CONSTRUCTION SPECIFICATION FOR MECHANICALLY STABILIZED EARTH SYSTEMS

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941.01 SCOPE

This specification covers the requirements for the design and construction of mechanically stabilized earth systems.

941.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Construction

OPSS 501 Compacting
OPSS 512 Installation of Gabions

Ontario Provincial Standard Specifications, Materials

OPSS 1004 Aggregates - Miscellaneous
OPSS 1010 Aggregates - Base, Subbase, Select Subgrade, and Backfill Material
OPSS 1355 Precast Concrete - Materials and Production

Ontario Ministry of Transportation Publications

MTO Designated Sources for Materials (DSM)

MTO Structural Manual
Guideline for Applying for Approval of Retained Soil Systems (RSS) on the Designated Sources of Materials (DSM) for MTO Projects

MTO Forms:
PH-CC-822 Certificate of Conformance

CSA Standards

S6:25 Canadian Highway Bridge Design Code (CHBDC)

941.03 DEFINITIONS

For the purposes of this specification the following definitions apply:

Alignment Elements means components specified by the manufacturer that are constructed on the foundation for MSE 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 a MSE that has been submitted by the manufacturer and accepted by the Owner for listing on the DSM.

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

Constructed Height means the vertical distance between the top of the foundation for MSE and the top of the currently placed and compacted backfill for MSE, 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 MSE warranty period.

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

External Stability means stability against sliding, overturning, and eccentricity failures of the MSE.

Facing Elements means components specified by the manufacturer that delineate the front face of the MSE and to which reinforcing elements may be attached, such as precast concrete panels, split-face concrete blocks, wire mesh, and geosynthetic panels or layers.

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

Global Stability means external stability against deep-seated and compound failure of the MSE, including adequate bearing capacity at specified settlements of the foundation.

Internal Stability means stability against failures within the reinforced soil mass and facing system of the MSE, including adequate resistance against connection, rupture, pull-out, and excessive elongation of the reinforcing elements.

Lot means all MSE elements from one structure, from a single MSE supplier, and of the same concrete mix design. The maximum lot size shall be 500 m² of vertical face of the MSE.

Manufacturer means the firm who supplies the design and proprietary components, and who specifies the backfill and other materials, for the MSE.

Manufacturer's Representative means an individual with continuous full-time employment with the manufacturer for a period of at least 3 years, and who is knowledgeable in the design and construction of the MSE.

Mechanically Stabilized Earth System (MSE) means a proprietary system listed on the MTO DSM list 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. MSE is formerly known as retained soil system (RSS).

MSE Superintendent means the Contractor's authorized representative in charge of the installation of the MSE.

Obstruction means any part of the work and any existing condition within the Working Area that affects the design, construction, and performance of the MSE, 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 MSE and the corresponding point on the theoretical MSE surface as specified in the Contract Documents.

Placing Tolerances means tolerances specified by the manufacturer on the placing of the MSE components and backfill for MSE to ensure compliance of the constructed MSE with the performance tolerances. Placing tolerances include lateral and vertical displacements that occur during erection of the MSE.

Reinforcing Elements means components specified by the manufacturer that are placed within the backfill for MSE and connected to the facing elements to mechanically stabilize the backfill for MSE, such as metal tie strips, metal grids and geosynthetic grids.

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

941.04 DESIGN AND SUBMISSION REQUIREMENTS

941.04.01 Design Requirements

941.04.01.01 General

The MSE shall be designed according to the approved product drawings, CSA S6, the Structural Manual, and as specified in the Contract Documents.

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

The foundation for MSE shall be as specified in the Contract Documents.

941.04.01.02 MSE Selection

A MSE shall be selected from the DSM that meets the application, performance and appearance requirements for that MSE, as specified in the Contract Documents.

A MSE shall be selected from the DSM designated as either 'A' (Accepted) or 'DE' (Demonstration). MSE designated as 'DE' status requires inspection, instrumentation, and monitoring of the constructed MSE, and the reporting of the findings to the Owner by the manufacturer as specified in the Guideline for Applying for Approval of Retained Soil Systems (RSS) on the Designated Sources of Materials (DSM) for MTO Projects.

When there is more than one MSE included in the same tender item number for payment, all MSE for the tender item shall be selected from the same DSM including type and colour of facing elements.

