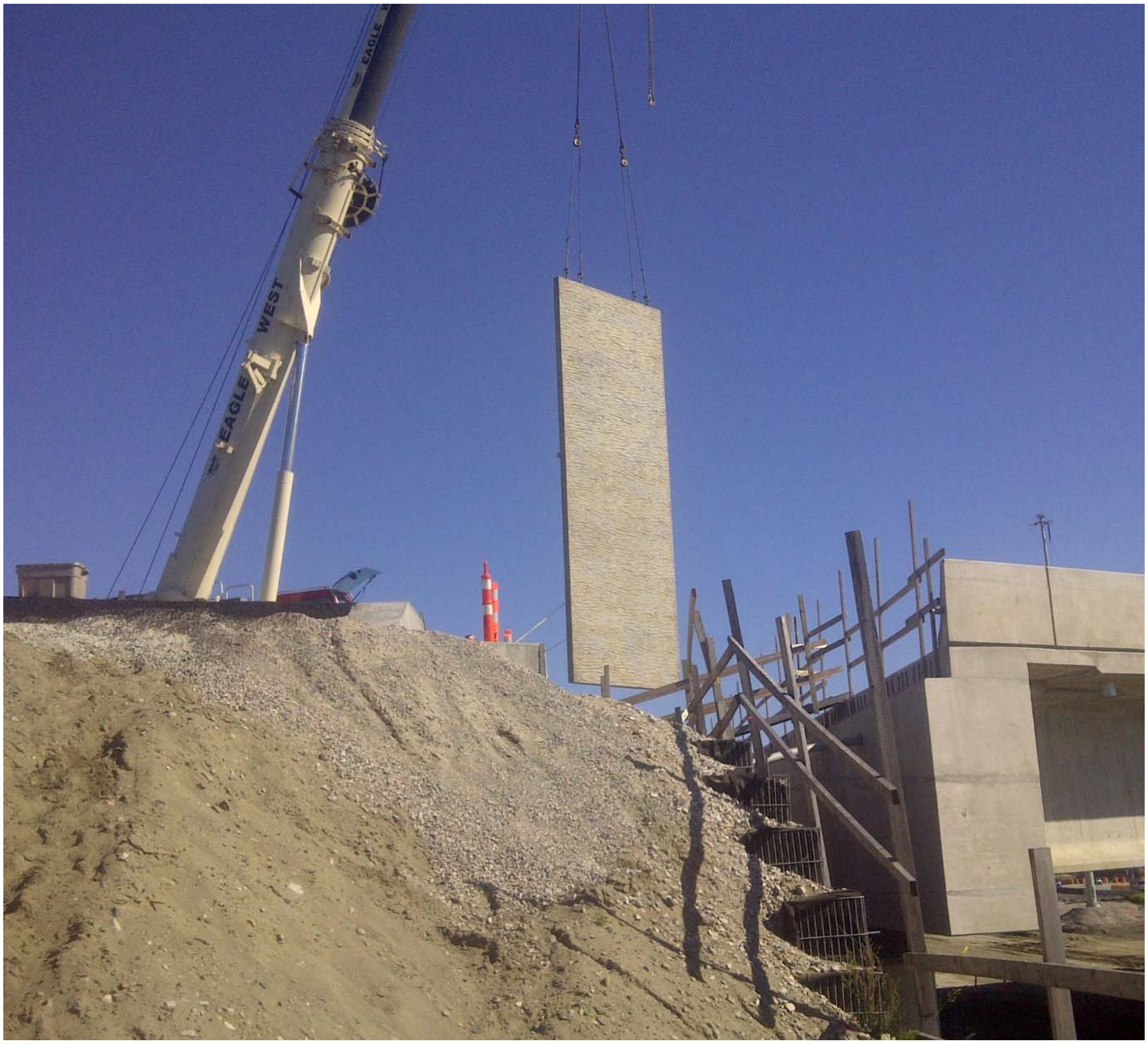


Photo courtesy of Nilex Inc.
Photo F: Initial False Fascia Panel Lift by Eagle West Cranes, Structure 8225, September 25th , 2013

Only on this specific structure(8225) did the panel installation contractor (SEA-JAE BUILDERS LTD) have the benefit of an open jump slab area where the panels could be installed from the topside of the structure as seen in photo F.

On the remaining six of seven, two stage structures, installation was much more complex.

