SECTION 925

INEXTENSIBLE MECHANICALLY STABILIZED EARTH (MSE) STRUCTURES

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925.01 SCOPE

This specification covers the design, supply, fabrication and construction of Mechanically Stabilized Earth (MSE) retaining walls and bridge abutments with precast concrete panels as facing elements. MSE retaining wall supplier shall be selected from a list pre-approved by the Department. All components of the MSE retaining wall system shall be sourced from one supplier. This includes but is not limited to, reinforced concrete face panels, inextensible soil reinforcement, geotextile filter fabric, and precast concrete coping caps.

In addition to the components listed above, the MSE wall structure also includes levelling pads, compacted engineered backfill, and perforated drainage pipe.

Face panels shall be cruciform or rectangular shaped.

925.02 MATERIALS

All concrete materials shall comply with CSA A23.1 “Concrete Materials and Methods of Concrete Construction” and CSA A23.2 “Test Methods and Standard Practices for Concrete.” All concrete work shall conform to the requirements of Section 904 unless otherwise stated herein.

Reinforcement for concrete face panels shall conform to the requirements of “Galvanized Reinforcing Steel” specified in Section 905.

925.03 SUBMISSION OF SHOP DRAWINGS AND DESIGN REQUIREMENTS

Prior to work commencing the Contractor shall prepare and submit to the Owner’s Representative for approval 1 electronic copy and 1 paper copy of detailed shop drawings, erection drawings and design calculations.

Design shall be in accordance with latest version of CSA S6, “Canadian Highway Bridge Design Code.” The structure shall have a design life of 100 years. Soil reinforcement shall have sufficient strength, frictional resistance and length as required by the design and as outlined in these specifications.

The Department requires a minimum of 4 weeks to review submitted documents.

Shop drawings shall contain:

a) Limits on backfilling, and compaction requirements, including gradation limits for engineered fill; Submitted drawings shall be stamped and signed by a Professional Engineer registered to practice in Newfoundland and Labrador;
b) Accommodation made to prevent buildup of hydrostatic pressure behind the wall;
c) Surcharge created by bridge structure and highway live loads if applicable;
d) Levelling pad details;
e) Type of soil reinforcement and length for each section of the MSE structure;
f) Factored and unfactored pressures applied to the MSE wall system;
g) Embankment pressures provided by the Geotechnical Engineer;
h) Precast concrete facing panel layout;
i) Precast concrete coping and top safety railing;
j) Representative typical details.

Wall panels will be laid out and sized so joints appear on a consistent multiple spacing. The Contractor must ensure all joints are visually continuous on the entire MSE wall face. The use of architectural strips may be required to give this appearance where necessary. Nominal concrete cover to reinforcing must be maintained. Shop drawings will be rejected if the MSE panel joint grid does not give an aesthetically pleasing appearance.

The maximum panel dimension permitted by the Department in a MSE structure will be 2000mm. In addition to the service loads provided by the owner, MSE structures shall be designed to support standard construction equipment. The use of heavy equipment used during construction, such as cranes or off road trucks, shall be taken in to consideration for design of MSE wall systems.

The Contractor shall not proceed with fabrication until acceptance of the Shop Drawings by the Owner’s Representative.

925.04 FABRICATION OF PRECAST CONCRETE PANEL FACING

925.04.01 General Requirements

The Contractor shall supply concrete panels constructed according to the MSE Supplier’s specifications and recommendations, including all necessary hardware for the lifting and aligning of panels. All panels shall be built in accordance with the accepted plans and shop drawings.

The fabricator for the concrete face panels must be certified as a precast yard, in accordance with CSA A23.4 "Precast Concrete - Materials and Construction". Proof of certification, as well as a detailed Quality Control Procedure, shall be provided to the Owner’s Representative prior to the construction of panels. The Contractor shall submit

a copy of test results upon completion of panel fabrication. Concrete shall conform to all relevant portions of Section 904.

925.04.02 Concrete Quality

Concrete shall be normal density and have a minimum compressive strength of 40 MPa at 28 days meeting all requirements for Substructure Concrete as per Section 904. Cement used shall be a blended Portland, fly ash, silica fume cement, Type GUb. Contractors are advised that the minimum proportion by mass of the total cementing materials for silica fume shall be 6% and a maximum of 8%. Contractors are advised that the maximum proportion by mass of the total cementing materials for fly ash is 25%.