All MSE that abut an existing structure, or a structure to be constructed as part of the Work, and that have the same performance and appearance requirements, shall be selected from the same DSM, including type and colour of facing elements.

941.04.01.03 Obstruction

Design details of the MSE shall be provided for all obstructions as specified in the Contract Documents. Where an obstruction exists but is not located to sufficient accuracy for the design of the MSE, the obstruction shall be located in the field to sufficient accuracy as required to design the MSE.

941.04.01.04 Foundation Investigation Report

A foundation investigation report that describes the subsurface conditions at the MSE 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.

941.04.02 Submission Requirements

941.04.02.01 Working Drawings

At least 14 Days prior to commencement of construction of the MSE, three sets of Working Drawings shall be submitted to the Contract Administrator for information purposes only. A separate submission of Working Drawings shall be made for each MSE in the Contract. All submissions shall bear the seal and signature of the design Engineer and the design checking Engineer.

The MSE superintendent shall always have a copy of the Working Drawings on site during the construction of the MSE.

The Working Drawings shall include as a minimum the following information:

a) 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 MSE;

b) All design, fabrication and construction drawings and specifications for the MSE;

c) Location and value of the design height of the MSE;

d) Defined lines and grades of reinforced volume, length of reinforcing elements, and type of backfill for MSE;

e) Details at obstructions, and connections to other structures, as specified in the Contract Documents;

f) Statement of contact pressure at the interface between the MSE backfill and foundation for comparison to the bearing resistance required by the MSE foundation according to CSA S6 and the Contract Documents;

g) Statement of satisfactory internal and external stability;

h) Joint gaps for concrete facing elements;

i) Placing tolerances for the MSE;

j) Inspection and testing details during construction; and

k) Stripping strength for formwork removal.

941.04.02.02 MSE Superintendent

At least 14 Days prior to commencement of construction of the MSE, the name(s) of the MSE superintendent responsible for each MSE in the Contract shall be submitted in writing to the Contract Administrator.

During construction of an MSE, the MSE superintendent shall not change without written permission from the Contract Administrator. A request for a change in the MSE superintendent shall be submitted at least 1 week prior to the actual change in MSE superintendent.

941.04.02.03 Manufacturer's Representative

At least 14 Days prior to commencement of construction of the MSE, the name(s) of the manufacturer's representative for each MSE shall be submitted in writing to the Contract Administrator.

The Contract Administrator shall be notified in writing 48 hours prior to each site visit by the manufacturer's representative. The advance notice shall include the dates and locations the manufacturer's representative will be on site.

941.04.02.04 Inspection Report

For each MSE, an inspection report shall be submitted to the Contract Administrator following an inspection by the Contractor's Engineer, after each of the following milestones, and prior to commencement of subsequent operations on that MSE:

a) Layout and marking of all lines and grades needed to construct the MSE; and construction of the alignment elements, where applicable;

b) Delivery and storage on site of facing elements and reinforcing elements, where applicable; and

c) Installation of the facing elements, placement and compaction of the backfill for MSE, and installation of the reinforcing elements, where applicable.

The Contractor's Engineer shall be knowledgeable in the design and construction of the manufacturer's MSE. The Contractor's Engineer shall have demonstrated experience and expertise to certify that the MSE work is in general conformance with the Contract Documents and Working Drawings and to issue inspection reports and Certificates of Conformance.

Where the design height of the MSE is greater than 5.0 m, the inspection report shall document inspections at the constructed height of the MSE at 5.0 m, 10.0 m, and 15.0 m, as applicable, up to and including the design height.

The inspections and inspection reports in no way supersede the inspection and testing intervals required for the construction of the MSE, specified in the Working Drawings.

941.05 MATERIALS

941.05.01 General

All materials for the selected MSE shall be according to the approved product drawings for that MSE.

941.05.02 Backfill

Granular backfill shall be according to OPSS 1010.

941.05.03 Gabions

Gabions shall be according to OPSS 512 and gabion stones shall be according OPSS 1004.

941.05.04 Precast Concrete MSE

Precast concrete MSE shall be according to OPSS 1355, except that GFRP, if used shall be according to the following:

a) GFRP reinforcement shall be grade I or higher as per CSA S807.