For the remaining six two stage structures, precast panels were installed under the new and existing bridge decks(Photo G), with no headroom for conventional overhead rigging techniques for the placement of panels. The reader will note the crane boom connecting direct to top of panel in this photo which was completed with unique hardware connecting the boom direct to top of panel, as seen just below the existing girders.

Although a challenging construction method, this allowed FTGC Constructors to install the pile supported bridge decks, and all earthworks well in advance of the final placement of precast false fascia.

It is understood by this author, that this two stage method of construction allowed the construction forces to complete the earthworks approximately one year earlier, than if conventional construction techniques had been employed for these seven bridge structures.

This is a significant benefit of two staged construction which was realized on this project.

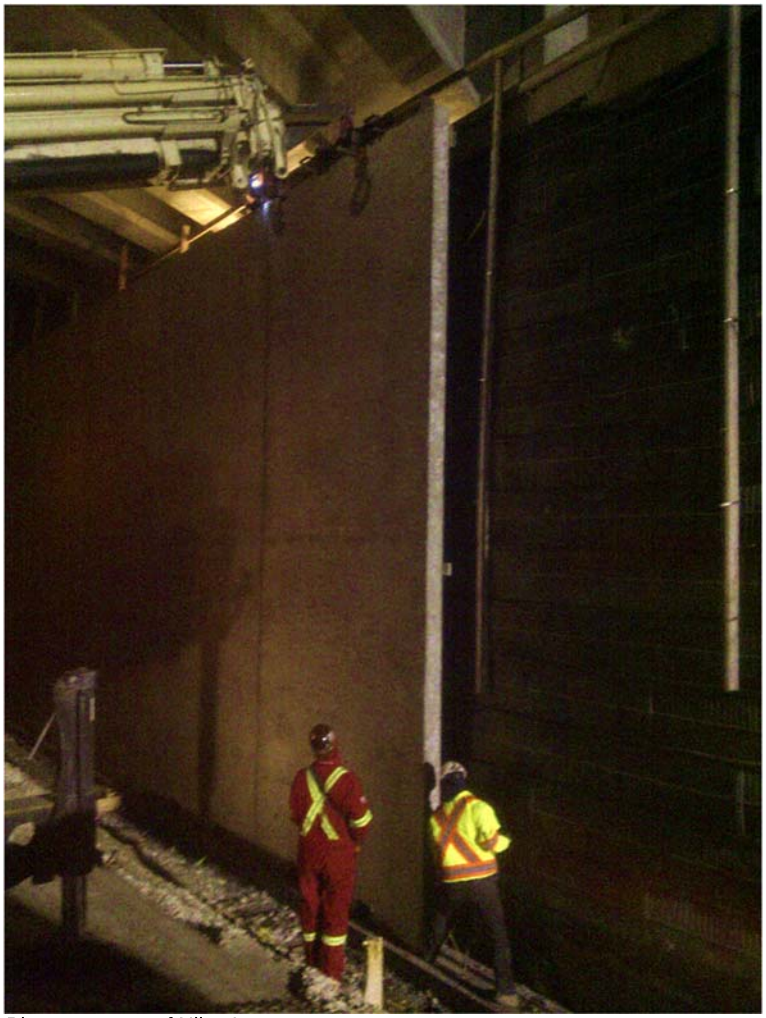
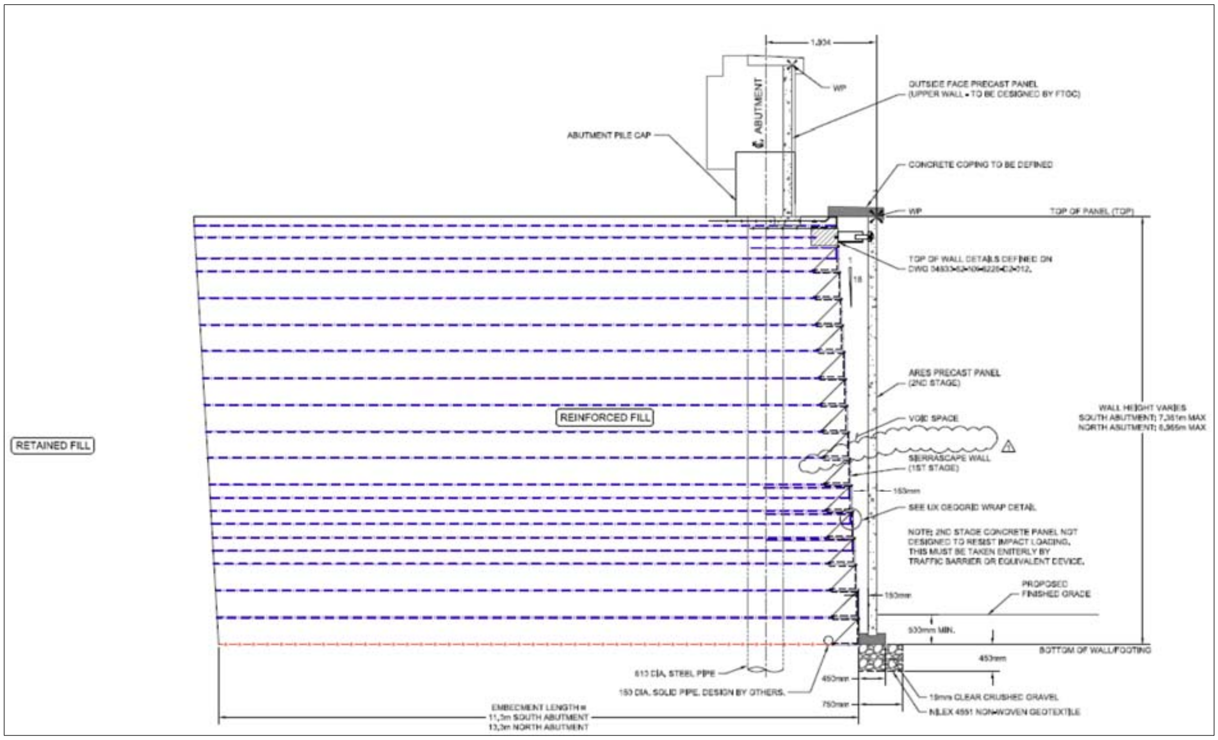


