Ontario

RSS Design Guidelines

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Acknowledgements

Retained Soil System (RSS) Work Group

Betty Bennett (Chair)
Foundation Engineer

Ken Ahmad
Foundation Engineer

Dave Dundas
Senior Foundation Engineer

Nick Garland
Central Region Structural Engineer

Walter Kenedi
Senior Evaluation and Inspection Engineer

David Lai
Head Rehabilitation Engineer

Jamie Stacey
Metallurgical Engineer

Enquiries regarding amendments, suggestions or comments should be directed to:

Bridge Office Ministry Of Transportation 2nd Floor 301 St. Paul Street St. Catharines, Ontario L2R 7R4 (905) 704-2406	OR	Pavements and Foundation Section Ministry Of Transportation Rm. 232 Building C 1201 Wilson Ave Downsview, Ontario M3M 1J8 (416) 235-3533

RSS DESIGN GUIDELINES

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1 INTRODUCTION

The purpose of the Retained Soil System (RSS) Design Guidelines is to assist Owners and Consultants to:

- Determine the need for a Retained Soil System (RSS);
- To assess the functional requirements for the RSS; and,
- To correctly specify the RSS in the Contract documents.

RSS are similar in designation to the Mechanically Stabilized Earth (MSE) walls that are used in the United States. RSS used in MTO contracts are proprietary systems that, once accepted, are listed in the Designated Sources for Materials (DSM). The tendering of RSS is thus “generic” as the contractor can select from a number of RSS suppliers satisfying the requirements for the RSS specified in the Contract documents. The supplier of the selected RSS carries out detail design of the RSS after tender award.

The intent of the RSS Design Guidelines is to:

- Describe each of the RSS applications;
- Define the roles and responsibilities of the designer, contractor and RSS supplier;
- Emphasize the importance of assessing a site and its geotechnical conditions for use of an RSS application;
- Explain the revised specifications for RSS, including new tender items and contract drawing requirements;
- Provide standard details for typical structures to develop consistency in design.

A summary of the process of selecting and specifying RSS is summarized in Appendix F.

1.1 BACKGROUND

Prior to the 1980’s most bridge abutments and retaining walls were constructed of reinforced concrete as either cantilever or gravity-wall types. These walls were essentially rigid and were supported on shallow footings or deep foundation units depending on the ground and subsurface conditions. As retained height increased, the reinforced concrete structure quickly became uneconomical and complicated in design.

MTO built its first RSS wall in the late 1970’s; successive installations showed that RSS offered a number of advantages over conventional concrete walls:

- cost savings of 25% to 50% for retained heights greater than about 4 m,;
- ease of construction with the elimination of formwork, placement of reinforcement, curing of cast-in-place concrete and driving of deep foundation piles
- reduced site preparation due to greater flexibility and tolerance to deformation;
- minimal construction equipment since installation generally independent of wall height;
- wall facings offered in a variety of aesthetic facing textures and colours.
- increased durability due to the use of precast elements.

The first RSS constructed by MTO consisted of metal reinforcing strips embedded in an engineered fill with precast concrete facing panels (the now familiar “RECO” wall). By the 1990’s a large number of RSS had become available using new configurations and a variety of materials.

The MTO RSS Work Group was established in 1991 to develop submission requirements and a review process for RSS products and suppliers, and to develop generic specifications reflecting these new types of RSS and ongoing “as-built” experience. The Work Group is made up of MTO staff from the Foundation and Materials Engineering, Structural, and Construction offices.

The supplier of every prospective RSS is required to submit a complete design package for that RSS, including design assumptions and methodology, material and construction specifications, and standard details, together with an independent assessment by a recognized engineering company, to the RSS Work Group for review. When the submission is acceptable to the Work Group, the RSS is listed in the DSM under the appropriate category for its use.

The Ministry of Transportation of Ontario (MTO) and the Ontario Good Roads Association (OGRA) jointly held an RSS Seminar for designers in November 1999 to highlight steps to be followed to specify RSS. Increasing use of RSS has highlighted the need for clarification with regards to the respective responsibilities of the designer, contractor and RSS supplier. In 2005/2006, MTO revised methods of specifying RSS and issued new Tender items into the Contract Preparation System (CPS), along a revised Non-Standard Special Provision (NSSP). Bridge Office issued a Design Bulletin entitled “Changes to RSS Design Requirements and Construction Specifications”, dated December 8, 2005 to provide some initial information to designers on these new RSS practices (Appendix C). This Guideline expands on principles contained in the Bulletin.

2 CATEGORIES OF RSS

Retained Soil Systems are divided into two categories based on the direction of loading. They resist either:

1) Horizontal Loads, or
2) Vertical Loads

2.1 RSS SYSTEMS RESISTING HORIZONTAL LOADS

RSS systems designed to resist the loads due to lateral earth pressure can be considered an alternative to conventional cantilever or gravity retaining walls and abutments. They are generally composed of a soil mass reinforced with metal strips or geogrids attached to a facing material that may consist of concrete panels, modular blocks, or geogrids. Each system listed in the DSM has a specified soil reinforcement and facing material that cannot be changed. RSS systems resisting horizontal loads may also include proprietary gravity or cantilever systems and systems using ground anchors or soil nails.

There are three applications of RSS retaining horizontal loads:

a) Vertical wall or steep slope
b) False Abutment
c) True Abutment.

2.1.1 WALL/SLOPE

The conventional method to support horizontal loads is to provide a cast-in-place reinforced concrete cantilever retaining wall either at the toe of the slope (as shown in Figure 2.1) or at the crest of the slope. As the wall becomes larger, the amount of excavation may be excessive and material costs may become prohibitive as the wall height becomes larger.

This category of RSS covers a wide range of proprietary systems where embankment heights are greater than 2m. Their function is to stabilize slopes steeper than their naturally stable angle. The safe slope of earth embankments can be estimated from slope stability analyses and depends on many factors, such as type of soil, compaction, moisture content, overburden, height of embankment, etc. A steeper slope than the stable slope may result in failure without the RSS system. Two typical RSS walls, one vertical and one inclined, are shown in Figure 2.2.

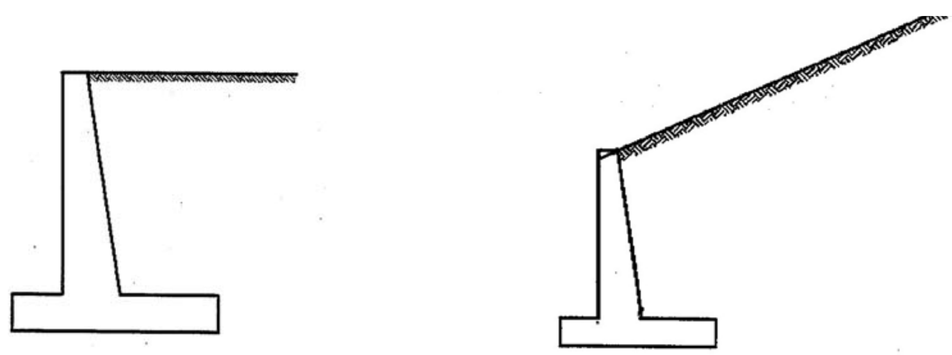
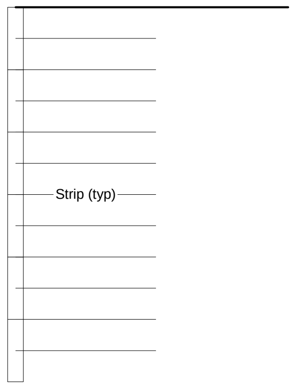


Figure 2.1: Cantilever Retaining Wall



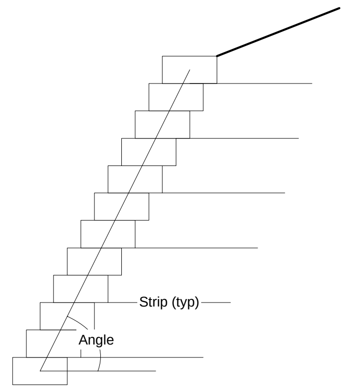


Figure 2.2: RSS Wall/Slope

Normally, systems that are steeper than 75^0 to the horizontal are considered retaining walls and require non-eroding facing elements. Steep slopes range from 30^0 to 75^0 and also require means to control erosion.

Facing elements provide protection against sloughing of backfill materials, erosion, salt spray and impact. They are not structure elements – the reinforced soil mass provides the structural stability. The facing elements come in a variety of materials and finishes. They include:

- Precast concrete panels, segmental and full height
- Modular concrete blocks
- Geo-cells
- Wire mesh
- Geogrid/geotextile

Wall/Slope systems are classified in the DSM according to their geometry (verticality), performance and appearance. Designers should ensure the appropriate requirements are specified in the contract drags for each specific RSS application.

2.1.2 FALSE ABUTMENTS

Traditionally, MTO had used cast-in-place reinforced concrete abutments supported either on spread footings or on piles as shown in Figure 2.3 and 2.4. These abutments resist both vertical loads from the earth, super-structure and their own self-weight, as well as lateral loads due to earth pressure and from the superstructure.

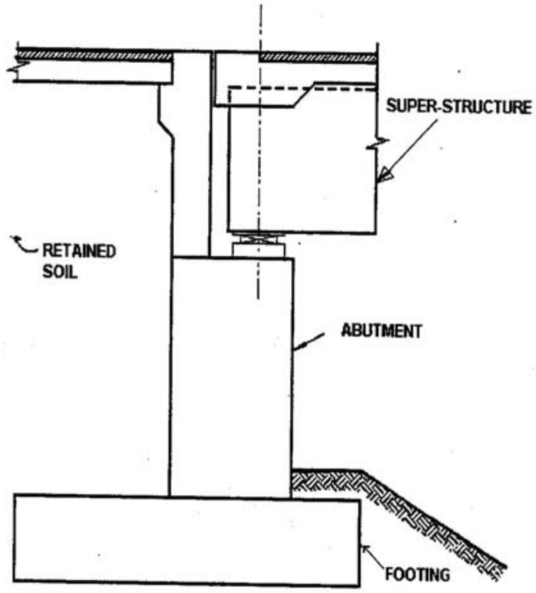


Figure 2.3: Conventional Abutment on Spread Footing

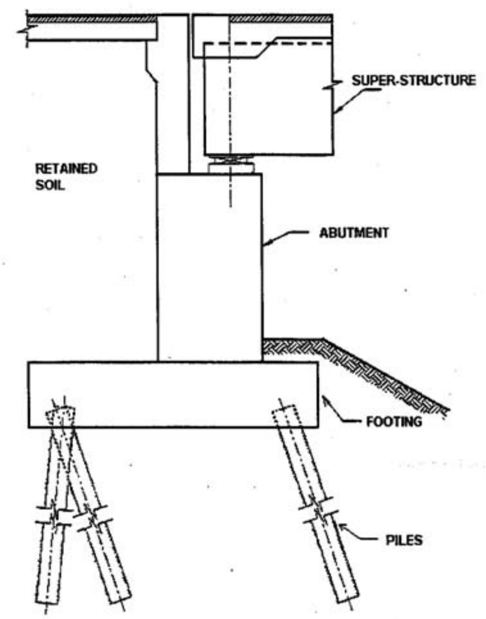


Figure 2.4: Conventional Abutment on Piles

MTO uses false abutments in situations where conventional cast-in-place retaining wall type abutments are not economical or feasible. This usually occurs in foundations with piles and in cases where the abutment is perched and the total height is greater than about 6m. This type of abutment can be used on multi-span structures with integral or semi-integral abutments and decks provided with expansion joints; and where the structural tolerance to settlement is small. Only systems with a high performance rating should be used.

A false abutment (Figures 2.5 through 2.8) consists of a stub abutment supported on deep foundations, columns, or walls with spread footings to resist the vertical loads from the superstructure. In addition, a reinforced soil system resists horizontal loads due to earth pressure. The false abutment with deep foundations is the most common application and has been used extensively by MTO. The false abutments with columns or walls shown in Figure 2.7 and 2.8 have not been used widely by MTO. Further design guidelines and construction details will be provided as more experience is gained with these systems. The false abutment with columns shown in Figure 2.7 has been used in limited situations where the columns are in a temporary stage and will eventually become a pier as the bridge is lengthened. The false abutment with concrete wall shown in Figure 2.8 has seen limited use in situations where the facing of the abutment is to be matched with the adjacent walls.

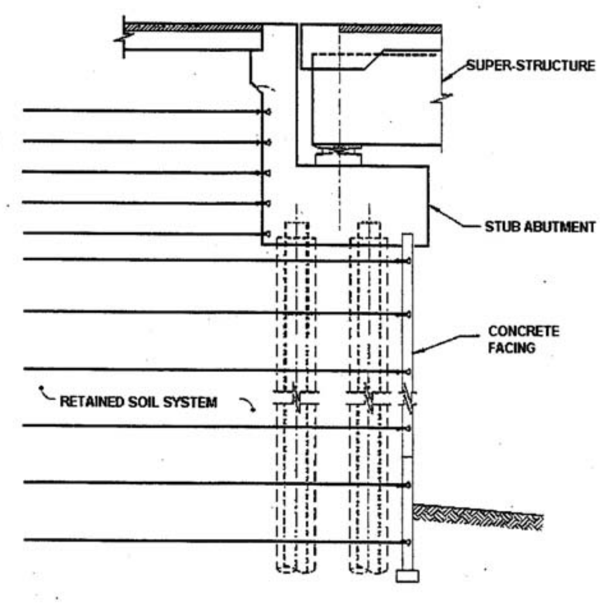


Figure 2.5: False Abutment with Multiple Rows of Piles

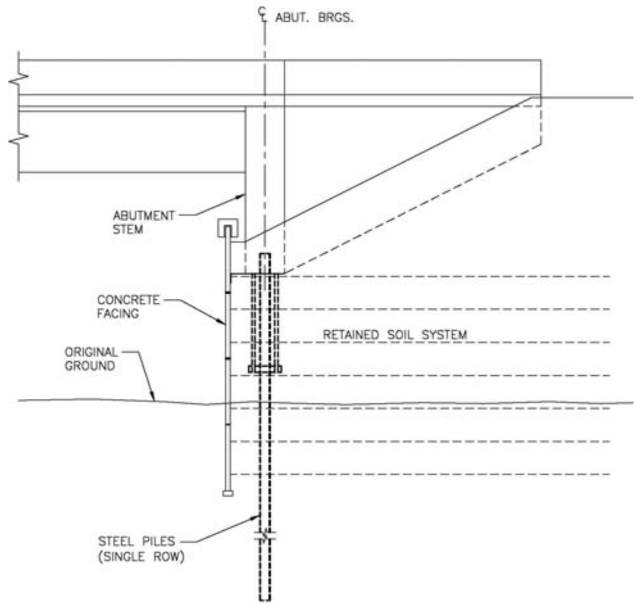


Figure 2.6: Integral Abutment with Single Row of Piles and RSS False Abutment.

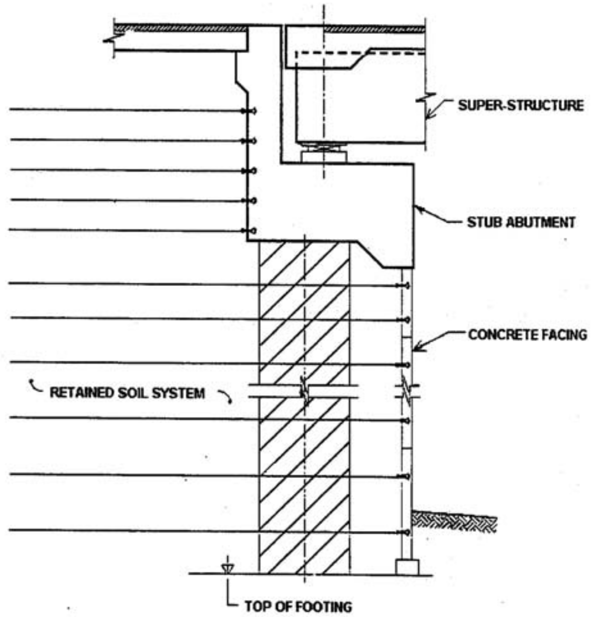


Figure 2.7: False Abutment with Columns

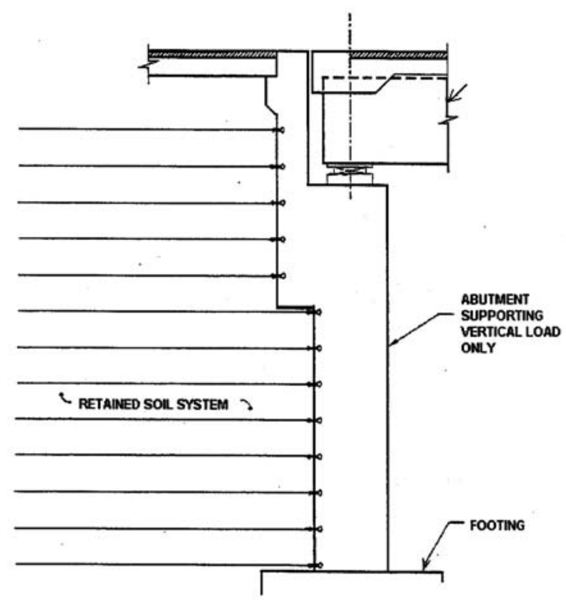


Figure 2.8: “False” Abutment with Concrete Abutment For Vertical Loads.

2.1.3 TRUE ABUTMENTS

A RSS true abutment is shown in Figure 2.9. It consists of a stub abutment supported on a reinforced soil mass with concrete facing. The reinforced soil mass fully supports the vertical and horizontal loads transferred through the stub abutment and the lateral load from the earth pressure and from the superstructure. This system is suitable where a conventional abutment would be too high and uneconomical to use.

Other jurisdictions have successfully used this application, but it has not yet been tried by MTO. MTO intends to select prospective sites for RSS True Abutments so that experience may be gained in the design, construction and monitoring of performance. Owing to concerns that the earth mass may settle under loading, for initial applications, it is recommended that RSS true abutment should only be used where the super-structure consists of a single span and where the deck is either provided with an expansion joint or has a semi-integral abutment arrangement.

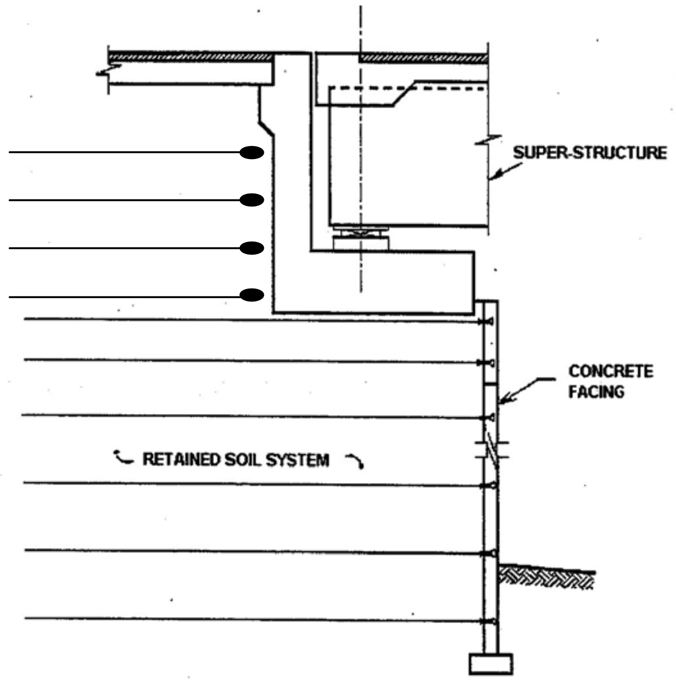


Figure 2.9: True Abutment

2.2 RSS SYSTEM RESISTING VERTICAL LOADS

RSS systems are designed to resist the vertical loads in areas where embankments are constructed on soft ground.

2.2.1 ROAD BASE EMBANKMENT

It is often necessary to improve the bearing resistance, settlement performance or deformation characteristics of a soil mass in order to support vertical loads or allow construction of a higher embankment. This application requires that the soil reinforcement design should be capable of sustaining the applied loads with deformation within the serviceability requirements of the roadway and that it should retain its strength and stability indefinitely, or at least for the duration of its application. A typical application is shown in Figure 2.10.

The need for road base embankment reinforcement is identified in the foundation investigation carried out during detail design. At this time, the designs are not generic and are managed on a site-specific basis by the Pavement and Foundation

Section. Guidance on contract drawing requirements and tendering details for these designs is not provided in this document.

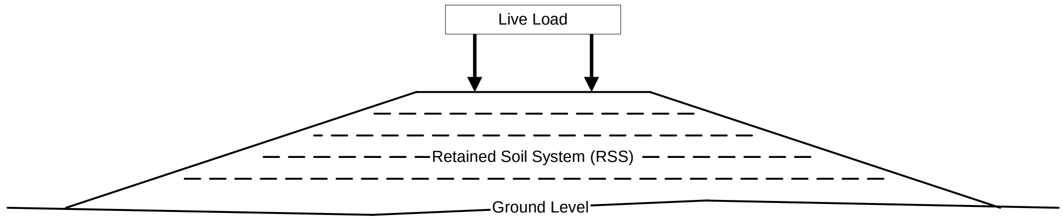


Figure 2.10: Road Base Embankment

2.3 DESIGNATED SOURCES FOR MATERIAL (DSM)

Approved RSS systems for the above categories are listed the DSM. There are four lists in the DSM, one for each application:

DSM 9.70.56	RSS Wall/Slope
DSM 9.70.52	Retained Soil Systems (RSS), False Abutment
DSM 9.70.53	Retained Soil Systems (RSS), True Abutment
DSM 9.70.59	Retained Soil Systems (RSS), Roadbase Embankment

The current DSM listings are provided in Appendix E; however, the most up-to-date DSM listing, administered by The Road Authority (TRA), shall always be referenced for specific contracts and designs. This up-to-date listing is availability from The Road Authority website at http://www.roadauthority.com/Home.asp. In order for the RSS to be accepted into the DSM, a rigorous evaluation and qualification process is required. This is a three-step process that requires:

1) The Product to be identified to Road Authority along with general product and company information.
2) That the company provide certification through a pre-qualified consultant that the RSS is in compliance with the qualification requirements.
3) The RSS demonstrate acceptable performance to the MTO prior to full Approval.

Details of the qualification procedure are available from the Pavements and Foundations Section, MTO.

3 RSS ATTRIBUTES

Selection of the most appropriate Retained Soil System is carried out on a site specific basis. For each RSS the following four attributes must be defined:

1) Application
2) Geometry
3) Performance
4) Appearance

In a contract, these attributes are provided in the contract drawings in order for the contractor to select the appropriate RSS from the DSM list.

3.1 APPLICATION

The application for the RSS is the primary attribute and has been described in Section 2. Table 3.1 summarizes the four application sub-categories.

Table 3.1: Sub-Categories for RSS Application.

Category	***Sub-Category***	***Description***
Horizontal Retainment	True Abutment	• Supports horizontal loads from earth pressure and from superstructure. • Supports vertical load surcharge from stub abutments. • Facing consists of high performance, pre-cast (wet-cast), reinforced concrete panels positively connected to soil reinforcement. • Verticality (90^0 to the horizontal) is required.
	False Abutment*	• Supports lateral earth pressure loads from retained earth. • Vertical load from abutment is transferred to the load bearing strata. • Facing consists of high performance, pre-cast (wet-cast), reinforced concrete panels positively connected to soil reinforcement. • Verticality **(**90^0 to the horizontal) is required.
	Wall/Slope*	• Supports lateral loads at slopes steeper than naturally stable slopes. • Slope geometry varies from 0 to 90^0 to the horizontal.
Vertical Retainment	Roadbase Embankment	• Supports vertical loads and permits higher embankments than would be possible without this treatment.

* For RSS adjacent to bridge structures (e.g. RSS wingwalls and attached retaining walls), False Abutment Application should be specified.

3.2 GEOMETRY

The geometry attribute refers to the verticality of the soil slope. RSS are described as either vertical or sloping as shown in Table 3.2. If site-specific geometric constraints are encountered that require a limit on the slope, they shall be specified clearly and shown on the contract drawings.

Table 3.2: Sub-Categories for RSS Geometry.

Category	***Sub-Category***	***Description***
Horizontal Retainment	Vertical (GV)	• Vertical or near vertical • Angle greater than 75^0 to the horizontal
	Slope (GS)	• Steep slopes • Angle greater than 30^0 and less than 75^0 to the horizontal

3.3 PERFORMANCE

The attribute for Performance for RSS is assigned based on application, proximity and relation to existing structures, proximity to traffic and salt spray, rigidity and durability of the facing elements. The RSS performance is defined by the magnitude of acceptable movements for a structure. The tolerance and flexibility of an RSS to accommodate movement should be a consideration in selecting the appropriate performance level. The notional performance limits are shown in Table 3.3a. Construction tolerances are provided in the RSS Non-Standard Special Provision (NSSP). Selection of the performance level is made using the Site Performance Rating shown in Table 3.3b.

Table 3.3a: RSS Performance Sub-Categories.

Category	***Sub-Category***	***Description***
Horizontal Retainment	High	Surface movement less than 1H : 500V
	Medium	Surface movement less than 1H : 250V
	Low	Surface movement less than 1H : I00V

Table 3.3b: Site Performance Rating *.

Structure	***RSS above Roadway***	***RSS below Roadway***
Bridge abutments and wingwalls.	HIGH	HIGH
Walls/slopes on 400 series highways.	HIGH (1)	MEDIUM (2)
Walls/slopes on all other paved roads.	MEDIUM (3)	LOW
Walls/slopes on unpaved roads.	LOW	LOW
Temporary Systems (4)	LOW	LOW

Notes:

* A higher performance may be required in some locations if other roadside constraints (catch basins, utilities, etc.) would provide additional restrictions on the allowable movements.

(1) If distance of the wall from the edge of the travelled surface is greater than 10m, the rating may be substituted with Medium Performance.

(2) If concrete barrier wall is provided with the RSS at the edge of the travelled surface, the rating could be substituted with the Low Performance.

(3) If offset from the edge of the travelled surface is greater than 10m the rating may be substituted with Low Performance.

(4) Temporary is defined, per the Canadian Highway Bridge Design Code (CHBDC) requirements, as five years. Situations for use of temporary systems include:
   - Detours
   - Grade changes between staged construction
   - Widening to accommodate construction staging.

   The preferred facing material for these systems is wire mesh, geogrid or geotextile, because, in most cases, the system is removed or buried. Deformations permitted for low performance systems should be reviewed to determine whether they can be tolerated for the specific temporary situation.

3.4 APPEARANCE

The sub-categories for appearance of the facing of the RSS are given in Table 3.4a along with general descriptions. Table 3.4b shows the specific criteria that are to be satisfied in order to meet the sub-category.

Table 3.4a: Sub-Categories for RSS Appearance.

Category	***Sub-Category***	***Description***
Horizontal Retainment	High	A high level of consistency and uniformity usually attributed to finished concrete surface
	Medium	A medium level of consistency and uniformity consisting of durable materials
	Low	Potentially low level of consistency and uniformity – generally vegetative covering.

Table 3.4b: Notional Criteria for Appearance#.

Criteria	***HIGH***	***MEDIUM***	***LOW***
No of visual cracks per panel or per m^2	None	1	N.A.
Max. width of cracks	None	0.15mm	N.A.
Uniformity of colour and Texture	Uniform from 10m distance	Uniform from 15m distance	*
Uniformity of joint width	1.5mm/l000	3mm/l000	*
Planarity of flat surface of wall	6mm/3000 and 3mm max. across joint	10mm/3000 and 5mm max. across joints	*
Surface damage and imperfection	No honeycombing or chipped edges	As per OPSS 904.07.03.12	*
Detailing of transition with adjoining structures	Uniform at 5m	Uniform at 10m	*
Susceptibility of post installation staining, discolouring, soil spillage etc.	Low	Medium	High

* Any system that does not satisfy the criteria for high and medium appearance.

\# Medium and Low appearances are usually not finished concrete surfaces and the applicability of the table is not necessarily valid for all criteria.

For certain applications, a further enhanced architectural finish is required to match adjacent structures or to simply enhance the appearance of the RSS. These can be used with any High

Appearance system and require a Non-Standard Special Provision (NSSP) to specify the details of the finish. Common finishes include: Ashlar Stone, Exposed Aggregate, Fractured Fin, etc. Several examples are shown in Figure 14.10 in Appendix G. There is additional cost associated with these finishes, but they are not cost prohibitive where enhanced aesthetics is required.

4 DESIGN CONSIDERATIONS

Although the use of RSS can be economical in many situations, careful consideration is required to determine its suitability for each application. For this reason, RSS should always be compared to conventional retaining systems. The following should be carried out for each location:

- Assessment of the cost/benefit of RSS versus the conventional retaining systems. Consideration should be given to the quantity of RSS for a particular site since small quantities (generally less than about 50 to 100 m^2) could be more expensive.
- Assessment of the suitability of the subsoil to support a Retained Soil System. Although RSS generally require less bearing resistance than conventional retaining walls each site should be analysed for settlement and global stability.
- The impact of other components that may interfere with the installation and performance of the RSS shall be considered, e.g. underground utilities, catch basins, etc.

The use of RSS should be discussed and agreed upon when other jurisdictions, such as railway companies, are involved.

This Section contains general guidance in determining whether a site is suitable for RSS and in selecting the type of RSS that satisfies the intended purpose. Particular attention should be placed on settlement and the impact that settlement may have on the performance of the RSS and adjacent structures, including pavement. The total settlement is derived from three potential sources:

1) Consolidation develops from settlement of a deep underlying soil layer and takes place over an extended period of time. Removal is not an option. This type of settlement can be minimized by preloading or a combination of wick drains and surcharging.
2) Elastic settlement generally occurs during or shortly after construction within soils closer to the original ground surface. If the amount of settlement is excessive for serviceability or for the acceptable tolerance of the RSS, it can be reduced by preloading and/or sub-excavation of the poor material and replacement with acceptable fill,
3) Settlement with the RSS backfill can be controlled and minimized by proper construction and compaction. It generally varies with the embankment height.

Where false abutments are supported on piles and are designed as integral (flexible) abutment, the design of the RSS should prevent the loads arising from the movement of piles from being transferred to the RSS facings. This can be done by encasing the pile in double concentric Corrugated Steel Pipes (CSP's), as described in section 4.3.3.

4.1 FOUNDATION INVESTIGATION AND DESIGN REPORT

A foundation investigation shall be carried out at all proposed RSS locations. The foundation investigation shall determine whether a site is appropriate for RSS. As with all designs, there should be regular communication between the structural and geotechnical engineer. In addition to the information that is normally obtained for retaining structures, the Foundation Design Report should include the following information to help in determining the suitability of the site for RSS:

- The magnitude and duration of settlement under the embankment/RSS loading.
- The presence and extent of poor soils and/or fills.
- Recommendations for managing settlement and poor subsurface conditions such as sub-excavation or preloading. For sub-excavations, the depth and extents of excavation shall

be determined. For preloading, the amount of preload, duration and the possibility of accelerating settlements (e.g. wick drains) shall be provided.

- The bearing resistance and foundation elevation for RSS. Depending upon the height of the RSS, a minimum 150 kPa to 200 kPa is required.
- Global soil stability analysis with the RSS in place.

4.2 RSS ON ROADWAYS

A RSS adjacent to the roadway will be either a wall or slope depending on the Performance attribute obtained from Table 3.3b. The following should also be considered in the selection of RSS Wall/Slopes in design:

a) Subsurface conditions
b) Proximity to roadway
c) Accessibility – for installation and maintenance
d) Acceptable settlement
e) Obstructions such as catch basins, sewers, guide rail and fence posts, light poles
f) Surcharges from adjacent structures, roadways, embankments
g) Erosion protection
h) Property restrictions that may preclude use of RSS due to length of soil reinforcing elements
i) Environmental restrictions – compatibility of RSS with surroundings, aggressive soils, etc.
j) Availability of materials.

Once performance, geometry and appearance attributes have been selected, designers should take into consideration:

a) Continuity and compatibility of adjacent landscape
b) Drainage external to the RSS – provisions to prevent overtopping and undermining, e.g. interceptor ditches along top of wall/slope
c) Aesthetics criteria for RSS facing.

4.3 RSS WITH STRUCTURES

Much of the difficulties with RSS at structures relate either to differential settlement or movement. Differential settlement concerns arise since any structure, especially those on piles, will settle differently than the RSS that abuts the structure. Adequate consideration is required for the structural details at these locations where differential settlements take place to ensure that serviceability and aesthetic problems do not occur. Movement concerns also arise from flexible abutments that move adjacent to a stationary RSS. Abutments can behave either as rigid elements that do not move or flexible (integral) elements that move with the expansion and contraction of the superstructure. Rigid abutments include those supported on more than one row of piles or have spread footings, as with bridges with expansion joints or semi-integral abutments. Flexible abutments include integral abutment bridges supported on single row of piles. The amount of movement depends, among other things, on the length of super structure and temperature change and can be quite significant. Integral abutment bridges are generally preferred due to their lower costs both initial and in terms of ongoing maintenance costs. The MTO guidelines for the use of "Integral Abutment Bridges" and "Semi-Integral Abutment Bridges" should be used to determine the suitability of a structure for either integral or semi-integral abutment design. Again, appropriate design details must be used to ensure that these movements between structure and associated RSS are compatible and/or accommodated and do not result in serviceability problems.

4.3.1 FLEXIBLE (INTEGRAL) ABUTMENT

If a flexible, integral abutment is chosen there are several configurations of RSS that may be used, as described below. Each figure has references to sections and details that are described in Section 5 of these Guidelines.

1) Full Height Cast-In-Place Abutment Stem with Cast-In-Place Wingwalls (Figure 4.1). This option is generally economical with low abutments (less than about 6m in height) and short wingwalls (less than about 7m in length). It may also be economical for construction projects where the total quantity of RSS is small and higher than normal prices would be expected per square metre. In lieu of RSS wingwalls, a separate cantilevered retaining wall could be used beyond the cast-in-place wingwall if the cantilever wingwall is too long to efficiently design.
2) Full Height Cast-In-Place Abutment Stem with RSS Wingwalls (Figure 4.2). This option is economical with longer wingwalls (greater than about 7m) and where sufficient quantities of RSS exist on the construction project.
3) Partial Height Cast-In-Place Abutment Stem with RSS False Abutment Located Under the Front Face of the Abutment Stem, along With RSS Wingwalls (Figure 4.3). This option is economical for locations with very little anticipated settlement (less than about 25mm) of the underlying soil. With larger settlement an unsightly gap may open at the front face between the cast-in-place abutment stem and the RSS and the settlement of the RSS can lead to cracking where the barrier on RSS settles adjacent to the barrier wall on the structure. It would be possible to remedy this gap problem, but it would add future maintenance costs and may not be aesthetically pleasing. It may be possible to modify the various details to allow for somewhat larger settlements.
4) Partial Height Cast-In-Place Abutment Stem with RSS False Abutment Located in Front of the Abutment Stem, along with RSS Wingwalls (Figure 4.4). This option is economical for locations with little anticipated settlement (less than about 50 mm) of the underlying soil and with smaller movements of the abutment stem (less than about +/- 20mm). The RSS in front of the abutment stem allows for greater settlement. However the settlement must still be restricted as a gap may open at the side where the RSS wingwall passes under the abutment stem, and also, since the settlement of the RSS can lead to cracking where the barrier wall on RSS settles adjacent to the barrier wall on the structure. Furthermore, since the RSS wingwall is partially surrounds the abutment stem, the abutment movement cannot be so large that it causes the abutment stem to come in contact with the RSS. Details for this design have not yet been in widespread use and option (3), or option (5) when lateral abutment movements are large, should be considered.
5) Partial Height Cast-In-Place Abutment Stem Short Cast-In-Place Wingwalls and with RSS False Abutment Located In Front of Abutment Stem and Flared RSS Walls (Figure 4.5). This option is economical with longer wingwalls and locations with somewhat larger settlements (less than 75mm) than allowed for in options (3) and (4) above. The RSS is completely independent of the structure so this arrangement allows for larger settlements than the other arrangements. This is used with the RSS walls either parallel to the RSS False

Abutment or flared at an angle between 0^0 and 90^0. There is some additional cost associated with this arrangement since cast-in-place wingwalls are required along with the RSS. However, this cost is offset, as it does not require a barrier wall on RSS and the associated cast-in-place footing.

