

**Proposed Instructions for Usage:** This should be used as an alternate to N Index SSP 12501: PRECAST MODULAR RETAINING WALL SYSTEMS.

For use on projects let after.

**I. DESCRIPTION** – This work is the designing, furnishing, and erecting of approved mechanically stabilized systems used as retaining walls. These systems, some of which are proprietary, employ either strip or grid type metallic reinforcements in the soil mass and a discrete modular precast facing.

**II. DESIGN** - Submit to the District Bridge Engineer, for review and for approval, 4 sets of plans and design calculations for mechanically stabilized earth retaining walls, prepared in accordance with PENNDOT Design Manual Part 4. Allow a maximum of 30 calendar days from the day final plans are received by the District Bridge Engineer for review and approval. Perform fabrication of standard panels in accordance with the approved plans using pre-approved standard shop drawings. Do not perform any construction before approval of design and completed plans. Use mylar furnished by the Department.

Have a Professional Engineer (P.E.), registered in the Commonwealth of Pennsylvania, sign and date the first sheet of the computations.

Include the following statement on the first sheet of the drawings above the P.E. seal:

"I hereby certify that all design assumptions have been validated either through construction details or notes on these drawings, or through the contract plans and provisions."

In the event certain design parameters, stresses, or specifications are in conflict, the following order of predominance will govern:

- Design requirements listed herein and in PART B, "SPECIAL DRAWINGS AND SPECIAL DESIGN REQUIREMENTS", of the special provisions.
- Design related Strike-off Letters in effect on the date of project advertisement. Refer to the list in PART B.
- PENNDOT Design Manual Part 4, "Structures".
- PENNDOT Bridge Design and Bridge Construction Standards.
- AASHTO Standard Specifications for Highway Bridges (date as indicated) and interim specifications.

In the event that a clear order of predominance cannot be established, or a difference in the interpretation of the design cannot be resolved, the Chief Bridge Engineer will arbitrate and such decision will be final.

If weep holes are not indicated, and no other provision for subsurface drainage has been incorporated into the design but is required to validate design assumptions of lateral earth pressure from dry backfill, provide a weep hole in every other precast face panel exposed at

ground elevation. Locate weep holes a minimum of 300 mm (1 foot) above finished ground elevation.

Provide cast-in-place or preapproved, precast concrete bridge barriers as shown on plans.

Provide cast-in-place or precast copings.

### III. MATERIAL -

**(a) Precast Concrete Face Panels.** Furnish precast face panels as specified in Section 714, except provide concrete having a 28-day minimum compressive strength of 28 MPa (4,000 pounds per square inch) when tested in accordance with PTM No. 604.

Provide panels having a minimum structural thickness of 140 mm (5 1/2 inches).

Place tie strips, reinforcement bars, connecting rods (where required), PVC pipe for weep holes when indicated, PVC tubes (where required), and handling devices, to the dimensions and tolerances indicated or as approved by the Representative, before casting.

**1. Testing and Inspection.** Acceptability of the precast panels will be determined on the basis of slump and entrained air content testing of the concrete mixture, compressive strength testing, and visual inspection. Furnish facilities for the Department to perform all necessary sampling and testing in an expeditious and satisfactory manner. Acceptance will be as specified herein.

Acceptance of precast concrete panels with respect to compressive strength will be based on the results of production lot testing. A production lot is defined as the panels represented by 1-day's production or forty panels whichever is less. Acceptance will be based on compliance with the requirements of Sections 714.4(b) and 714.7(a), except the lot compressive strength will be determined as the average of the compressive strength testing of two cylinders and no individual test result may be below 25 MPa (3,600 pounds per square inch).

Acceptance with respect to visual inspection will be based on compliance with the requirements of Section 713.2(d). In addition, precast units may be rejected for color variations on the front.

Completed precast units will be inspected before shipment, and cracked, damaged, or otherwise unsatisfactory units will be rejected. Properly patch all excessive voids and other defects on exterior surfaces in accordance with the approved QC Plan.

Repairs and repair procedures beyond the limits of repair defined in Publication 145 require the approval of the Representative. Mark rejected panels with the words "Rejected for Department Use" using waterproof paint.

**2. Forms.** Construct forms of steel in a manner that assures the production of uniform units, and leave forms in place until they can be removed without damage to the unit.

Replace damaged forms or forms having a deteriorated surface on the finished face.

**3. Mixing and Placing Concrete.** Mix and deliver concrete as specified in Section 704. For transporting, placement, and consolidation of concrete, use methods that will prevent segregation of concrete materials and displacement of steel reinforcement from its proper position in the

form. Do not place concrete in forms or casting beds when ambient temperatures are below 4 °C (40F) or above 38 °C (100F). Do not use admixtures containing chlorides.