Photo courtesy of Nilex Inc.
Photo G: Precast Install SEA-JAE BUILDERS LTD , November 2013

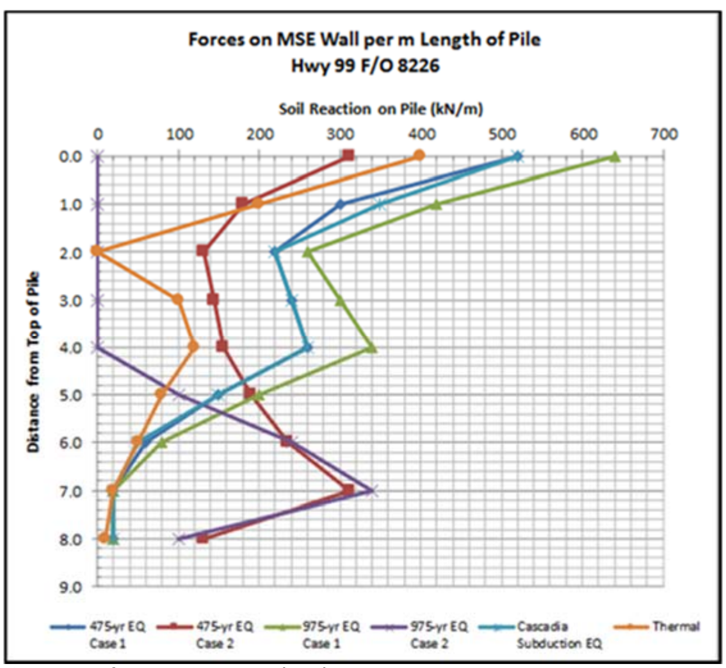
The remaining six two stage structures had vertical pile obstructions within the MSE backfill as noted in Figure 5 below.



Courtesy of Tensar® International

Figure 5: Typical Section at Piled Supported Two Stage Abutment, Structure 8226

The reader may note that the vertical spacing or density of geogrid is more closely spaced in the lower portion of the wall in Figure 5. This increase in grid density, or alternatively decrease in vertical grid spacing, was required to accommodate the additional loading demands the piles imparted to the MSE wall mass(refer to Chart 1 below).



Courtesy of Tensar® International

Chart 1: Pile Forces on MSE Wall

5.0 REINFORCED SOIL SLOPES (RSS) as SUSTAINABLE INFRASTRUCTURE

An 8m high Sierra® RSS slope with a facing inclination of 69.3 ° is in the midst of construction as illustrated in Photo H. The slope is more specifically; located to the right of the heavy rail corridor, and is located beneath the upper cut-slope excavation.

This vegetated slope supports the 4 lane roadway which primarily moves industrial truck traffic along proximal to the Fraser River Foreshore, and safely directs traffic destined for the Canada/USA border. This slope is also noted to extend on a right hand curve as viewed in the far distance.