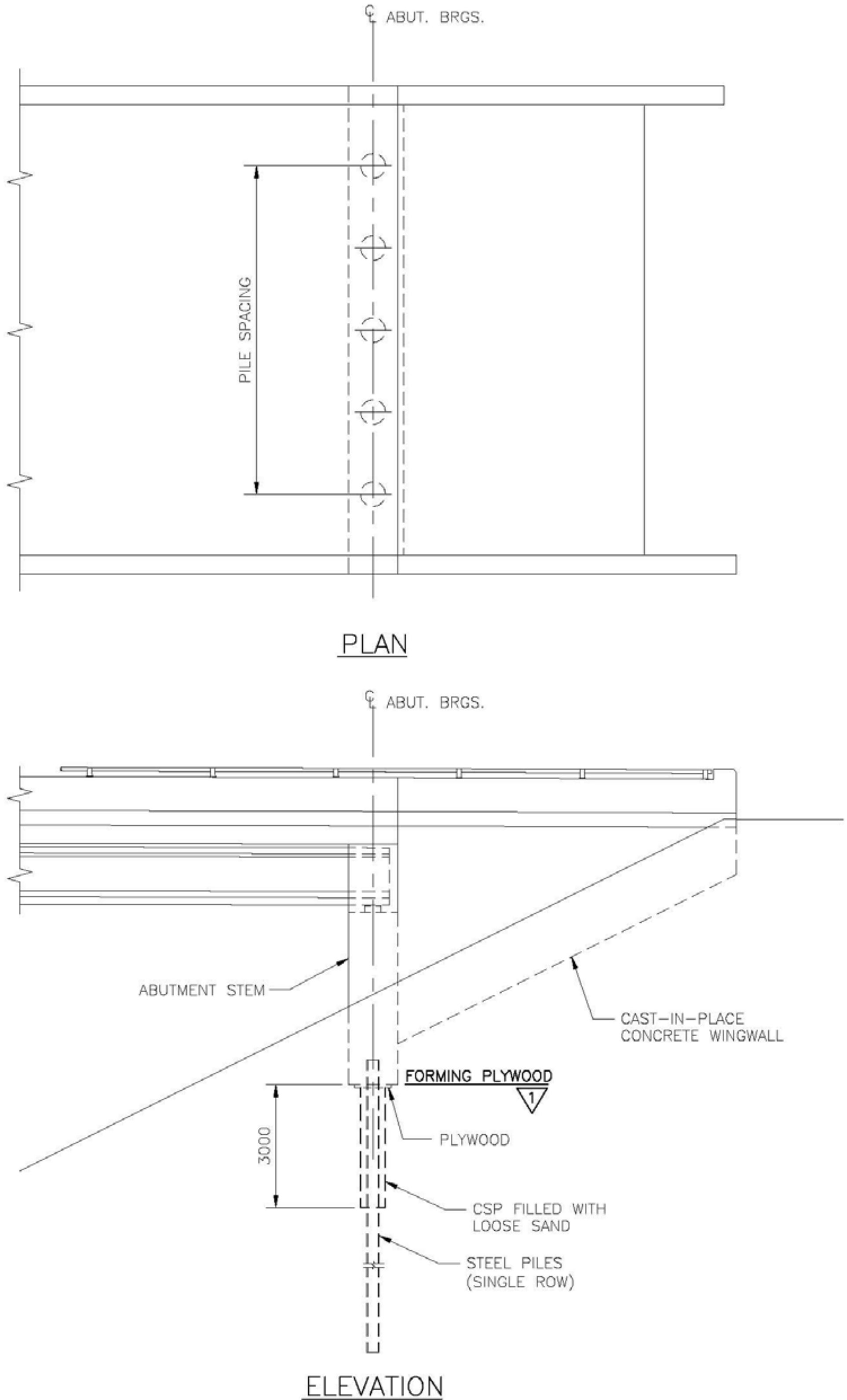


Figure 4.1: Cast-in-Place Abutment and Wingwalls – For Section 1 ("FORMING PLYWOOD"), see Figure 5.5.

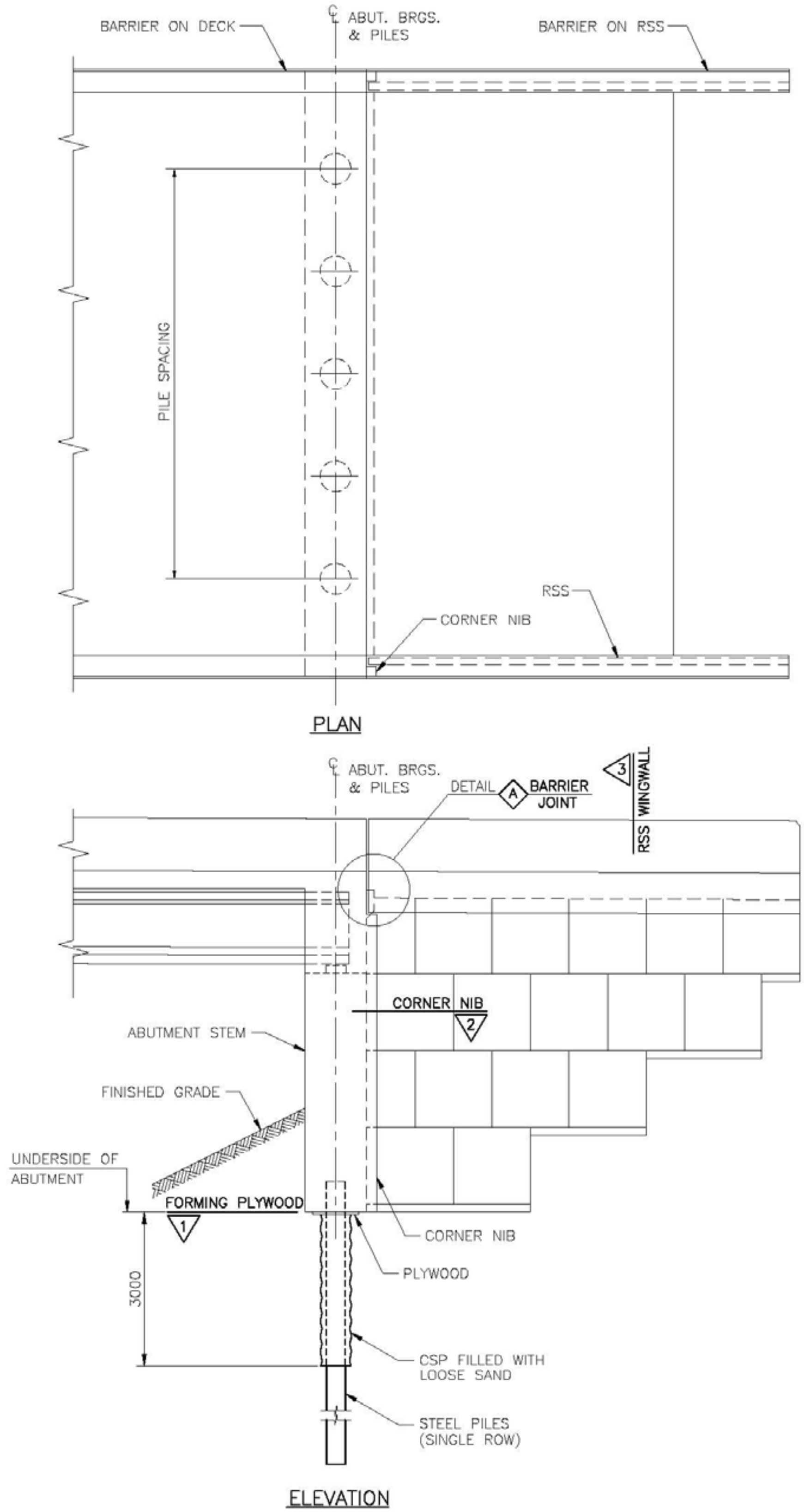


Figure 4.2: Integral Abutment with RSS Wingwalls. For Section 1, 2, 3, see Figures 5.5, 5.11, and 5.1 respectively. For Detail A, see Figure 5.14.

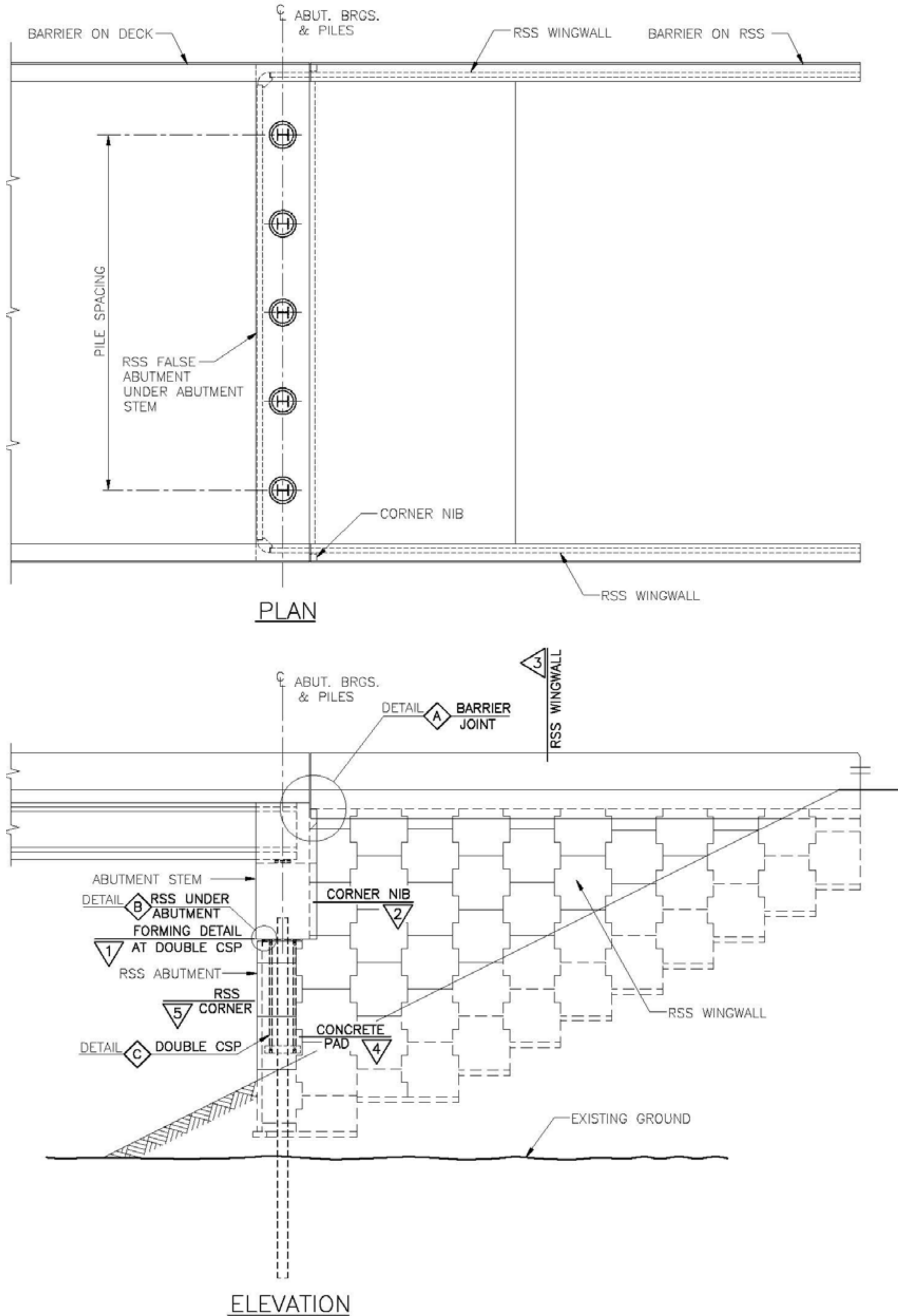


Figure 4.3: RSS False Abutment (Under Integral Abutment Stem) with RSS Wingwalls. For Section 1, 2, 3, 4 and 5 see Figures 5.6, 5.11, 5.1, 5.7 and 5.15 respectively. For Detail A, B and C see Figure 5.14, 5.8 and 5.4 respectively.

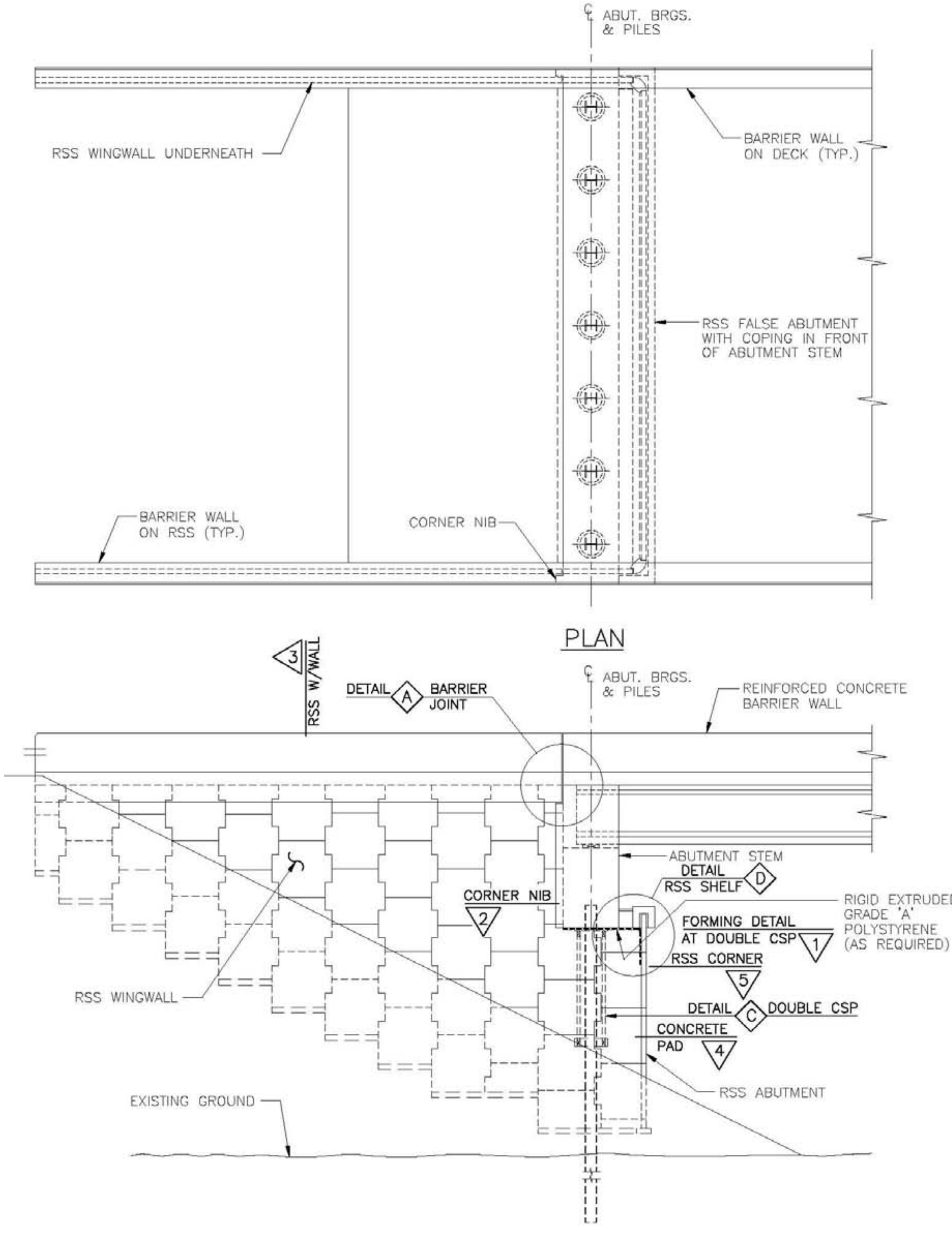


Figure 4.4: RSS False Abutment (in Front of Integral Abutment Stem) with RSS Wingwalls. For Section 1, 2, 3, 4 and 5 see Figures 5.6, 5.11, 5.1, 5.7 and 5.15 respectively. For Detail A, C and D see Figure 5.14, 5.4 and 5.9 respectively.

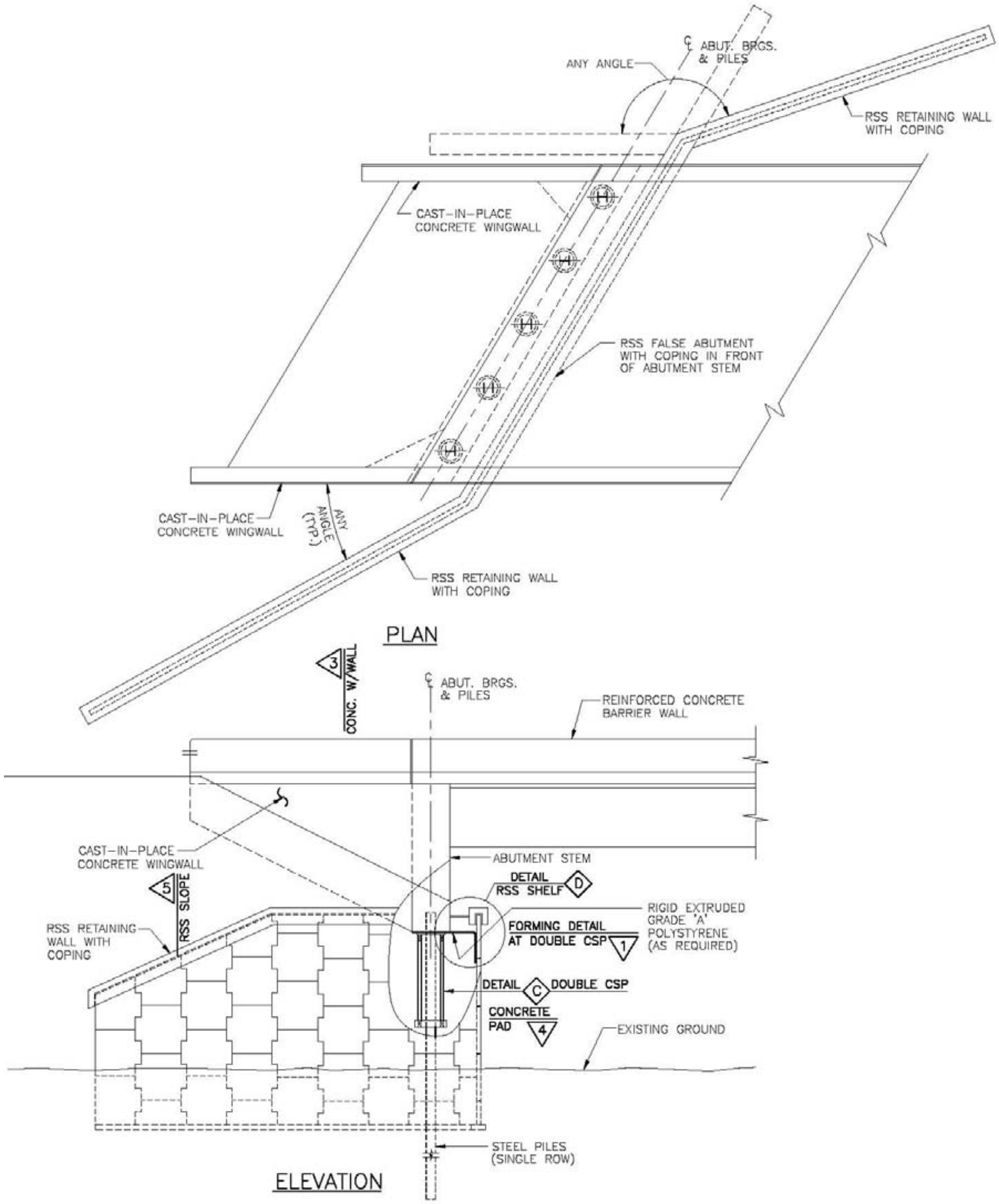


Figure 4.5: RSS False Abutment (in Front of Integral Abutment Stem) with Flared RSS Walls. For Section 1, 3, 4 and 5 see Figures 5.6, 5.1, 5.7 and 5.16 respectively. For Detail C and D see Figure 5.4 and 5.9 respectively.

4.3.2 RIGID ABUTMENT

These details are used for both jointed bridge and semi-integral abutment designs. The options for RSS details are described below:

1) Conventional Abutment with Cast-in-Place Wingwalls and optional Retaining Walls (Figure 4.6). This option may be used when the length of a cantilever wingwall would be less than about 7m although it is often feasible to use longer walls with a U-shaped footing (up to 11m in length) or by adding retaining walls beyond the wingwall. It is the length of retaining wall required adjacent to the abutment and the amount of RSS in the project that influences the decision on whether to use RSS.
2) Conventional Abutment with Cast-in-Place Wingwalls and RSS Retaining Walls (Figures 4.7 and 4.8). This option may be used when the length of a cantilever wingwall would be excessive (greater than about 7m). As described in option (1) above, the length of possible retaining wall beyond the wingwall and the amount of RSS in the project influences the decision on whether or not to use RSS. The RSS shown in Figure 4.7 is not a very aesthetically pleasing option as typically only a very small amount of RSS is exposed. It should therefore be avoided wherever possible.
3) RSS False Abutment (under front face of abutment stem) with RSS Wingwalls (Figure 4.9). This option may be used with high abutments (greater than 8m). For such abutments the wingwalls are usually long and use of RSS walls provides better aesthetics and economy. It should be used in locations where the amount of settlement is not excessive (less than 25mm). With larger settlements, an unsightly gap may open at the front face between the cast-in-place abutment stub and the RSS and the settlement of the RSS can lead to cracking where the barrier on RSS settles adjacent to the barrier wall on the structure. It is possible to remedy this gap problem, but it adds future maintenance costs and may be aesthetically unpleasant. Various details can be modified to allow for or hide somewhat larger settlements.
4) Partial Height Cast-In-Place Stub Abutment with Short Cast-In-Place Wingwalls and with RSS False Abutment and Flared RSS Walls (Figure 4.10). This option may be used in similar locations to those describe in 4.3.2.2 above, with somewhat larger allowable settlements (less than about 75mm) since the RSS is completely independent of the structure. The RSS walls are either parallel to the front RSS False abutment or flared at an angle between 0^0 and 90^0. There is additional cost associated with this arrangement because cast-in-place wingwalls are required along with the RSS. However, this cost is offset as it does not require a barrier wall on RSS and the associated cast-in-place footing.

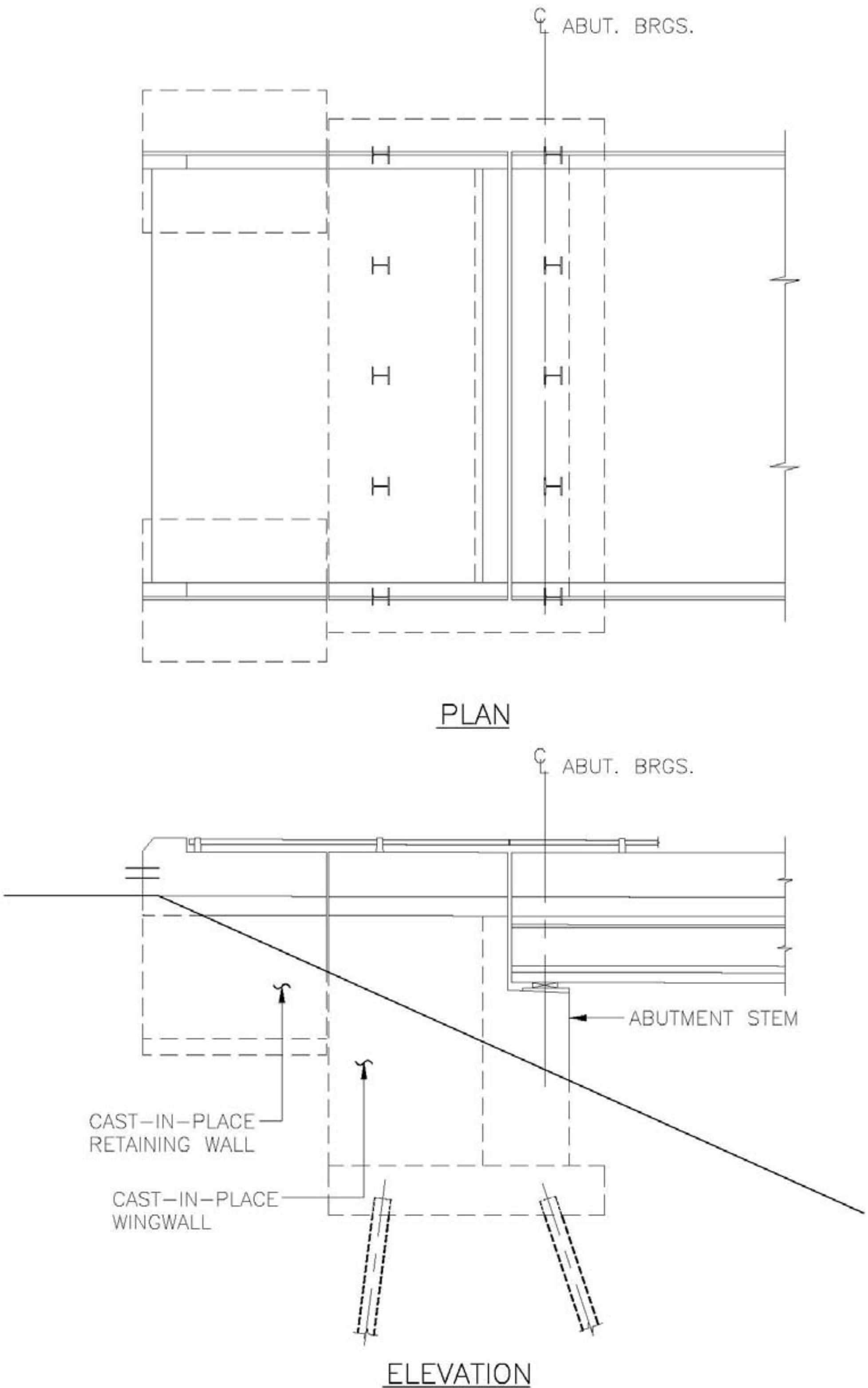
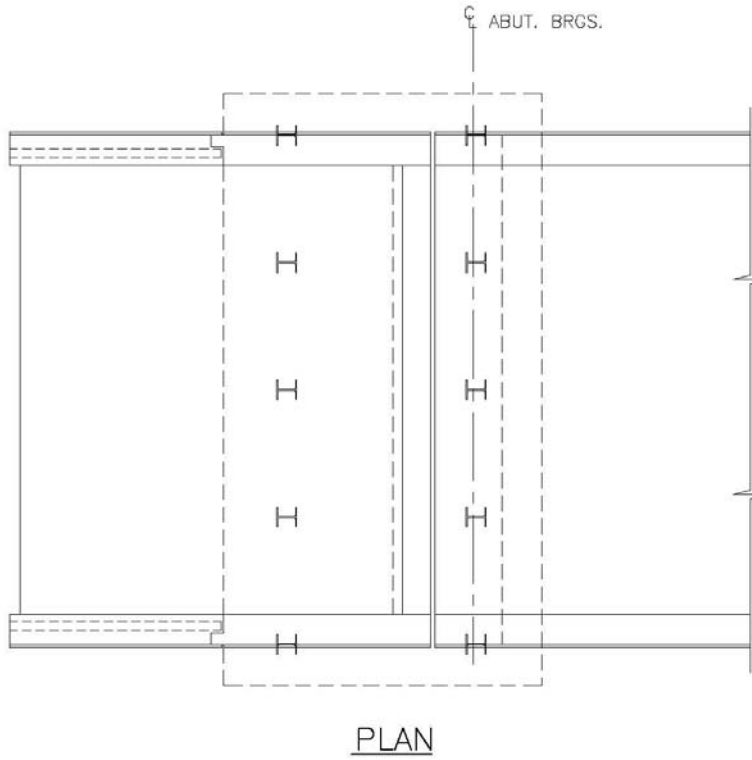


Figure 4.6: Conventional Abutment with Cast-in-Place Retaining Walls.



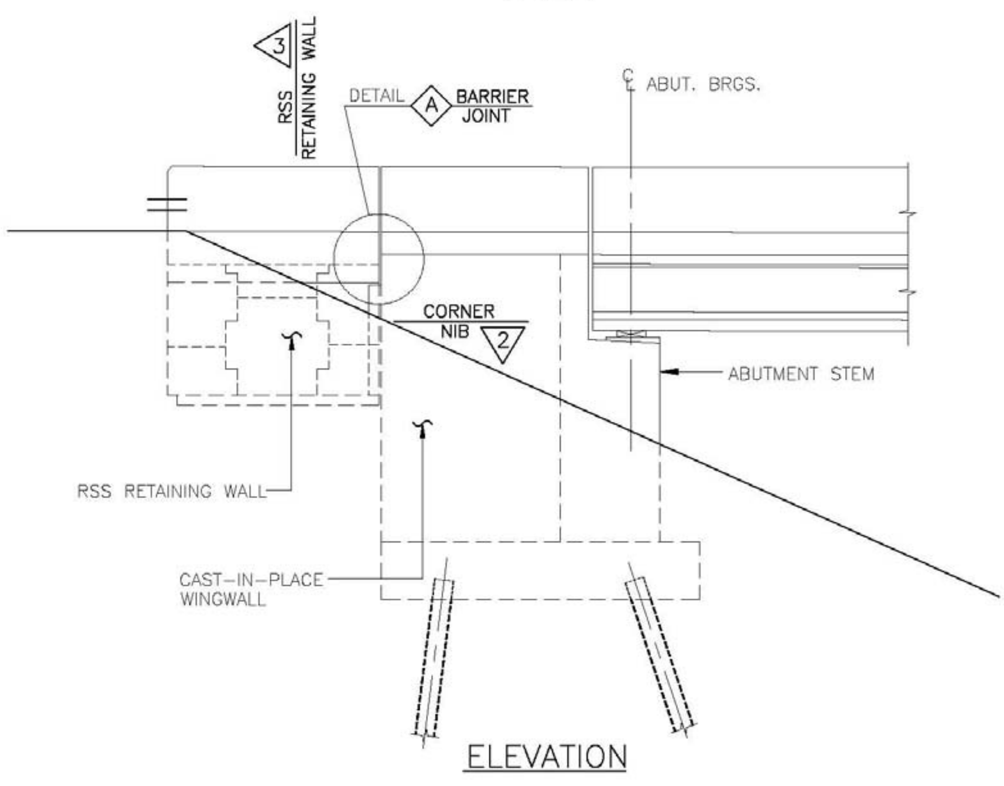


Figure 4.7: Conventional Abutment with RSS Retaining Walls (in line with wingwalls). For Section 2 and 3, see Figures 5.12 and 5.1 respectively. For Detail A, see Figure 5.14.

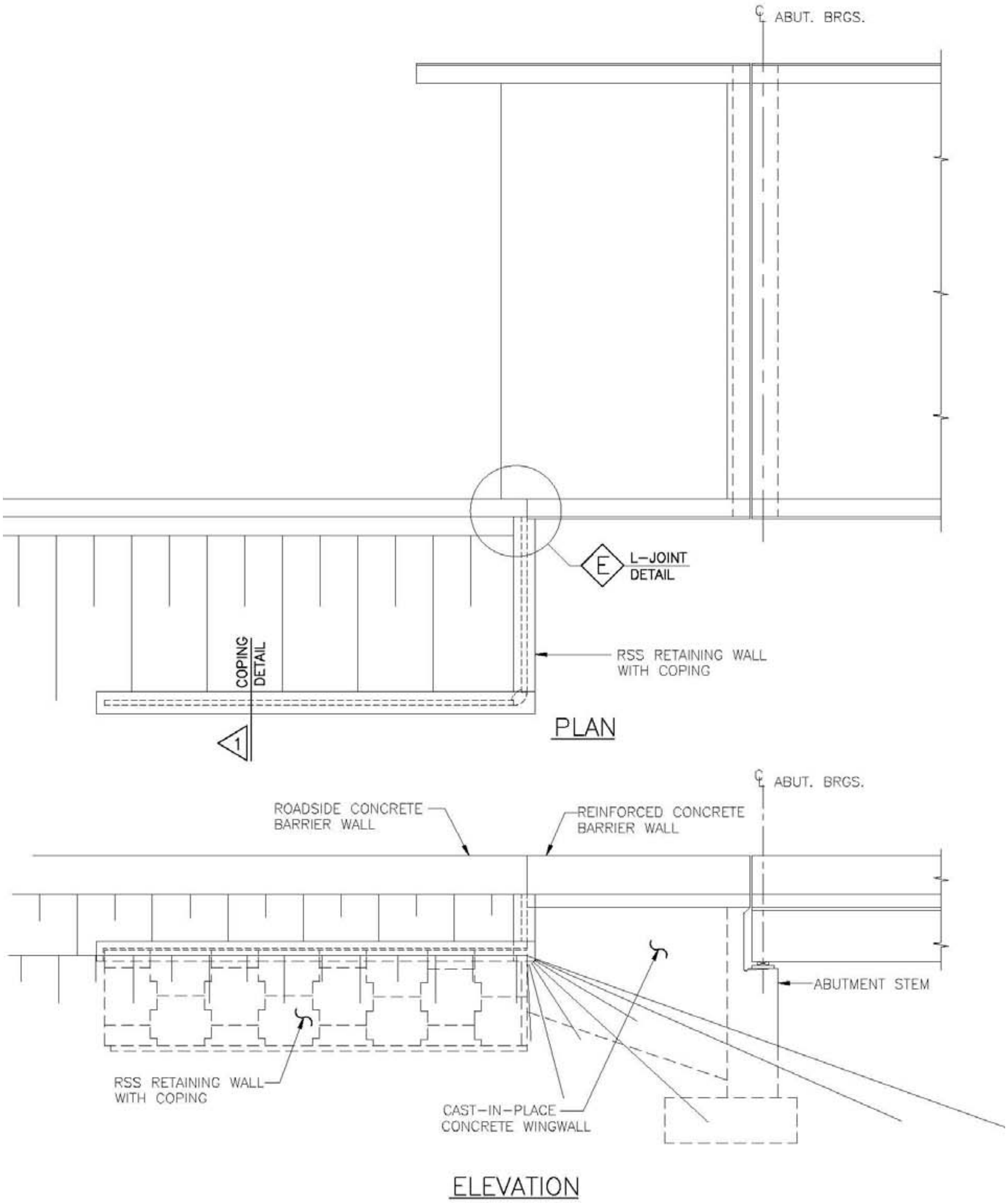


Figure 4.8: Conventional Abutment with RSS Retaining Walls (offset from wingwalls). For Section 1, see Figure 5.16. For Detail E, see Figure 5.13.

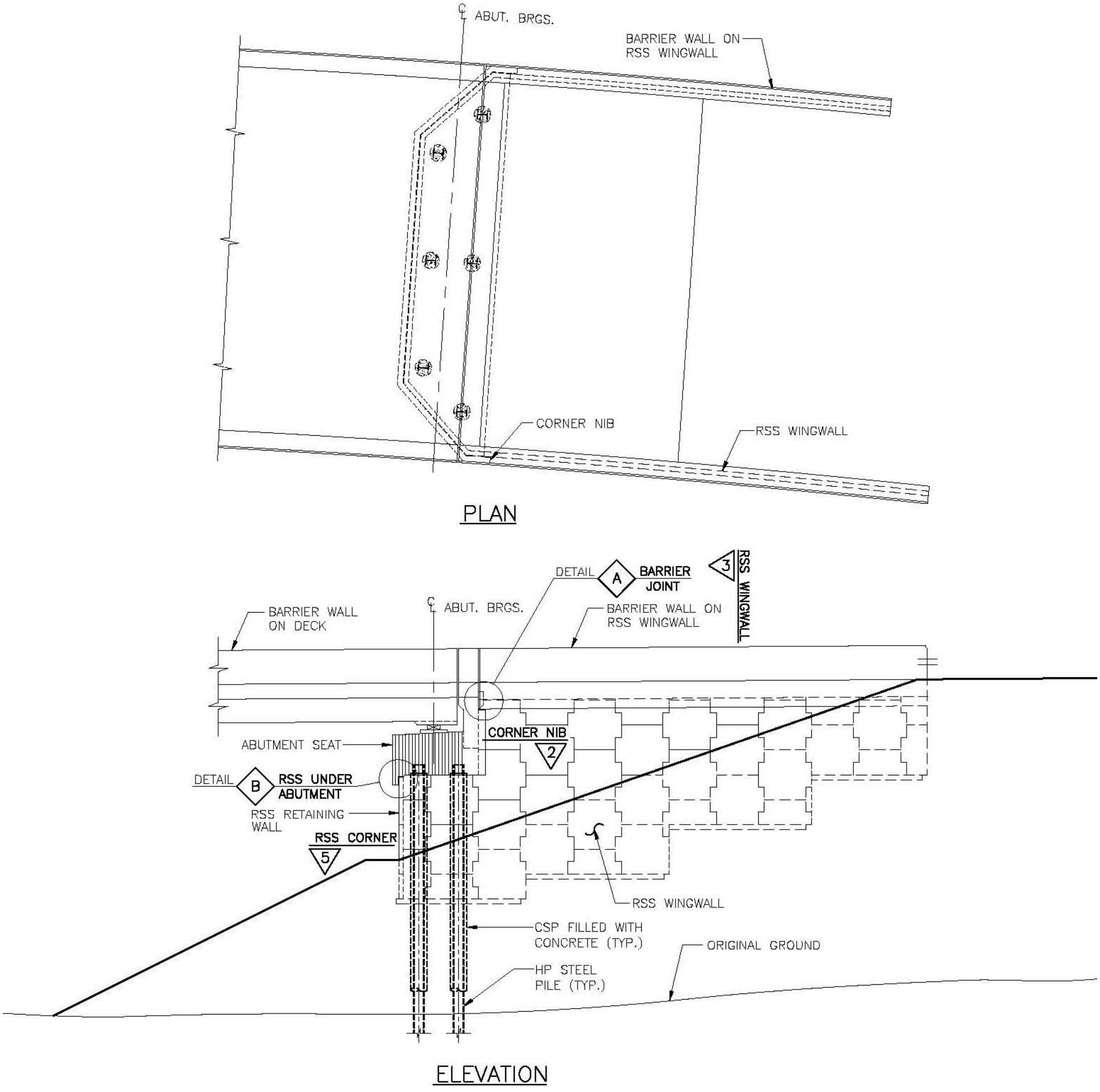


Figure 4.9: RSS False Abutment (Under Stub Abutment) with RSS Wingwalls. For Section 2, 3 and 5, see Figures 5.11, 5.1 and 5.15 respectively. For Detail A and B, see Figures 5.14 and 5.10 respectively.

