CITY OF DULUTH
PURCHASING DIVISION
Room 120 City Hall
411 West First Street
Duluth, Minnesota 55802-1199
218/730-5340
purchasing@duluthmn.gov

Addendum #1
File # 19-99241
Project No. 1665
Lift Station No. 9, 17, and 26 Improvements

This addendum serves to notify all bidders of the following changes to the solicitation documents:

DRAWINGS

1. Drawing G-5 Segmental Retaining Wall Detail. **DELETE** this entire drawing, it will not be used. Bidders shall refer to Specification Section 32 32 23 Prefabricated Modular Block Wall (PMBW) With and Without Soil Reinforcement.

2. Drawing G-6 Site Civil Details. **REPLACE** with the attached Drawing G-6 Civil Details.

3. Drawing E-6 Lift Station 17 Site Plan. **REPLACE** with the attached Drawing E-6 Lift Station 17 Site Plan.

SPECIFICATIONS

1. Under SP-22 WLSSD Permit on page 9 – this section shall be omitted. There are no WLSSD permits for this project.

2. Under Technical Specification Section 26 05 00 Part 1.03 Description of Work – the SCADA allowance of $50,000 shall be omitted. All allowances for this project are shown in Technical Specification Section 01 21 00 in addition to the bid tab.

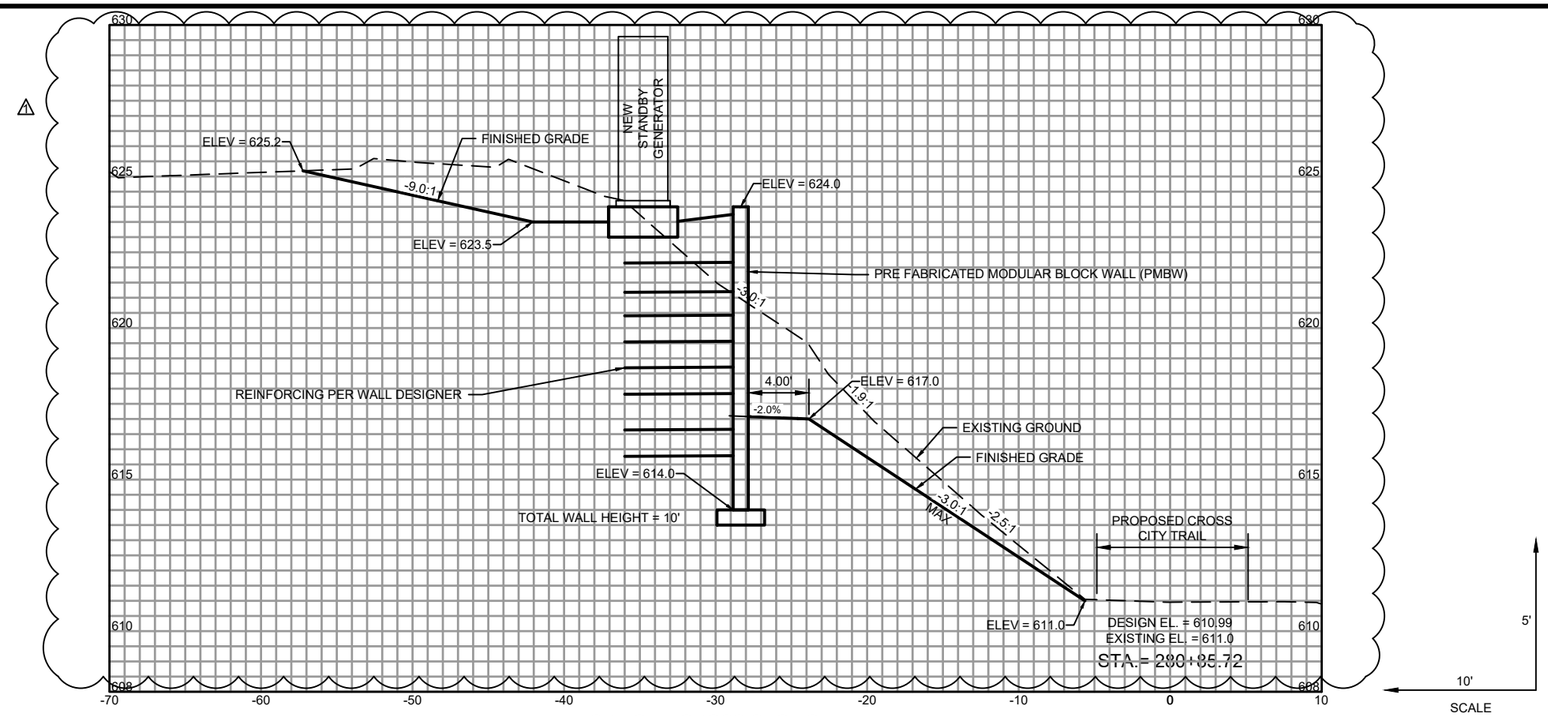
3. Under Technical Specification Section 26 05 02 Utility Services Part 1.03 Description of Work – the Electrical Service contact person with Mn Power shall be changed to: Aaron Nelson (218) 355-2039