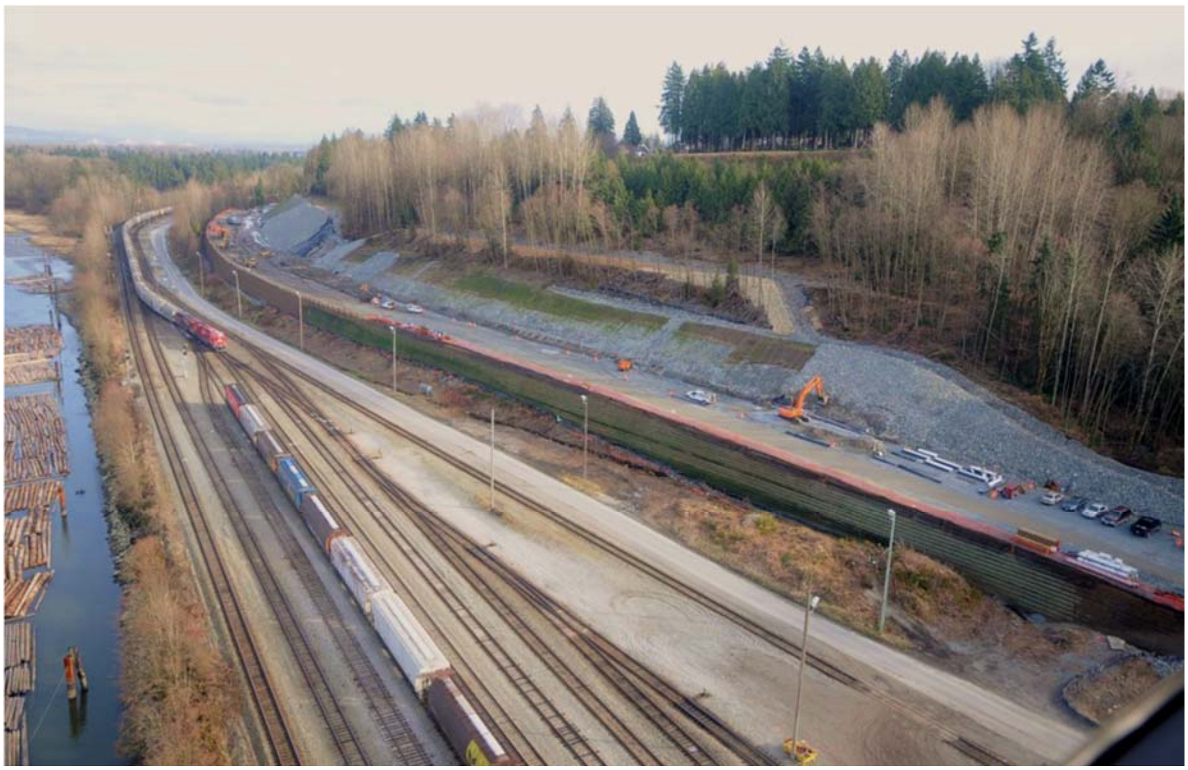
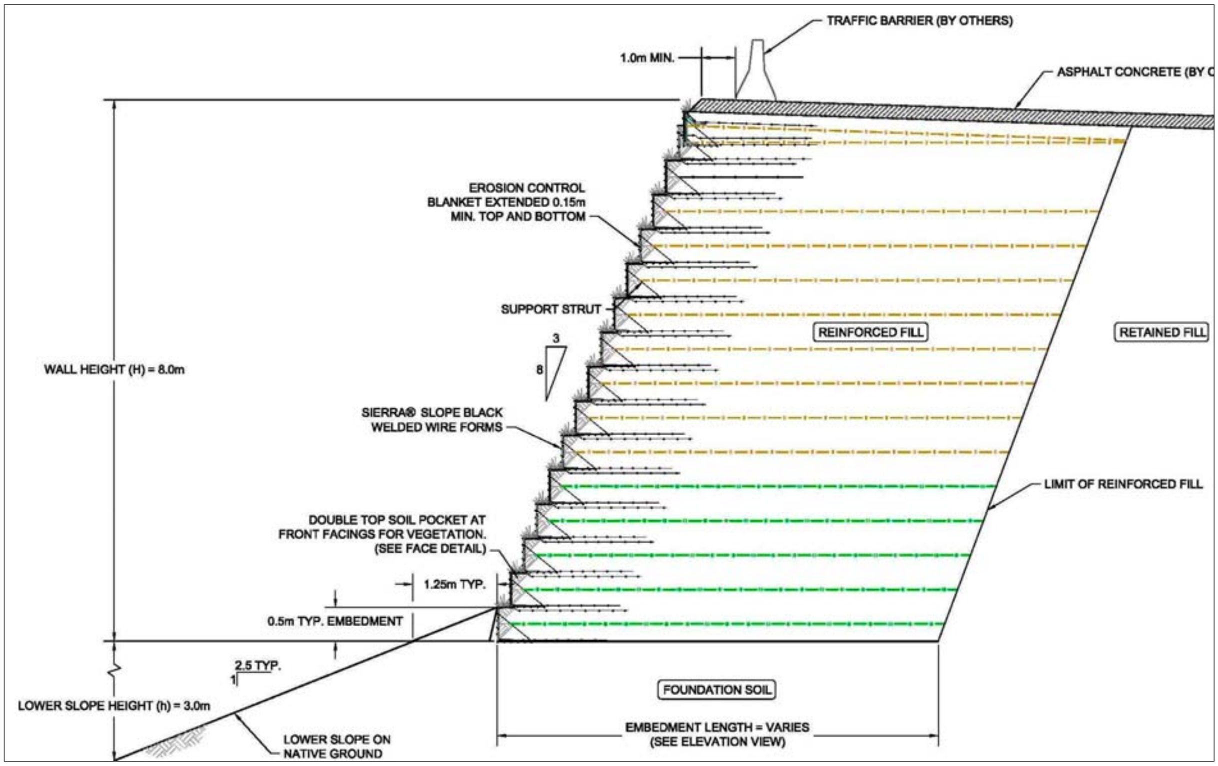