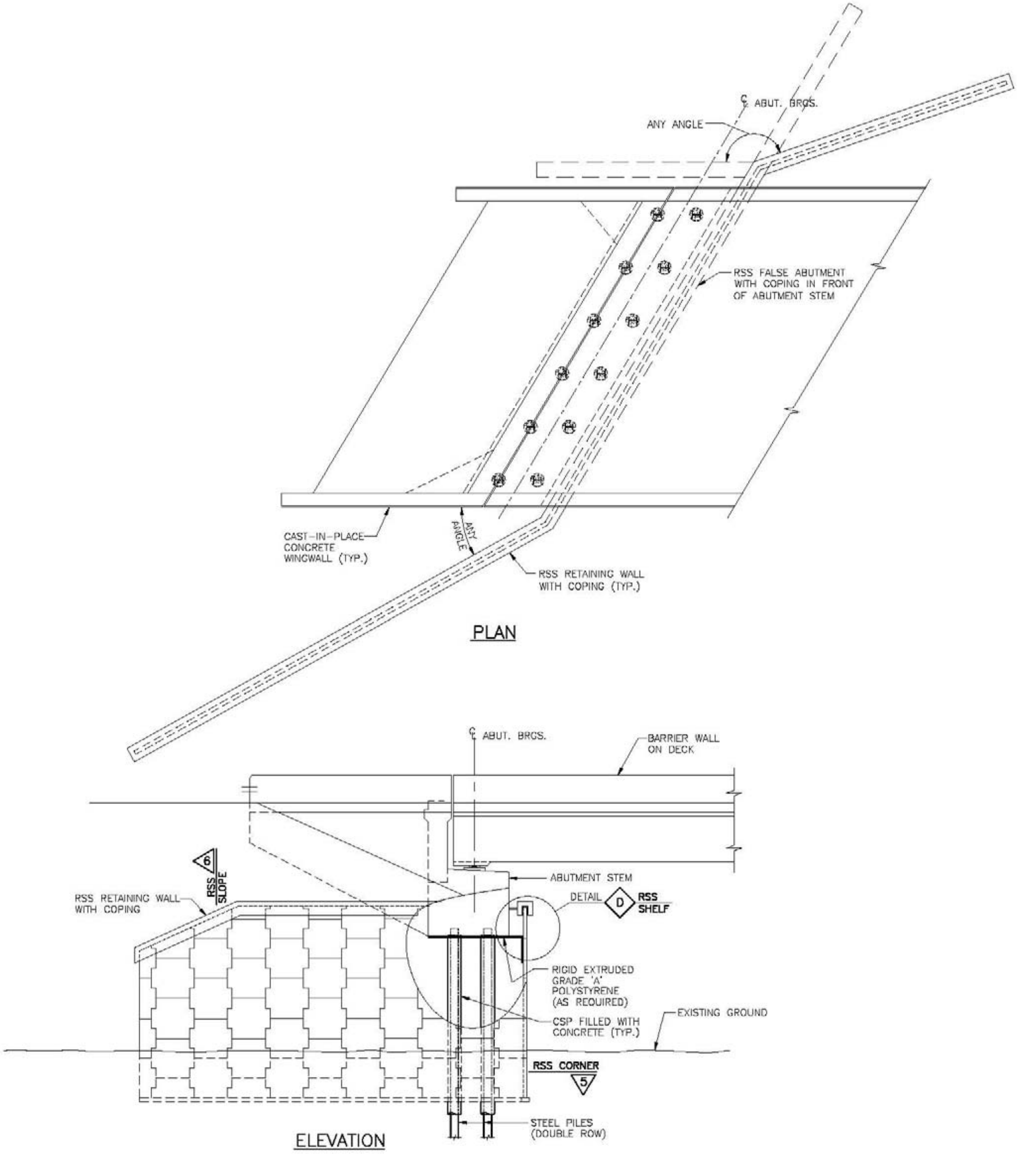


Figure 4.10: Rigid Piled Bridge with RSS False Abutment and Flared RSS Walls. For Section 5 and 6, see Figures 5.15 and 5.16 respectively. For Detail D, see Figure 5.9.

4.3.3 MISCELLANEOUS FEATURES

It is required that any movement of the abutment piles of an integral abutment structure does not add additional lateral loading to the RSS or RSS facing. As such, when the piles are in close proximity to the RSS they shall be furnished with a system of double CSP's concentric with the pile. The inner CSP is filled with loose sand and the annular space between the two CSP's is left unfilled. This allows the pile to move laterally without transferring loads to the RSS. Where there is no RSS in front of the piles, generally a single CSP can be used as described in the MTO report "Integral Abutment Bridges". If the native soil is sufficiently stiff, a CSP may not be required.

The standard detail of a barrier wall on top of an RSS wall is for interim use, since a crash test has not been performed on such an arrangement. It is desired to resist a large PL3 barrier loading without transferring the lateral load to the RSS. Some jurisdictions provide a barrier on grade with some offset to the RSS. This solution requires a wider road section above, resulting in additional backfill quantities. Other jurisdictions have barriers with footings tied together across the roadway to resist the lateral loads and piles to prevent uplift. This is an exceedingly expensive solution. The Ministry developed a Structural Standard Drawing (SS110-64), which is based on barriers that have been used successfully in Ontario for some time. This utilizes an 'L' shaped barrier with footing that resists the lateral barrier load. The size of this footing depends on the wall length. This barrier is considered adequate for most locations requiring a PL3 barrier (Bridge Office Design Bulletin, November 1, 2005 – Appendix D). Barrier footings also exist for locations requiring PL2 barriers.

5 CONTRACT PREPARATION

Following assessment of the site suitability for RSS and the determination of RSS application attributes, the structural and/or highway designer is required to prepare contract documents. Sufficient details are required to ensure that the RSS are constructed as desired to meet performance requirements. The RSS Supplier is responsible for all aspects of their product, including design, material components and backfill.

The RSS process is intended to offer options to the contractor and encourage competitive bidding. Although it should generally be avoided, some situations require a specific RSS for reasons of complexity, uniformity (with a previous contract), etc. The specific supplier shall be clearly specified in the Contract Documents (Drawings and Special Provisions). Regional approval should be sought for sole sourcing.

Drawings to be included in the Contract package are described below. The inclusion of these drawings ensures that adequate information is specified to allow for proper construction. Sample Contract Drawings are provided in Appendix A, showing the level of detail that is required on typical drawings. Appendix G provides some photographs of the various RSS wall types and structural details. The process of choosing an RSS system and including it in the Contract Package is summarized in Appendix F.

5.1 RSS ON ROADWAY

The extent of all RSS adjacent to roadway and not associated with a bridge shall be shown in the Grading drawings of the Contract package.

For each RSS, a layout and elevation drawing along with details shall be shown in the Structural portion of the Contract package.

The information to be shown includes:

1. Identification of RSS application, performance, geometry and appearance requirements.
2. A three-dimensional envelope showing alignment, profile, cross-sectional space constraints for each wall/slope.
3. An elevation view for each wall identifying top of RSS levelling pad elevation and details of any foundation preparation requirements, e.g. sub-excavation extending across the entire RSS footprint and replacement with granular material. Top of footing and top of wall elevations should be provided every 10m and at breakpoints.
4. Foundation drawing for each RSS, showing borehole locations and stratigraphic profile (where applicable) of the subsurface conditions.
5. Locations of obstructions such as catch basins, sewers, lighting poles, fence posts, guide rail, etc.
6. Details for management of surface runoff, such as interceptor ditches along top of wall/slope, erosion protection at ends of wall/slope
7. Identification of limits of earth/rock excavation for RSS on the “Structural Excavation” grading drawing; confirm plan dimensions of excavation with Pavements and Foundations Section.
8. Provision for “Protection Systems” and/or “Unwatering Structure Excavation” where recommended in the Foundation Design Report.
9. Provision for topsoil and vegetative cover on RSS slopes.

10. Traffic barriers or finishing caps, where required; only applicable to high performance walls and medium performance, high appearance walls; include limits or required clearance to roadway and any other critical parameters.

5.2 RSS WITH STRUCTURE

The following drawings are to be included in RSS Contracts for RSS associated with structures:

1) Layout drawing. When the RSS is associated with a structure, the RSS layout is shown on the General Arrangement drawing. This drawing would generally be to the detail shown in Section 4, showing a plan and elevation. A sample General Arrangement drawing is shown in Appendix A. A note should be placed on either the layout drawing or the elevation drawing reminding the Contractor to review all Contract Documents to determine if any property restrictions or utilities (manholes, piles, etc.) may need to be considered in the design of the RSS.

2) Foundation Drawing. This drawing is part of the Foundation Investigation and Design Report prepared for the project. It is included with the structural drawings and is generally identified as Drawing 2 Borehole Location and Strata. An example is provided in Figure 5.18. The Foundation Investigation Report describing the subsurface conditions at the site is also provided with the Contract Documents.

3) Elevation drawing. An elevation Drawing is required to design and construct the RSS, not unlike what is provided for a conventional wall design. Elevations of the fill/cut slope, the elevations and profile of the top of the RSS wall, the levelling pad elevations at the lowest base level and at the ends, as well as schematics of steps in the footing should be shown.

   For RSS wingwalls, a schematic elevation can be made of each wingwall. For RSS false abutment, an elevation can be made of the abutment, or alternatively, the entire RSS wall can be opened-up and shown in one elevation. The top of wall elevations should generally be given at a spacing of about 5m, or at break points. The top of fill slope elevations should be given at a spacing of about 5 to 10m, or at break points. A sample of an RSS elevation is shown in Figure 5.20, and a sample of an opened-up view of an RSS false abutment and RSS wingwalls is shown in Figure 5.21. The elevations of the levelling pad are determined with the following considerations (shown diagrammatically in Figure 5.22):

   i) **C1, C2, and C3**: The minimum soil cover to the underside of the levelling pad shall be at least 800mm, or 40% of the actual frost depth for the area, whichever is greater. The minimum soil cover to the top of the levelling pad shall be at least 500 mm.

   ii) **E1**: The underside of the levelling pad shall be placed at an elevation at or below that specified in the Foundation Design report as having competent soil, adequate for the bearing resistance required RSS. This elevation is either close to the original ground with nominal stripping of organic soils, or below, if sub-excavation is required.

iii) **L1**: The drawing shall be shown with a lowest step in the RSS levelling pad at least 3.0m in length. This is shown only schematically without dimensions, but is used for calculations of quantities. The RSS supplier will determine the exact step lengths.

iv) **H1 and H2**: The drawing shall be shown with steps in the levelling pad, but elevations are not required for the steps. The step should be determined and shown schematically without dimensions so that the depth of soil to the top of the pad is not greater than 2.5m. These elevations are used for the calculation of backfill quantities, but the RSS supplier will determine the exact step heights.

v) **L2**: The length of a typical step should not be less than 3.0m. This is shown only schematically without dimensions, but is used for calculations of quantities. The RSS supplier will determine the actual step locations.

vi) **H3**: The last step in the levelling pad shall be shown with the specified elevation so that the soil cover to the underside, at the free end of the wall, is at least 1.0m or 50% of the frost depth, whichever is greater. This value can be reduced by 20% if there is no barrier wall.

vii) **L3**: The length of the final step shall be specified as at least 2.0 m.

4) Excavation at structure (earth or rock). This drawing, one per structure, is shown in the Grading drawings just before the Typical Sections and not in the Structural drawings, shall be included to identify the excavation needed for the abutment, wingwall and RSS. This includes any sub-excavation required. Preloading can also be shown on this drawing. A sample drawing is shown in Figure 5.23. Refer to Section 5.4 on Tender Items for guidance on the calculation of excavation quantities.

5) Backfill for structure. This drawing, one per structure, is shown in the Grading drawings just before the Typical Sections and not in the Structural drawings, shall be included to identify the backfill needed for the abutment and cast in place wingwalls. For simple cases, it may be combined with the excavation drawing. A sample drawing is shown in Figure 5.24. Refer to Section 5.4 on Tender Items for guidance on the calculation of backfill quantities.

6) Backfill for RSS. This drawing, shown on the Grading drawings and not in the Structural drawings, shall be included to identify the backfill needed for the RSS. For simple cases, it may be combined with the excavation drawing or backfill for structure drawing. A sample drawing, showing both backfill for structure and backfill for RSS, is shown in Figure 5.24. Refer to Section 5.4 on Tender Items for guidance on the calculation of backfill quantities.

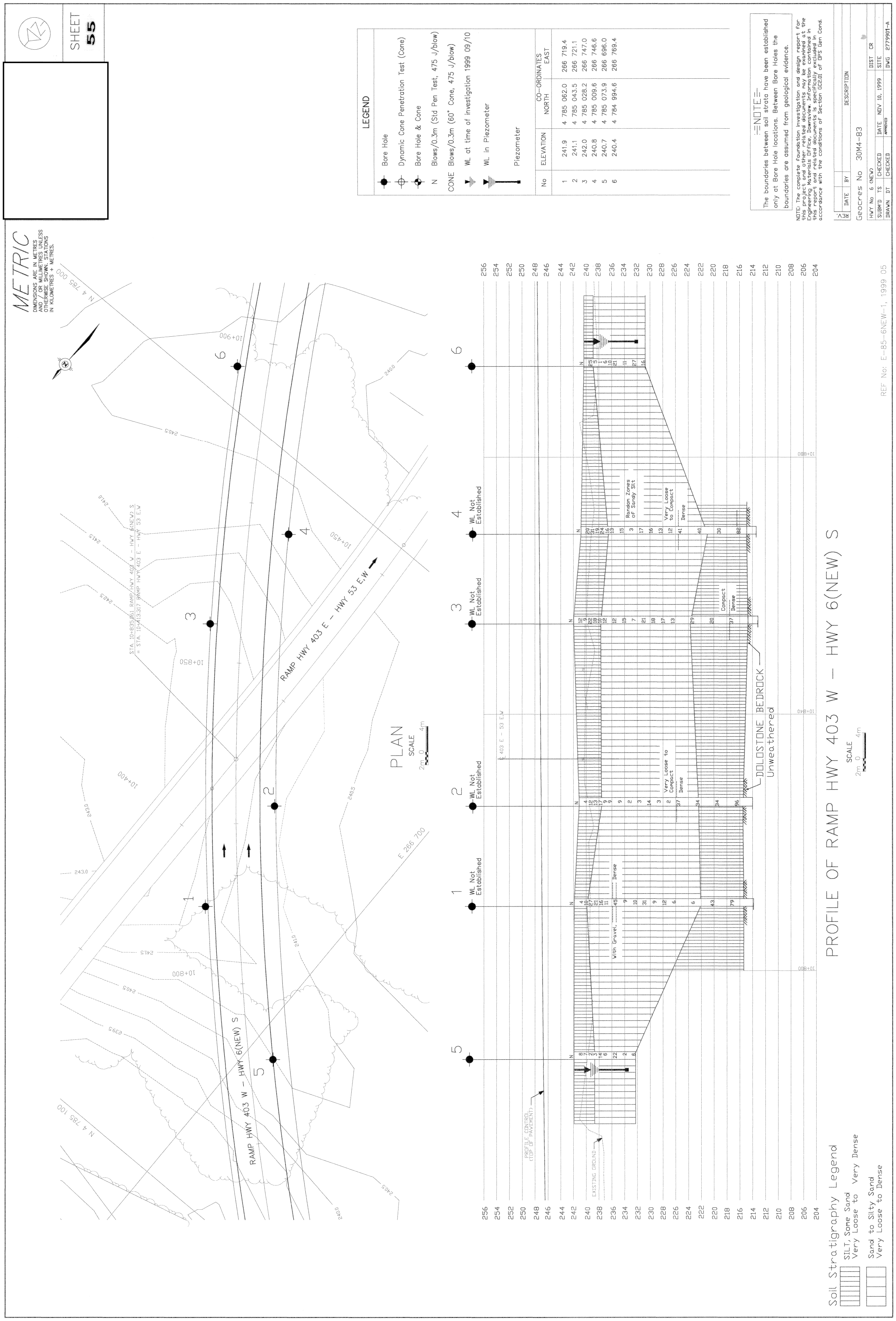


Figure 5.18: Sample Drawing Showing Soil Strata and Bore Hole Locations.

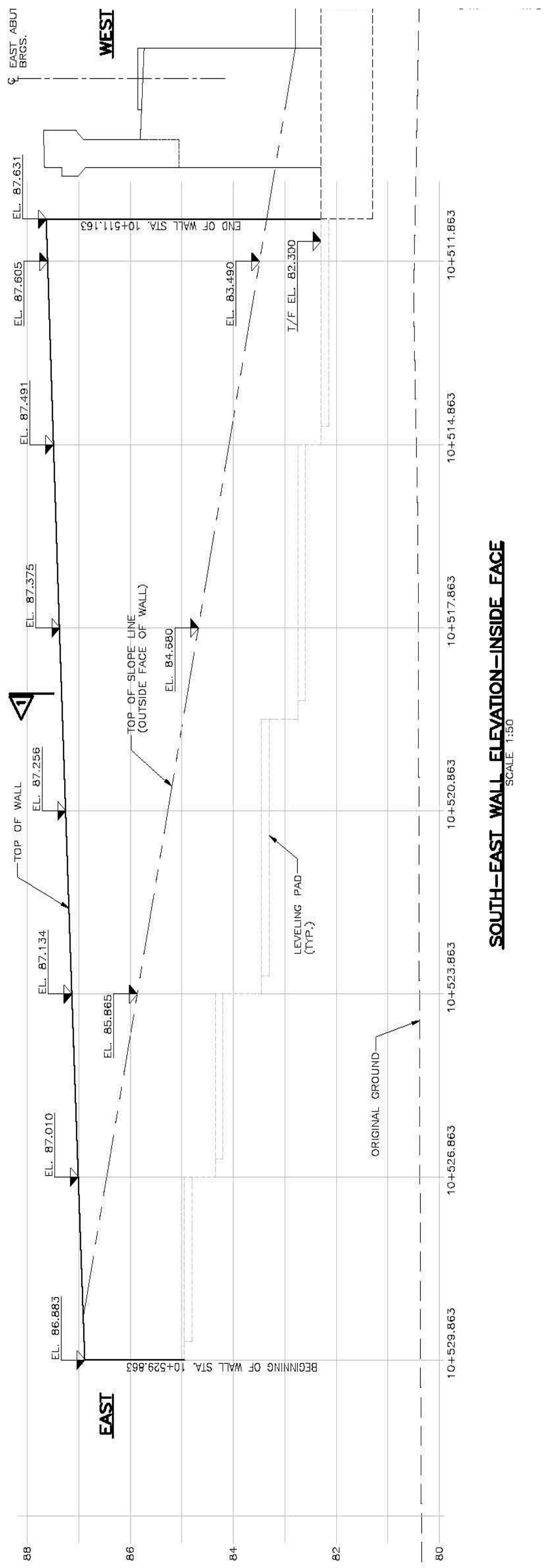


Figure 5.20: Sample Drawing Showing Top of RSS Elevations and Slope.

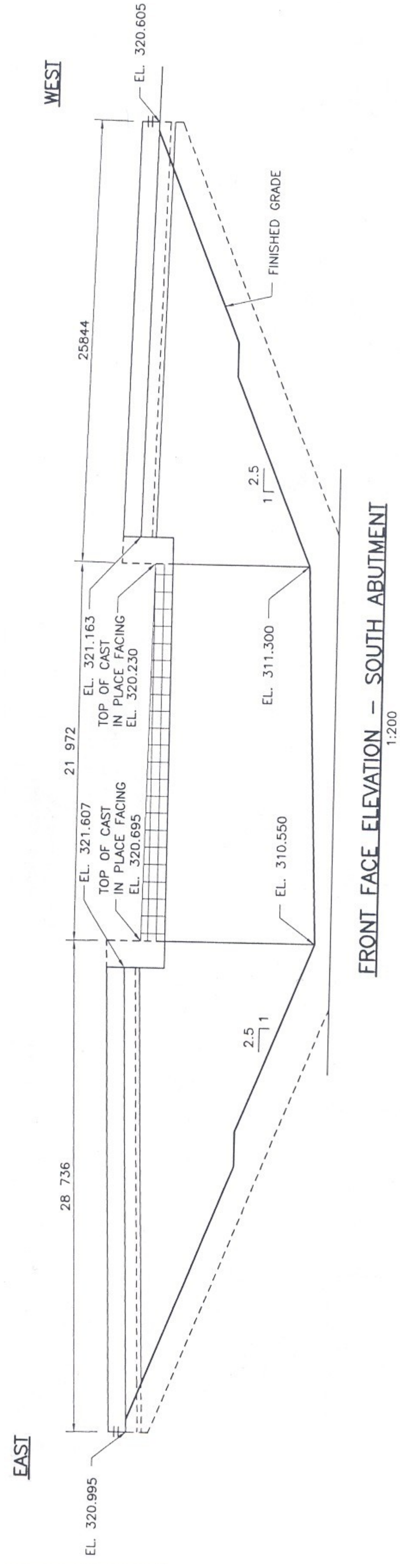
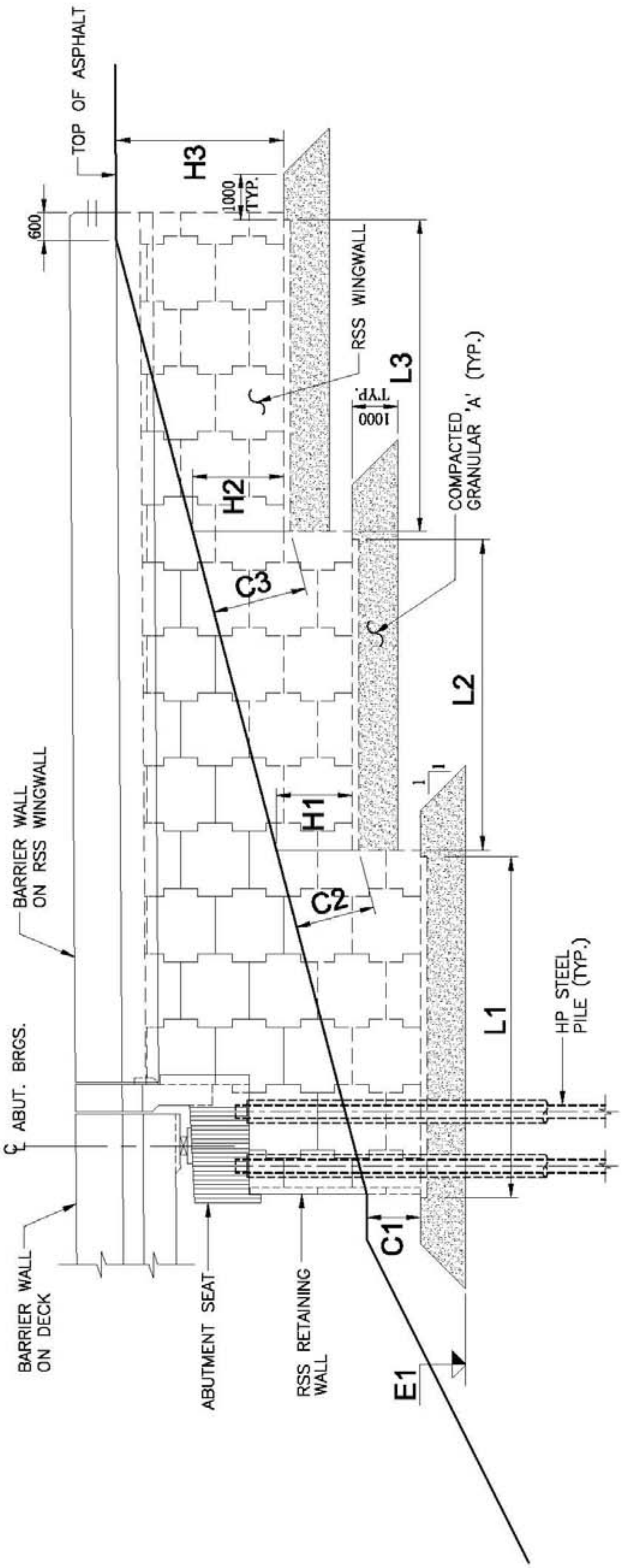


Figure 5.21: Sample Drawing Showing Opened-Up RSS Elevation.



C1, C2 and C3	-	Not less than – Larger of 800 mm and 40% of Frost Depth to underside of levelling pad.
	-	Not less than – 500 mm to top of levelling pad/bottom of panels.
L1 and L2	-	Not less than 3000 mm.
H1 and H2	-	Not greater than 2500 mm.
H3	-	Not less than – Larger of 1000 mm and 50% of Frost Depth to underside of levelling pad.
L3	-	Not less than 2000 mm.

Figure 5.22: Guidelines for determining RSS Elevations.

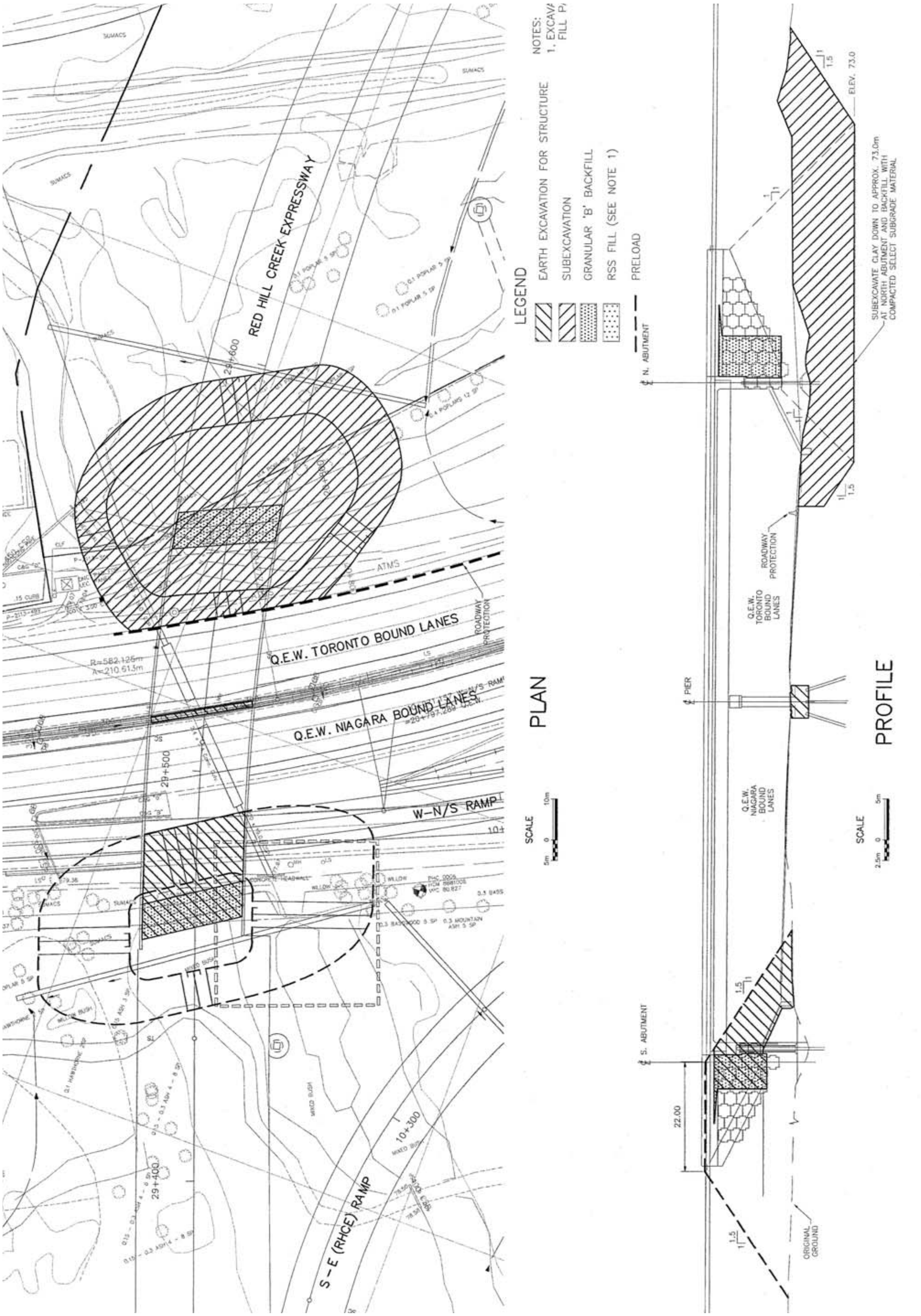


Figure 5.23: Sample Drawing Showing Earth Excavation at Structure.

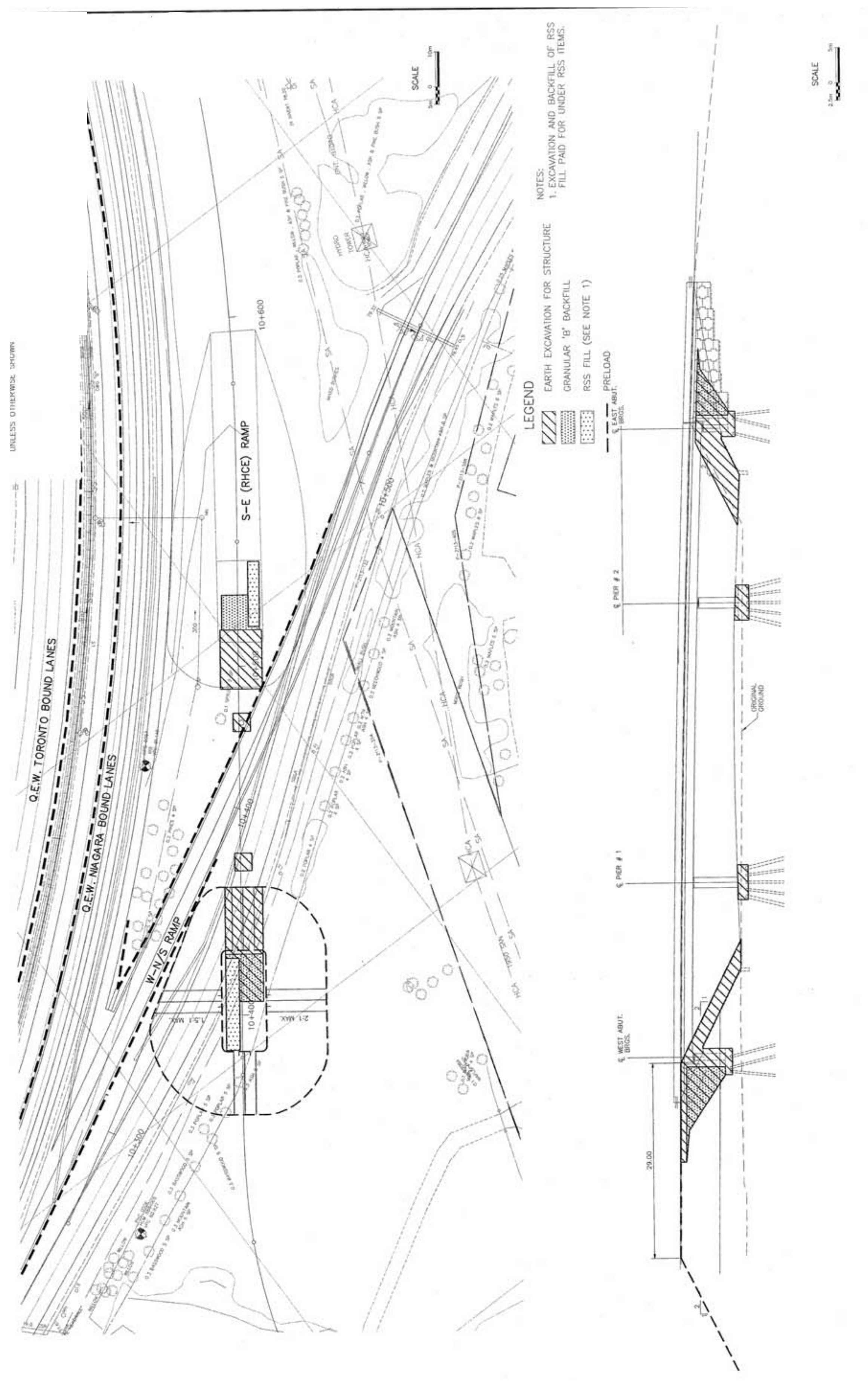


Figure 5.24: Sample Drawing Showing Backfill for Structure and for RSS.

5.3 RSS STRUCTURAL DETAILS

Structural details that have been used successfully in the past are shown and discussed below. The use of these details will help simplify construction and ensure quality and durability. Typically, these details would appear on the substructure drawings. The following details are shown:

1) RSS wingwall section. This section (Figure 5.1) is applicable with RSS wingwalls.
2) RSS Levelling Pad on Backfill. This detail (Figure 5.2) shows the backfill required under an RSS levelling pad in fill conditions. This is provided to ensure that some free draining soil exists below the pad that is not placed below the frost depth.
3) Barrier on RSS. This detail (Figure 5.3) shows the barrier footing required for a barrier on RSS. This drawing is currently included in the Structural Manual as a Design Aid and will soon be included as a Structural Standard drawing. The Structural Manual should be checked for the most recent drawing revision.
4) Double CSP Detail. This detail (Figure 5.4) ensures that no additional lateral pressure is transferred to the RSS due to pile movement.
5) Forming underside of integral abutment. This detail (Figure 5.5) ensures that the excavation around the pile does not fail and ensures that the upper portions of the pile are free to move without putting addition soil pressure against the embankment.
6) Forming underside of integral abutment with double CSP. This detail (Figure 5.6) ensures that the upper portions of the pile are free to move without putting additional soil pressure on the RSS wall in locations where the pile is very close to the RSS wall.
7) Concrete pad for double CSP. This detail (Figure 5.7) ensures that the double CSP’s remain concentric during the backfill operation.
8) RSS under abutment. This detail (Figure 5.8) eases construction, ensures that the backfill will be retained and ensures that the gap between the abutment and the RSS is not excessive.
9) RSS Shelf in front of abutment. This detail (Figure 5.9) allows for some settlement of the RSS to occur and not cause visual problems since the RSS is above and offset from the bottom of the abutment stem.
10) RSS under abutment with lip. This detail (Figure 5.10) allows for some settlement of the RSS to occur and not cause visual problems since the top edge of the RSS is above the underside of the abutment lip.
11) Abutment nib at RSS. This detail (Figure 5.11) allows for some settlement and rotation of the RSS wall in relation to the concrete abutment without visual problems by hiding the RSS edge behind the nib.
12) Wingwall Nib at RSS. This detail, (Figure 5.12) allows for some settlement and rotation of the RSS wall in relation to the concrete wingwall without visual problems by hiding the RSS edge behind the nib.
13) RSS Angled Joint at Wingwall. This detail, (Figure 5.13) allows for some settlement and rotation of the RSS wall in relation to the concrete wingwall without visual problems by hiding the RSS edge behind the wingwall.
14) Top of Nib Detail. This detail, (Figure 5.14) allows for some settlement and rotation of the RSS wall in relation to the concrete wingwall without damage to the RSS facing elements.
15) RSS corner element detail. This detail (Figure 5.15) is used where the RSS makes a change in angle and provides an aesthetic smooth edge. It also shows the clearance

requirements from the CSP to the RSS (both at the false abutment and wingwall) to allow for proper compaction and installation of the corner element.