941.07 CONSTRUCTION

941.07.01 General

The MSE shall be constructed according to the Working Drawings and this specification.

Skidsteer, tired, and tracked vehicles shall not be permitted on any area where the depth of backfill for MSE over installed reinforcing elements is less than 0.3 m. Construction vehicles shall not be permitted to be in direct contact with installed reinforcing elements at any time.

941.07.02 MSE Superintendent

The construction of the MSE shall be scheduled such that it is at all times under the responsible charge of the MSE superintendent. The MSE superintendent shall be advised on site by the MSE manufacturer's representative as to the required procedures for the construction of the MSE, for the specified operations, and time periods.

941.07.03 Manufacturer's Representative

The manufacturer's representative shall be on site to oversee installation of the MSE and to advise the MSE superintendent of the procedures and placing tolerances required for the construction of the MSE according to the manufacturer's requirements as approved on the MTO's DSM.

For each MSE item number, the manufacturer's representative shall be on site at the commencement of the MSE construction for a time period of 3 Working Days to observe the following operations, where applicable:

a) Layout of the MSE and construction of the alignment elements;

b) Installation of the facing elements; and

c) Placement and compaction of the backfill for MSE and installation of the reinforcing elements.

Whenever there is a change in the MSE superintendent during construction of the MSE, the manufacturer's representative shall return to the site to advise the new MSE superintendent of the procedures and placing tolerances required for the construction of the MSE according to the manufacturer's requirements as approved on the MTO's DSM.

941.07.04 Certificates of Conformance - Foundation

MTO Form PH-CC-822, Certificate of Conformance, for the foundation of the MSE shall be submitted to the Contract Administrator prior to the construction of the MSE.

941.07.05 Backfill for MSE

Backfill for MSE and placement of reinforcement elements shall be placed within the lines and grades specified in the Working Drawings. All backfill for MSE shall be compacted according to OPSS 501.

Unless otherwise specified in the Contract Documents, backfill for MSE shall not be placed against an adjacent concrete structure that is part of the work until the concrete in that structure has obtained at least 70% of the compressive strength specified in the Contract Documents.

941.07.06 Performance Tolerances

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

941.07.07 Certificates of Conformance

MTO Form PH-CC-822, Certificate of Conformance, shall be submitted to the Contract Administrator upon completion of each MSE.

941.07.08 Corrective Work

941.07.08.01 General

All deficiencies shall be repaired for corrective work as specified in the Repair Procedures clause. All corrective work shall be carried out within the MSE warranty period, unless prevented by seasonal shutdown, in which case the corrective work shall be carried out prior to June 30 of the following year.

At least 1 week prior to commencement of any corrective work, a written notice of commencement of work shall be submitted to the Contract Administrator and the Owner.

Access to the corrective work shall be provided for inspection by the Owner when requested.

941.07.08.02 Repair Procedures

Three copies of repair procedures for corrective work shall be submitted to the Contract Administrator 14 Days prior to commencement of any corrective work.

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 and be signed by the manufacturer's representative.

941.07.09 MSE Warranty

The warranty period shall be 36 months from the date of the Contract Completion Certificate.

941.07.10 Management of Excess Materials

Management of excess materials shall be as specified in the Contract Documents.

941.08 QUALITY ASSURANCE

941.08.01 Acceptance of MSE

941.08.01.01 End of MSE Construction

The Contract Administrator will inspect the work to determine if the completed MSE has any deficiencies identified in Table 2. If the MSE contains any of the deficiencies listed in Table 2, the MSE shall be deemed rejectable.

941.08.01.02 End of the MSE Warranty Period

The Owner will accept the MSE at the end of the MSE warranty period if none of the deficiencies listed in Table 2 are found during the warranty inspections. The MSE shall not be accepted until all deficiencies have been repaired by corrective work.

941.08.02 Warranty Inspections

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

Within 2 weeks following a warranty inspection, the Owner will notify the Contractor in writing of all deficiencies that require corrective work.

941.09.0 MEASUREMENT FOR PAYMENT

941.09.01 Actual Measurement

941.09.01.01 Backfill for MSE, Ultra Lightweight
Backfill for MSE, Lightweight
Backfill for MSE, High Performance
Backfill for MSE, Medium Performance
Backfill for MSE, Low Performance

Measurement shall 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 as specified in the Contract Documents.