Concrete shall be of sufficient workability, so the desired finish as specified in 925.04.03 can be achieved.

Precast units shall be considered acceptable for early placement in the wall when 7-day strengths exceed 75% of the 28 day requirements, unless local strength gain experience dictates a longer period of time.

925.04.03 Reinforcement

Panel reinforcement shall be placed as shown on the accepted shop drawings with care taken to ensure specified cover is maintained.

Reinforcement shall be steel bars meeting the requirements of Section 905. Other types of reinforcement such as welded wire mesh or FRP bars shall be submitted to the Department for review and accepted on a case by case basis.

925.04.04 Forms

Accepted fabricated steel forms are to be used for precast panels. Forms will be set on a rigid foundation. Forms are to be smooth, mortar tight, true to the required lines and grades and of sufficient strength and rigidity to resist springing out of shape or alignment. All precast units shall be manufactured within the following tolerances:

a) All dimensions within 5 mm, including diagonals measured between opposite corners.
b) Surface defects on formed surfaces shall not exceed 2.5 mm.

925.04.05 Concrete Finish

For panels being used as bridge abutments, the colour shall match that of the superstructure. The front face of all panels shall have a smooth grey finish conforming to

CSA A23.4 Section 24.2.5 Grade A. Consistency of finish shall be maintained with the use of the same concrete mix and the same type of form oil for the entire project. The rear face of the panels shall be an unformed surface finish, roughly screeded with no open pockets or distortions in excess of 6 mm.

925.04.06 Handling, Storage and Shipping

All panels shall be handled, stored, and shipped in such a manner as to eliminate the potential for damage such as chipping, cracks, fractures etc., as well as excessive bending stresses and damage to protruding or otherwise exposed components. Panels, when stacked, shall be supported on firm hardwood blocking located immediately adjacent to the tie strips to avoid bending them.

Panels shall be protected from discoloration and staining of the front face.

925.04.07 Rejection

The Owner's Representative shall be the sole judge of a panel's acceptability before it is placed. Panels will be subject to rejection in the case of failure to meet the required specified strength and concrete quality requirements. In addition, any or all of the following defects shall be sufficient cause for rejection:

a) Defects that indicate warped or imperfect molding;
b) Defects indicating honeycombed or open texture concrete;
c) Any structural crack as defined in Section 32.3.2 of CSA A23.4;
d) Lifting inserts or connecting hardware improperly set;
e) Cracking resulting from lifting and transport operations, and broken or cracked corners;
f) Exposed reinforcing steel;
g) Dimensions out of tolerance;
h) Non-uniform appearance.

925.05 SOIL REINFORCING SYSTEMS

925.05.01 General Requirements

Soil reinforcing systems material shall be inextensible galvanized steel in normal conditions. In cases where the soil PH is high and steel reinforcement corrosion is a concern, high density polyethylene geogrid is required. All reinforcing systems must be pre-approved by the Department.
For MSE walls which will be permanently submerged, the Contractor shall complete relevant testing of the watercourse and provide the results to the MSE wall supplier for consideration into their design.

925.05.02 Inextensible Strip Type Soil Reinforcing Systems

Where strip type reinforcing systems are used strips shall consist of hot rolled, shop fabricated ribbed structural steels conforming to CSA G40.21 “Structural Quality Steels” Grade 400 W or ASTM A572/A572M “Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel” grade 65 as shown on the shop drawings. Galvanizing shall follow shop fabrication and shall be in accordance with CSA G164 “Hot Dip Galvanizing of Irregularly Shaped Articles”. Strips shall be cut to length and tolerances as shown on the shop drawings.

Tie strips shall consist of shop fabricated structural steel conforming to ASTM A36 “Standard Specification for Carbon Structural Steel” or CSA-G40.21 Grade 300W and shall be galvanized in accordance with CSA G164 after fabrication. Bolt hole alignment, dimensions, and end distances shall be within the tolerances shown on the shop drawings.

All bolted connections shall be made using hot dip galvanized ASTM A325 bolts and nuts.

Any damage done to the galvanizing prior to installation shall be repaired in an acceptable manner to the Department and provide a galvanized coating comparable to that provided by CSA G164.