16) RSS finishing cap. This detail (Figure 5.16) is used on top of an exposed RSS wall to give an aesthetic appearance of a uniform finished top.
17) Barrier Wall in Front of RSS. This detail (Figure 5.17) is used to ensure cast-in-place barrier concrete does not flow between the RSS panels. It also provides additional distance for protection of piles in case of vehicle impact.
18) Additional loading on RSS. When the RSS is required to resist lateral forces/reactions from the super-structure, the values, at SLS and ULS, are required. For most integral abutments, there is no load transferred to the RSS due to the use of a single or double CSP. Generally it does apply for the cases shown in Figures 4.9 and 4.10 – where two rows of piles are used. An example is provided in Figure 5.19.

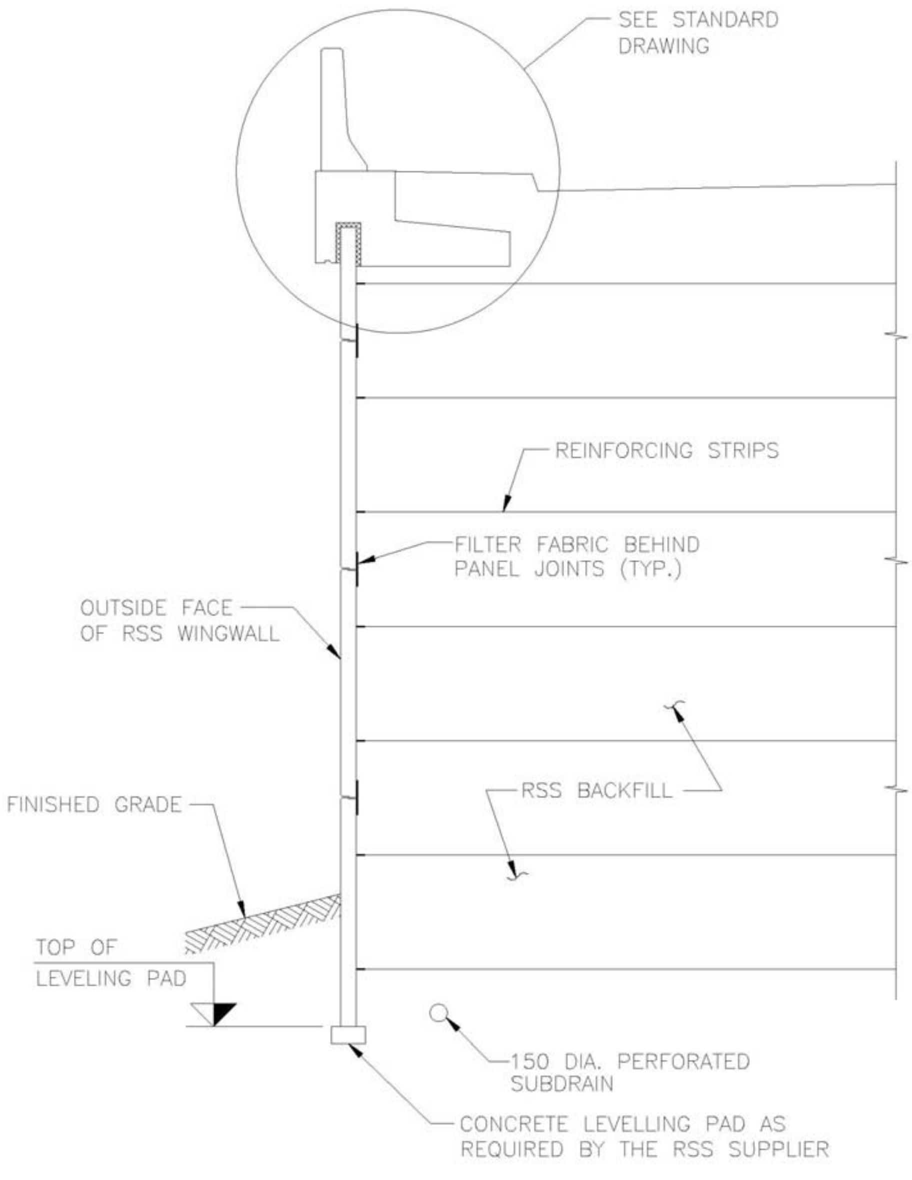


Figure 5.1: RSS Wingwall Section.

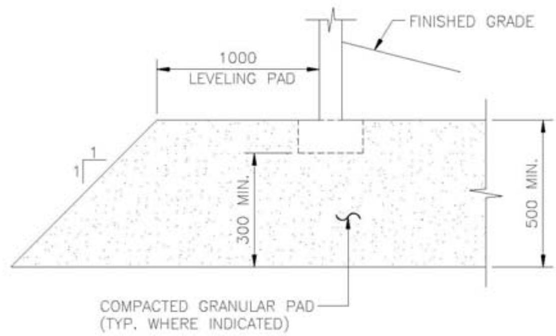


Figure 5.2: RSS Levelling Pad on Backfill (Where Required).

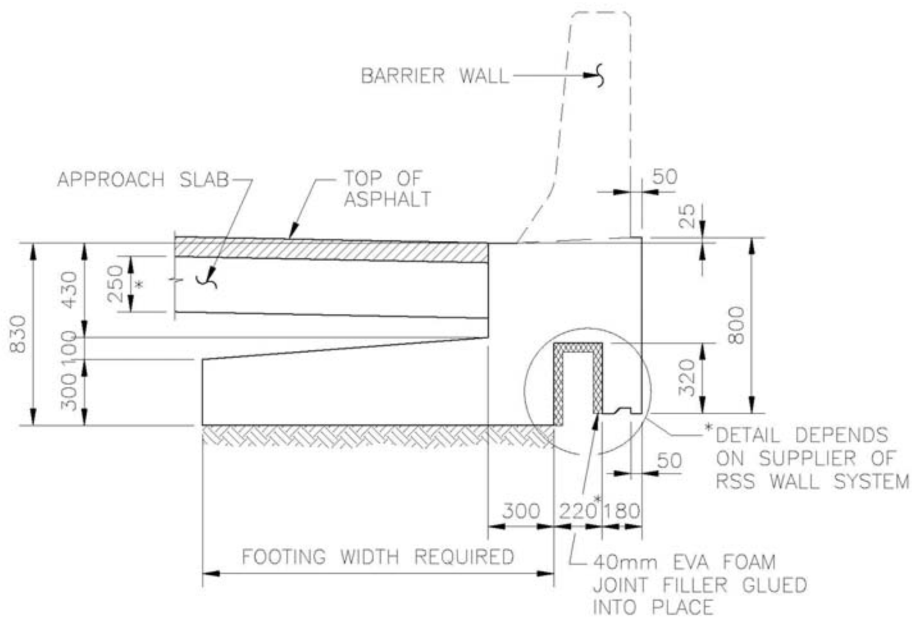


Figure 5.3: Barrier on RSS.

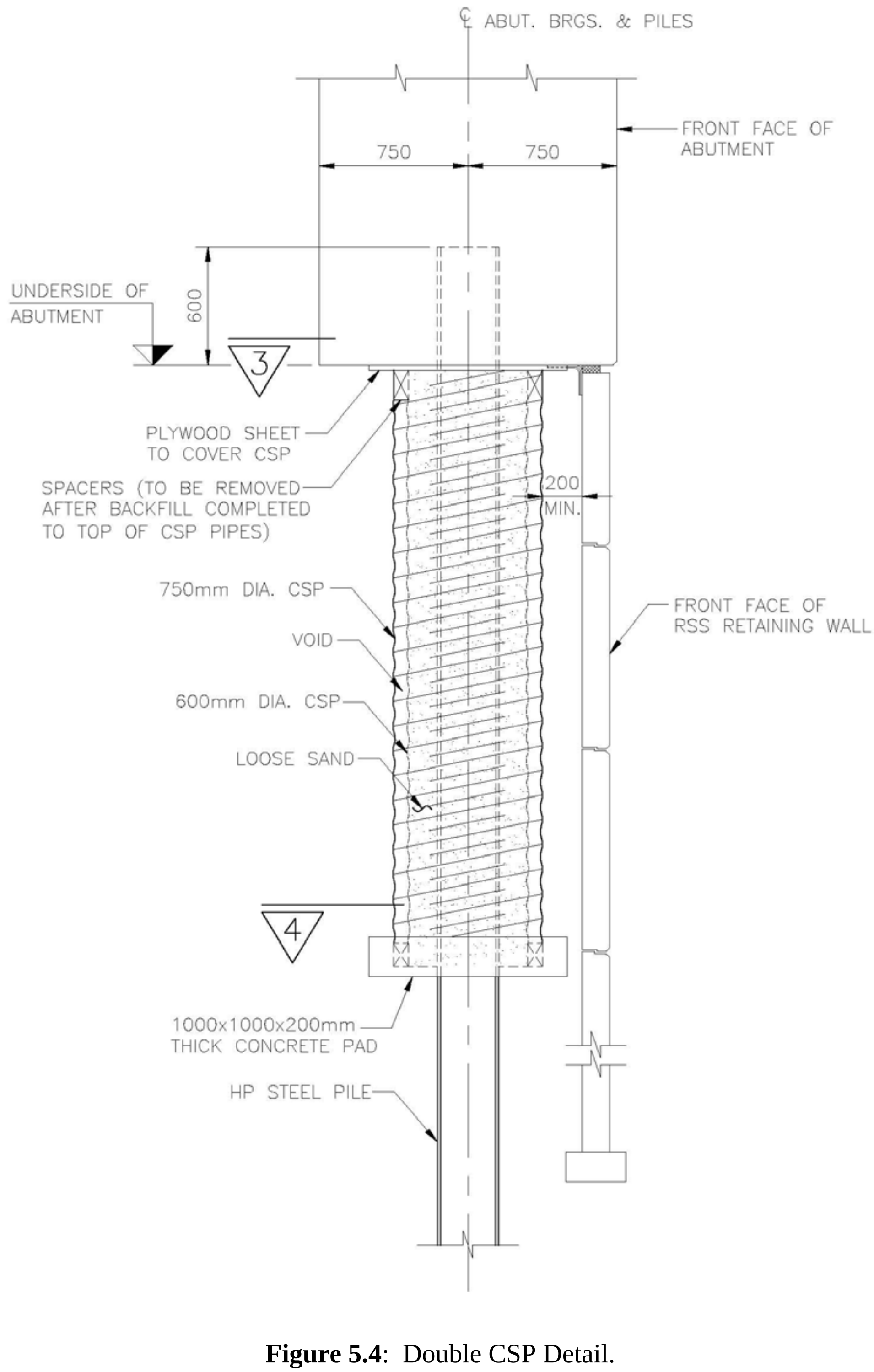


Figure 5.4: Double CSP Detail.

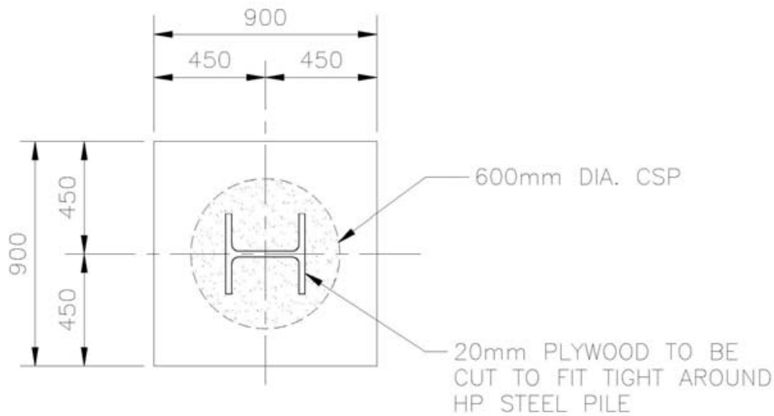


Figure 5.5: Forming Underside of Integral Abutment.

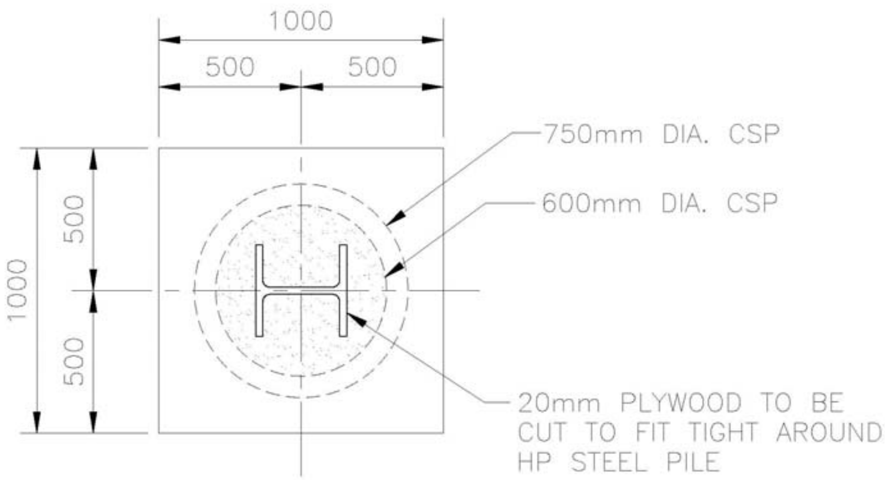


Figure 5.6: Forming Underside of Abutment with Double CSP.

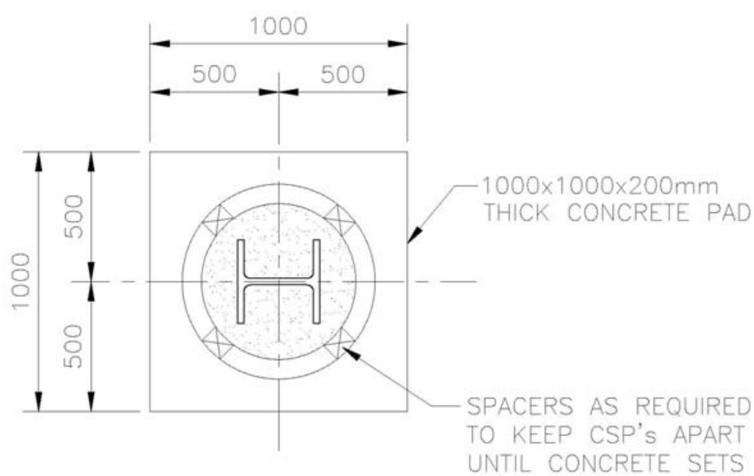


Figure 5.7: Concrete Pad for Double CSP.

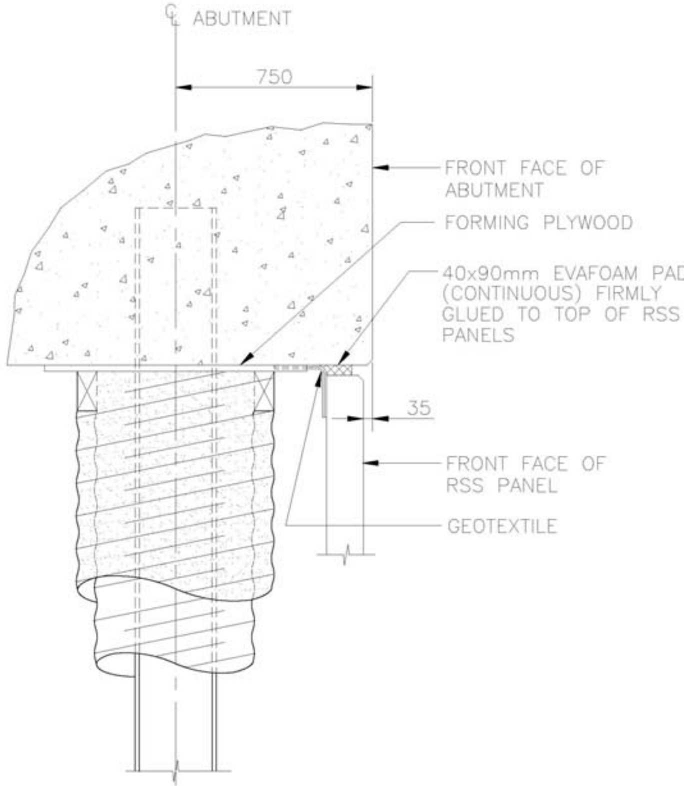


Figure 5.8: RSS Under Abutment.

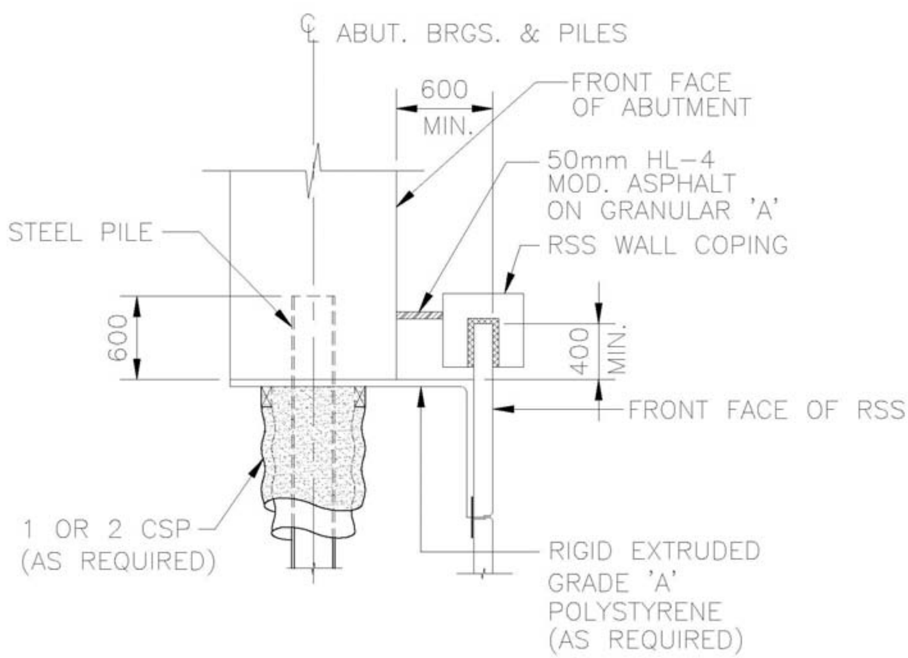


Figure 5.9: RSS Shelf in Front of Abutment.

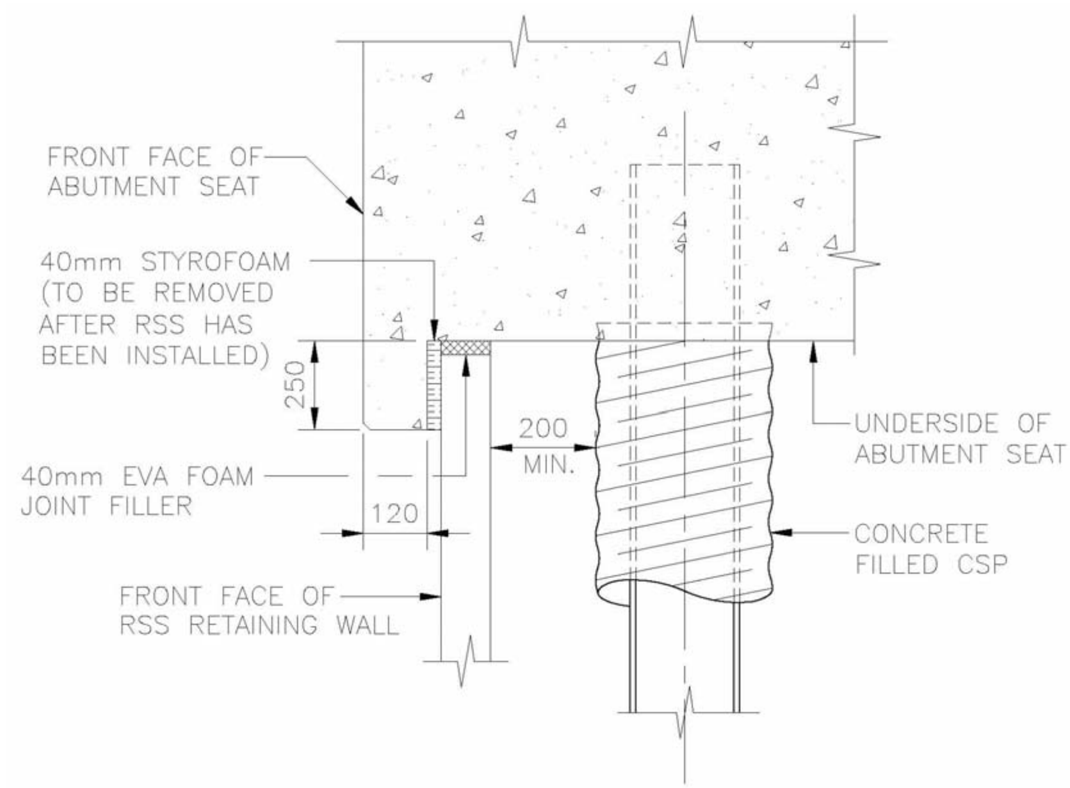


Figure 5.10: RSS Under Abutment with Lip.

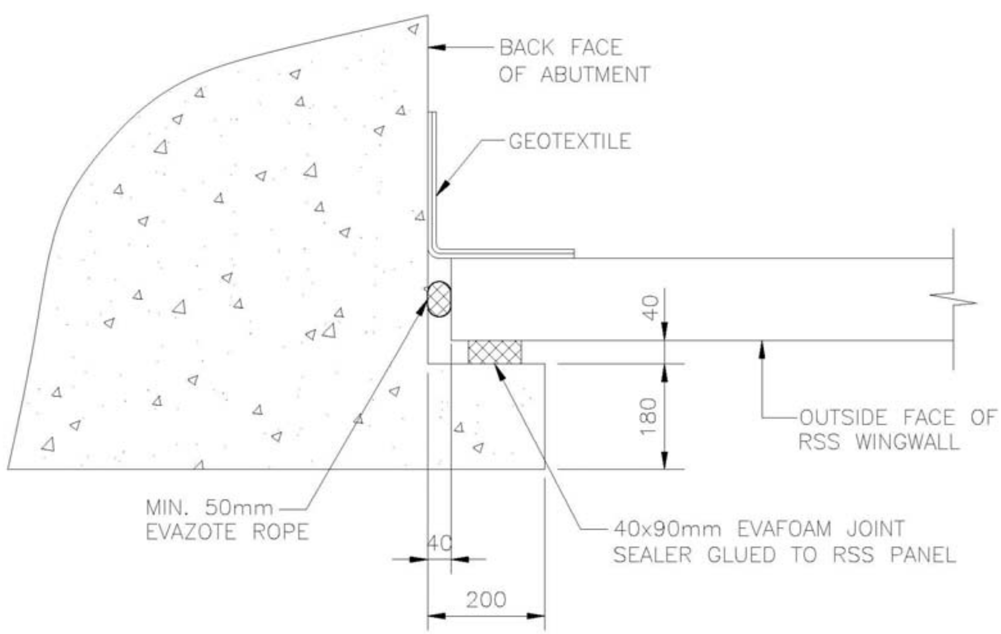


Figure 5.11: Abutment Nib at RSS (Plan View).

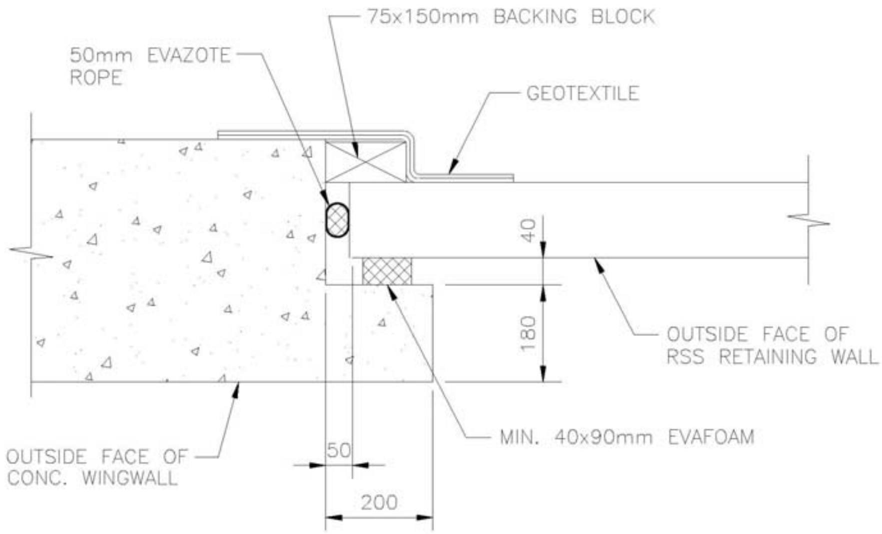


Figure 5.12: Wingwall Nib at RSS (Plan View).

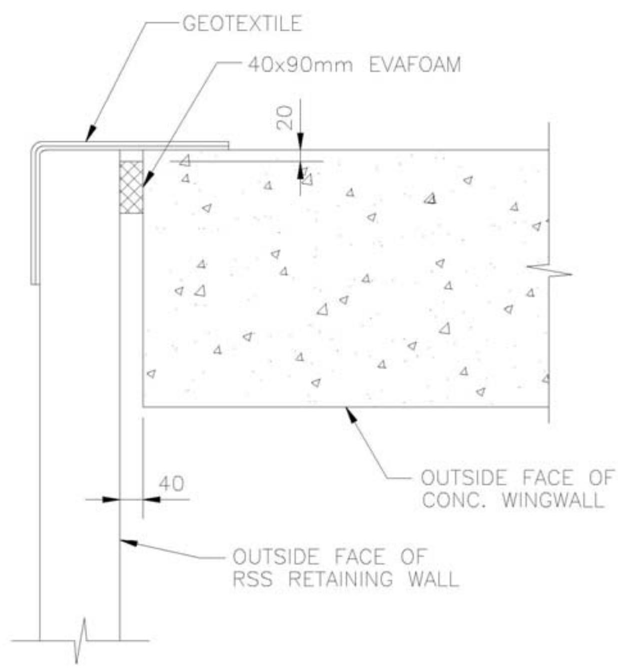


Figure 5.13: RSS Angled Joint at Wingwall (Plan View).

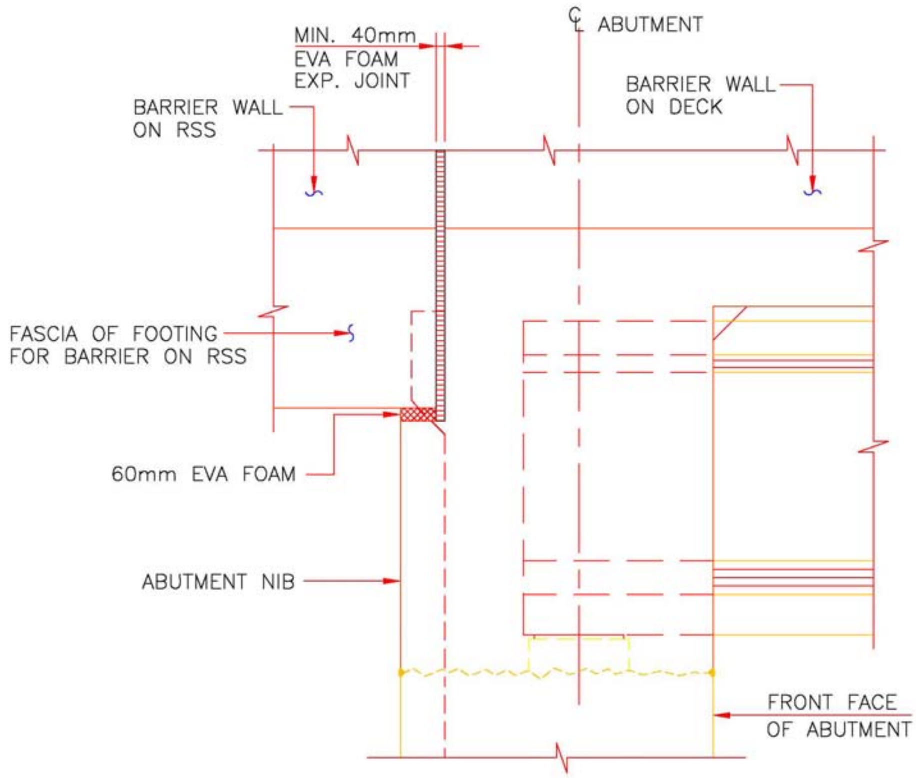


Figure 5.14: Top of Nib Detail.

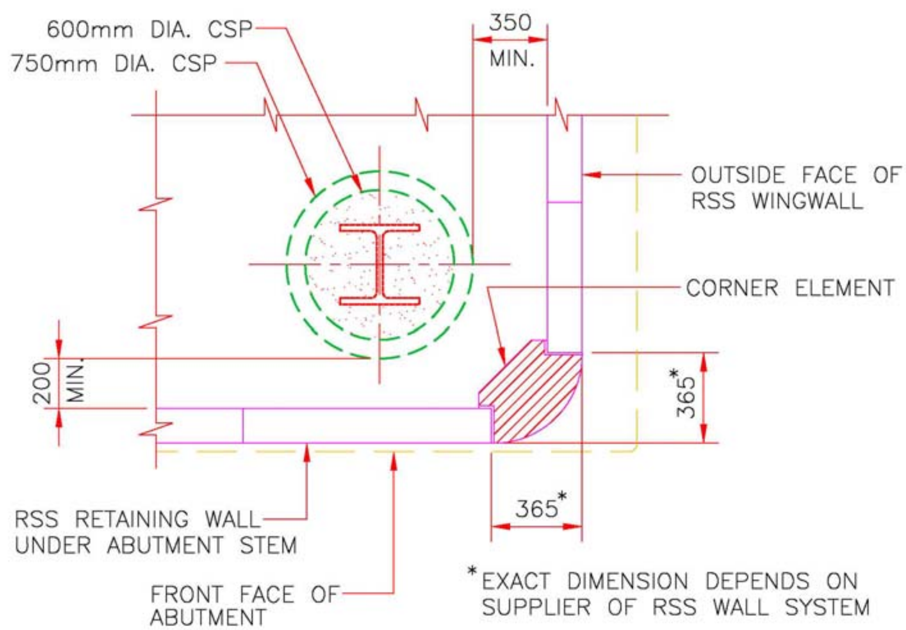


Figure 5.15: RSS Corner Element Detail (Plan View).

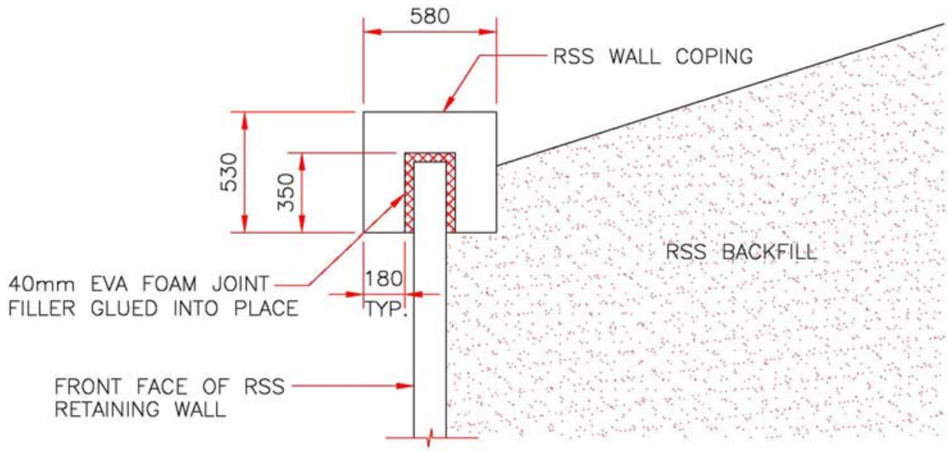
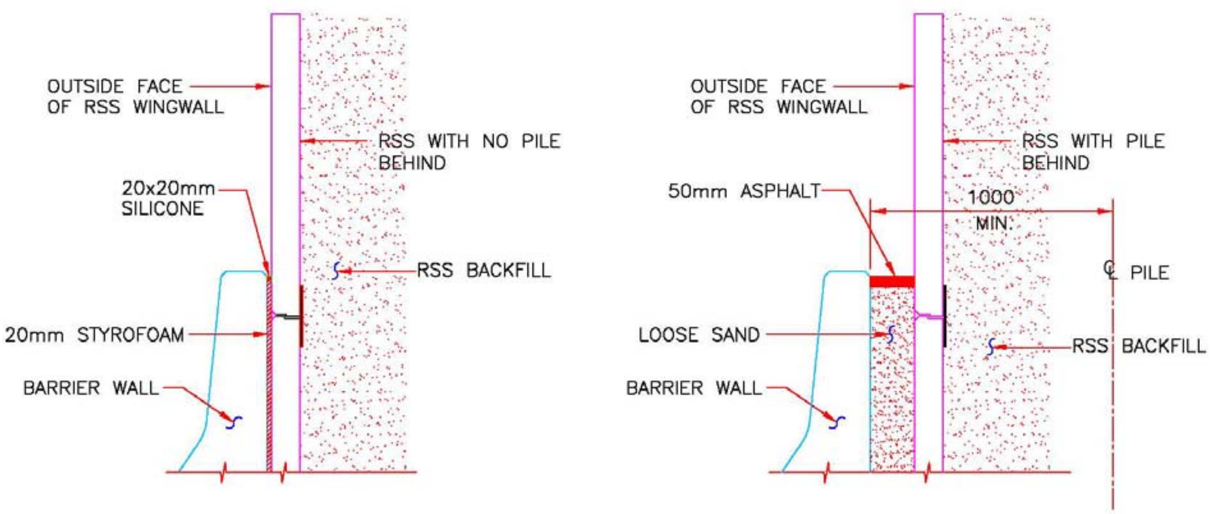


Figure 5.16: RSS Finishing Cap Detail.



RSS With No Pile Behind RSS With No Pile Behind

Figure 5.17: Barrier Wall in Front of RSS.

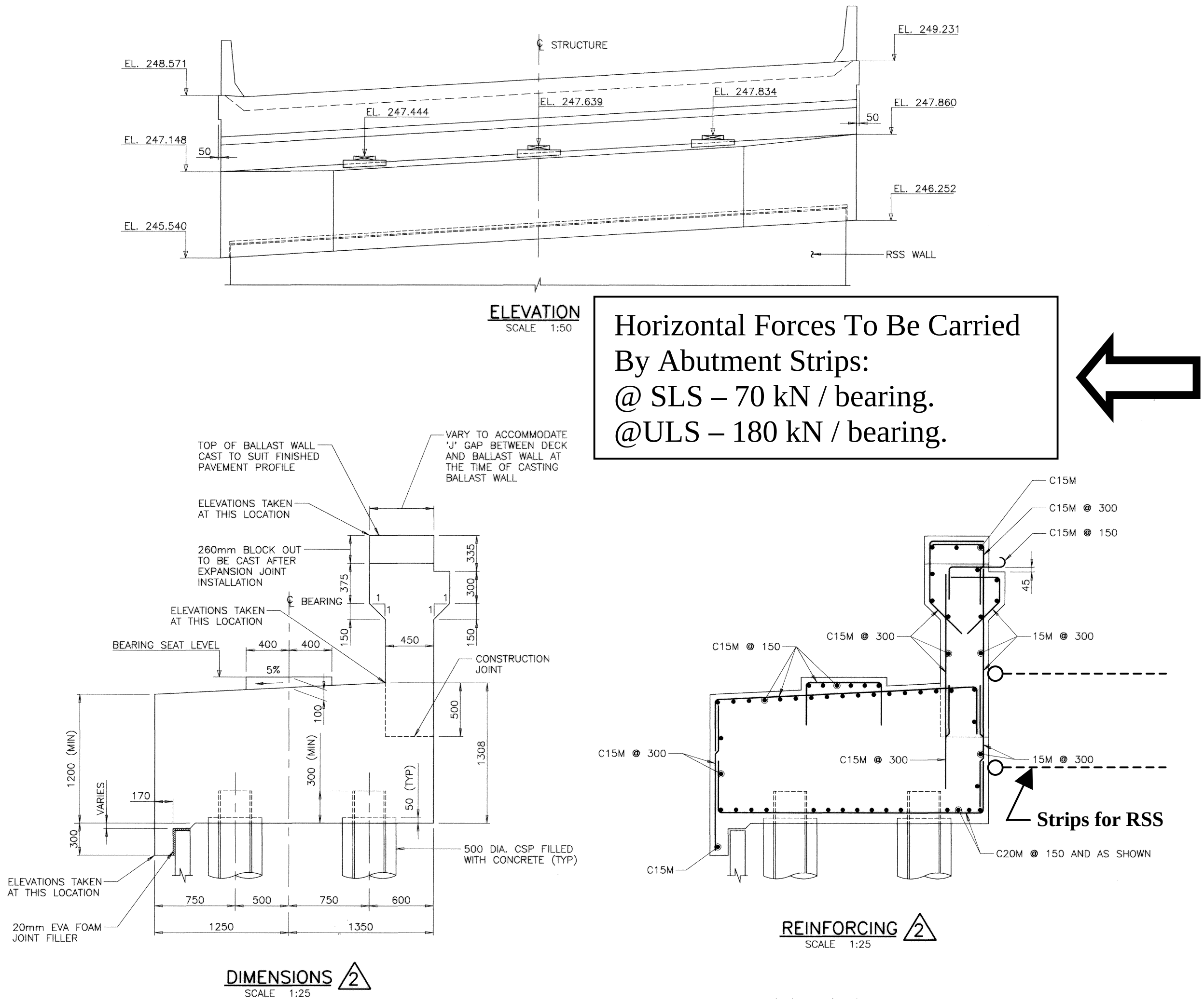


Figure 5.19: Sample Drawing Showing Forces Transferred to RSS.