941.09.01.02 MSE, True Abutment, Fabrication
MSE, False Abutment, Fabrication
MSE, Wall/Slope, High Performance, Fabrication
MSE, Wall/Slope, Medium Performance, Fabrication
MSE, Wall/Slope, Low Performance, Fabrication
MSE with Finishing Cap, Wall/Slope, High Performance, Fabrication
MSE with Finishing Cap, Wall/Slope, Medium Performance, Fabrication

Measurement shall be by area in square metres of facing elements.

941.09.02 Plan Quantity Measurement

When measurement is by Plan Quantity, such measurement shall be based on the units shown in the clause under Actual Measurement.

941.10 BASIS OF PAYMENT

941.10.01 Backfill for MSE, Ultra Lightweight - Item
Backfill for MSE, Lightweight - Item
Backfill for MSE, High Performance - Item
Backfill for MSE, Medium Performance - Item
Backfill for MSE, 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 MSE, the Contract price for the MSE installation items in which the backfill for MSE is incorporated shall include full compensation for all labour, Equipment and Material required to place and compact the backfill for MSE.

941.10.02 MSE, True Abutment, Fabrication - Item
MSE, False Abutment, Fabrication- Item
MSE, Wall/Slope, High Performance, Fabrication - Item
MSE, Wall/Slope, Medium Performance, Fabrication - Item
MSE, Wall/Slope, Low Performance, Fabrication - Item
MSE with Finishing Cap, Wall/Slope, High Performance, Fabrication - Item
MSE with Finishing Cap, Wall/Slope, Medium Performance, Fabrication - Item

941.10.02.01 General

Payment at the Contract price for the above tender items shall be full compensation for all labour, Equipment, and Material to do the work, subject to payment adjustments according to OPSS 1355.

Corrective work, including investigation of defects and deficiencies, design of repairs, site access, traffic staging and removal of existing work, shall be at no additional cost to the Owner, except where the defects and deficiencies are not the fault of the Contractor.

Unacceptable lots shall be rejected and replaced, except when the Contract Administrator permits an unacceptable lot to remain in the Work with a payment adjustment.

941.10.03 MSE, True Abutment, Delivery - Item
MSE, False Abutment, Delivery - Item
MSE, Wall/Slope, High Performance, Delivery - Item
MSE, Wall/Slope, Medium Performance, Delivery - Item
MSE, Wall/Slope, Low Performance, Delivery - Item
MSE with Finishing Cap, Wall/Slope, High Performance, Delivery - Item
MSE with Finishing Cap, Wall/Slope, Medium Performance, Delivery - Item

Payment at the Contract price for the above tender item shall be full compensation for all labour, Equipment, and Material to do the work.

941.10.04 **MSE, Roadbase Embankment, Installation - Item**
MSE, True Abutment, Installation - Item
MSE, False Abutment, Installation - Item
MSE, Wall/Slope, High Performance, Installation - Item
MSE, Wall/Slope, Medium Performance, Installation - Item
MSE, Wall/Slope, Low Performance, Installation - Item
MSE with Finishing Cap, Wall/Slope, High Performance, Installation - Item
MSE with Finishing Cap, Wall/Slope, Medium Performance, Installation - 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 having the manufacturer's representative on site.

Payment for construction of the foundation for MSE shall be made under the appropriate tender items in the Contract.

Corrective work, including investigation of defects and deficiencies, design of repairs, site access, traffic staging and removal of existing work, shall be at no additional cost to the Owner, except where the defects and deficiencies are not the fault of the Contractor.

TABLE 1
Performance Tolerances for MSE

Performance Requirement	Performance Tolerance (mm)	
	Local	Global
Abutments	Joint Gap ± 5 (Note 1)	≤ 20
High	Joint Gap ± 10 (Note 1)	≤ 30
Medium	N/A	≤ 50
Low	N/A	≤ 100

Notes:
1. Joint Gap shall be as specified on the Working Drawings.

TABLE 2
MSE Deficiencies

Number	Description of Deficiency
1	Performance tolerance exceeds tolerances according to Table 1.
2	Damaged or deficient facing elements, and damaged or deficient alignment elements, including elements exhibiting scaling, delaminations, and cracks.
3	Dead and dying vegetative elements that are an integral part of the MSE.