**4. Casting.** Cast the panels on a flat area, front face down. Set connection guides into the rear face. Do not attach the panel reinforcing steel to or allow contact with embedded loops, tie strips, reinforcing steel, or other devices. Hold attachment devices in place during concrete placement to ensure that proper alignment is maintained. Place concrete in each unit without interruption and consolidate by use of a vibrator, supplemented by such hand tamping as may be necessary to force concrete into the corners of the form and prevent formation of honeycomb segregation, cracking, or cleavage planes. Use clear form oil throughout the casting operation.

**5. Concrete Finish.** Provide a conventional surface finish for the front face, unless otherwise indicated or specified, and, for the rear face, a floated surface finish. Scream to eliminate open pockets of aggregate and surface distortions in excess of 6 mm (1/4 inch) on the rear face of the panel.

When a special or decorative surface finish is required, display for approval a typical sample of the face panels, showing the color, texture, and finish intended to be used, before standard production of panels. Acceptability of the production units with respect to their architectural surface treatment will be made at a distance of 9000 mm (30 feet), in natural daylight, when compared to the approved sample(s).

**6. Curing.** Cure units in accordance with the approved QC Plan until the concrete obtains 80% of the specified minimum 28-day compressive strength.

**7. Tolerances.** Manufacture all units within the following tolerances:

- Do not exceed an angular distortion with regard to height of 5 mm (0.02 inch) in 1525 mm (5 feet).
- Panel Dimensions. Position of panel connection devices within 25 mm (1 inch). All other dimensions within 5 mm (3/16 inch).
- Panel Squareness. Not to exceed 13 mm (1/2 inch), as determined by the difference between two diagonals.
- Panel Surface Finish. Surface defects on smooth formed surfaces, measured over a length of 1525 mm (5 feet), not to exceed 3 mm (1/8 inch) and on texture finished surfaces not to exceed 8 mm (5/16 inch).

For panels using welded wire fabric as grid reinforcement, fabricate panels in a manner that ensures compliance with the wire mesh to panel connection requirements indicated in BC-799M.

**8. Marking.** Clearly scribe or paint with waterproof paint, on the rear face of each panel, the date of manufacture, lot production number, and piece mark.

**9. Handling, Storing, and Shipping.** Handle, store, and ship all units in such a manner as to eliminate the danger of chipping, cracking, fracture, and excessive bending stress, or damage to connection hardware. Support the panels in storage, on firm blocking located immediately adjacent to the tie strips, to avoid bending tie strips. Care should be taken to not bend or damage tie strips when handling with a forklift. Use dunnage or blocking which will not stain the face of the precast unit.

Do not ship units until the 28-day minimum compressive strength is attained. Provide 24-hour advance notice of loading and shipping schedule.

Repair or replace any unit damaged during handling, transporting, erecting, or backfilling, or any unit that cannot be placed satisfactorily in the wall, in accordance with the approved QC Plan.

**(b) Reinforcement.**

**1. Reinforcing Strips and Tie Strips.** Fabricate tie strips of hot rolled steel conforming to the requirements of ASTM-A1011/1011M, ~~Structural Steel (SS), Grade 340, or ASTM A1011/A1011M, High-Strength Low-Allow Steel (HSLAS), Grade 340 (Grade 50), Class 1, including all trace elements.~~ Hot roll reinforcing strips from bars conforming to ASTM-A36/A36M or ASTM-A572/A572M (AASHTO-M223/223M), Grade 450, or equivalent, to the required shape and dimensions. Hot dip galvanize reinforcing strips and tie strips, after fabrication, as specified in Section 1105.02(s) ) and in accordance with ASTM-123. Cut to length within the tolerances indicated on approved shop drawings. Punch holes for bolts, in the location shown, before galvanizing. Carefully inspect all reinforcing and tie strips to ensure they are true to size and free from defects that may impair their strength and durability. Cutting of reinforcing strips at pile locations, vertical obstacles, or utilities is not acceptable.

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Care must be taken to avoid bending or damage to the galvanized coating on reinforcing and tie strips during handling, storing, and shipping.