5.4 TENDER ITEMS

The following section describes the Tender Items that exist in RSS applications. As described, some items are lump sum and others are based on quantities, however, quantities are required even for the lump sum items for MTO internal cost estimation purposes (HiCo). Refer to Appendix F for a sample Quantity Sheet for RSS related Tender Items.

Some Tender Items, such as 'Protection Systems', and 'Unwatering Structure Excavation' may also be applicable. However, these Tender Items are not described in this document since they are in no way unique to, or altered in, applications with RSS.

5.4.1 RSS

Several Tender Items exist for the various RSS attributes and are included in Item Codes 599.5960 through 599.5969. Table 5.1 shows the applicable Tender Items for various applications and performances of RSS.

Table 5.1: RSS Tender Items.

Item Code	Title
0599-5960	Retained Soil System, True Abutment
0599-5961	Retained Soil System, False Abutment
0599-5962	Retained Soil System, Wall/Slope, High Performance
0599-5963	Retained Soil System, Wall/Slope, Medium Performance
0599-5964	Retained Soil System, Wall/Slope, Low Performance
0599-5969	Retained Soil System, Roadbase Embankment

The RSS tender items are Lump Sum and are currently coded as Grading Items. However, they are to be documented individually in the contract package under the Structural Items. This applies to all RSS - whether a false or true abutment, or a high, medium or low performance wall or slope. The application, geometry, performance and appearance category for each RSS application shall be shown on the drawings and shall be determined as described in Section 3.

The quantity of RSS wall is the total area above the RSS footing or levelling pad and not just the exposed area. The area of a RSS slope is measured from the toe of the slope.

The calculation of RSS quantity shall be carried out by the Roadway Designer in consultation with the Structural Designer. The quantities shall be calculated for each location and listed on the Structural Quantity sheets. On roadways, RSS with the same attributes can be grouped under a single tender item for payment.

Where a concrete traffic barrier on RSS is required, it is no longer part of the RSS tender item. Concrete barrier is paid for under the appropriate concrete item. Refer to Sections 5.4.6 and 5.4.7.

5.4.2 EXCAVATION

Table 5.2 shows the Tender Items associated with excavation. This quantity is measured in Cubic Metres and separate items exist for excavation in earth and rock.

Table 5.2: Excavation Tender Items.

Item Code	Title
0902-0010	Earth Excavation for Structure
0902-0020	Rock Excavation for Structure

Quantities for excavation for RSS should be included under the appropriate Earth Excavation for Structure and Rock Excavation for Structure tender items.

The limits of earth / rock excavation should be shown on the Structural Excavation drawing for each RSS. When associated with a bridge, the drawing will include for excavation for all structural components, i.e. abutments, footings, wingwalls and RSS. The RSS quantities are estimates only and documented for each RSS separately to better negotiate overruns and under runs.

The calculation of RSS excavation quantities shall be carried out by the Roadway Designer in consultation with the Structural Designer.

The extent of excavation shall be that required to properly construct the footings, abutments, wingwalls and adjacent retaining walls.

Figure 5.25 shows the extent of excavation required for abutments and retaining walls.

For RSS, the required excavation is estimated as extending 80% of the wall height beyond the wall and at a 1.5H to 1.0V slope as shown in Figure 5.26. Although shown as a 1.5H:1.0V slope, the recommended slope of temporary excavations is provided in the Foundation Design Report.

For excavation behind cantilever wingwalls, the excavation can be assumed to be as shown in Figure 5.27.

When RSS is associated with a bridge, the structure excavation in the longitudinal direction has some overlap with the RSS or wingwall excavation in the transverse direction. There is often complete overlap between the excavations for cantilever wingwalls since they are shorter than RSS and fall entirely within the excavation required for the abutment. Care shall be exercised to ensure that any overlap is not double counted.

Excavated materials should be made available for fill and estimated quantities transferred to the grading quantity sheets. A sample quantity sheet is shown in Appendix F.

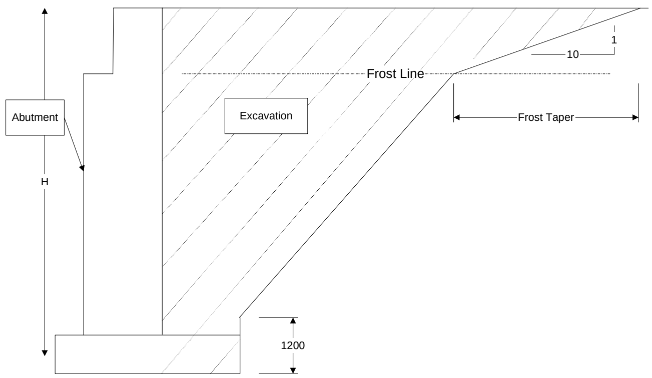


Figure 5.25: Excavation behind Abutment

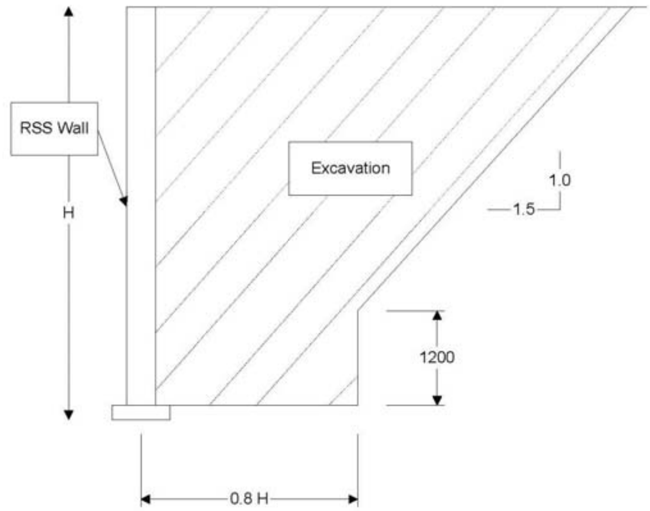


Figure 5.26: Excavation behind RSS

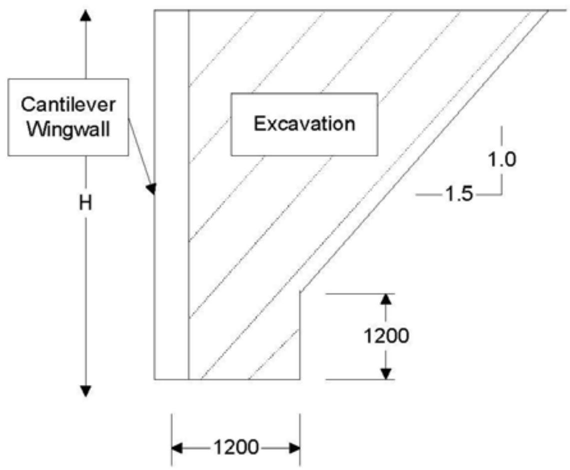


Figure 5.27: Excavation behind Cantilever Wingwall

5.4.3 BACKFILL FOR RSS

Three (3) Tender Items exist for Backfill for RSS, one for each performance category of RSS, as shown in Table 5.4. Currently, these are all non-standard Tender Items. This quantity is measured in tonnes and tabulated separately for each structure. The backfill material depends on the type of RSS selected and is specified by the RSS Product Supplier.

For calculation of Backfill for RSS, the reinforced soil mass is assumed to occupy a uniform rectangular block of fill extending back 80% of the wall height, as shown in Figure 5.28. If the proposed RSS varies in height, the assumptions of Section 5.2 bullet 3) shall be used to estimate the steps in the wall, and thus the height along the length of the RSS.

The calculation of RSS backfill quantities shall be carried out by the Roadway Designer in consultation with the Structural Designer.

A factor of 2.1 may be used to convert cubic metres to tonnes for estimating quantities of backfill for Low, Medium and High Performance RSS. For Ultra Lightweight Backfill, the density of the fill can vary significantly depending on the source of fill and site-specific settlement issues. The foundations consultant or the MTO Foundations Group should be contacted for the appropriate conversion factor.

Often backfill for RSS overlaps with Structure backfill, in which case the quantity shall be counted only towards the backfill for RSS.

The quantity for Backfill to Structure, including backfill for sub-excavation, shall be shown in a separate column (non-tender item) next to the tender item for Earth Excavation for Structure on the Structural Quantity Sheets. The column subtotal is transferred to the main granular item on the Quantities - Hot Mix and Granulars Sheet of the Grading Quantity Sheets. A sample quantity sheet is shown in Table 5.3.

If the quantity is small (less than 50 to 100 m^3), the Tender Item for RSS Backfill may be omitted and the entire backfill paid as Lump Sum under the RSS Tender Item. A NSSP should be included in the contract to include payment of the RSS backfill against the appropriate RSS tender item.

Table 5.4: RSS Backfill Tender Items.

Item Code	Title
9999-1595	Backfill for Retained Soil System, Ultra Lightweight
9999-1597	Backfill for Retained Soil System, Low Performance
9999-1598	Backfill for Retained Soil System, Medium Performance
9999-1599	Backfill for Retained Soil System, High Performance

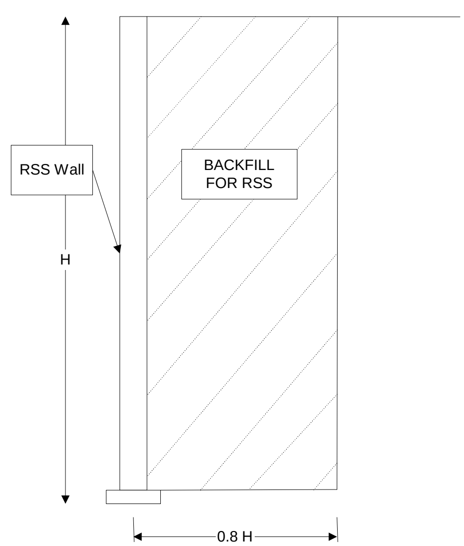


Figure 5.28: Backfill for RSS.

5.4.4 BACKFILL FOR STRUCTURE

The Backfill for Structure is not a separate tender item. It is included as part of the general granular items, Item Codes 314.xxxx.

The earth pressure coefficients for backfill materials (granular A, B, or other) are provided in the Foundation Design Report for use by the Structural Designer. Granular B, Type 1 and 2 are generally used. This quantity is measured in tonnes. It includes backfill for the abutments, wingwalls, retaining walls and culverts, but not for RSS.

The calculation of Backfill for Structural quantities shall be carried out by the Roadway Designer in consultation with the Structural Designer.

OPSD 3501.000 and 3504.000 (for granular fill for abutments and retaining walls respectively) and OPSD 3505.000 (for rock fill) can be used as a guide to determine this quantity. Excerpts from the OPSD for granular fill at abutments are shown in Figure 5.29 and 5.30 since these are most commonly used in conjunction with RSS. This defines the backfill requirements in the longitudinal direction.

For a cantilever wingwall, in the transverse direction, the backfill required would be as shown in Figure 5.31. Similar to what is described in Section 5.4.2 (excavation), this quantity of backfill often overlaps with the abutment backfill and this must be considered when calculating the quantity.

For each structure, the backfill quantities should be determined (by the Roadway designer) and the following backfill locations (including type of granular) should be listed as non-tender items in the structural quantity sheets:

1) Backfill for structure
2) Backfill for structure sub-excavation
3) Backfill for RSS levelling pads
4) Any other backfill categories of Backfill

These quantities will be transferred to the appropriate grading tender items in the grading quantity sheets. A sample Structural Quantity Sheet is shown in Table 5.3.

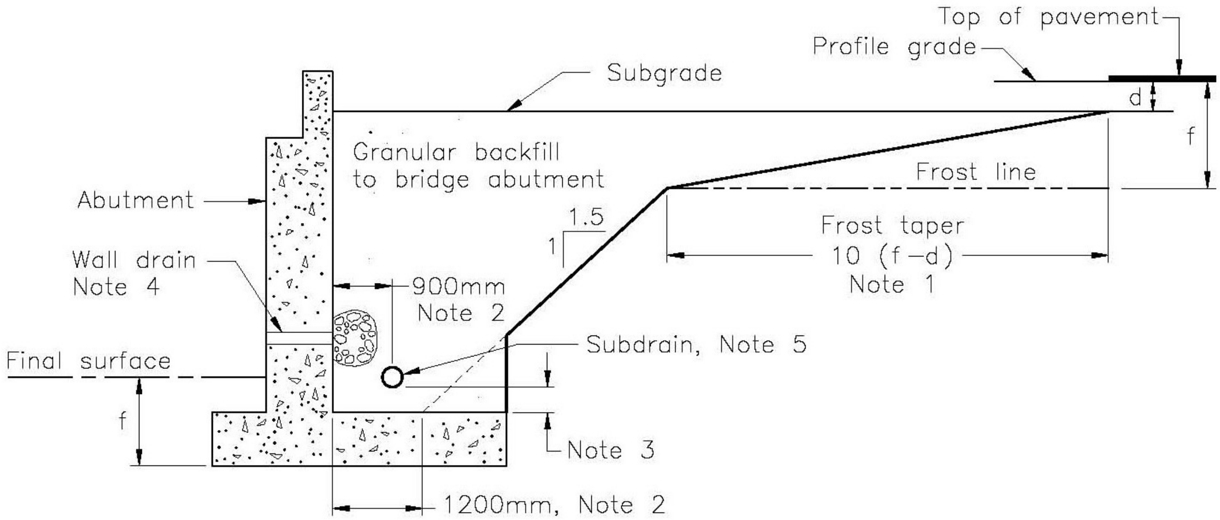


Figure 5.29: Backfill at Conventional Abutment.

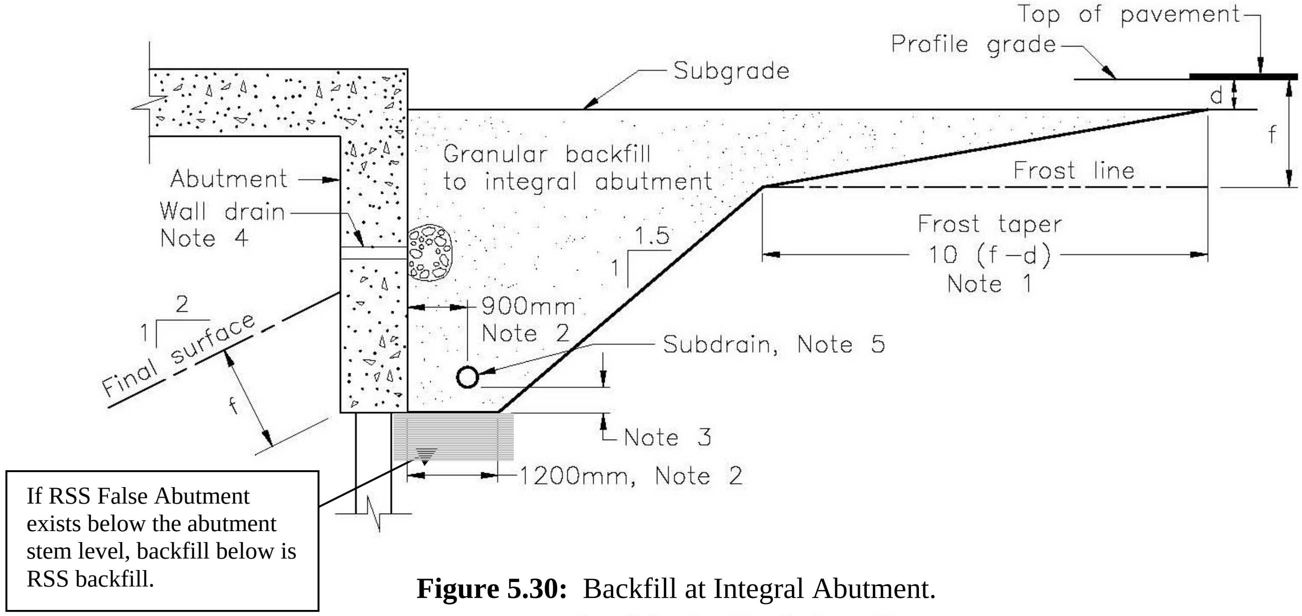


Figure 5.30: Backfill at Integral Abutment.

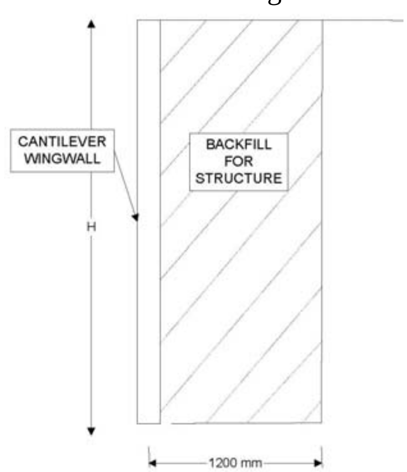


Figure 5.31: Backfill at Cantilever Wingwall.

The quantity of backfill for the structure shall be determined based on the above stated guidance. Whenever there is an overlap in the backfill for RSS and the backfill for structure, the quantity shall be counted only towards the backfill for RSS. Figures 5.32 through 5.36 schematically show the structure and backfill requirements for several RSS scenarios. For these diagrams, care shall be taken at corners where the various types of backfill intersect. For many cases, one type of backfill may be located at a lower elevation and a different type of backfill at a higher elevation. Where the backfill for RSS overlaps with the structure backfill, care should be exercised to ensure that the quality and compaction of the backfill meets the requirement of the RSS used, to minimize the chances of settlements and rotation.

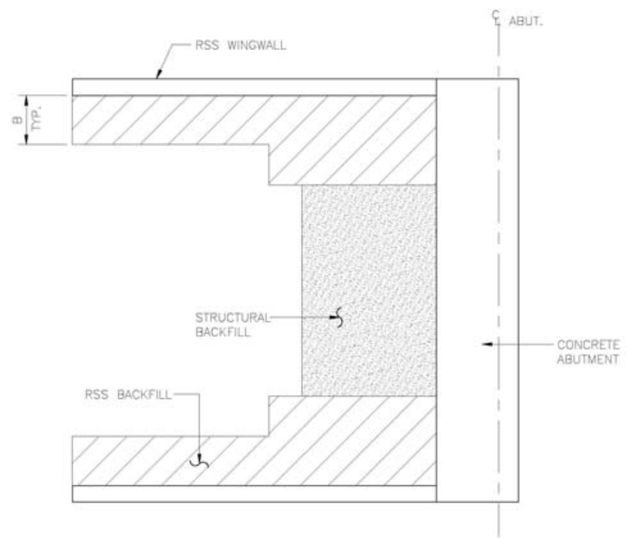


Figure 5.32: Backfill for Concrete Abutment with RSS Wingwalls (B=0.8H).

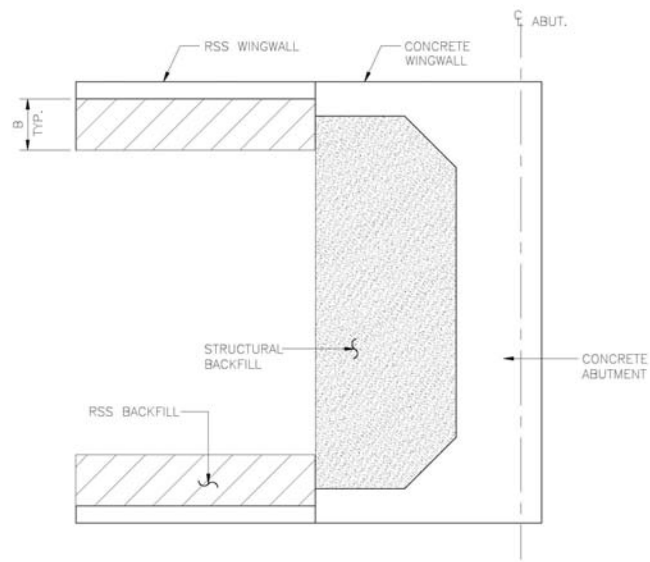


Figure 5.33: Backfill for Concrete Abutment and Wingwalls with RSS Walls (B=0.8H).

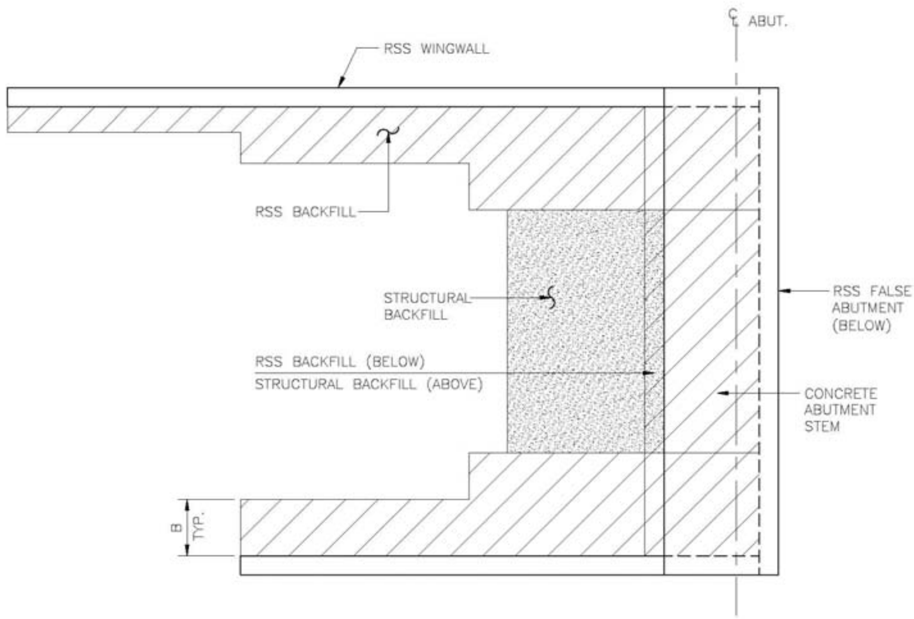


Figure 5.34: Backfill for RSS False Abutment with RSS Wingwalls (B=0.8H).

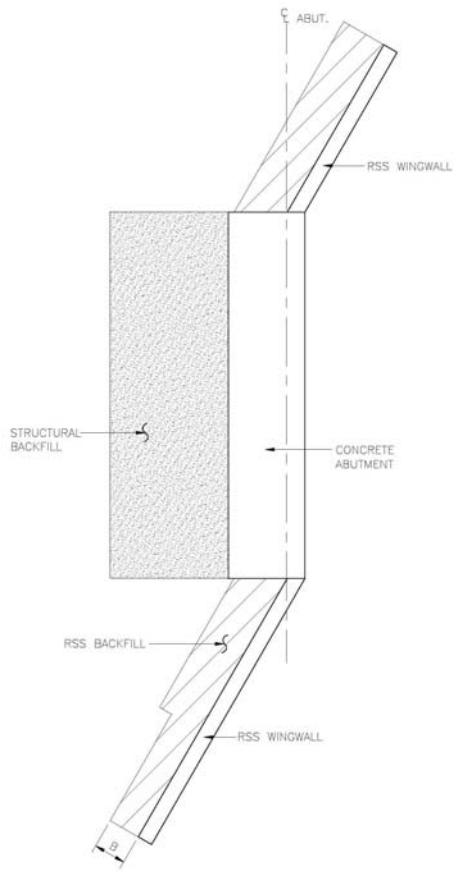


Figure 5.35: Backfill for Concrete Abutment with Flared RSS Wingwalls (B=0.8H).

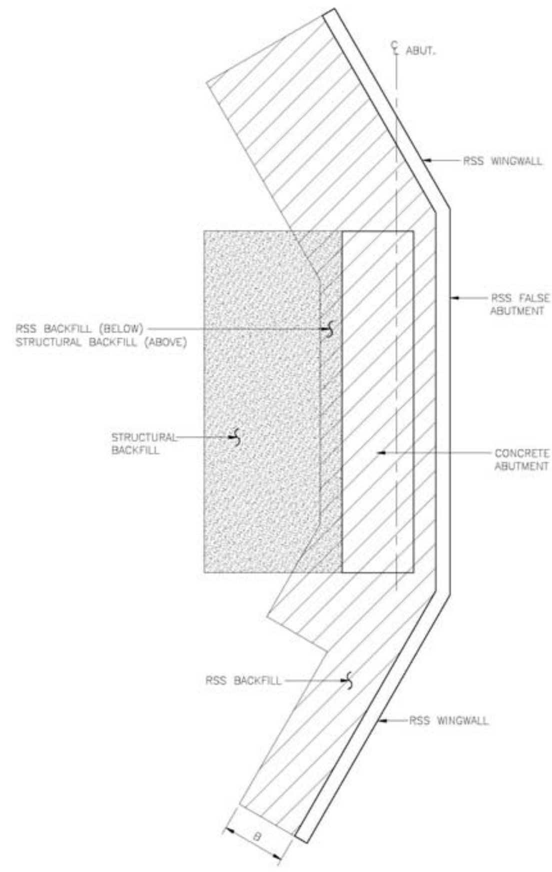


Figure 5.36: Backfill for RSS False Abutment with Flared RSS Wingwalls (B=0.8H).

5.4.5 BACKFILL EXAMPLE

An example backfill calculation is provided in the following section. Figure 5.37 shows the specific example, an integral abutment structure with RSS false abutment and wingwalls. All assumed structural and geotechnical information is shown, along with structure granular backfill requirements taken from Figure 5.30. The competent soil and footing elevations are determined using the methods described in Section 5.2 bullet 3).

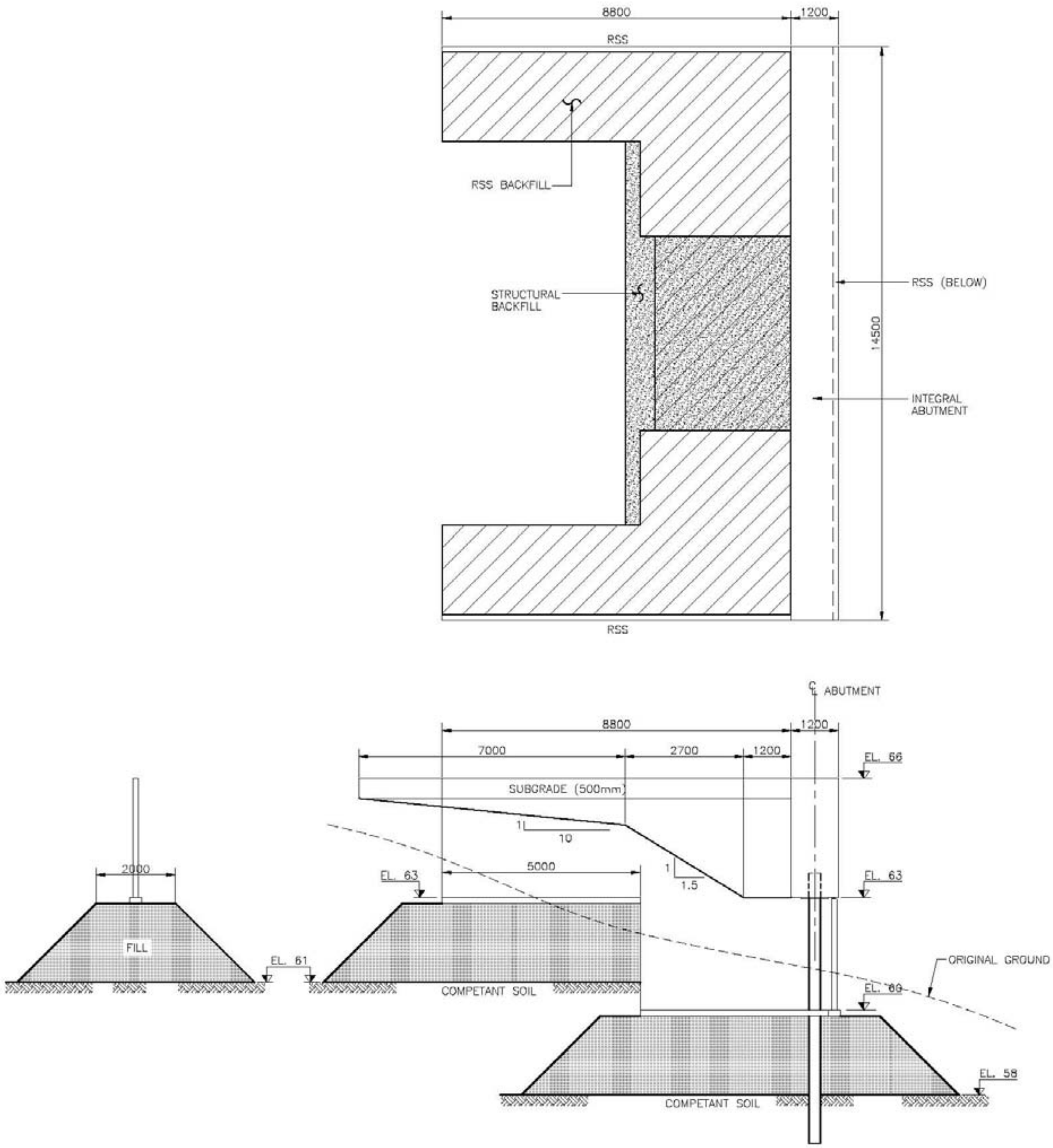


Figure 5.37: Example Backfill Calculation (Plan and Elevation).

Note: Fill under RSS levelling pad and under RSS False Abutment not shown on plan for clarity

1) **Calculation of RSS Backfill** (Refer to Figure 5.28 and 5.34)

At Low RSS Wingwall	Height at far end of RSS wingwall (lower height): = 3.0 m. Thickness of RSS Backfill: = 0.8 H = 0.8 x 3.0 = 2.4 m. Height of RSS Backfill: 3.0 m - 500mm subgrade = 2.5 m. Length of RSS Wingwall: = 5.0 m Quantity of RSS Backfill = 2.5 x 2.4 x 5.0 x 2 walls = 60.0 m^3.
At High RSS Wingwall	Height at abutment end of RSS wingwall (larger height): = 6.0 m. Thickness of RSS Backfill: = 0.8 H = 0.8 x 6.0 = 4.8 m. Height of RSS Backfill: 6.0 m - 500mm subgrade = 5.5 m. Length of RSS Wingwall: = 5.0 m. Quantity of RSS Backfill = (5.5 x 4.8 x 5.0 – 14.4*) x 2 walls = 235.2 m^3. * - *no fill at abutment stem = 1.2m x 2.5m high x 4.8m fill = 14.4 m^3*
At False Abutment	Height at abutment end of RSS false abutment: = 6.0 m. Thickness of RSS Backfill: = 0.8 H = 0.8 x 6.0 = 4.8 m. Height of RSS Backfill: 6.0 m - 3.0 m abutment = 3.0 m. Length of Backfill: = 14.5 m. – 2 x 4.8 m (fill counted with wingwall) = 4.9m Quantity of RSS Backfill = 3.0 x 4.8 x 4.9 = 70.6 m^3.
Sum	Total RSS Backfill = 60.0 + 235.2 + 70.6 = 365.8 m^3.

2) **Calculation of Backfill for Structure** (Refer to Figure 5.30 and 5.32)

At First 1200	For the backfill behind the abutment, 4.8m of backfill have been accounted for with the RSS fill. Height at abutment: = 3.0-0.5 (subgrade) = 2.5 m. Length: = 1.2 m. Width: 14.5 m - 2 x 4.8 = 4.9 m. Quantity of Backfill for Structure = 2.5 x 1.2 x 4.9 = 14.7 m^3.
At 1.5:1 taper	For the backfill at the 1.5:1 taper, 4.8m of backfill has been accounted for with the RSS fill. *(Actually, since the end of this taper and the end in the wingwall does not quite coincide, this assumption underestimates the backfill by 0.35 m^3.)* Height at start of frost taper: = 1.2 - 0.5 (subgrade) = 0.7 m. Length: = 2.7 m. Width: 14.5 m - 2 x 4.8 = 4.9 m. Quantity of Backfill for Structure = ½ (2.5 + 0.7) x 2.7 x 4.9 = 21.2 m^3.
At Frost Taper	For the backfill at the frost taper, 2.4m of backfill have been accounted for with the RSS fill. *(Actually, since the end of this taper and the step in the wingwall does not quite coincide, this assumption underestimates the backfill by 2.1 m^3.)* Length: = 7.0 m. Width: 14.5 m - 2 x 2.4 = 9.7 m. Quantity of Backfill for Structure = ½ (0.7) x 7.0 x 9.7 = 23.8 m^3.
Sum	Total Backfill for Structure = 14.7 + 21.2 + 23.8 = 59.7 m^3. *(Assumptions stated underestimated the actual quantity by 2.5 m^3 (4%).*

3) Calculation of Backfill for Levelling Pad [Refer to Section 5.3 bullet 2) and Figure 5.2]

	The levelling pad is required at both wingwalls (low and high portions) and at the false abutment Length of backfill required: 2 x 10.0 (wingwall) + 14.5 + 2 x 1.0 (beyond end of wall) = 36.5 m Height of Backfill = 2.0 m Width of backfill at base = 2 (1 x 2.0) + 2.0 = 6.0 m Quantity of Backfill for Levelling Pad = 36.5 x 2.0 x ½ (2.0 + 6.0) + 20.8 = 312.8 m^3. * - *sloped portion at ends of fill = 2 [½x2x2x2 +* $2x^{1}/_{3}x2^{2}x2=20.8\ m^{3}$.

5.4.6 CONCRETE IN BARRIER WALL FOOTING

This Tender Item (Item Code 904.0065) is measured in Cubic Metres. The Structural Standard drawings listed in Table 5.5 give the required footing size (along with the barrier dimensions and reinforcement) depending on the barrier type and wall length. As described in Section 4.3.3 and Appendix D, the Bridge Office Design Memo allows the barrier wall without railing (SS110-64) to be used in most locations requiring a PL3 barrier. The other barriers are for use with PL2 barriers. An excerpt from this Structural Standard drawing is provided in Figure 5.38. This is a "Structural Item" and is the responsibility of the Structural Designer to complete the drawing and determine quantities (in cubic metres). The reinforcing steel in the barrier wall footing and in the barrier wall, as well as the concrete in the barrier wall are paid under a separate items.

Table 5.5: Structural Standard Drawings for Barrier.

Drawing #	Title
SS110-64	Barrier Wall with out Railing – PL3 on RSS Wall, Stainless Steel Reinforcement.
SS110-65	Parapet Wall with Railing – PL2 on RSS Wall, Stainless Steel Reinforcement.
SS110-68	Barrier Wall with Railing – PL2 on RSS Wall, Stainless Steel Reinforcement.