925.05.03 Inextensible Mesh Type Soil Reinforcing Systems

Where mesh type reinforcing systems are used reinforcing mesh shall be shop fabricated cold drawn steel wire conforming to the minimum requirements of ASTM A1064 “Standard Specification for Steel Wire and Welded Wire, Plain and Deformed, for Concrete.”

Galvanization shall be applied after the mesh is fabricated and shall conform to ASTM A123 “Standard Specification for Zinc (Hot Dipped Galvanized) Coatings on Iron and Steel Products.”

All connection devices and connector bars shall be fabricated from cold drawn steel wire conforming to ASTM A1064 and galvanized in accordance ASTM A123.

Any damage done to the galvanizing prior to installation shall be repaired as detailed in ASTM A780 “Standard Practice for Repair of Damaged and Uncoated Areas of Hot Dipped Galvanized Coatings” Method 2.

925.06 RUBBER BEARING PADS

Panels, except for the bottom course, shall be supported on rubber bearing pads. Rubber bearing pads shall be secured into the panel below. The rubber shall be an elastomer with a Shore Hardness of 70 ± 5, as measured in accordance with ASTM D2240 "Standard Test Method for Rubber Property – Durometer Hardness."

925.07 FILTER FABRIC

Filter fabric to be placed over the joints at the back of the panels shall be a non-woven geotextile. Filter fabric shall be attached using an adhesive approved by the Manufacturer. These strips shall have a nominal width of 500mm and be placed over the inside of all joints between precast panels. Strips shall have a minimum overlap of 100mm at all lap locations. The material shall have the following minimum average roll values:

Grab Tensile Strength	530 N	(ASTM D4632)
Mullen Burst	1665 kPa	(ASTM D3786)
Permeability	0.22 cm/sec	(ASTM D4491)
UV Resistance	70%	(ASTM D4355)

925.08 PRECAST CORNER AND/OR COPING ELEMENTS

Corner and/or coping elements are required on all structures. All coping elements shall be precast unless a cast in place construction has been accepted in the tender documents. They shall be cast as shown on the Shop Drawings and in accordance with the specifications for concrete panels. Coping shall provide a continuous smooth appearance with no discontinuities or kinks visible. If they do not meet this criteria coping will be rejected. Concrete mix for face panels shall apply to the precast coping.

925.09 FRICTIONAL BACKFILL REQUIREMENTS

All MSE wall backfill shall be obtained from a single source.

The angle of internal friction for backfill material shall not be less than 35 degrees as determined by the Standard Direct Shear Test according to ASTM D3080/D3080M.

It is the Contractor's responsibility to conduct the required testing and provide exact values of unit mass and angles of internal friction to the MSE Supplier prior to the design of the structure.

The MSE frictional backfill will be a crushed blasted rock with the following gradation:

100mm	100% passing by dry weight
75mm	75- 100%
4.76mm	20-55%
1.2mm	10- 35%
0.3mm	6-20%
0.075mm	2-5%

Gradation requirements will be strictly enforced and variances to a coarser or less well graded material will not be accepted even if meeting the minimum gradation requirements of the MSE wall supplier.

The frictional backfill shall extend at least 500 mm beyond the end of soil reinforcing straps.

The backfill within the R/E volume shall be tested in accordance with AASHTO or ASTM standard methods and meet the following criteria:

ELECTRO-CHEMICAL PARAMETER	ELECTRO-CHEMICAL REQUIREMENT	TEST METHOD	
		AASHTO	ASTM
Chlorides (Cl^-)	< 100 ppm	T 291	D4327
Sulphates (SO_4^{2-})	< 200 ppm	T 290	D4327
Resistivity	> 3000 ohm-cm	T 288	G187
pH	5 - 10	T 289	D4972

At least two weeks prior to start of wall construction the Contractor shall identify the source of materials to be used for the MSE wall backfill and provide initial testing for the MSE wall backfill. This testing shall include both gradation and electrochemical testing as a minimum. A copy of these test results shall be provided to the Owner's Representative. In addition, the Contractor shall provide the Department with a letter of conformance from the MSE wall supplier stating that the backfill meets the electro-chemical and geotechnical requirements assumed in the design of the wall.