Photo courtesy of Fraser Transportation Group

Photo H: 8M HIGH RSS SLOPE, LOOKING EAST ALONG THE FORESHORE OF THE FRASER RIVER



Courtesy of Tensar® International

Figure 6: RSS 8m high section [6.5m long geogrid embedment lengths per design].

As observed in Figure 6 the arrangement of geogrid is similar with the vertical spacing of geogrid in this instance at 500mm intervals, with the facing inclined to form a steepened slope face at 3H : 8V or 69.3°.

This RSS system offers an added benefit from a sustainability point of view in that it allows the incorporation of a vegetated facing which has the encouragement of our professional organizations such as follows below.

As published within the Association of Professional Engineers and Geoscientists of British Columbia article, entitled "Sustainability Guidelines" professionals within their scope of practice have a responsibility to remain current with respect to the following bullets as borrowed by this author and summarized below.(1)

1. *Maintain a Current Knowledge of Sustainability*
2. *Integrate Sustainability into Professional Practice*
3. *Collaborate With Peers and Experts from Concept to Completion*
4. *Develop and Prepare Clear Justifications to Implement Sustainable Solutions*
5. *Assess Sustainability Performance and Identify Opportunities for Improvement*

RSS slopes offer one method for highway/infrastructure engineers to incorporate sustainability into their roadway designs. In the following photos(F1 and F2), the benefit is now realized by the Trucking Industry as westbound truckers head along the perimeter road towards the awaiting Industrial, Rail, Port, and Ferry facilities which abound along this area of the Fraser River / BC Lower Mainland Region.

Photo courtesy of Nilex Inc.
Photo F1: SFPR / Hwy 17 over RSS, [2014]

Photo courtesy of Nilex Inc.
Photo F2: SFPR 69° RSS EARLY GREEN- UP, [2014]

6.0 GRADE SEPARATION WITH UNEVEN SOIL REINFORCEMENT LENGTHS

On other sections of this project, it was required to establish MSE wall systems within steeply sloped hillsides, with the geotechnical requirement to not over excavate too far into the bank in the lower wall portions for reasons of global stability.