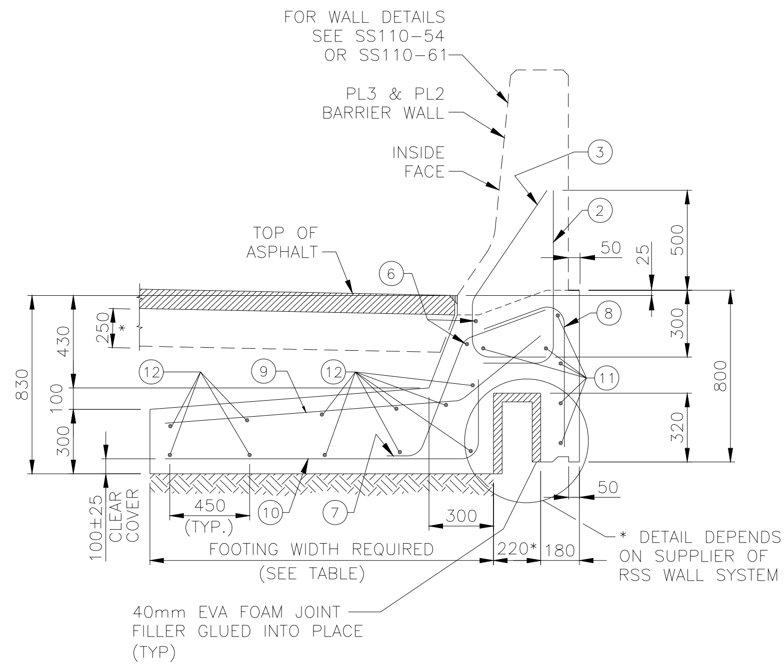


Figure 5.38: Footing for Barrier Wall on RSS.

5.4.7 CONCRETE IN BARRIER/PARAPET WALL

These Tender Items (Item Codes 904.0115, 904.0125, 904.0205 and 904.0210) are included with the Barrier Wall on the structure – there is no separate item for the portion of wall on the RSS. The exact type of barrier required depends on the location and several standard designs are provided in the Structural Manual. This is a Lump Sum, "Structural Item" and the item is the responsibility of the Structural Designer.

5.4.8 CSP AND FILL FOR PILES

This Tender Item shall be used for all locations requiring loose fill and/or CSP around the piles, including; single CSP, double CSP and concrete filled CSP situations. It shall also include the polystyrene, CSP, loose sand fill, concrete, and concrete pad under the double CSP's. This is a Lump Sum, "Structural Item" and is the responsibility of the Structural Designer. At the time of this writing, this tender item is in the process of being transferred to the list of standard items. It is preferable to have a separate tender item for these activities (as opposed to including them with the unit price Pile Item) since they are a fixed amount of work. In some situations, it may be possible (but not preferable) to include this work in the Pile Items, by using a Non-Standard Special Provision (NSSP).

5.5 SPECIAL PROVISIONS

The Special Provisions available for RSS is always changing and the latest versions should always be used. Details of the Special Provisions are available in Appendix B. At the time of this writing, there are the following Special Provisions available:

1) **Special Provision 599S22**

   This provision covers the design, submission, supply and construction requirement of RSS. This Special Provision is replaced by **Non-Standard Special Provision for RSS** (Jan. 2008). Do not use this SP.

2) **Special Provision 599S23**

   This provision covers the submission, material and quality control requirements for the concrete facing elements of RSS.

3) **Non Standard Special Provision for RSS** (Jan. 2008)

   This provision covers the design, submission, supply and construction requirement of RSS and is updated to conform to the methodologies of this report. This shall be used in place of SP 599S22.

4) **Non Standard Special Provision for CSP**

   This does not exist as a Standard Special Provision. An existing Non-Standard Special Provision (dated April 2004) can be modified to cover the requirements for all installations of CSP's around piles (if required), all concrete, sand fill and polystyrene sheets.

5) **Non Standard Special Provision for Finish of RSS Panels**

If a specific enhanced finish is required on the RSS, a separate NSSP should be added to describe the finish requirements.

6 CONTRACTOR AND SUPPLIER ROLE

For all RSS uses, the application, geometry, performance and appearance category is shown for each RSS application.

- The Contractor may use any Retained Soil System designated as A (Accepted) or DE
- (Demonstration) on the Designated Sources of Materials list that meets the specified project requirements. The RSS qualified as DE (Demonstration) must, for the first installation, inspect, install instrumentation and monitor the RSS for a period of one year. The monitoring results are presented in a report as detailed in the Generic Specification for RSS. The report is evaluated by the RSS Work Group to determine if the system achieves A (Accepted) status.
- The eligibility status of RSS for site-specific requirements can be determined by referring to the appropriate Designated Sources for Materials (DSM) list. The selected RSS must deliver the site-specific geometry requirements as illustrated in the contract drawings.
- The Contractor is given access to the Foundation Investigation Report (factual portion only) for use by the RSS supplier. The RSS supplier is responsible for the design of the system, including accommodation for all obstructions (such as catch basins, electrical conduits, etc.) that are shown in the Contract Drawings.
- The Contractor must obtain all design, construction and fabrication drawings and the specifications required to complete this work from the supplier of the proprietary RSS listed on the appropriate DSM list.
- The Contractor is responsible for completing the work in accordance with the construction specification for the RSS. The work shall consist of the design, supply and construction of the RSS including traffic barriers and base, finishing caps, where required, and including excavation, unwatering (a separate Tender Item if applicable) and backfilling for the construction of the RSS. The contractor is responsible for the performance of the installation, including internal stability of the RSS and external stability as affected by the RSS.
- The Contractor shall provide copies of all quality control tests required in the contract to the Contract Administrator (CA) as soon as they are available, as required in the specifications.
- Prior to the acceptance of the work by the Owner, the Contractor shall obtain a Certificate of Performance sealed and signed by the professional Engineer representing the RSS company and submit that certificate to the Contract Administrator, as required in the specifications. The certificate shall state that all the work has been completed in accordance with that RSS Company's requirements and to their satisfaction.
- The Contractor shall submit a warranty from the RSS Company to the Owner, and to implement any maintenance requirements to the system related to workmanship and material (including lack of vegetation and repair of concrete spalling) for a period of three years from the date of certification or completion of RSS works.
- Construction issues such as Quality Assurance acceptance and change proposals etc. should be referred back to the RSS Committee.

Where there is more than one RSS in the Contract, the Contractor shall select the RSS from the same DSM listing, including type and colour of facing elements (as stated in the specifications), according to the following groupings:

i) All RSS covered under the same tender item for payment;
ii) All RSS with the same Application, Performance and Appearance requirements that abut the same structure, existing and/or part of the work.

7 CONTRACT ADMINISTRATOR (CA) ROLE

For each RSS in the contract, the Contract Administrator (CA) is responsible for checking that the contractor has selected a wall or slope system that is approved on the RSS DSM list. This includes confirming that the selected RSS:

1. is approved for the application intended, e.g. false abutment, and
2. meets the performance, geometry and appearance criteria.

A checklist for RSS is contained in the CA Inspection Task Manual (CAITM).

A copy of the working drawings is sent to the Pavements and Foundations Section for information purposes.

RSS components and installation are verified by a Quality Verification Engineer (QVE) at interim stages and at completion of the RSS construction. Interim inspections are required for the following milestones:

a) Layout and marking of all lines and grades needed to construct the RSS; and construction of the alignment elements, where applicable;
b) Delivery and storage on site of facing elements and reinforcing elements, where applicable;
c) Installation of the facing elements; placement and compaction of the backfill for RSS; and installation of the reinforcing elements, where applicable.

A Milestone Inspection Report is prepared by the QVE for each of the interim and submitted prior to commencement of subsequent operations on that RSS.

For RSS where the design height is greater than 5.0 m, the Contractor shall submit a series of interim milestone reports corresponding to the constructed height of the RSS at 5.0 m, 10.0 m, and 15.0 m, as applicable, up to and including the design height.

Upon completion of each RSS the Contractor is required to submit a final Certificate of Conformance.

Backfill for structure and backfill for RSS are separate tender items that are measured on site. The RSS working drawings are required to include the quantity of RSS backfill.

8 REFERENCES

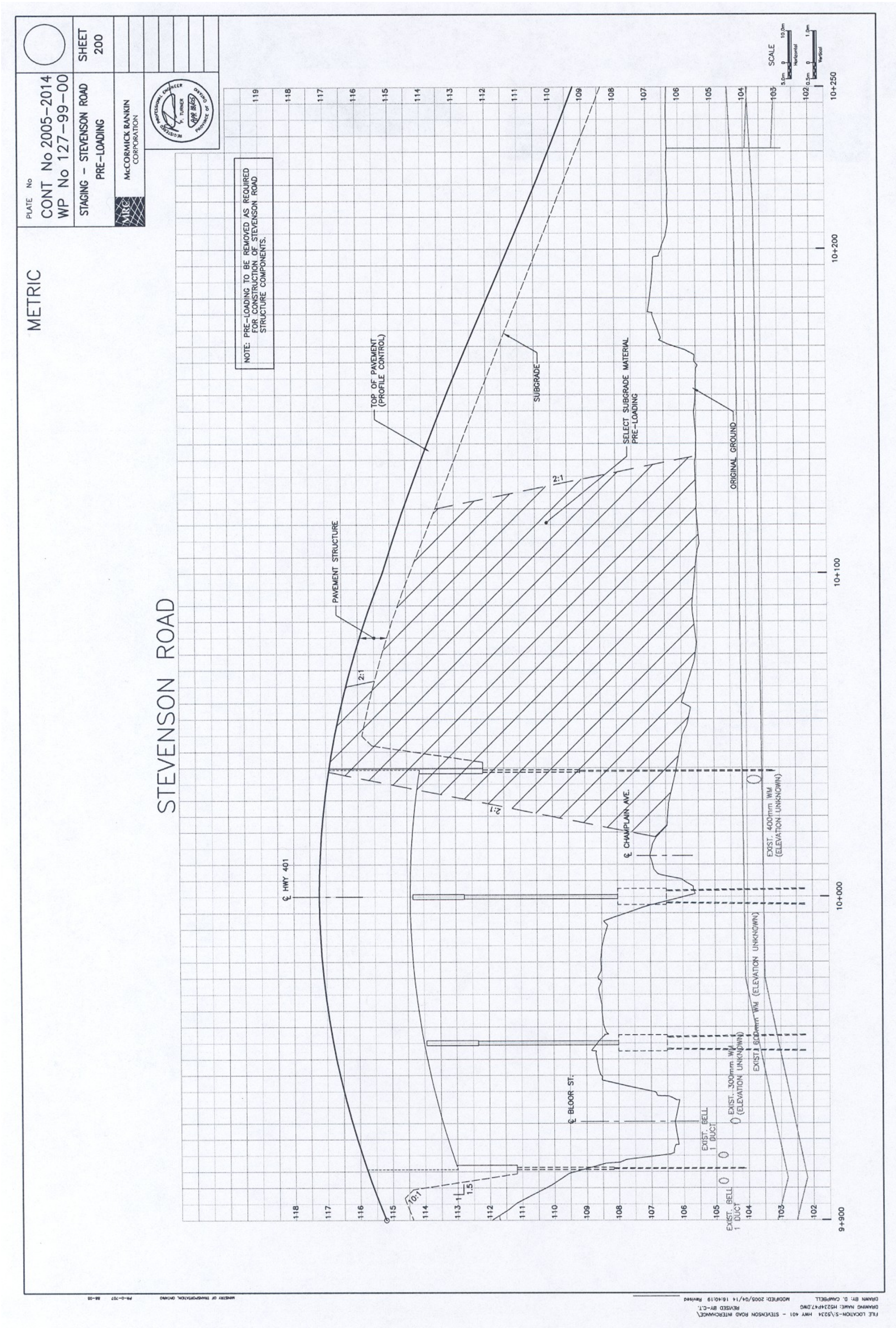
- “Canadian Highway Bridge Design Code (CHBDC)”, CAN/CSA-S6-00, December 2000.
- “Structural Manual”, Ontario Ministry of Transportation Publication, Engineering Standards Branch.
- Ontario Ministry of Transportation (MTO) and Ontario Good Roads Association (OGRA) Retained Soil Systems Seminar in November 25, 1999.
- “Contract Preparation System (CPS)”, Ontario Ministry of Transportation, 2001.
- “Semi-Integral Abutment Bridges”, Ontario Ministry of Transportation, Engineering Standards Branch, Structural Office Report SO-99-03.
- “Integral Abutment Bridges”, Husain, I., Bagnariol, D., Ontario Ministry of Transportation, Engineering Standards Branch, Structural Office Report SO-96-01.
- “Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines", Report Number FHWA-SA-96-071, Federal HighWay Administration.
- Bridge Office Design Bulletin, “Interim Design Guidelines of Traffic Barriers on Retained Soil System Retaining Walls”, November 1, 2005.
- “Designated Sources of Material (DSM)”, Ontario Ministry of Transportation/The Road Authority.

APPENDICES

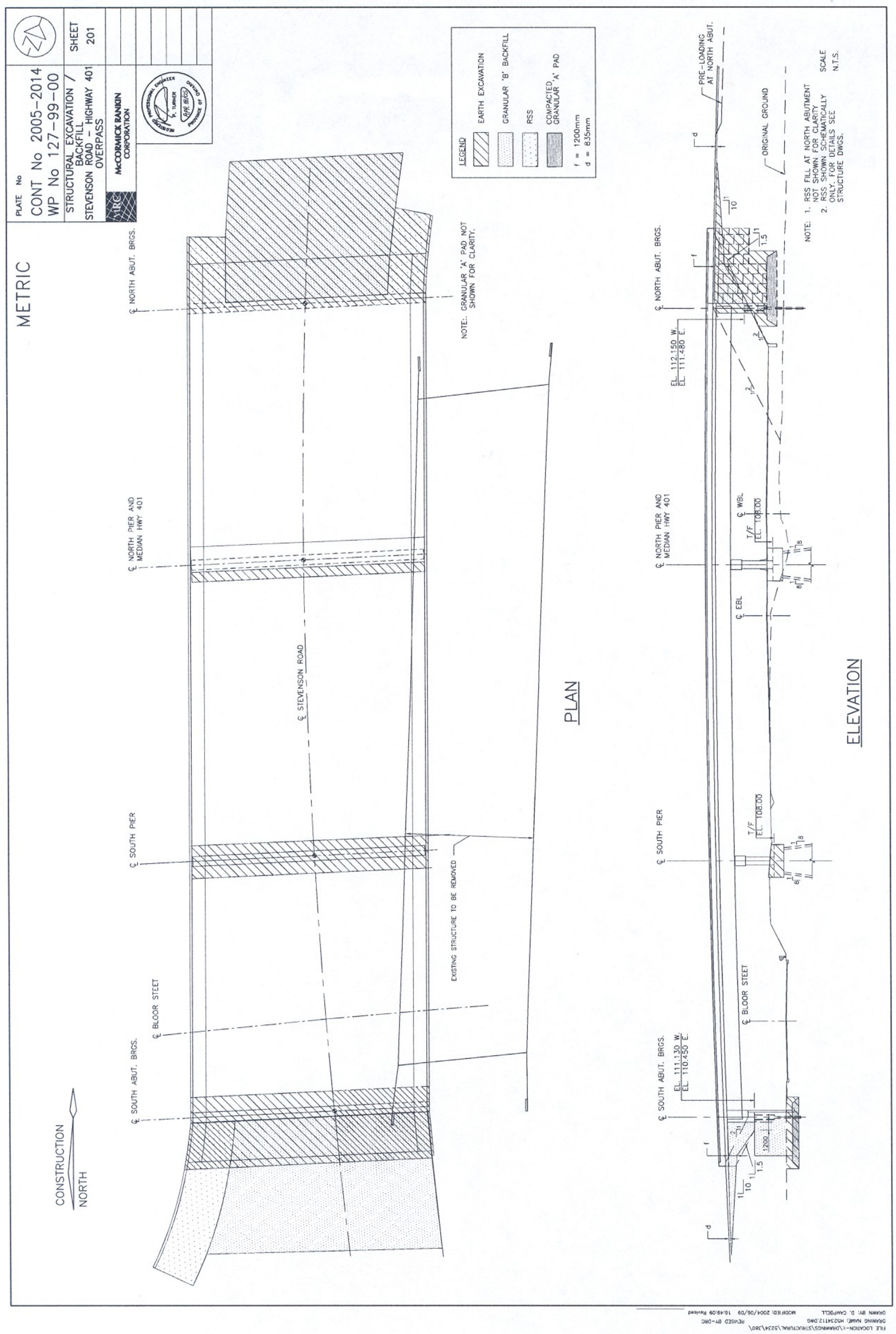
9 APPENDIX A – SAMPLE CONTRACT DRAWINGS

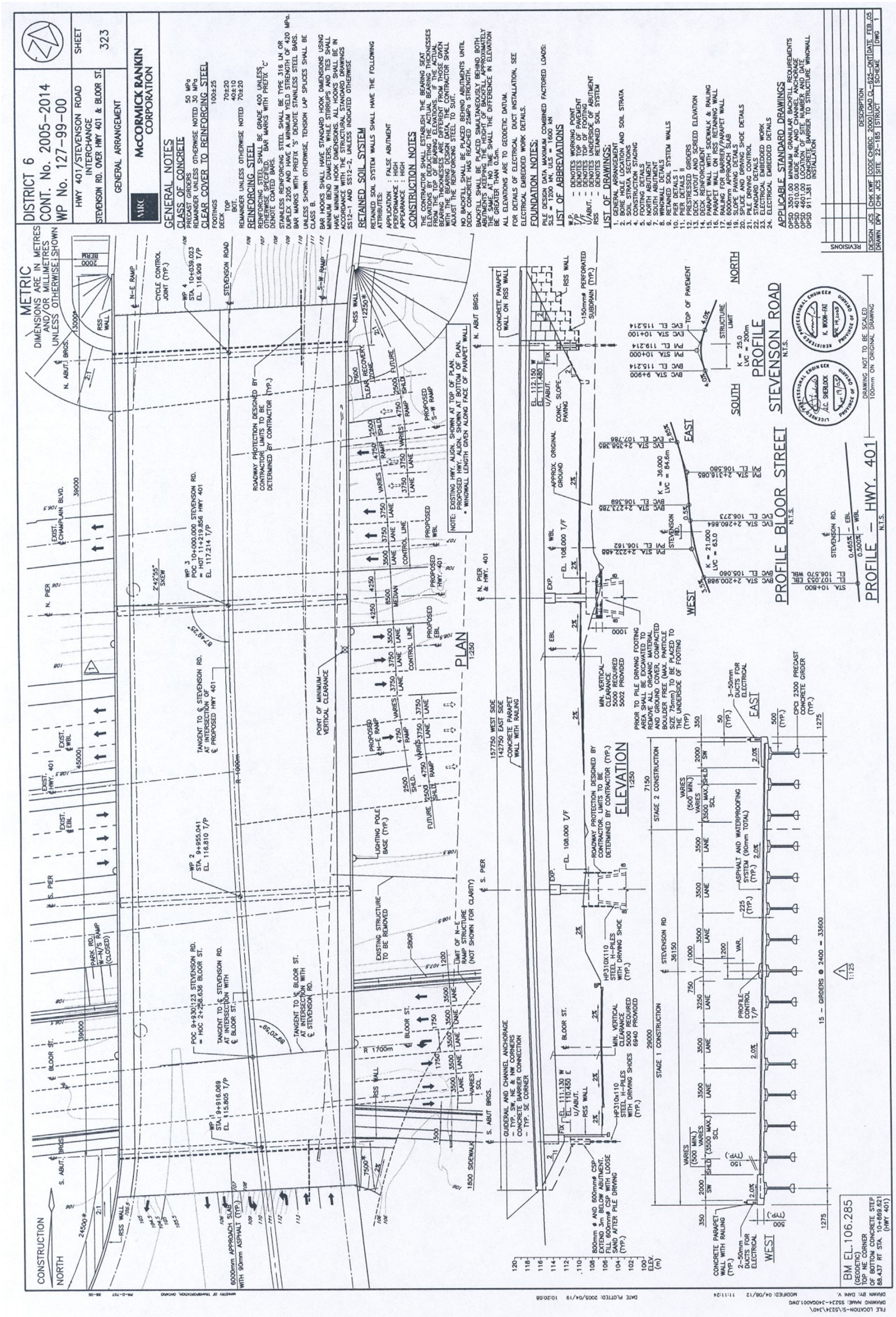
This Appendix shows several drawings from a typical Contact to illustrate the degree of information required.

Included are both the grading drawings and the structural drawings related to RSS.

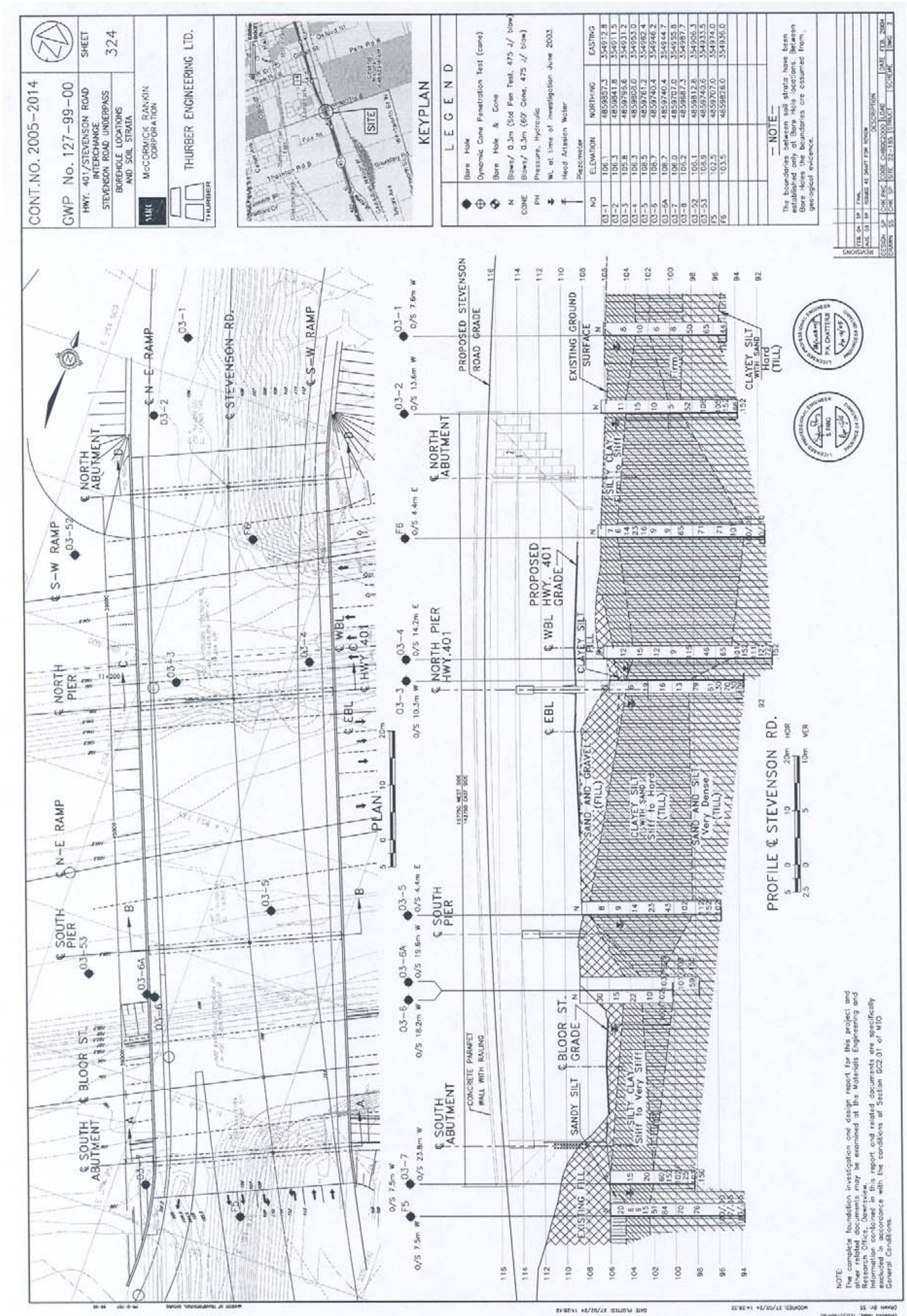


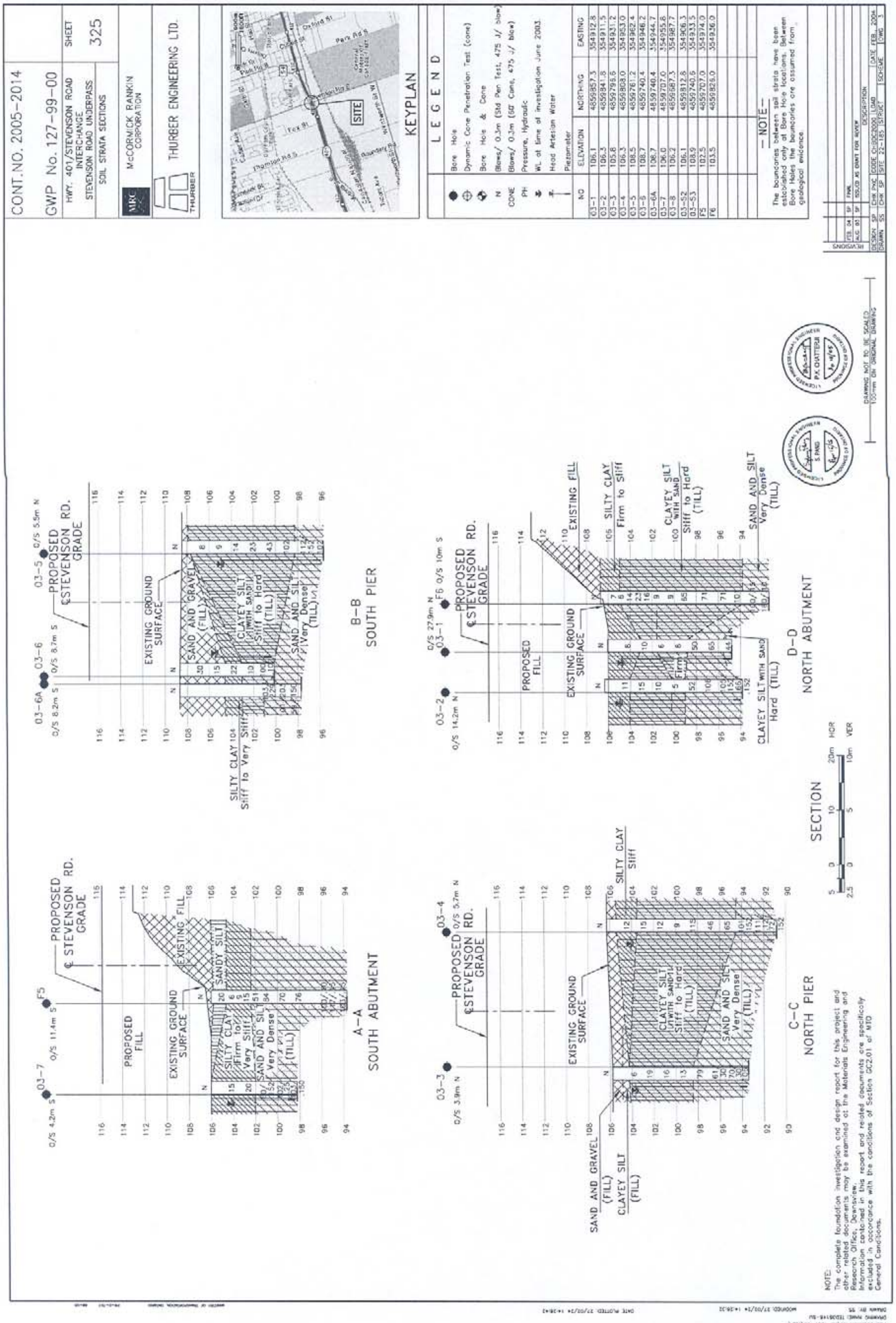
METRIC
STEVENSON ROAD
CONT No 2005-2014
WP No 127-99-00
STAGING - STEVENSON ROAD PRE-LOADING
SHEET 200
McCORMICK RANKIN CORPORATION
NOTE: PRE-LOADING TO BE REMOVED AS REQUIRED FOR CONSTRUCTION OF STEVENSON ROAD STRUCTURE COMPONENTS.
TOP OF PAVEMENT (PROFILE CONTROL)
SUBGRADE
SELECT SUBGRADE MATERIAL PRE-LOADING
ORIGINAL GROUND
PAVEMENT STRUCTURE
℄ HWY 401
℄ CHAMPLAIN AVE.
℄ BLOOR ST.
EXIST. 400mm WM (ELEVATION UNKNOWN)
EXIST. 300mm WM (ELEVATION UNKNOWN)
EXIST. BELL 1 DUCT
9+900
10+000
10+100
10+200
10+250
SCALE

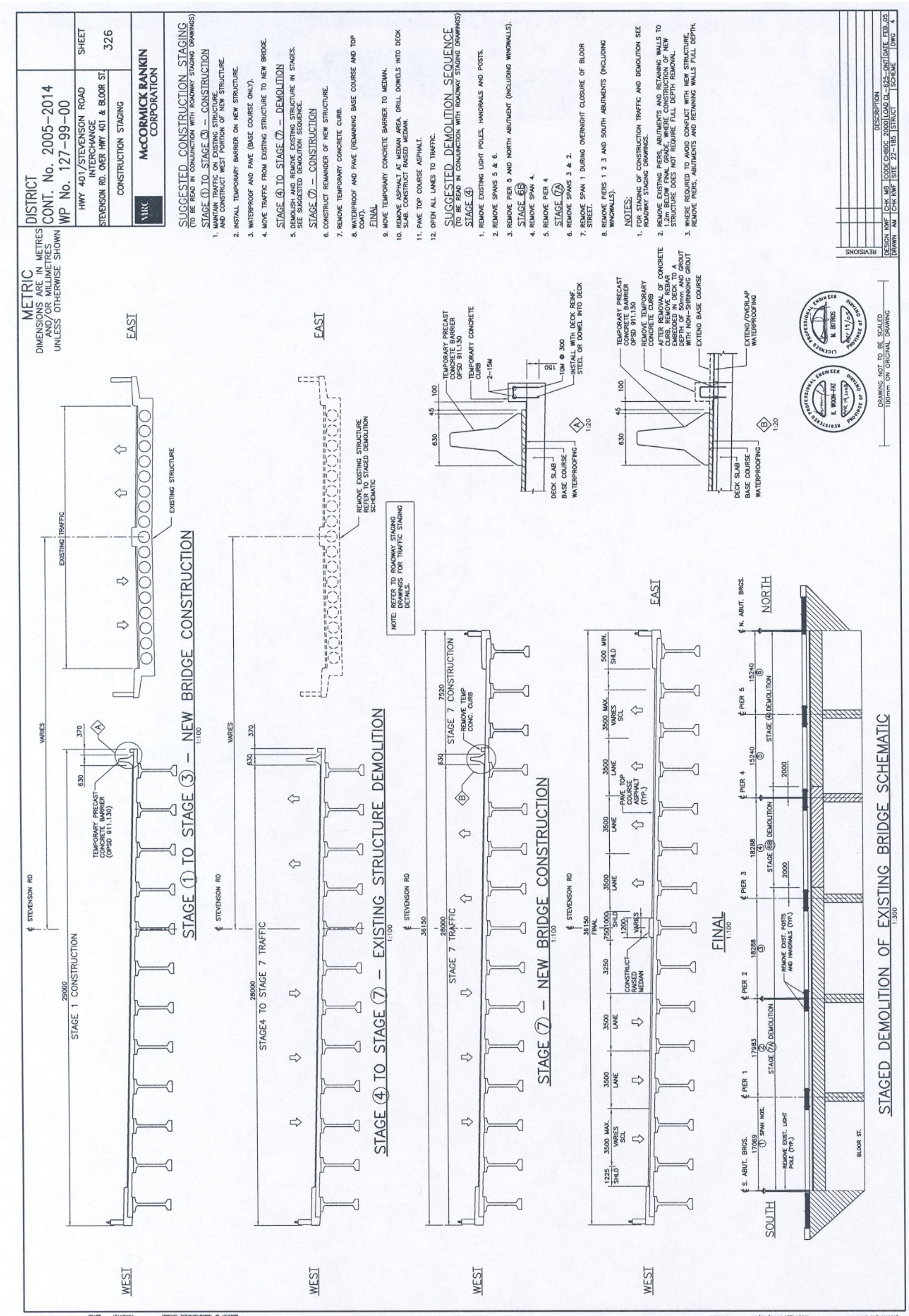

METRIC
PLATE No
CONT No 2005-2014
WP No 127-99-00
STRUCTURAL EXCAVATION / BACKFILL
STEVENSON ROAD - HIGHWAY 401 OVERPASS
McCORMICK RANKIN CORPORATION
SHEET
201
LEGEND
EARTH EXCAVATION
GRANULAR 'B' BACKFILL
RSS
COMPACTED GRANULAR 'A' PAD
f = 1200mm
d = 835mm
NOTE: GRANULAR 'A' PAD NOT SHOWN FOR CLARITY.
℄ NORTH ABUT. BRGS.
℄ NORTH PIER AND MEDIAN HWY 401
℄ STEVENSON ROAD
℄ SOUTH PIER
EXISTING STRUCTURE TO BE REMOVED
℄ BLOOR STEET
℄ SOUTH ABUT. BRGS.
CONSTRUCTION NORTH
PLAN
PRE-LOADING AT NORTH ABUT.
ORIGINAL GROUND
EL. 112.150 W.
EL. 111.480 E.
℄ WBL
T/F EL. 108.00
℄ EBL
EL. 111.130 W.
EL. 110.450 E.
ELEVATION
NOTE: 1. RSS FILL AT NORTH ABUTMENT NOT SHOWN FOR CLARITY
2. RSS SHOWN SCHEMATICALLY ONLY. FOR DETAILS SEE STRUCTURE DWGS.
SCALE
N.T.S.