In addition to this initial testing, the Contractor shall sample and test the backfill for conformance with the gradation requirements at least once for every 250 cubic metre of material placed.

All sampling shall be carried out in the presence of the Owner's Representative. Additional gradation testing at the contractors cost maybe required if based upon visual inspection in the field it is evident to the Owner's Representative that the gradation of the backfill material has changed.

The Contractor shall use professional engineering services and a qualified testing firm licensed in Newfoundland and Labrador for all sampling and testing of the backfill.

In addition to testing done by the Contractor, one 20 kg representative sample of the backfill proposed for construction shall be submitted to the Owner's Representative for testing and approval two weeks prior to start of construction. The sample shall meet the geotechnical parameters as specified by the Supplier.

925.10 CONSTRUCTION REQUIREMENTS

925.10.01 General Requirements

The MSE structure shall be constructed in conformity with the lines, grades, details and dimensions as shown on the Contract drawings or established by the Department. Poor conformance with respect to this criteria is subject to rejection.

925.10.02 Structure Excavation

All necessary excavation for the MSE structure shall be in accordance with "Excavation for Foundations" in Section 902. Excavation shall be in close conformity to the lines and grades shown on the Drawings.

925.10.03 Foundation Preparation

The structure foundation shall be graded level for a width equal to the length of reinforcing elements plus approximately 500 mm or as shown on the Shop Drawings. Prior to wall construction, the foundation shall be proof rolled and/or compacted to the satisfaction of the Owner's Representative. Any foundation soils found to be unsuitable shall be removed and replaced with Engineered Fill. The foundation conditions shall be accepted by the MSE wall designer, the Contractor's Geotechnical Engineer, and the Owner's Representative prior to MSE wall erection.

925.10.04 Levelling Pad

Concrete footings shall be formed and poured as per relevant portions of the General Specifications Section 904. Cast-in-place concrete for the unreinforced concrete levelling pad shall have a 28 day design strength of 35 MPa or better and shall be screeded uniformly smooth with a variation of not more than 3 mm and without protrusions.

Elevation differences between steps shall not vary more than 5 mm from those shown on the drawings. Plan dimensions and step locations (if any) shall be in reasonable conformity with the drawings and shall be located such that panels will be positioned reasonably centred on the pad. The levelling pad shall be cured in accordance with CSA A23.1 or as directed by the Owner's Representative.

925.10.05 Backfill and Soil Reinforcing System Placement

Backfill placement shall closely follow the erection of each row of panels. At each soil reinforcing level, backfill shall be roughly levelled and compacted before placing and connecting reinforcing elements to the panels. Unless otherwise shown on the Erection Drawings, reinforcing elements shall be placed approximately perpendicular to the face of the wall or as directed by the MSE wall designer.

The Contractor will notify the Owner's Representative a minimum of 7 days prior to the commencement of backfilling operations.

The Contractor will be responsible for testing to establish the Standard Proctor Maximum Dry Density and will be responsible for having the compaction of each lift of backfill tested for conformance to the compaction requirements. All results will be provided to the Owner's Representative as the work progresses

The maximum backfill lift thickness shall not exceed 250 mm (compacted). Backfill shall be compacted to a minimum of 95% Standard Proctor Maximum Dry Density unless otherwise specified by the Owner's Representative or on the drawings. The Contractor shall decrease this lift thickness if necessary to obtain the specified density. The moisture content of the backfill during placement shall be such that temporary pore water pressure buildup during compaction is avoided. A moisture content of about 2% below optimum is recommended. Backfill compaction shall be accomplished without disturbance or distortion of reinforcing system and panels. Compaction in a zone 1.5 metres wide adjacent to the wall facing shall be achieved using light mechanical tampers. For bridge abutments, backfill beneath the bridge seat shall be compacted to 100% Standard Proctor Maximum Dry Density within the zone outlined on the Shop Drawings.

925.10.06 Panel Erection

The Contractor shall make use of the guidance services provided by the supplier and provide adequate notice to the supplier of the intended date for start of erection.

Precast concrete panels shall be placed with the aid of a light crane or other equipment as approved by the MSE wall designer. Panels are lifted by means of inserts (minimum

of two per panel) set into the upper edge of the panels. Panels shall be placed level in successive lifts, staggered as shown on the drawings, as backfill placement proceeds.