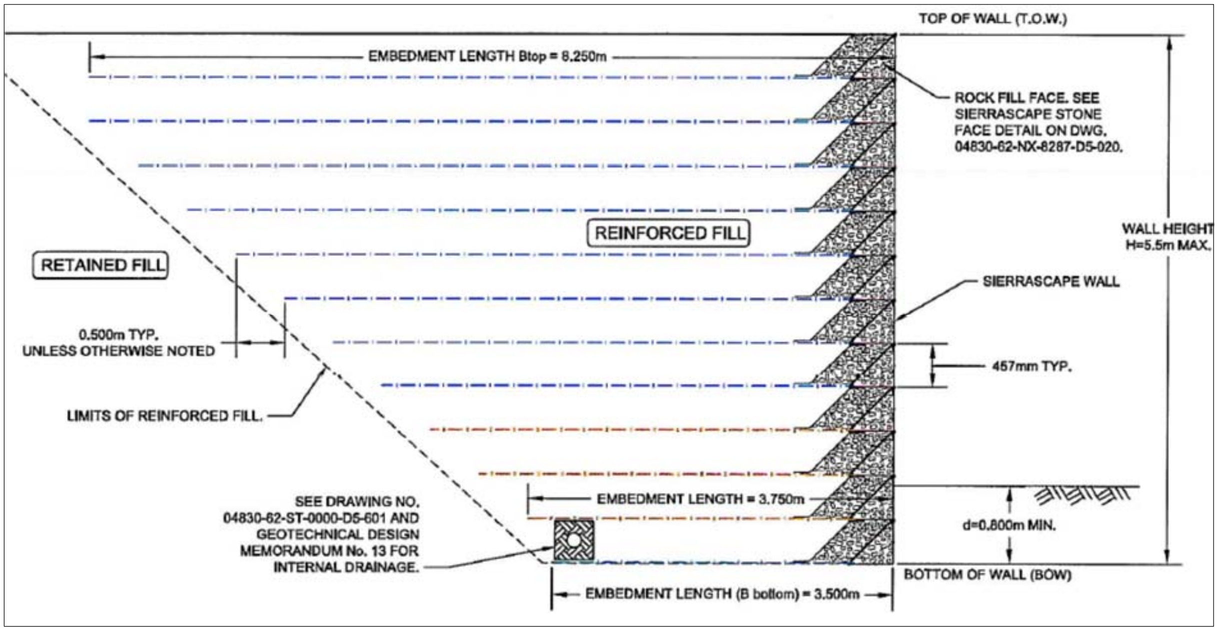
In these instances a unique design method which is often referred to as truncated or trapezoidal design method was employed. The technique involves utilizing shorter soil reinforcement lengths in the lower portion of wall, where foundation, or geotechnical stability conditions, permit.

The facing system employed in this scenario consisted of the galvanized SierraScape® system previously discussed, with Grid Length/Wall Height Ratio in this case at 0.63 H.

Although this method enables construction in challenging steep terrain, it does additionally offer a sustainable advantage from the perspective of not requiring extensive excavation into the hillside at lower elevations, more typical of a convention MSE design approach.

The detail of this unique geogrid arrangement is noted in the following Figure 6. Construction of this particular wall is observed in following Photo G.

The reader will note the hilly terrain in this location where the truncated section was employed. The SFPR is observed on the left hand side of the photo, often serving as a corridor for commercial truck traffic in this region.