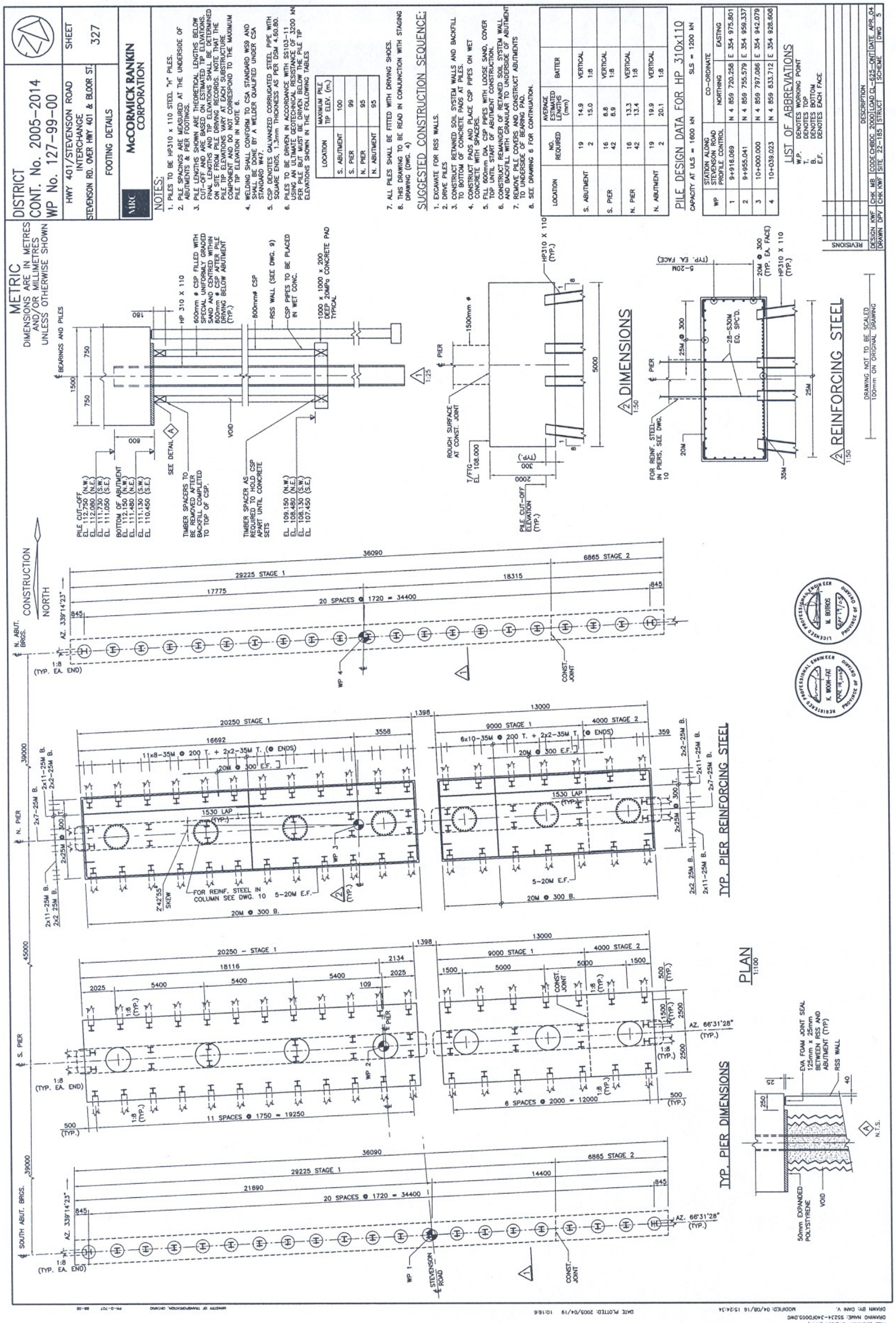


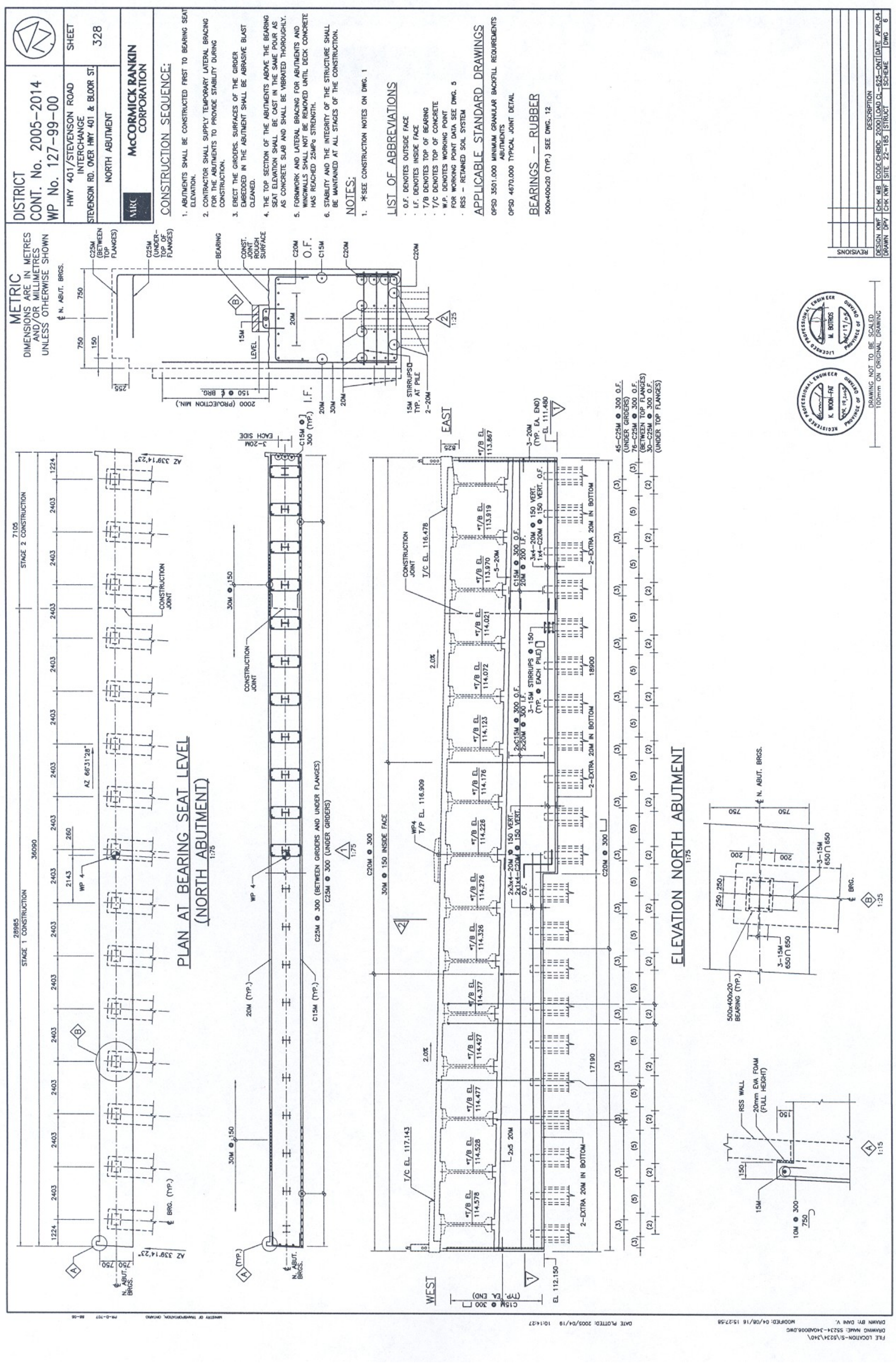
DISTRICT 6
CONT. No. 2005-2014
WP No. 127-99-00
HWY 401/STEVENSON ROAD INTERCHANGE
STEVENSON RD. OVER HWY 401 & BLOOR ST.
GENERAL ARRANGEMENT
McCORMICK RANKIN CORPORATION
SHEET
323
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN
GENERAL NOTES
PLAN
ELEVATION
PROFILE BLOOR STREET
PROFILE STEVENSON ROAD
PROFILE – HWY. 401

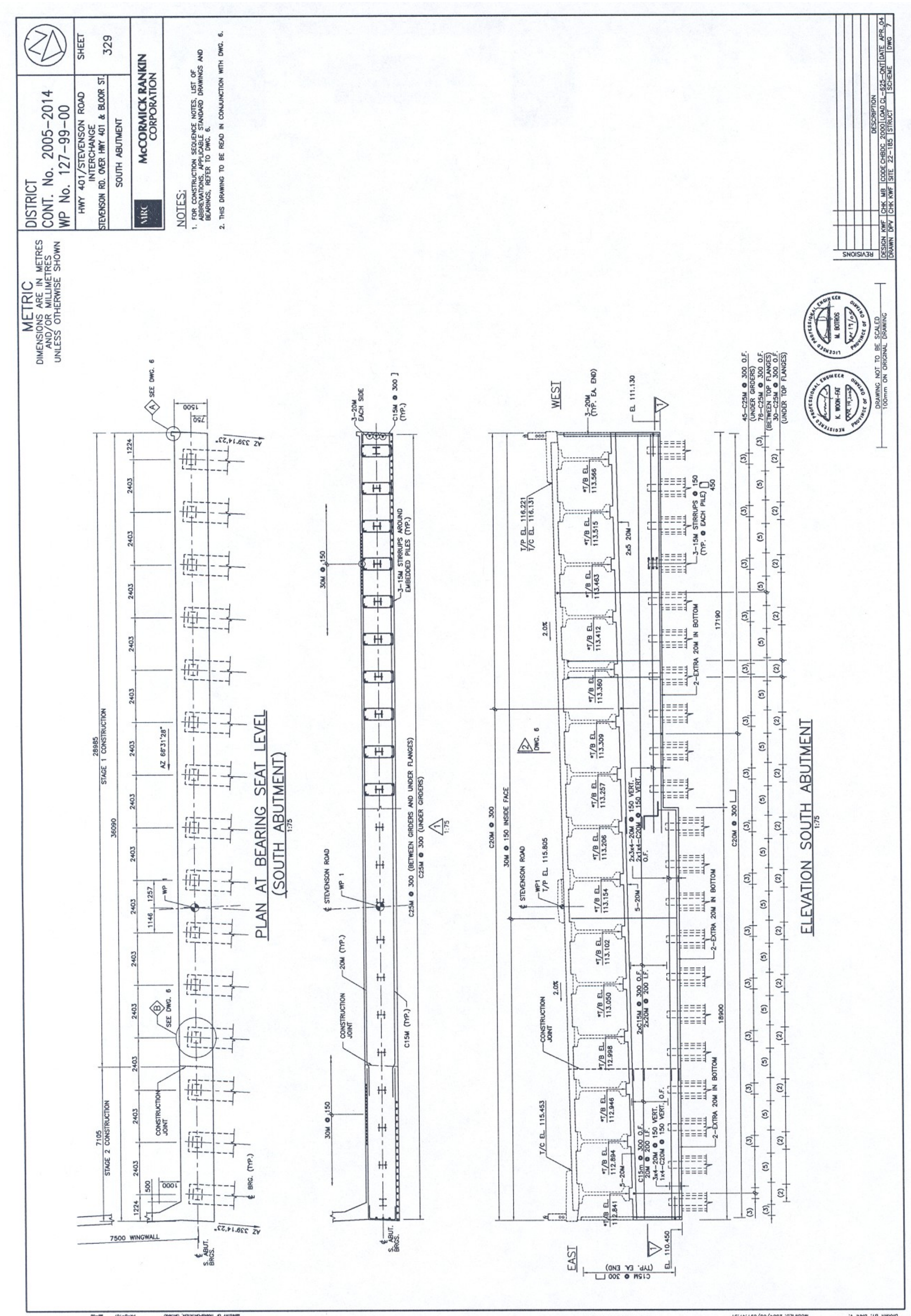

CONT.NO. 2005-2014
GWP No. 127-99-00
HWY. 401/STEVENSON ROAD INTERCHANGE
STEVENSON ROAD UNDERPASS
BOREHOLE LOCATIONS AND SOIL STRATA
McCORMICK RANKIN CORPORATION
THURBER ENGINEERING LTD.
SHEET
324
KEYPLAN
LEGEND
PLAN
PROFILE ℄ STEVENSON RD.
PROPOSED STEVENSON ROAD GRADE
EXISTING GROUND SURFACE
PROPOSED HWY. 401 GRADE
℄ NORTH ABUTMENT
℄ SOUTH ABUTMENT
℄ NORTH PIER
℄ SOUTH PIER
℄ STEVENSON RD.
℄ BLOOR ST.
℄ N-E RAMP
℄ S-W RAMP
℄ EBL
℄ WBL
— NOTE —

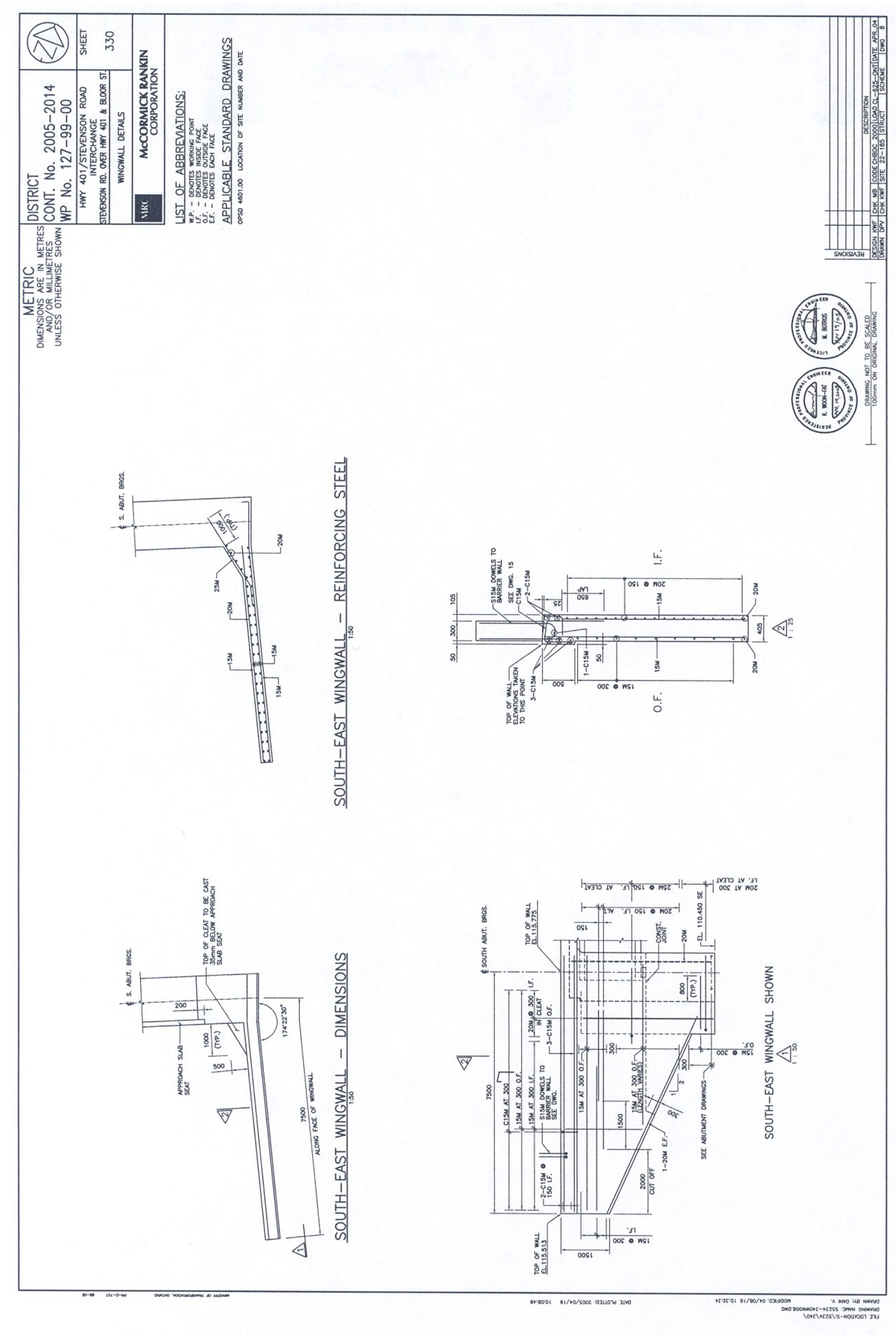

CONT. NO. 2005-2014
GWP No. 127-99-00
SHEET
325
SOIL STRATA SECTIONS
McCORMICK RANKIN CORPORATION
THURBER ENGINEERING LTD.
KEYPLAN
LEGEND
A-A
SOUTH ABUTMENT
B-B
SOUTH PIER
C-C
NORTH PIER
D-D
NORTH ABUTMENT
SECTION

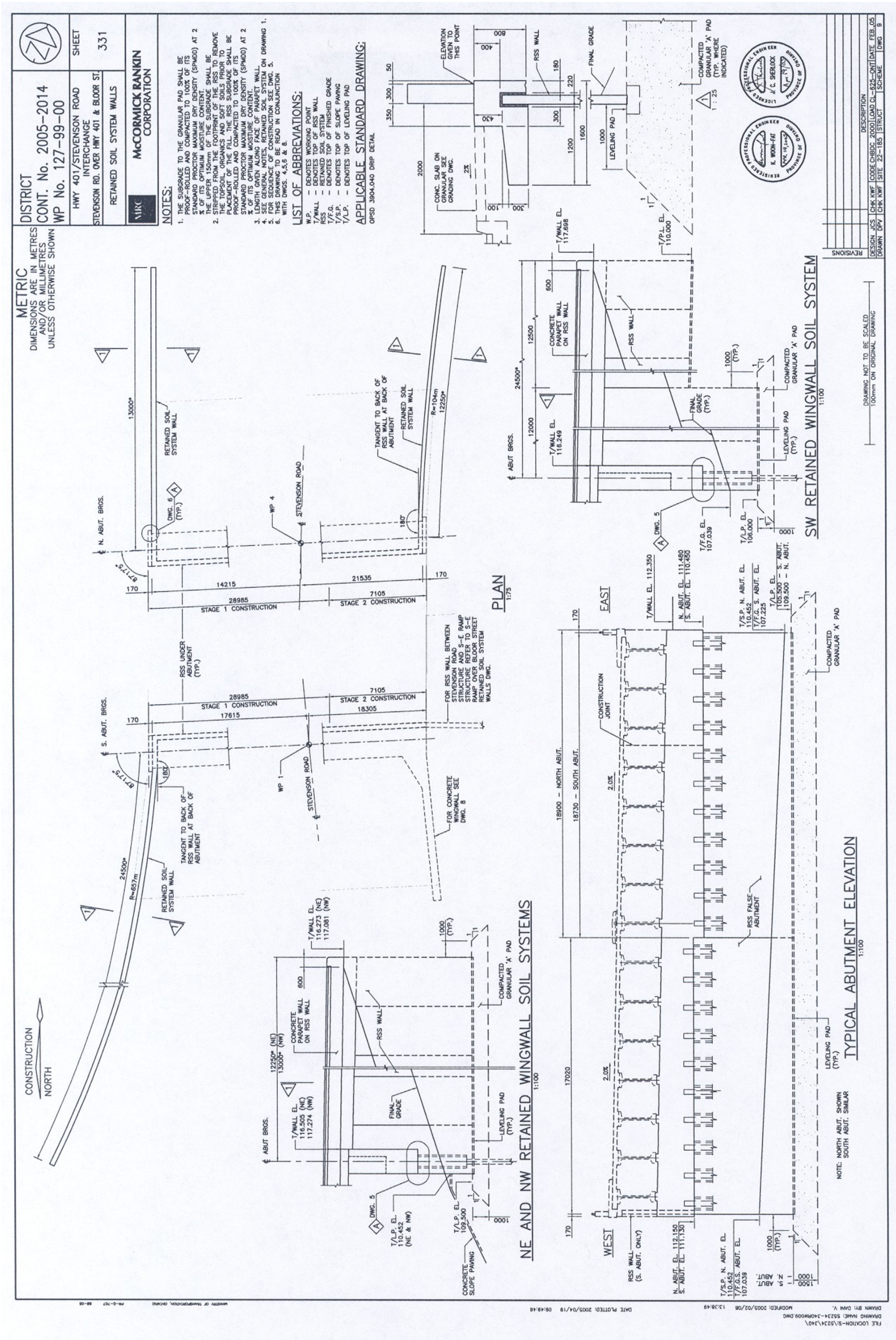

METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN
DISTRICT
CONT. No. 2005-2014
WP No. 127-99-00
HWY 401/STEVENSON ROAD INTERCHANGE
STEVENSON RD. OVER HWY 401 & BLOOR ST.
CONSTRUCTION STAGING
SHEET
326
McCORMICK RANKIN CORPORATION
SUGGESTED CONSTRUCTION STAGING
SUGGESTED DEMOLITION SEQUENCE
NOTES:
STAGE ① TO STAGE ③ - NEW BRIDGE CONSTRUCTION
STAGE ④ TO STAGE ⑦ - EXISTING STRUCTURE DEMOLITION
STAGE ⑦ - NEW BRIDGE CONSTRUCTION
FINAL
STAGED DEMOLITION OF EXISTING BRIDGE SCHEMATIC
WEST
EAST
SOUTH
NORTH
DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING


DISTRICT
CONT. No. 2005–2014
WP No. 127–99–00
HWY 401/STEVENSON ROAD INTERCHANGE
STEVENSON RD. OVER HWY 401 & BLOOR ST.
FOOTING DETAILS
SHEET
327
McCORMICK RANKIN CORPORATION
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN
NOTES:
SUGGESTED CONSTRUCTION SEQUENCE:
PILE DESIGN DATA FOR HP 310x110
LIST OF ABBREVIATIONS
DIMENSIONS
REINFORCING STEEL
PLAN
TYP. PIER REINFORCING STEEL
TYP. PIER DIMENSIONS


DISTRICT
CONT. No. 2005-2014
WP No. 127-99-00
HWY 401/STEVENSON ROAD INTERCHANGE
STEVENSON RD. OVER HWY 401 & BLOOR ST.
NORTH ABUTMENT
SHEET
328
McCORMICK RANKIN CORPORATION
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN
CONSTRUCTION SEQUENCE:
NOTES:
LIST OF ABBREVIATIONS
APPLICABLE STANDARD DRAWINGS
BEARINGS – RUBBER
PLAN AT BEARING SEAT LEVEL
(NORTH ABUTMENT)
ELEVATION NORTH ABUTMENT
WEST
EAST
DRAWING NOT TO BE SCALED 100mm ON ORIGINAL DRAWING
REVISIONS


METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN
DISTRICT
CONT. No. 2005-2014
WP No. 127-99-00
HWY 401/STEVENSON ROAD INTERCHANGE
STEVENSON RD. OVER HWY 401 & BLOOR ST
SOUTH ABUTMENT
SHEET
329
McCORMICK RANKIN CORPORATION
PLAN AT BEARING SEAT LEVEL
(SOUTH ABUTMENT)
ELEVATION SOUTH ABUTMENT
EAST
WEST


METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN
DISTRICT
CONT. No. 2005-2014
WP No. 127-99-00
HWY 401/STEVENSON ROAD INTERCHANGE
STEVENSON RD. OVER HWY 401 & BLOOR ST.
WINGWALL DETAILS
McCORMICK RANKIN CORPORATION
SHEET
330
LIST OF ABBREVIATIONS:
W.P. - DENOTES WORKING POINT
I.F. - DENOTES INSIDE FACE
O.F. - DENOTES OUTSIDE FACE
E.F. - DENOTES EACH FACE
APPLICABLE STANDARD DRAWINGS
OPSD 4601.00 LOCATION OF SITE NUMBER AND DATE
SOUTH-EAST WINGWALL – REINFORCING STEEL
1:50
SOUTH-EAST WINGWALL – DIMENSIONS
1:50
SOUTH-EAST WINGWALL SHOWN
1:50
DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING
REVISIONS



DISTRICT
CONT. No. 2005-2014
WP No. 127-99-00
HWY 401/STEVENSON ROAD INTERCHANGE
STEVENSON RD. OVER HWY 401 & BLOOR ST.
RETAINED SOIL SYSTEM WALLS
SHEET 331
McCORMICK RANKIN CORPORATION
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN
NOTES:
LIST OF ABBREVIATIONS:
APPLICABLE STANDARD DRAWING:
PLAN
SW RETAINED WINGWALL SOIL SYSTEM
NE AND NW RETAINED WINGWALL SOIL SYSTEMS
TYPICAL ABUTMENT ELEVATION
CONSTRUCTION NORTH

10 APPENDIX B – SPECIFICATIONS

Included in this Appendix is the new Non-Standard Special Provisions (NSSP) applicable with RSS systems. The Contract Preparation System (CPS) should always be referred to in order to obtain the current NSSP's. The Special Provision (SP599S23) relating to the concrete facing has not been included in this Appendix, but is available for the Contract Preparation System (CPS).

Page 1 of 9

RETAINED SOIL SYSTEM, TRUE ABUTMENT - Item No.
RETAINED SOIL SYSTEM, FALSE ABUTMENT - Item No.
RETAINED SOIL SYSTEM, WALL/SLOPE, HIGH PERFORMANCE - Item No.
BACKFILL FOR RETAINED SOIL SYSTEM, HIGH PERFORMANCE - Item No.
RETAINED SOIL SYSTEM, WALL/SLOPE, MEDIUM PERFORMANCE - Item No.
BACKFILL FOR RETAINED SOIL SYSTEM, MEDIUM PERFORMANCE - Item No.
RETAINED SOIL SYSTEM, WALL/SLOPE, LOW PERFORMANCE - Item No.
BACKFILL FOR RETAINED SOIL SYSTEM, LOW PERFORMANCE - Item No.

Non Standard Special Provision — January, 2008

1.0 SCOPE

This special provision covers the requirements for the design and construction of Retained Soil Systems (RSS) walls and steep slopes.

Additional requirements for RSS precast concrete facing elements shall be as specified in the Contract documents.

2.0 REFERENCES

This special provision refers to the following standards, specifications or publications:

Ontario Provincial Standard Specifications, General:

OPSS 102	Weighing of Materials
OPSS 180	Management and Disposal of Excess Materials

Ontario Provincial Standard Specifications, Construction

OPSS 501	Compacting

Canadian Standards Association Standards:

CAN/CSA-S6-00	Canadian Highway Bridge Design Code (CHBDC)

Ministry of Transportation Publications:

MTO Designated Sources of Materials (DSM)
Qualification Criteria for RSS

3.0 DEFINITIONS

For the purposes of this special provision the following definitions apply:

Alignment Elements: means components specified by the manufacturer that are constructed on the foundation for RSS to facilitate placing of the facing elements to the correct lines and grades, such as concrete levelling pads and soldier piles.

Approved Product Drawings: means the documentation for an RSS that has been submitted by the manufacturer and accepted by the Ministry for listing in the DSM, according to the Qualification Criteria for RSS.

Backfill for RSS: means the material specified by the manufacturer as part of the engineered materials comprising the backfill for the RSS.

Constructed Height: means the vertical distance between the foundation for RSS and the top of the currently placed and compacted backfill for RSS, measured at the point of the design height.

Corrective Work: means work carried out by the Contractor to repair deficiencies identified by the Owner during the RSS warranty period.

Design Checking Engineer: means the Engineer retained by the Contractor who checks the original design and working drawings.

Design Engineer: means the Engineer retained by the Contractor who produces the original design and working drawings.

Design Height: means the maximum difference in elevation between the foundation for RSS and the corresponding top of backfill for RSS, over the full length or perimeter of the RSS.

External Stability: means stability against deep-seated failure of the foundation for RSS, including adequate bearing capacity at specified settlements of the foundation.

Facing Elements: means components specified by the manufacturer that delineate the front face of the RSS and to which reinforcing elements may be attached, such as precast concrete panels, split-face concrete blocks, and geo-synthetic panels.

Foundation for RSS: means the base on which the RSS is constructed, such as excavation to a specified elevation and construction of a granular 'A' pad.

Internal Stability: means stability against failure of the engineered materials comprising the RSS, including adequate resistance against excessive elongation, breakage and pullout of the reinforcing elements.

Manufacturer: means the firm who supplies the design and proprietary components, and who specifies the backfill and other materials, for the RSS selected by the Contractor.

Manufacturer's Representative: means an individual with continuous full-time employment with the manufacturer for a period of at least three (3) years, and who is knowledgeable in the design and construction of the RSS selected by the Contractor.

Obstruction: means any part of the work and any existing condition within the Contract limits that affects the design, construction and performance of the RSS, such as structures, catch basins and manholes, drainage pipes and sewers, and utilities.

Performance Tolerance – Local: means the joint gap between any two constructed facing elements, measured at any point along the joint between the facing elements and perpendicular to the line of the joint.

Performance Tolerance – Global: means the vector distance between any point on the constructed RSS and the corresponding point on the theoretical RSS surface as defined in the Contract documents.

Placing Tolerances: means tolerances specified by the manufacturer on the placing of the RSS components and backfill for RSS to ensure compliance of the constructed RSS with the performance tolerances.

Reinforcing Elements: means components specified by the manufacturer that are placed within the backfill for RSS and connected to the facing elements to mechanically stabilize the backfill for RSS, such as metal tie strips, metal grids and geo-synthetic grids,

Retained Soil System (RSS): means a proprietary system listed in the DSM used to retain horizontal loads for applications such as true and false abutment structures, retaining walls and steep slopes; or, to retain vertical loads for applications such as embankments over soft ground.

RSS Superintendent: means the Contractor's authorized representative in responsible charge of the construction of the RSS.

Structure: means any bridge, culvert, tunnel, retaining wall, overhead sign, high mast light pole, wharf, dock, or any part thereof.

4.0 SUBMISSION AND DESIGN REQUIREMENTS

4.1 Submissions

4.1.1 Working Drawings

The Contractor shall submit working drawings for all RSS. A separate submission shall be made for each RSS in the Contract. All submissions shall bear the seal and signature of the Design Engineer and the Design Checking Engineer.

The RSS Superintendent shall have a copy of the working drawings on site at all times during the construction of the RSS.

At least two weeks prior to commencement of construction of the RSS, the Contractor shall submit to the Contract Administrator, for information purposes only, three (3) sets of the working drawings.

4.1.2 Working Drawing Requirements

Working drawings shall include at least the following:

- Statement from the manufacturer confirming the experience and expertise of the Design Engineer and Design Checking Engineer to provide design services for the manufacturer's RSS;
- All design, fabrication and construction drawings and specifications for the RSS;
- Location and value of the design height of the RSS;
- Defined lines and grades, type, and quantity in m^3 of the backfill for RSS;

- Details at obstructions, and connections to other structures, where shown in the Contract drawings;
- Statement of bearing resistance required by the RSS foundation according to the CHBDC;
- Statement of satisfactory internal and external stability;
- Placing tolerances for the RSS.

4.1.3 RSS Superintendent

At least two weeks prior to commencement of construction of the RSS, the Contractor shall submit in writing to the Contract Administrator the name(s) of the RSS Superintendent for each RSS in the Contract.

During construction of an RSS, the Contractor shall not change the RSS Superintendent for that RSS without written permission from the Contract Administrator. The Contractor shall submit in writing to the Contract Administrator the proposed change for RSS Superintendent at least one week prior to the actual change in RSS Superintendent.

4.1.4 Manufacturer's Representative

At least two weeks prior to commencement of construction of the RSS, the Contractor shall submit in writing to the Contract Administrator the name(s) of the manufacturer's representative for each RSS in the Contract.

For each occasion the Contractor arranges for the manufacturer's representative to be on site, the Contractor shall submit 48 hours advance notice in writing to the Contract Administrator giving the dates and locations the manufacturer's representative will be on site.

4.1.5 Certificates of Conformance

For each RSS in the Contract, the Contractor shall submit to the Contract Administrator a Certificate of Conformance sealed and signed by the QVE upon completion of the RSS.

4.1.6 Milestone Inspection

For each RSS in the Contract, the Contractor shall submit to the Contract Administratora Milestone Inspection Report following an Interim Inspection by the QVE at each of the following milestones, and prior to commencement of subsequent operations on that RSS:

a) Layout and marking of all lines and grades needed to construct the RSS; and construction of the alignment elements, where applicable;
b) Delivery and storage on site of facing elements and reinforcing elements, where applicable;
c) Installation of the facing elements; placement and compaction of the backfill for RSS; and installation of the reinforcing elements, where applicable;

For RSS where the design height is greater than 5.0 m, the Contractor shall submit a series of Written Permissions to Proceed for milestone c) corresponding to the constructed height of the RSS at 5.0 m, 10.0 m, and 15.0 m, as applicable, up to and including the design height.

The Milestone Inspection submissions in no way supersede the inspection and testing intervals required for the construction of the RSS, as specified in the working drawings.

4.1.7 RSS Warranty

The Contractor shall submit a warranty to the Owner to address all deficiencies identified by the Owner related to the performance of the RSS for a period of 36 months from the date of certification of completion of the Contract.

4.1.8 Repair Procedures for Corrective Work

At least two weeks prior to commencement of any corrective work at an RSS during the warranty period, the Contractor shall submit to the Manager of Contracts, for information purposes only, three copies of his repair procedures for that RSS.

The repair procedures shall include a description of the cause and fully detail the corrective work required to correct the deficiencies identified by the Owner.

The repair procedures shall bear the seal and signature of an Engineer (who may be different than the Design Engineer and Design Checking Engineer), and be signed by the manufacturer's representative.

4.2 Design

4.2.1 General

The Contractor shall be responsible for the design of the RSS and for ensuring the RSS as designed is compatible with the work.

The geometric requirements of the RSS, such as lines and grades of the facing elements and typical cross-sections, shall be as specified in the Contract drawings.

The foundation for RSS shall be as specified in the Contract documents.

4.2.2 RSS Selection

The Contractor shall select an RSS from the DSM that meets the Application, Performance and Appearance requirements for that RSS, as specified in the Contract drawings.

The Contractor shall select an RSS from the DSM designated as either 'A' (Accepted) or 'DE' (Demonstration). RSS designated as 'DE' status require inspection, instrumentation and monitoring of the constructed RSS, and reporting of the findings to the Ministry by the manufacturer, according to the Qualification Criteria for RSS.

Where there is more than one RSS in the Contract, the Contractor shall select the RSS from the same DSM listing, including type and colour of facing elements, according to the following groupings:

a) All RSS covered under the same tender item number(s) for payment;

b) All RSS with the same Performance and Appearance requirements that abut the same structure, existing and/or part of the work.

4.2.3 Performance Tolerances

Performance tolerances for the RSS shall be according to Table 1.

TABLE 1 – PERFORMANCE TOLERANCES FOR RSS		
Performance Requirement	Performance Tolerance (mm)	
	Local	Global
Abutments	Joint Gap[1] ± 5	≤ 20
High	Joint Gap[1] ± 10	≤ 30
Medium	N/A	≤ 50
Low	N/A	≤ 100

Note 1.: Joint Gap shall be as specified in the working drawings.

4.2.4 Obstructions

The Contractor shall be responsible for developing design details of the RSS at obstructions, for all obstructions shown in the Contract drawings.

Where an obstruction is shown in the Contract drawings but not located to sufficient accuracy for the design of the RSS, the Contractor shall locate the obstruction in the field to sufficient accuracy as required to design the RSS.

4.2.5 Foundation Report

A Foundation Investigation Report that describes the subsurface conditions at the RSS is available, as specified in the Contract documents.

The Owner warrants the data in the Foundation Investigation Report, except that interpretations of the data and opinions expressed in the Foundation Investigation Report are not warranted.

5.0 MATERIALS

5.1 General

All materials for the selected RSS shall be according to the Approved Product Drawings for that RSS.

6.0 EQUIPMENT

6.1 Restriction on Skid-Steer Vehicles

Skid-steer vehicles will not be permitted on any area where the depth of backfill for RSS over installed reinforcing elements is less than 0.5 m.

7.0 CONSTRUCTION

7.1 General

The RSS shall be constructed according to the working drawings and this Special Provision.

Construction of the RSS shall not commence until the Contractor has submitted all applicable Certificates of Conformance for the foundation for RSS.

7.2 RSS Superintendent

The Contractor shall schedule his operations such that the construction of an RSS is at all times under the responsible charge of an RSS Superintendent who has been advised on site by the manufacturer's representative as to the required procedures for the construction of that RSS, for the specified operations and time periods.

7.3 Manufacturer's Representative

The manufacturer's representative shall be on site to advise the RSS Superintendent as to the procedures and placing tolerances required for the construction of the RSS.

For each RSS in the Contract, the Contractor shall arrange for the manufacturer's representative to be on site at commencement of each of the following operations, for a time period of three (3) working days per operation or until the operation is complete, whichever is less:

a) Layout of the RSS; and construction of the alignment elements, where applicable;
b) Installation of the facing elements;
c) Placement and compaction of the backfill for RSS; and installation of the reinforcing elements, where applicable.

Whenever there is a change in the RSS Superintendent during construction of an RSS, the Contractor shall arrange for the manufacturer's representative to return to the site for the same operations and time periods as at commencement.

7.4 Backfill for RSS

Backfill for RSS shall be placed within the lines and grades shown on the working drawings. All backfill for RSS shall be compacted according to OPSS 501.

Unless otherwise shown in the Contract drawings, the Contractor shall not place backfill for RSS against an adjacent concrete structure that is part of the work until the concrete in that structure has obtained a compressive strength at least 70% of the concrete strength specified in the Contract.

7.5 Management of Excess Materials

Management of excess materials shall be according to OPSS 180.

7.6 Corrective Work

At least one week prior to commencement of any corrective work at an RSS during the warranty period, the Contractor shall submit written notice of commencement to the Manager of Contracts.

The Contractor shall repair all deficiencies according to the repair procedures for corrective work. All corrective work shall be done within the RSS warranty period, unless prevented by seasonal shutdown, in which case the corrective work shall be done during the first eight weeks of the following construction season.

The Contractor shall provide access to the corrective work for inspection by the Owner when requested.

8.0 QUALITY ASSURANCE

8.1 Acceptance Criteria at End of the RSS Warranty Period

The Owner will accept the RSS at the end of the RSS warranty period if none of the deficiencies listed in Table 2 are found during the warranty inspections. Where deficiencies are found, the RSS will not be accepted until the Contractor has carried out corrective work to repair the deficiencies.

TABLE 2 – RSS DEFICIENCIES	
Number	Description of Deficiency
1.	Performance tolerance exceeds tolerances given in Table 1.
2.	Damaged facing elements and damaged alignment elements, where applicable.
3.	Dead and dying vegetative elements that are an integral part of the RSS.

8.2 Warranty Inspections

Throughout the warranty period the Owner will carry out warranty inspections of the RSS for deficiencies as per Table 2. The Owner will notify the Contractor as to the date and time of the inspection(s) and the Contractor may, at his discretion, be present during the inspection(s).

Within two weeks following a warranty inspection the Owner will notify the Contractor in writing of all deficiencies that require corrective work.

9.0 MEASUREMENT FOR PAYMENT

9.1 Actual Measurement

9.1.1 Backfill for Retained Soil System, High Performance
Backfill for Retained Soil System, Medium Performance
Backfill for Retained Soil System, Low Performance

Measurement will be of the mass in tonnes of the material placed within the theoretical lines and grades shown in the stamped working drawings. The method of determining the mass shall be according to OPSS 102.

10.0 BASIS OF PAYMENT

10.1 Retained Soil System, True Abutment - Item
Retained Soil System, False Abutment - Item
Retained Soil System, Wall/Slope, High Performance – Item
Retained Soil System, Wall/Slope, Medium Performance – Item
Retained Soil System, Wall/Slope, Low Performance – Item

Payment at the contract price for the above tender items shall be full compensation for all labour, equipment and material to do the work, including all costs associated with the manufacturer's representative on site.

Payment for construction of the foundation for RSS will be made under the appropriate tender items in the Contract.