4. Under Technical Specification Section 32 32 23 Segmental Retaining Wall (Modular Units). **REPLACE** entire section with the attached section 32 32 23 (2411) Prefabricated Modular Block Wall (PMBW) With and Without Soil Reinforcement

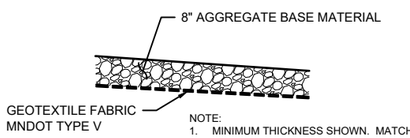
Please acknowledge receipt of this Addendum by checking the acknowledgment box within the www.bidexpress.com solicitation.

Posted: 3/20/19

⚠1 NOT USED



LS 17 SITE CROSS SECTION
SCALE AS NOTED



NOTE:
1. MINIMUM THICKNESS SHOWN. MATCH EXISTING.

TYPICAL GRAVEL DRIVEWAY RESTORATION DETAIL
NO SCALE

NOT USED

NOT USED

PROJECT NO.:	00616118	SCALE: AS SHOWN	NO.	DATE	REVISION	BY
PROJECT DATE:	7/25/2018	DRAWN BY: AK	⚠1	03/19/2019	REVISION 1	JJ
F.B. :	.	CHECKED BY: SRC	.	.	.	.
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PLOT DATE: 3/19/19, P:\610s\616\00616118\CADD - 2016\Construction Drawings\00616118 Site Civil Details.dwg

I HEREBY CERTIFY THAT THIS PLAN, REPORT, OR SPECIFICATION WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.

7/25/18 Date — 44287 License No.

SCOTT R. CHILSON

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LIFT STATION NO. 9, 17 & 26 IMPROVEMENTS
CITY OF DULUTH, MINNESOTA
CITY OF DULUTH, ST. LOUIS COUNTY, MN