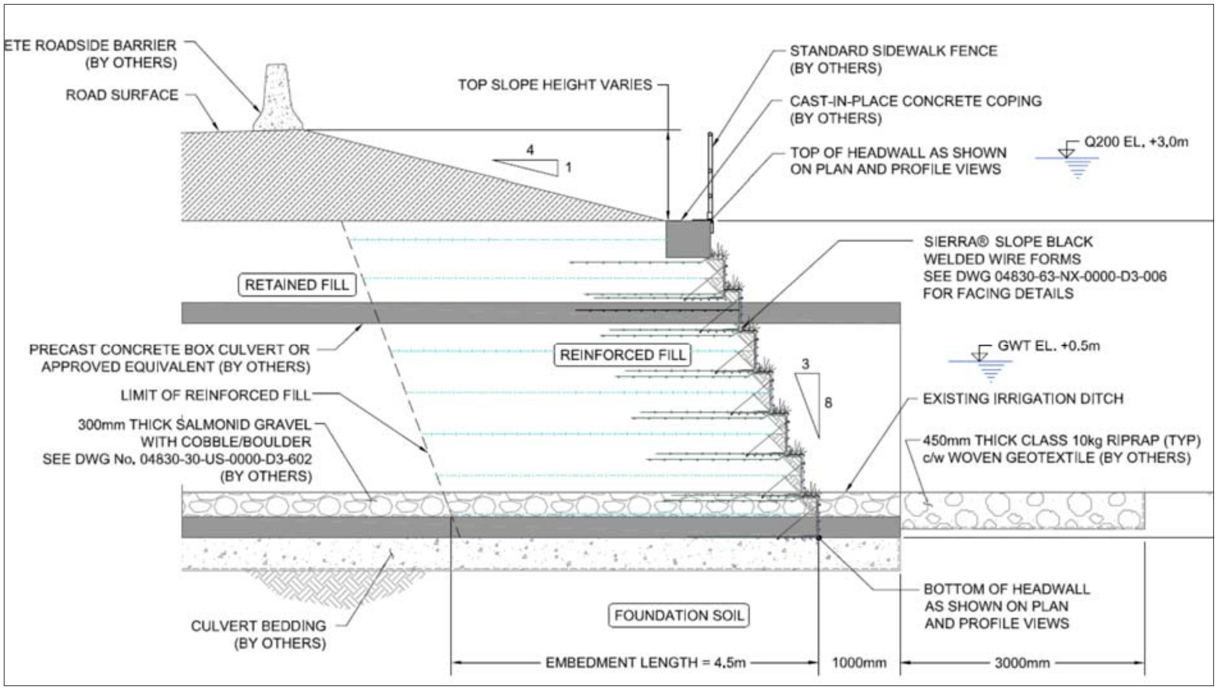
Courtesy of Tensar® International

Figure 6: Typical Section At Wall Structure 8287 [Gunderson] With Uneven Soil Reinforcement Lengths

Photo courtesy of Nilex Inc.

Photo G: Retaining Wall No. 8287 at Gunderson, and just above SFPR alignment [May 2015].

7.0 SUSTAINABLE RSS SLOPES AT WETLAND CULVERT STRUCTURES



Courtesy of Tensar® International

Figure 7: Typical RSS Section Utilized At Box Culvert Wing wall At Wetland Location

RSS systems inclined at 3H : 8V were also employed at a variety of structures in and around water as observed in Figure 7 above.

Such RSS structures when employed at locations such as this one offer a supporting landscape to complement the natural wetland area typical of the SFPR project and Burns Bog Area.

It should be noted in Figure 7, that the structure is also designed for the submerged condition during the 1:200 year flood level (noted in the upper right hand corner of Figure 7).

Photo H illustrates the completed RSS culvert wingwall, with established vegetation(as noted by this author), approximately three years after initial installation.

In wetland environments, soil reinforcements will often be exposed to either fresh, brackish, or saline waters.

Photo courtesy of Nilex Inc.
Photo H: RSS wing wall at box culvert 3 years post construction [May 2015]

HDPE geogrid as the prime supporting member can offer many additional benefits when exposed to an aggressive environment or where corrosion is of concern. As noted in Table 2 below, HDPE is suggested for aggressive soil environments with a pH > 3.

Table 2

Recommended Limits of Electrochemical Properties for Reinforced Fills with **Geosynthetic Reinforcements**

Base Polymer	Property	Criteria	Test Method
Polyester (PET)	pH	3 < pH < 9	AASHTO T-289
Polyolefin (PP & ***HDPE***)	pH	**pH > 3**	AASHTO T-289

Note: Table reproduced from Table 3-4, page 3-10, Berg, R. R., Christopher, B.R, Samtani, N.C, U. S. Department of Transportation, Federal Highway Administration, Publication No. FHWA-NHI-10-024, FHWA GEC 011 – Volume I November 2009, NHI Courses No. 132042 and 132043, Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes – Volume I.

In contrast, where steel soil reinforcements are utilized in wall/slope design, a more exhaustive evaluation of the soil properties which have an impact on durability should be completed. This key difference is further illuminated by the ***suggested properties*** to be tested as noted in Table 3 below.

Table 3

Recommended Limits of Electrochemical Properties for Reinforced Fills with ***Steel Reinforcement***

Property	Criteria	Test Method
Resistivity	> 3000 ohm-cm	AASHTO T-288
pH	**> 5 and < 10**	AASHTO T-289
Chlorides	< 100 PPM	ASMT D4327
Sulfates	< 200 PPM	ASTM D4327
Organic Content	1% max.	AASHTO T-267

Note: Table reproduced from Table 3-3, page 3-9, Berg, R. R., Christopher, B.R, Samtani, N.C, U. S. Department of Transportation, Federal Highway Administration, Publication No. FHWA-NHI-10-024, FHWA GEC 011 – Volume I November 2009, NHI Courses No. 132042 and 132043, Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes – Volume I.