**2. Steel Mesh Reinforcement.** Conform to the requirements of ASTM-A82 for cold drawn wire. Shop fabricate and weld the finished mesh fabric in accordance with ASTM-A185. In addition, comply with the following:

- Fabricate, transport, store, and place steel mesh in a manner that ensures compliance with the wire mesh to panel connection requirements as indicated in BC-799M.
- Fabricate wire mesh in a manner that produces a flat mesh with straight longitudinal and transverse wires meeting the following tolerances:

Flatness:

Length of Wire Mesh:	3000 mm (10') or less	3300 mm (11') to 6000 mm (20')	6300 mm (21') to 9000 mm (30')	9300 mm (31') or greater
Permissible Variation:	50 mm (2")	70 mm (2 3/4")	90 mm (3 1/2")	100 mm (4")

Straightness of Longitudinal Wires:

Length of Wire Mesh:	3000 mm (10') or less	3300 mm (11') to 6000 mm (20')	6300 mm (21') to 9000 mm (30')	9300 mm (31') or greater
Permissible Variation:	50 mm (2")	70 mm (2 3/4")	90 mm (3 1/2")	100 mm (4")

Maintain flatness and straightness of the wire mesh during transportation and assembly. Wire mesh not meeting the flatness and straightness tolerances may be realigned using a method that does not damage the galvanizing, damage or weaken the weld at intersection points

of the longitudinal and transverse wires, or weaken the strength of the wires. Submit the realignment procedure to the Representative for approval.

Galvanize mesh panels as specified in Section 1105.02(s) and in accordance with ASTM-A641, after fabrication. Provide wire size and mesh configuration as indicated. Carefully inspect all mesh reinforcement and attachment devices to ensure they are true to size and free from any defects that may impair their strength and durability. Cutting of steel mesh or grids at pile locations, vertical obstacles, or utilities is not acceptable.

Care must be taken to avoid bending or damage to the galvanized coating on reinforcing mesh or grids during handling, storing, and shipping.

**3. Reinforcement Bars.** Grade 420 (Grade 60), Section 709.1(a)1. Provide epoxy coated reinforcement bars, as specified in Section 709.1(c) or galvanized reinforcement bars, as specified in Section 709.1(e), for cast-in-place or precast concrete bridge barrier, moment slab (cast-in-place), curb, and copings and precast panels.

**(c) Fasteners and Attachment Devices.**

- Provide galvanized, high strength hexagonal bolts and nuts as specified in Section 1105.02(d) for reinforcement in Section III(b)1.
- Provide embedded loops fabricated from cold drawn steel wire conforming to ASTM-A82 and welded in accordance with ASTM-A185. Galvanize loops as specified in Section 1105.02(s) and in accordance with ASTM-A641 for reinforcement in Section III(b)2.
- Provide connector bar fabricated from cold drawn steel wire conforming to ASTM-A82 and galvanized as specified in Section 1105.02(s) and in accordance with ASTM-A641 for reinforcement in Section III(b)2.
- Fabricate connector rods (where required) from PVC conforming to material as recommended by the manufacturer or steel conforming to ASTM-A36/A36M and galvanized as specified in Section 1105.02(s) and in accordance with ASTM-A123. Fabricate to required diameters and lengths as indicated.
- Provide galvanized lifting devices to facilitate panel erection, and galvanize as specified in Section 1105.02(s) and in accordance with ASTM-A123.

**(d) Bearing Pads.**

- For horizontal joints between panels, provide preformed EPDM rubber pads conforming to ASTM-D 2000 2AA 812 A13 C12 F17, neoprene elastomeric pads having a Durometer Hardness of  $80 \pm 5$ , or preformed high density polyethylene panel pads conforming to ASTM-D1505 and having a minimum density of  $0.946 \text{ g/cm}^3$ .

**(e) Granular Fill Material.** Provide crushed or natural sand, crushed or uncrushed gravel, blasted limestone, blasted sandstone, or any standard size coarse aggregate meeting the following gradation as determined in accordance with PTM 616:

<u>Sieve Size</u>	<u>Percent Passing</u>
75 mm (3 inches)	100
19 mm (3/4 inch)	20 - 100

425 µm (No. 40)	0 - 60
75 µm (No. 200)	0 – 10*

\*Determination of the fines content (minus 75 µm (No. 200) sieve material for MSE wall reinforced backfill must be determined by wash test according to PTM No. 100, Amount of Material Finer Than 75 µm (No. 200) sieve in Aggregate. This is in addition to PTM No. 616, Sieve Analysis of Coarse and Fine Aggregate.

Have the backfill conform to all of the following additional requirements:

1. Furnish materials meeting the quality requirements of Type C coarse aggregate or better as specified in Section 703.2(a), Table B, except furnish materials free of clay lumps, friable particles, coal and coke. Do not use metallurgical slag or cinders.
2. Furnish materials with a maximum plasticity index (PI) of 3 as determined in accordance with AASHTO T89 and T90.
3. Furnish material exhibiting an angle of internal friction of not less than 34 degrees as determined, in accordance with AASHTO-T236, on the portion finer than the 2.0 mm (No. 10) sieve compacted to 95% of PTM No. 106, Method B, at optimum moisture content, except for coarse aggregate as specified in Section 703.2.