During backfilling operations each panel will rotate away from the fill about its lower edge as fill is placed to the top of the panel. The rotation results from initial stressing of the reinforcing elements. To allow for rotation each panel shall be inclined inward (towards the fill) by an amount equivalent to the outward rotation observed for the previously placed and completely backfilled panels.

The first panels erected shall be inclined inward as directed by the MSE wall designer. All subsequently placed panels shall be inclined inward based on the continuously monitored actual rotation. External bracing of the first level of panels will be required and shall be maintained during placement of the initial 1500 mm of fill.

Vertical (or sloped, as shown on the drawings) tolerances and horizontal alignment tolerance shall not exceed 18 mm when measured along a 3000 mm long straight edge. The overall vertical (or sloped) tolerance of the wall (measured from top to bottom) shall not exceed 12 mm per 3000 mm of wall height. If Supplier tolerances are not maintained the Contractor shall disassemble and reinstall the structure at no cost to the Department.

The Contractor will arrange for the mechanically stabilized earth company to provide experienced construction staff during commencement of the project. This technical staff will provide instruction both to the Contractor and the Owner's Representative for as long a period as required by the Owner's Representative.

The construction and erection work shall be executed under the continuous supervision and direction of a competent foreman/superintendent accepted in writing by the MSE wall supplier. This person must have experience in the construction and erection of MSE wall structures. The contractor shall provide suitable written evidence of tradesmen/supervisor qualifications if required by the Owner's Representative.

925.10.07 Drainage Pipe Installation

Perforated drainage pipe wrapped in filter fabric shall be installed to the lines and grades shown on the drawings and in accordance with the General Specifications or as directed by the Owner's Representative.

925.10.08 Traffic Barrier or Coping Placement

Precast traffic barrier or coping, on top of the concrete face panels, requires a smooth transition concrete/grout filler between the panel top and the underside of the barrier/coping. This concrete/grout filler shall be cured as per the Manufacture's

instructions and installed in accordance with the lines and grades as shown on the Drawings and General Specifications.

Ensure a uniform top of wall alignment. Traffic barrier or coping, placed on top of the concrete face panels, shall have construction/expansion joints to be spaced no greater than 2000 mm on centre or coincident with the panel joints, whichever is less. Coping shall be installed in accordance with the General Specifications and have evenly spaced joints positioned as shown on the drawings.

925.11 MEASUREMENT FOR PAYMENT

The unit of measurement for Mechanically Stabilized Earth (MSE) structures shall be per square metre of total wall face area from top of levelling pads to the top of the uppermost panels (excluding levelling pad and coping heights), based on the accepted panel areas given in the Shop Drawings.

925.12 BASIS FOR PAYMENT

Payment at the contract price for “Design, Supply and Install Mechanically Stabilized Earth Retaining Walls” in the Unit Price Table shall be full compensation for all labour equipment and materials required to construct the wall in accordance with the plans and specifications. Included will be all costs associated with the wall foundation, levelling pad, concrete panels, bearing pads, soil reinforcing system, frictional backfill, zones of non-frost-susceptible fill, geotextiles and adhesive over joints, perforated drainage pipe and precast coping.

Excavation - Other Material as required by the mechanically stabilized earth retaining wall designer for the installation of the mechanically stabilized earth retaining wall (panels, soil reinforcement, levelling slab, coping and frictional backfill) will be considered incidental to the work. If Excavation of rock is necessary to install the MSE Structure it will be paid for as Excavation for Foundations - Solid Rock. Actual quantity of rock to be removed is to be accepted by the Owner’s Representative.

If sub-excavation is required beneath the reinforced earth soil mass then it will be paid for as Excavation for Foundations - Other Material.

Placement of material behind the reinforced soil block will be paid for separately either as “Rock Fill in Place” or “Other Material in Place” in accordance with Section 204.

All work associated with soil testing by the Contractor and the preparation of shop drawings, erection drawings, erection procedures, calculations, etc. shall be considered incidental to the work. There will be no payment for MSE wall installation until all initial

testing results and the letter of conformance from MSE wall supplier for the backfill has been submitted to the Owner's Representative. Submission of the required gradation and compaction testing results on the backfill will be required as the MSE wall construction progresses prior to the approval of payment for MSE wall installation.