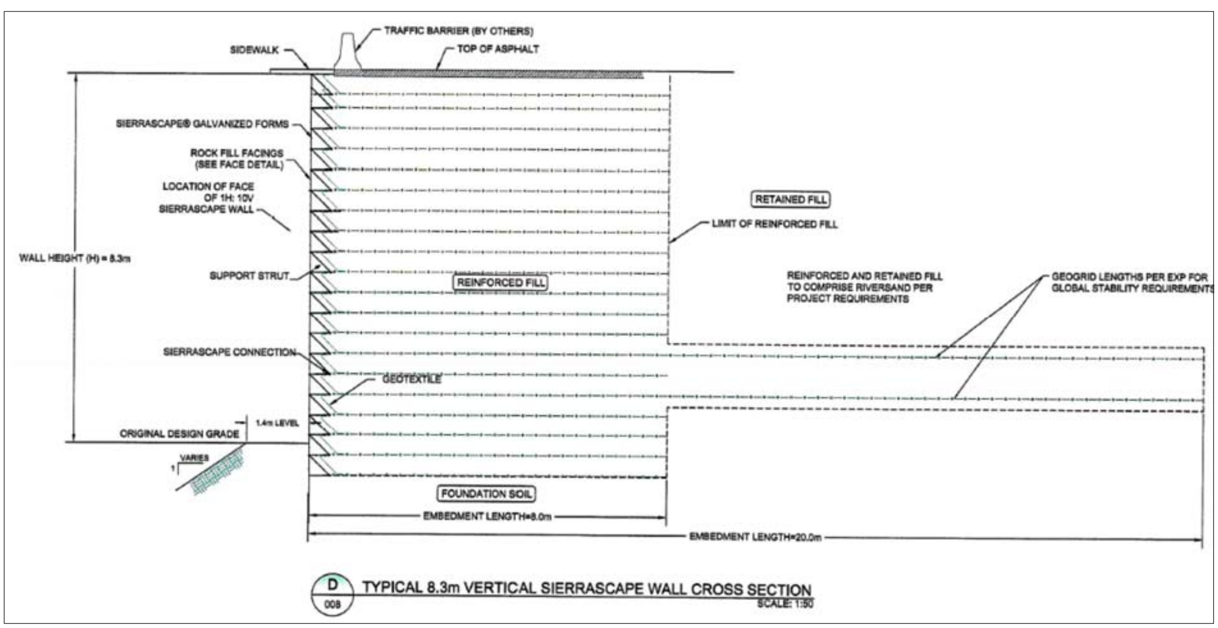
8.0 COMBINATION WALL [SierraScape® and RSS] and COLUMN SUPPORTED BRIDGE

This last example is a combination of an MSE wall inclined at 1H : 10V in behind the pile/column supported bridge structure, which transitions to a vegetated RSS as one progresses towards the wing-wall areas beyond the bridge deck. The method of design and arrangement of HDPE geogrid is essentially the same as previously described within this paper. However this area was not preloaded prior to construction. Instead, piles were driven at close spacing, and a transfer platform constructed above in order to transfer the embankment loading into the piles. The transfer platform comprised closely spaced high strength geogrid interlayered with high friction granular material such as gravel and sand.

The vegetated RSS is very tolerable to differential settlement and was used in areas where the embankment transitioned from being supported on piles to grade support without piles. In addition, the vegetated RSS can be constructed at a lower cost compared to a rock faced wall.

Photo courtesy of Nilex Inc.
Photo I: Column Supported Bridge Deck with Galvanized Wire Faced Walls, and RSS Approach Slopes

The wire faced wall system can be seen in Photo I, behind the column supported bridge structure, where the retaining systems transitions to a vegetated RSS system as one proceeds to the center / left side of Photo G.



Courtesy of Braun Geotechnical Ltd.
Figure 8: Typical Section Behind Column Supported Bridge Deck at Tannery Interchange

As noted in Figure 8, this particular structure was designed consistent with designs previously discussed although due to unique geotechnical conditions at this site; long soil reinforcement lengths were required in the lower portion of the wall to satisfy overall geotechnical requirements as required by the owner's geotechnical engineers at Exp. Services Inc.

This author would encourage designers to contemplate RSS methods of grade separation along our future highway system, as our engineering community continually evolves on the "path of enhanced sustainability in future design and construction".

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15. REFERENCES

The following references although not specifically cited were generally relied on as additional technical resources in the overall preparation of this paper.

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http://conf.tac-atc.ca/english/annualconference/tac2014/s-31/macdonald.pdf

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Specific References

The following references were specifically cited or paraphrased within the text of this white paper as noted.

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