Direct shear testing may be performed on samples containing material larger than the 2.0 mm (No. 10) sieve, if the shear device conforms with AASHTO-T236, Sections 5.4 and 5.5.

4. Provide materials meeting the following electrochemical criteria:

<u>Test</u>	<u>Criterion</u>
pH, AASHTO T289	6 - 10
Resistivity, AASHTO T288	<ul style="list-style-type: none"> <li>• &gt; 5000 ohm-centimeters - No chloride or testing is required.</li> <li>• 2000 - 5000 ohm centimeters - Perform the specified chloride and sulfate tests.</li> </ul>
Chlorides, AASHTO T291, Method B	< 100 parts per million (ppm)
Sulfates, AASHTO, T290, Method B	< 200 parts per million (ppm)

Provide randomly selected backfill samples for testing 30 calendar days before use, as directed by the Representative. Obtain approval for backfill material, before use. Each sample submitted is to consist of the following:

- Three bags of approximately 20 kg (40 pounds) containing a normal specimen representing the complete gradation.
- One bag containing approximately 5 kg (10 pounds) of material passing the 2.36 mm (No. 8) sieve.

During the backfilling operation, under the direction and supervision of the Representative, obtain verification samples (n=3) as specified in Section 703.5(b), Table F. The Representative will select sample locations according to PTM No. 1.

If the material sampled fails to meet the specified requirements, immediately discontinue its use, and remove and replace all material placed since the last passing acceptance or verification sample was obtained. Do not continue backfilling until new backfill material has been sampled and approved.

**(f) Pipe Underdrain.** Section 610.2(a)

**(g) Polyvinyl Chloride (PVC) Pipe.** Section 610.2(a)4.

**(h) Cast-in-Place Concrete.** Section 704. Provide Class A Cement Concrete for footings and leveling pads and Class AA Cement Concrete for curbs, concrete bridge barriers or traffic barriers, moment slabs, and backwalls above bridge seats.

**(i) Geomembrane.** Section 736.

- Dimensional Stability (ASTM-D1204).....+2 %

**(j) Geotextiles.** Class 2, Type A, Section 735

**(k) Certification.** Certify as specified in Section 106.03(b)3. Furnish a copy of the results of all tests performed which are necessary to assure compliance with the specifications. Furnish a copy of Form CS-4171 with each shipment of precast products.

**(l) Nonshrink Grout.** Section 1080.2(c)

#### IV. CONSTRUCTION -

**(a) Shop Drawings.** Before fabrication, submit and obtain approval for shop drawings. Show complete fabrication details and dimensions, as well as handling, transportation, and construction procedures for all wall elements.

**(b) Excavation and Foundations.** Grade the structure foundation level, or to the indicated slope, for a width equal to or exceeding the length of the reinforcing strips or mesh, or as indicated. Before wall construction, except where constructed in rock, compact the foundation with a smooth wheel vibratory roller. Remove any foundation soils found to be unsuitable and replace with granular material. Excavate, as specified in Section 204, to the limits and construction stages indicated.

Do not begin wall erection until the foundation has been accepted.

Construct cast-in-place footings and leveling pads as specified in the applicable portions of Section 1001.3, to the dimensions and details indicated and within the right of way, before placement of precast wall units.

Place bottom of footing and/or leveling pad at a minimum depth equal to prevailing frost depth but not less than 900 mm (3 feet) below finished ground elevation unless otherwise indicated.

**(c) Stub Abutment on Piles.** If stub abutment supported on piles is indicated, construct stub abutment support system, during placement of MSE wall backfill, as follows:

- Drive all piles before MSE wall installation.

- Encase each pile in a Smooth Wall or Corrugated Galvanized Steel (SWCGS) pipe of sufficient thickness to prevent buckling or distortion during placement and compaction of wall backfill.
- Place spacers between the pile and the SWCGS pipe to prevent the pipe from coming in contact with the pile during backfilling of the wall.
- Extend SWCGS pipe from the bottom of MSE wall backfill to the bottom of the bridge stub abutment footer.
- After positioning, seal the top of the SWCGS pipe to prevent debris accumulation during placement of wall backfill, and keep the pipe sealed until filled with Type A fine aggregate.
- Fill the SWCGS pipe loosely with Type A fine aggregate either before or after completion of MSE wall construction and as directed and approved by the Representative.