No payment will be made for corrective work, including investigation of deficiencies, design of repairs, site access, traffic staging and removal of existing work, except where the corrective work is required as a result other than an act or fault of the Contractor.

10.2 Backfill for Retained Soil System, High Performance – Item
Backfill for Retained Soil System, Medium Performance – Item
Backfill for Retained Soil System, Low Performance – Item

Payment at the contract price for the above tender items shall be full compensation for all labour, equipment and material to do the work.

When the Contract does not contain a separate tender item for backfill for RSS, the contract price for the RSS contract items in which the backfill for RSS is incorporated shall include full compensation for all labour, equipment and material required to place and compact the backfill for RSS.

WARRANT: Always with these tender items.

11 APPENDIX C – BRIDGE OFFICE DESIGN BULLETIN (RSS)

Ontario

Ministry of Transportation — Ministère des Transports

Bridge Office
Engineering Standards Branch
301 St Paul St., 2nd Floor
St Catharines, ON L2R 7R4
Tel: (905) 704-2406 Fax: (905) 704-2060

MEMORANDUM

DATE: December 8, 2005

FROM: Bala Tharmabala
Manager, Bridge Office

TO: Distribution List (attached)

RE: Bridge Office Design Bulletin
Changes to RSS Design Requirements and Construction Specification

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Purpose

This bulletin is an interim guide on changes to the design and contract documentation preparation for retained soil system (RSS) retaining walls and abutments.

Background

Following a review of the performance of retained soil systems across the Regions, changes have been recommended to the RSS construction specification and the contract design and documentation process. The previous specification placed the onus on the contractor to design and build the appropriate RSS based on the specified application and performance attributes. The suitability of the founding stratum and global stability were also the contractor's responsibility. This situation has resulted in the construction of some RSS that have excessive settlement and large irregularities in the wall facia. In order to improve the quality of construction a new revised construction specification replacing SP 599S22 has been written which now transfers some of the design responsibility back to the MTO designer and geotechnical consultant. The changes require an increased effort in the design phase to improve the short and long term performance of RSS, including specific consideration of the suitability of the founding stratum in the soil report and the necessity of any sub-excavation.

In the past there has been some confusion regarding whether the excavation and backfilling behind the RSS is part of the RSS tender item and how to quantify them in relation to the adjoining granular when the specific RSS system is not known. This bulletin endeavours to clarify how this work is to be handled and which tender items are to be used. Hopefully these new changes will maintain consistency across the Regions.

Design and Contract Preparation

Contract drawings

Where the designer previously identified the RSS application and performance levels as well as basic geometry requirements for the RSS in the contract drawings, contracts specifying RSS shall now, in addition, also include the following:

- Foundation for RSS – the designer is responsible for identifying the elevation of the RSS foundation, including any sub-excavation and replacement of founding materials; the drawings shall also include the elevations for stepped foundations. Since the actual system is not known during contract preparation, the designer shall make a conservative but reasonable assumption based on the systems in the DSM and the final quantities could be adjusted in the field.
- Excavation limits for RSS shall be identified in the grading and structural drawings. Plan dimensions of excavation may be confirmed with the Pavements and Foundations Section.
- Quantities for 'Backfill for RSS' volumes shall be calculated and included in the grading quantity sheets. Method of calculating backfill quantity may be confirmed with the Pavements and Foundations Section; quantity calculations shall generally be based on a 80% ratio of RSS reinforcing element embedment to RSS wall height.
- Concrete traffic barrier on RSS: see Bridge Office Design Bulletin "Interim Design Guidelines of Traffic Barriers on Retained Soil System Retaining Walls" dated November 1, 2005.

Designers are reminded that retained soil systems are flexible systems and could undergo more movements compared to conventional retaining walls. The designer must assess the suitability of using RSS for the site-specific conditions and be satisfied that the RSS will perform as intended both aesthetically and structurally.

The RSS Supplier is still responsible for the quality and performance of their product, however, more details and more specific requirements will be provided in the contract to ensure consistent quality in the final product.

Construction and Material Specifications

The standard special provision SP599S22 dated March 2001, which is the construction specification for RSS, will be replaced by an interim NSSP that can be obtained from Pavement and Foundations Section. Standard special provision SP599S23 for materials has not been changed and shall also be included in the contract documents for the respective RSS tender item.

Tender Items

The tender items of the revised RSS specification include:

RETAINED SOIL SYSTEM, TRUE ABUTMENT - Item No.
RETAINED SOIL SYSTEM, FALSE ABUTMENT - Item No.
RETAINED SOIL SYSTEM, WALL/SLOPE, HIGH PERFORMANCE - Item No.
BACKFILL FOR RETAINED SOIL SYSTEM, HIGH PERFORMANCE - Item No.
RETAINED SOIL SYSTEM, WALL/SLOPE, MEDIUM PERFORMANCE - Item No.

BACKFILL FOR RETAINED SOIL SYSTEM, MEDIUM PERFORMANCE - Item No.
RETAINED SOIL SYSTEM, WALL/SLOPE, LOW PERFORMANCE - Item No.
BACKFILL FOR RETAINED SOIL SYSTEM, LOW PERFORMANCE - Item No.

The list of tender items has been modified as follows:

- Concrete traffic barrier on RSS is no longer part of the RSS lump sum bid, but shall be included under the appropriate concrete tender item in the contract. Since the concrete barrier requires a footing of substantial size for stability against impact load, a separate tender item "Concrete in Barrier Wall Footing" or "Concrete in Parapet Wall Footing" shall be used for the footing. "Concrete in Barrier Wall Footing" is a standard tender item in OPSS 904, a special provision will be developed by Concrete Section to include the tender item "Concrete in Parapet Wall Footing".
- Excavation for RSS is no longer part of the RSS lump sum bid. Quantities for excavation shall be included in the appropriate 'Earth Excavation for Structure' and 'Rock Excavation for Structure' tender items
- Three new tender items "Backfill for RSS" have been created for the respective performance levels of the RSS; quantities and dimensioning of the backfill shall be shown in the grading contract drawings. This will be a non-standard tender item until the special provision is standardized. "Backfill For Retained Soil System, High Performance" shall be used for backfill behind True and False Abutment.
- Where required for construction of the RSS, separate tender items for ' Protection Systems' which includes roadway protection and track protection, and 'Unwatering Structure Excavation' shall be included in the contract.
- A single tender item may be used for RSS provided that each RSS has the same Application, Performance and Appearance attributes.

Implementation

1. These guidelines shall be effective immediately for all new designs.

2. A more comprehensive RSS guideline for designers is being prepared and will be available in Spring 2006.

T. Tharmabala

Bala Tharmabala
Manager, Bridge Office

c: G. Chaput
J. Bucik
B.Bennett

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12 APPENDIX D – BRIDGE OFFICE DESIGN BULLETIN (BARRIER ON RSS)

Ministry of Transportation
Ontario

Bridge Office
301 St. Paul Street, 2nd Floor
St. Catharines, ON L2R 7R4
(905) 704-2406

Memorandum

November 1, 2005

From: Bala Tharmabala
Manager, Bridge Office

To: Distribution List (Attached)

Bridge Office Design Bulletin
Interim Design Guidelines of Traffic Barriers on Retained Soil System Retaining Walls

Purpose

To provide interim guidelines for the design of traffic barriers mounted on retained soil system retaining walls.

Background

The Canadian Highway Bridge Design Code (CHBDC) provides no design details or guidelines for traffic barriers mounted on mechanically stabilized earth (MSE) structures. (In the Ministry the term retained soil system (RSS) is used for these types of structures.) Furthermore CHBDC has increased traffic rail impact load requirements for Performance Level 1 (PL1) to Performance Level 3 (PL3) compared with the earlier Ontario Highway Bridge Design Code (OHBDC). Designing for this loading, and in particular at the PL 3 level, without knowledge of its distribution through the barrier and transfer to a structural slab and wall system can result in costly or overly conservative designs using conventional design methods. This problem has been recognised in the USA, and the Transportation Research Board has initiated a National Cooperative Highway Research Program (NHCRP) project "Design of Roadside Barrier Systems Placed on MSE Retaining Walls" due for completion in 2007.

In Ontario the design of the current traffic barriers on RSS walls has been based on the impact load given in OHBDC. To avoid severe wall damage during vehicle impact, top mounted traffic barriers are connected integrally to continuous footings (named anchor slab, moment slab) that are independent of the retained soil system retaining walls. So far no unsafe performance or damage in over 20 years of use on Ministry highways has been reported. Given that the PL 2 loadings in CHBDC are just marginally higher than that used for OHBDC it seems reasonable to use the application of PL 2 loadings given in CHBDC as an interim basis for design of both PL2

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and PL3 traffic barriers on RSS retaining walls. Furthermore in the USA, AASHTO generally accepts PL2 loading for the majority of its applications on highways and freeways with a normal mixture of trucks and vehicles and this is seems appropriate in Ontario for the majority of its highways.

Therefore, until the NHCRP report is published, and for the reasons given above, the following interim guidelines should be used for the design of traffic barriers on retained soil systems.

Guidelines

1. For the PL 3 traffic barrier the applied loading shall be equivalent to the PL 2 loading as given in clause 12.5.2.4 of CHBDC.

2. For the PL 2 and PL 1 traffic barriers the applied loading shall be as given in clause 12.5.2.4 of CHBDC.

3. Top mounted traffic barriers shall be connected integrally to continuous footings (i.e. anchor slab, moment slab) and independent of the retained wall system. The loading stipulated in (1) shall be used to design the barrier's footing.

4. A traffic barrier integral with the retained soil wall system and crash tested to NHCRP 350 for the performance level required may be accepted as an alternative.

5. Consideration shall be given, where practical, to locating the RSS wall away from the traffic barrier.

Implementation

1) These guidelines shall be effective immediately for all new designs, designs currently underway and stockpiled designs.

2) A design aid complementing the requirements of this guideline for PL2 and PL3 situations is available and will be in the next revision to the Structural Manual.

3) Consultants working on ministry projects should be notified of these requirements by the office responsible for the contract assignment.

J. Tharmabala

Bala Tharmabala,
Manager, Bridge Office

Cc: G. Chaput
B. Bennett
J. Bucik

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13 APPENDIX E – DSM PRODUCT LISTING

Included in this Appendix are the Designated Sources for Materials (DSM) lists at the time of release of this document. The current DSM should always be used, which is available at the Road Authority Website: http://www.roadauthority.com/home.asp

Structural **DSM # 9.70.52**
Retainment of Soil Page 1
Retained Soil Systems (RSS), False Abutment, High Performance Level Date: 01-Mar-2007

SPECIFICATIONS: SP 599S22, SP 599S23, Manufacturer's Standards
DRAWINGS: Contract Plans, Manufacturer's Drawings
CUSTODIAL OFFICE: MERO - Foundation Design - (416) 235-3533 Bidders Tendering Queries call (905) 704-2203

NOTES:
-Systems eligible for inclusion in MTO work are defined during the project design phase and identified in contract documents.
- Maximum angle is measured from the backface of the horizontal.
- Maximum wall height is for each continuous tier at maximum slope.
- Performance is a rating either High (H), Medium (M) or Low (L).
- Appearance is a rating either High (H), Medium (M) or Low (L).
- Acceptance is a category, with status of demonstration (DE) or Acceptance (A).
- RSS is also identified as mechanically stabilized earth (MSE).

Company	RSS No.	Trade Identity	Max Angle (Deg)	Max Height	Appearance	Acceptance
Durisol Inc. 67 Frid St Hamilton ON L8P 4M3 Tel: 905-521-0999 Fax: 905-521-8658 Email: durisol@durisol.com Homepage: www.durisol.com	26	Durisol False Abutment System (DFAS)	90	15 m	H	A
Reinforced Earth Company Ltd. 1550 Enterprise Road, Suite 229 Mississauga ON L4W 4P4 Tel: 905-564-0896 Fax: 905-564-2609 Other Tel: 800-263-7097 Email: info@recocanada.com Homepage: www.reinforcedearth.ca	9	Reinforced Earth, Cruciform (FA)	90	15 m	H	A
	10	Reinforced Earth,Terratrel with cast-in-place facing	90	15 m	H	A
Ontario Source: **Tensar Earth Technologies Inc.** 5883 Glenridge Drive, Suite 200 Atlanta GA 30328 Tel: 404-250-1290 Fax: 404-250-9185 Toll Free: 800-292-4459 Homepage: www.tensarcorp.com **Ontario Source:** **Terrafix Geosynthetics Inc.** 178 Bethridge Road Toronto ON M9W 1N3 Tel: 416-674-0363 Fax: 416-674-1159 Email: terrafix@terrafixgeo.com Homepage: www.terrafixgeo.com	30	ARES Full Height Panel Wall System	90	15 m	H	DE

Structural **DSM # 9.70.53**
Retainment of Soil Page 1
Retained Soil Systems (RSS), True Abutment Date: 01-May-2001

SPECIFICATIONS: SP 599S22, SP 599S23, Manufacturer's Standards
DRAWINGS: Manufacturer's Drawings
CUSTODIAL OFFICE: MERO - Foundation Design - (416) 235-3731 Bidders Tendering Queries call (905) 704-2203

NOTES:
-Systems eligible for inclusion in MTO work are defined during the project design phase and identified in contract documents.
- Maximum angle is measured from the backface of the horizontal.
- Maximum wall height is for each continuous tier at maximum slope.
- Performance is a rating either High (H), Medium (M) or Low (L).
- Appearance is a rating either High (H), Medium (M) or Low (L).
- Acceptance is a category, with status of demonstration (DE) or Acceptance (A).
- RSS is also identified as mechanically stabilized earth (MSE).

Company	RSS No.	Trade Identity	Max Angle (Deg)	Max Height	Appearance	Acceptance
Reinforced Earth Company Ltd. 1550 Enterprise Road, Suite 229 Mississauga ON L4W 4P4 Tel: 905-564-0896 Fax: 905-564-2609 toll free: 800-263-7097 Email: info@recousa.com Homepage: www.recousa.com	8	Reinforced Earth, CRUCIFORM	90	15 m	H	DE

Structural DSM # 9.70.56
Retainment of Soil Page 1
Retained Soil Systems (RSS), Wall / Slope Date: 01-Apr-2008

SPECIFICATIONS: SP 599S22, SP 599S23, Manufacturer's Standards
DRAWINGS: Contract Plans, Manufacturer's Drawings
CUSTODIAL OFFICE: MERO - Foundation Design - (416) 235-3533 Bidders Tendering Queries call (905) 704-2203

NOTES:
-Systems eligible for inclusion in MTO work are defined during the project design phase and identified in contract documents.
- Maximum angle is measured from the backface of the horizontal.
- Maximum wall height is for each continuous tier at maximum slope.
- Performance is a rating either High (H), Medium (M) or Low (L).
- Appearance (App in header) is a rating either High (H), Medium (M) or Low (L).
- Acceptance (Acc in header)) is a category, with status of demonstration (DE) or Acceptance (A). Both eligible to bid MTO contracts.
- RSS is also identified as mechanically stabilized earth (MSE).
- Traffic Barrier - Y (yes) designates approved cast-in-place concrete traffic barrier for use with specific RSS.

Company	RSS No.	Trade Identity	System	Max Angle (Deg)	Max Wall Ht	App	Acc	Perfor mance	Cast-in-place Traffic Barrier
Armtec Limited 370 Speedvale Rd Guelph ON N1H 6P2 Tel: 519-763-2360 Fax: 519-763-0437 Toll Free: 800-265-9391 Homepage: www.armtec.com	6	GEOWEB / Armtec PWG	Cell, Tieback	75	8 m	M	A	M	N
	23	GEOWEB / Armtec PWG	Cell on Wrapped Slope Face, Tieback	55	6 m	L	A	L	N
	29	TC Mirafi Woven Geotextile	Temporary	90	8	L	A	L	N
	29	TC Mirafi Woven Geotextile	Temporary	90	8-10	L	DE	L	N
	32	GEOWEB / Armtec PWG	Cell on Slope Face, Tieback	35	6m	L	DE	L	N
Durisol Inc. 67 Frid St Hamilton ON L8P 4M3 Tel: 905-521-0999 Fax: 905-521-8658 Email: durisol@durisol.com Homepage: www.durisol.com	2	Durisol	Post and Panel	90	4 m	H	A	H	Y
	25	Durisol Anchored Retaining Wall	Durisol Panel / T-Anchor	90	15 m	H	A	H	Y
Ontario Source: Maccaferri Canada Ltd. 400 Collier MacMillan Dr. Unit B Cambridge ON N1R 7H7 Tel: 519-623-9990 Fax: 519-623-1309 Other Tel: 800-668-9396 Email: hq@maccaferri-canada.com Homepage: www.maccaferri-canada.com	19	Gabion Wall	Gabions	90	8 m	L	A	M	N
	17	Terramesh System	Gabion Basket, wire mesh tie back	90	8 m	L	DE	M	N
	31	Green Terramesh System	Steep Slope	70	8 m	L	DE	M	N
Reinforced Earth Company Ltd. 1550 Enterprise Road, Suite 229 Mississauga ON L4W 4P4 Tel: 905-564-0896 Fax: 905-564-2609 Other Tel: 800-263-7097 Email: info@recocanada.com Homepage: www.reinforcedearth.ca	1	CRUCIFORM	Reinforced Earth	90	15 m	H	A	H	Y
	13	TERRATREL	Temporary	90	15 m	L	A	L	N
	10	TERRATREL	Reinforced Earth with cast-in-place facing	90	10	H	A	H	
	1	CRUCIFORM	Reinforced Earth	90	15 m	H	A	H	Y
	13	TERRATREL	Temporary	90	15 m	L	A	L	N
	10	TERRATREL	Reinforced Earth with cast-in-place facing	90	10	H	A	H	

Structural **DSM # 9.70.56**

Retainment of Soil Page 2

Retained Soil Systems (RSS), Wall / Slope Date: 01-Apr-2008

SPECIFICATIONS: SP 599S22, SP 599S23, Manufacturer's Standards
DRAWINGS: Contract Plans, Manufacturer's Drawings
CUSTODIAL OFFICE: MERO - Foundation Design - (416) 235-3533 Bidders Tendering Queries call (905) 704-2203

Company	RSS No.	Trade Identity	System	Max Angle (Deg)	Max Wall Ht	App	Acc	Perfor mance	Cast-in-place Traffic Barrier
Tensar Earth Technologies Inc. 5883 Glenridge Drive, Suite 200 Atlanta GA 30328 Tel: 404-250-1290 Fax: 404-250-9185 Toll Free: 800-292-4459 Homepage: www.tensarcorp.com **Ontario Source: Terrafix Geosynthetics Inc.** 178 Bethridge Road Toronto ON M9W 1N3 Tel: 416-674-0363 Fax: 416-674-1159 Email: terrafix@terrafixgeo.com Homepage: www.terrafixgeo.com	14	SIERRA TF	Cell, Tensar Tieback	75	8 m	M	A	M	N
	15	SIERRA GF	Wrap, Tensar Tieback	45	6 m	L	A	L	N
	5	SIERRA BF	Blanket, Tensar Tieback	35	6 m	L	A	L	N
	16	SIERRA WF	Basket, Tensar Tieback	60	6 m	L	A	L	N
	4	MESA	Block, Tensar Tieback	90	10 m	H	A	M	Y
	26	ARES	Segmental Panel, Tensar Tieback	90	15 m	H	DE	H	Y
	27	ARES	Full Height Concrete Panel, Tensar Tieback	90	15 m	H	A	H	Y
	30	Sierra WF	Wire Basket, Tensar Tieback	90	8m	L	DE	L	No
Unilock Ltd.	21	SIENA STONE	Gravity Block Wall	90	2.5 m	H	DE	M	N

Structural **DSM # 9.70.59**
Retainment of Soil Page 1
Retained Soil Systems (RSS) Roadbase Embankment Date: 01-Apr-2001

SPECIFICATIONS: SP RSSjan01, Manufacturer's Standards, MTO Generic Criteria for RSS
DRAWINGS: Contract Plans, Manufacturer's Drawings
CUSTODIAL OFFICE: MERO - Foundation Design - (416) 235-3731 Bidders Tendering Queries call (905) 704-2203

NOTES:
-Systems eligible for inclusion in MTO work are defined during the project design phase and identified in contract documents.
- Maximum angle is measured from the horizontal.
- Maximum wall height is for each continuous tier at maximum slope.
- Performance is a rating either High (H), Medium (M) or Low (L).
- Appearance is a rating either High (H), Medium (M) or Low (L).
- Acceptance is a category, with status of demonstration (DE) or Acceptance (A).
- RSS is also identified as mechanically stabilized earth (MSE).

Company	RSS No.	Trade Identity	System	Max Angle (Deg)	Max Wall Height	Appearance	Acceptance
Tensar Earth Technologies Inc. Ontario Source: **Terrafix Geosynthetics Inc.** 178 Bethridge Road Toronto ON M9W 1N3 Tel: 416-674-0363 Fax: 416-674-1159 Email: terrafix@terrafixgeo.com Homepage: www.terrafixgeo.com Ontario Source: **Terrafix Geosynthetics Inc.** 178 Bethridge Road Toronto ON M9W 1N3 Tel: 416-674-0363 Fax: 416-674-1159 Email: terrafix@terrafixgeo.com Homepage: www.terrafixgeo.com	11	PRISM	Tensar Geogrid	Not Applicable	Not Applicable	Not Applicable	A

14 APPENDIX F – RSS CONTRACT REQUIREMENT SUMMARY

The process of choosing an RSS system and including it in the Contract Package is summarized by following flow diagrams. Figure 14.1 shows the process for selecting the attributes of the RSS. Figures 14.2 and 14.3 show the various considerations in preparing the complete contract drawings and documents for RSS adjacent to a roadway (stand-alone roadway project) and RSS adjacent to structure respectively. Tables 14.1 and 14.2 show sample Quantity Sheets for RSS adjacent to a road (stand-alone roadway project) and with a structure.

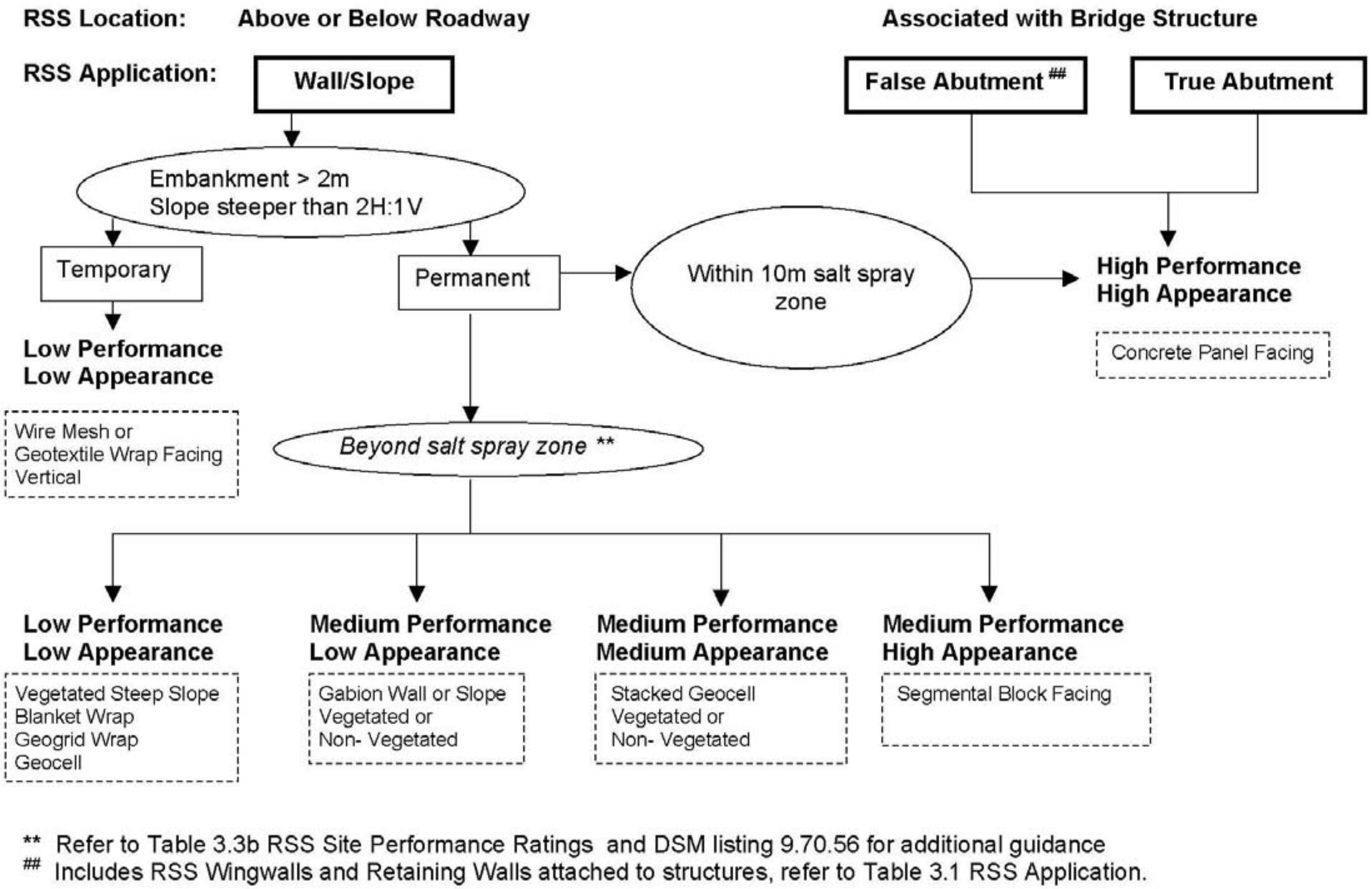


Figure 14.1: Retained Soil Systems Selection Process..

Designer identifies embankment > 2m in height requiring slopes steeper than 2H:1V

Foundation investigation is conducted to confirm suitability of site for RSS

Based on Tables 3.3a and 3.3b and site conditions (e.g. soils, property, environmental conditions),
Design Team selects appropriate RSS performance, geometry and appearance attributes

For High Performance walls, Structural Designer prepares layout and elevation Drawings
For Medium to Low Performance walls/slopes, Roadway Designer prepares RSS Drawings

Foundation elevation of top of RSS levelling pad or founding elevation of RSS slope to be shown per Section 5.1, including stepped footings and any sub-excavation and replacement of poor soils

Foundation Drawing required for each RSS per Section 5.1

Drawings to show RSS attributes, limits of RSS excavation and RSS backfill assuming soil-reinforcing elements extend 0.8H into embankment

Roadway Designer to include provision for external drainage management (e.g. grading to minimize overtopping, tying-in of drainage behind wall) and seeding of steep slopes.

Tender Items for:

- RSS per Section 5.1
- RSS Backfill
- Excavation
- Concrete in barrier wall footing where required per Sections 5.1 and 5.4.6

Quantities for:

- RSS Backfill
- RSS Excavation
- Concrete in barrier wall footing

NSSP's as required to alert contractor of obstructions, surcharges, environmental restriction, etc.

Figure 14.2: RSS on Roadway (Wall/Slope Application) - Considerations for Contract Preparation.

Table 14.1: Sample Structural Quantity Sheet for RSS on Roadway.

QUANTITIES – STRUCTURE	Site No: Dwg. No:	W.P. No. Cont. No.	Sheet

		Retained Soil System, Wall/Slope High Performance	Retained Soil System, Wall/Slope Medium Performance	Retained Soil System, Wall/Slope Low Performance			Backfill for RSS, High Performance	Backfill for RSS, Medium Performance	Backfill for RSS, Low Performance		Backfill for RSS Levelling Pad (Granular XX)	References
											**	
Sta xx		1					140				50	
Sta yy			1					160				
Sta zz				1					180			
Sta aa			1					80				
Sta bb				1					130			
		100%	100%	100%			140	240	310		50	
TOTALS		100%	100%	100%			140	240	310			
UNIT		LS	LS	LS			t	t	t		t	
ITEM No.		11	12	13			14	15	16		-	

Remarks:	Chkd. Appr. Date

* - Quantities to be made available for fill and transferred to Grading Quantity Sheets.

** - Granular quantities to be transferred to appropriate granular tender item Grading Quantity Sheets.

Design Team To Determine From The Foundation Design Report If The Site Is Suitable For RSS.

Design Team To Determine The Appropriate RSS Application:
True Abutment, False Abutment, Or Wall/Slope per Section 2, Structural Considerations

Structural Designer To Determine Configuration Of RSS Considering Anticipated Magnitude of Settlement And Structural Considerations per Section 4.

Based on Tables 3.3a and 3.3b and site conditions (e.g. soils, property, environmental conditions), RSS performance, geometry and appearance attributes are selected

Structural Designer To Show:

- General RSS Layout On General Arrangement Drawings per Section 5.2 1
- Foundation Drawing or Borehole Location and Strata Drawing required for each RSS per Section 5.2.2
- RSS Elevation, Including Steps In Footing per Section 5.2 3
- Required Structural Details On Substructure Drawings per Section 5.3

Roadway Designer To Show:

- Structure Excavation Required, per Section 5.2 4
- Structure Backfill Required, per Section 5.2 5
- RSS Backfill Required, per Section 5.2 6

Structural And Roadway Designers To Show All Remaining Drawings And Details To Complete The Package, e.g. drainage, obstructions

Structural Designer To Include Tender Item For RSS (And Determine Quantity For Estimating Purposes), As Described In Section 5.4.1

Roadway Designer To Include Tender Item And Quantity For:

- Structure Excavation, per Section 5.4.2
- RSS Backfill, As per Sections 5.4.3 And 5.4.5
- Structure Backfill, per Sections 5.4.4 And 5.4.5

Structural Designer To Include Tender Item And Quantity For:

- Concrete In Barrier Wall Footing per Section 5.4.6
- CSP and Fill For Piles, As Described In Section 5.4.8

Structural Designer To Include Special Provisions (SP's) And Non-Standard Special Provisions (NSSP's) As Described In Section 5.5

Structural Designer And Roadway Designer To Include Special Provisions (SP's) And Non-Standard Special Provisions (NSSP's) To Complete The Contract Package

Figure 14.3: RSS with Structures (False Abutment) - Considerations For Contract Preparation.

Table 14.2: Sample Structural Quantity Sheet for RSS with Structures.

QUANTITIES – STRUCTURE	Site No: Dwg. No:	W.P. No. Cont. No.	Sheet

Bridge 1	Driving Shoes	Concrete in Footings			Retained Soil System, False Abutment	Earth Excavation for Structure	Rock Excavation for Structure	Backfill for RSS, High Performance	Backfill for Structure (Granular XX)	Backfill for RSS Levelling Pad (Granular YY)	Backfill for Sub-Excavation (Granular ZZ)	References
						*	*		**	**	**	
	50											
		150										
Bridge 1					100%	125	75	180	150	50		
Sub Ex 1						175					175	
	50	150			100%	300	75	180	150	50	175	
	(P)	(P)				(P)	(P)					
TOTALS	50	150			100%	300	75	180				
UNIT	Ea	m3			LS	m3	m3	t	t	t	t	
ITEM No.	9	10			11	12*	13	14	-	-	-	
Remarks:												Chkd. Appr. Date

* - Quantities to be made available for fill and transferred to Grading Quantity Sheets.

** - Granular quantities to be transferred to appropriate granular tender item Grading Quantity Sheets.

15 APPENDIX G – PHOTOGRAPHS OF RSS WALLS

15.1 RSS PRODUCT PHOTOGRAPHS

Figure 15.1: Reinforced Earth Company Ltd (RECO), Cruciform FA – False Abutment, High Performance Wall.

Figure 15.2: Durisol Inc., DFAS – False Abutment, High Performance Wall.

Figure 15.3: Reinforced Earth Company Ltd (RECO), Cruciform – Wall/Slope, High Performance, High Appearance Wall.

Figure 15.4: Durisol Inc., Anchored Retaining Wall – Wall/Slope, High Performance, High Appearance Wall.

Figure 15.5: Tensar Earth Technologies Inc., Ares – Wall/Slope, High Performance, High Appearance Wall.

Figure 15.6: Tensar Earth Technologies Inc., Mesa – Wall/Slope, Medium Performance, High Appearance Wall.

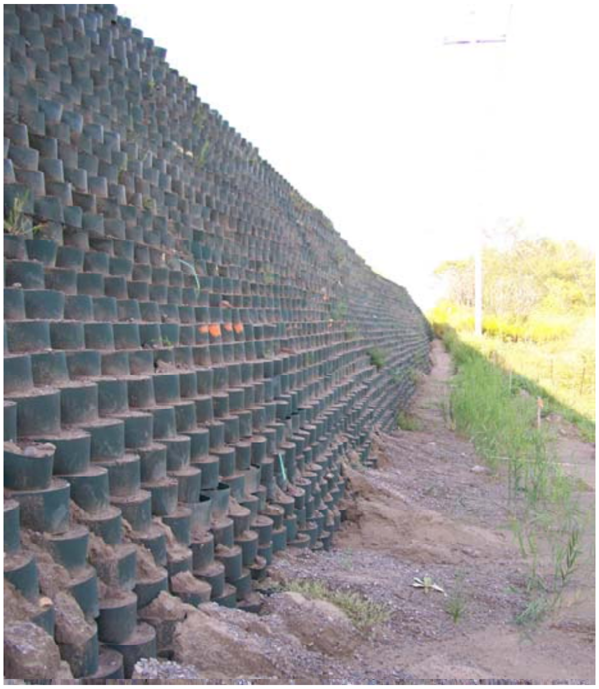


Figure 15.7: Armtec Ltd., Geoweb – Wall/Slope, Medium Performance, Medium Appearance Wall.

Figure 15.8: Tensar Earth Technologies Inc., Sierra TF (Terraweb) – Wall/Slope, Medium Performance, Medium Appearance Wall.

Figure 15.9: Maccaferri Canada Ltd., Terramesh System (Gabion) – Wall/Slope, Medium Performance, Low Appearance Wall.

Figure 15.10: Armtec Ltd., Geoweb/Armtec PWG – Wall/Slope, Low Performance, Low Appearance Wall.

Figure 15.11: Tensar Earth Technologies Inc., Sierra – Wall/Slope, Low Performance, Low Appearance Wall.

15.2 GENERAL STRUCTURE PHOTOGRAPHS

Figure 15.1: Concrete Integral Abutment with RSS Wingwalls.

Figure 15.2: RSS False Abutment (Integral) with RSS Wingwalls.

Figure 15.3: Conventional Abutment with RSS Wingwalls.

Figure 15.4: RSS False Abutment (Rigid Abutment with 2 Rows of Piles) with RSS Wingwalls.

Figure 15.5: RSS False Abutment and RSS Wraparound Walls (Cast in Place Wingwalls Above).

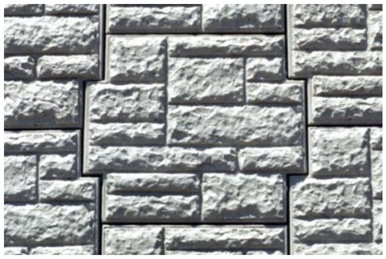
Figure 15.6: Medium Performance RSS.

Figure 15.7: RSS Under Construction.

15.3 DETAIL PHOTOGRAPHS

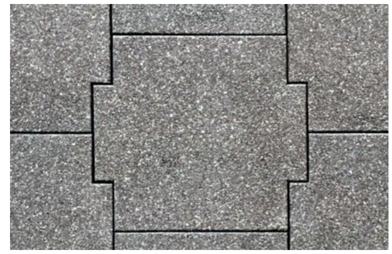
Figure 15.8: RSS Corner Element.

Figure 15.9: Catch Basin Interfering with RSS Strips.

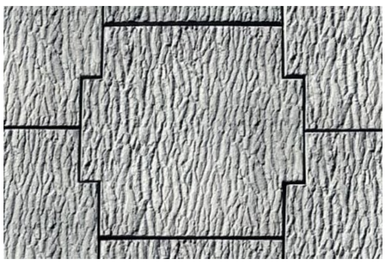


Ashlar Stone Finish

Fractured Fin Finish



Exposed Aggregate Finish



Vertical Fractured Finish

Custom Finish

Custom Finish

Figure 15.10: Examples of RSS High Appearance Walls with Architectural Finishes.

15.4 PROBLEM PHOTOGRAPHS

The following Appendix contains several photographs of RSS installations, RSS details and RSS problems.

Figure 15.11: Cracking of Abutment due to Inadequate Allowance for RSS Settlement.

Figure 15.12: Bulge in RSS.

Figure 15.13: Concrete Barrier Cast Against RSS Preventing RSS Deflection.

Figure 15.14: Settlement of Barrier Wall on RSS Causing Opening of Joint.