**(d) Wall Erection.** Align precast concrete panels, vertically, using inserts cast into the top edge of the panels. Place panels in successive horizontal lifts, in the sequence indicated or shown on the approved shop drawings, as backfill placement proceeds. As the specified granular fill material is placed behind a panel, maintain the panel in a vertical position by means of clamps placed at the junction of adjacent panels and temporary wooden wedges placed in the horizontal joint at the junction of the two adjacent panels on the external side of the wall. Provide external bracing, if required, for the initial lift.

Install drainage system behind the wall as indicated or as shown on the approved shop drawings.

At least two, but no more than three, rows of panel wedges are to remain in place at all times during construction. Carefully remove wooden wedges, as panel erection progresses, so as to prevent chipping or cracking of concrete panels. Properly repair any damage to erected concrete panels as directed. Remove all wedges when the wall is completed.

Install joint filler as indicated or as shown on the approved shop drawings.

Cover all joints between panels, on the back side of the wall, with geotextile fabric. Apply adhesive to panels only. Do not apply adhesive to geotextile fabric or within 50 mm (2 inches) of a joint. Provide geotextile fabric having a minimum width of 300 mm (12 inches), and overlap fabric a minimum of 100 mm (4 inches).

**(e) Backfilling.** Have backfill placement closely follow the erection of each lift of panels. Roughly level the backfill at each reinforcing element location before placing and bolting.

As indicated, place reinforcing elements normal to the face of the wall. Do not exceed 200 mm (8 inches) (loose) for the maximum lift thickness and closely follow panel erection. Decrease lift thickness if necessary, to obtain the specified density.

Place backfill in such a manner as to avoid any damage or disturbance to wall materials or misalignment of facing panels. Remove and replace any wall materials which become damaged during backfill placement. Correct any misalignment or distortion of wall facing panels due to placement of backfill. Place backfill to the level of the connection and in such a manner as to assure that no voids exist directly beneath reinforcing elements.

Under fill conditions, place specified backfill material to the dimensions as indicated.

At the end of each day, slope the last level of backfill away from the wall in order to rapidly direct runoff away from the wall face. In addition, do not allow surface runoff from adjacent areas to enter the wall construction site. Place and compact the backfill as specified in Section 1001.3(q)2.b; except, the 7 day waiting period for backfilling is not required. Place backfill material at a moisture content less than or equal to the optimum moisture content. Compact backfill without causing disturbance to or distortion of reinforcing members and panels. Achieve compaction within 900 mm (3 feet) of the wall by making at least three passes with light mechanical tampers, rollers, or vibratory systems.

For applications where stub abutments are to be used to support bridge or other structural loads, compact the top 1525 mm (5 feet) below footing elevation to 100% of the determined dry mass (weight) density.

Do not exceed 20 mm (3/4 inch) for vertical tolerances and horizontal alignment tolerances when measured along a 3 m (10-foot) straightedge. The maximum allowable offset in any panel joint is 20 mm (3/4 inch). Do not exceed an overall vertical tolerance for the wall (top to bottom) of 12 mm per 3 m (1/2 inch per 10 feet) of wall height. Provide uniform vertical and horizontal joint openings between panels.

Check the top row of panels with a level and 3 m (10-foot) straightedge, after each layer of backfill material is placed and compacted. Satisfactorily correct panels not within specified tolerances, before placing additional backfill material.

For structures at stream crossings, provide a blanket of No. 57 coarse aggregate behind the wall panels, to a width of 460 mm (18 inches), for the full length and to the height indicated (minimum 100-year flood level).

Provide Class 2, Type A geotextile fabric, with a minimum overlap of 100 mm (4 inches), at the interface of the coarse aggregate blanket and the granular fill material.

Place geomembrane as indicated. Overlap seams a minimum of 457 mm (18 inches) or seam joints by use of extrusion welding methods with a maximum overlap of 100 mm (4 inches).

Perform site-specific field or laboratory pullout tests, for fully saturated conditions, as indicated or directed and in the presence of the Representative.

**(f) Pipe Underdrain.** Place, as required, as specified in Section 610.3 and as indicated.

**(g) Dewatering.** Furnish, install, operate, and maintain satisfactory dewatering systems as required to maintain the site in a dry and workable condition. Include all equipment and materials, and continue as long as necessary.

**(h) Technical Assistance.** Arrange for a company representative to be present at the project site to assist the fabricator, Contractor, and Representative until they are familiar and confident in casting, installation, and erection procedures. Arrange for monthly visits to the project site by a company representative/engineer during wall construction. Provide a technical representative to assist in the event unusual problems or special circumstances arise.