SITE CIVIL DETAILS

Contract No. L 30784

FILE NO. 00616118

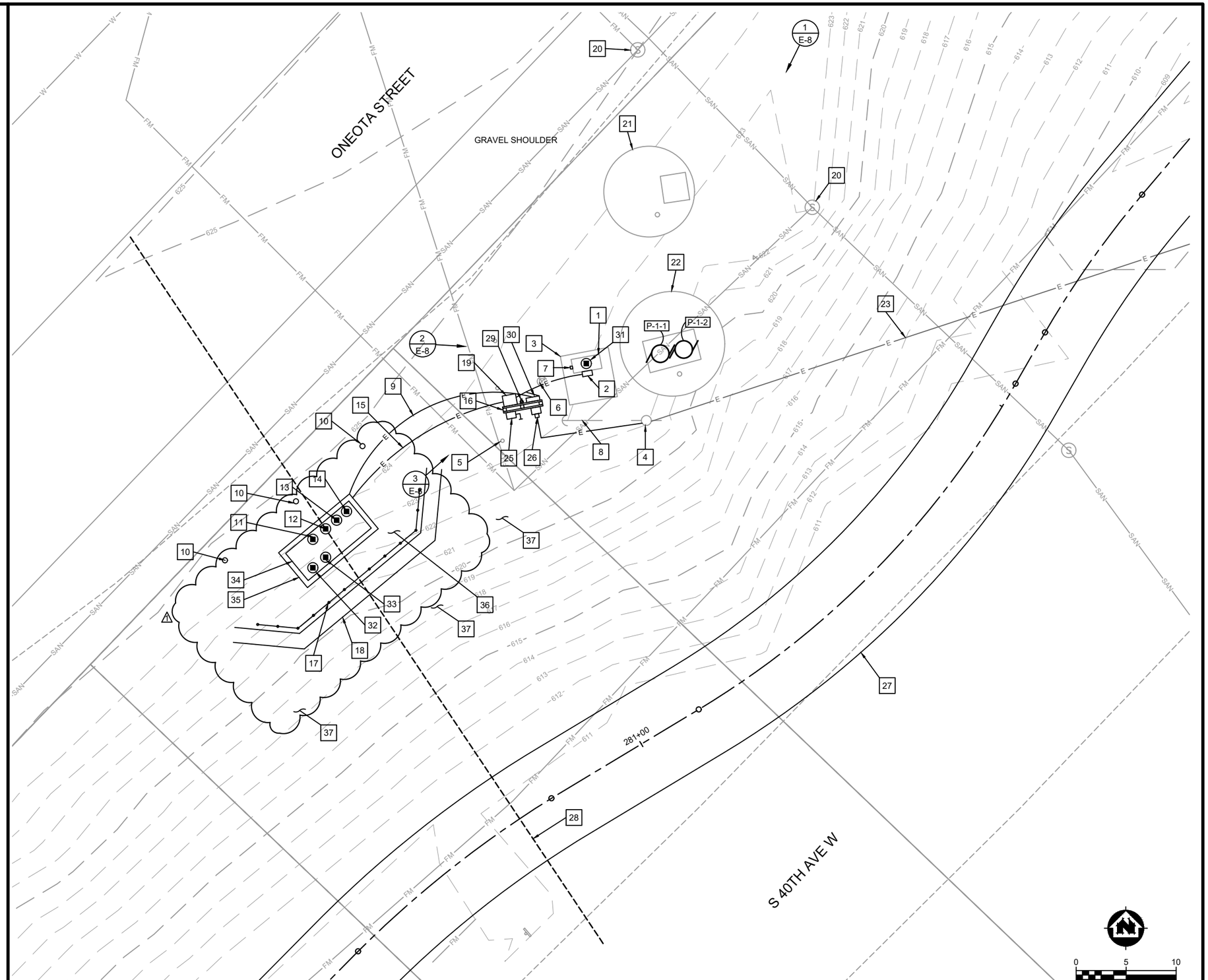
SHEET G-6

GENERAL NOTES

1. DO NOT SCALE DRAWINGS. IF DIMENSIONS ARE IN QUESTION, THE CONTRACTOR SHALL BE RESPONSIBLE FOR OBTAINING CLARIFICATION FROM ENGINEER PRIOR TO PROCEEDING WITH WORK.
2. SIZE HOMERUN WIRING PER ONE-LINE DIAGRAM AND WIRE SCHEDULE.
3. CONTRACTOR TO VERIFY ACTUAL FIELD WIRING REQUIREMENTS WITH EQUIPMENT SUPPLIER. PROPER SEPARATION OF POWER AND CONTROL CIRCUITS SHALL BE MAINTAINED.
4. ALL TRENCHING SHALL BE A MINIMUM OF 24" IN DEPTH TO THE TOP OF CONDUIT. CONTRACTOR SHALL BE RESPONSIBLE FOR LOCATING EXISTING UTILITIES PRIOR TO PERFORMING ANY TRENCHING OR BACKFILLING.
5. THE CONTRACTOR SHALL REVIEW AND FOLLOW GUIDELINES OF THE TYPICAL DETAILS.
6. CONTRACTOR SHALL REVIEW CONTRACT DOCUMENT AND PROVIDE ALL WORK, MATERIALS, AND EQUIPMENT FOR A COMPLETE AND OPERABLE ELECTRICAL SYSTEM.
7. ALL EXTERIOR RACEWAYS THAT EXTEND FROM BELOW GRADE TO ABOVE GRADE SHALL BE INSTALLED WITH EXPANSION COLLAR SLEEVES.
8. FINAL INSTALLATION LOCATION OF STANDBY GENERATOR SHALL BE CONFIRMED WITH OWNER AND ENGINEER.

KEY NOTES [X]

1. EXISTING LIFT STATION CONTROL PANEL, TO REMAIN. PANEL TO BE MODIFIED AS SPECIFIED AND SHOWN HEREIN. LS17-LCP-1
2. EXISTING UTILITY METER ENCLOSURE, TO REMAIN. METER ENCLOSURE TO BE MODIFIED AS SPECIFIED AND SHOWN HEREIN.
3. EXISTING CONTROL PANEL CONCRETE MOUNTING PAD, TO REMAIN.
4. EXISTING UTILITY POWER POLE, TO REMAIN.
5. EXISTING BOLLARD, TO REMAIN.
6. EXISTING TELEMETRY ANTENNA MOUNTING POLE, TO REMAIN.
7. EXISTING CONTROL PANEL PORTABLE GENERATOR PLUG CONNECTOR, TO REMAIN.
8. EXISTING POWER POLE GUY WIRE.
9. PROVIDE CONDUIT FOR 120 VAC CKTS FROM LP TO GCP
10. PROVIDE BOLLARD (TYP)
11. LS17-BATCHG-1 BATTERY CHARGER
12. LS17-BATHTR-1 BATTERY HEATER
13. LS17-BLOCKHTR-1 BLOCK HEATER
14. LS17-GCP-1 GENERATOR CONTROL PANEL
15. SIGNAL AND CONDUIT CONNECTING ATS AND GCP. PROVIDE 1 CONDUIT FOR I/O AND 1 FOR 480 POWER FROM ATS TO GCP.
16. EQUIPMENT RACK (TYP)
17. PROVIDE HANDRAIL
18. PREFABRICATED MODULAR BLOCK WALL WITH SOIL REINFORCEMENT
19. LS17-ATS-1
20. EXISTING MANHOLE
21. EXISTING LIFT STATION VALVE VAULT
22. EXISTING LIFT STATION WET WELL
23. EXISTING OVERHEAD ELECTRICAL LINES (APPROXIMATE LOCATION)
24. NOT USED
25. LS17-MDS-1
26. PROVIDE LS17-METER SOCKET INSIDE TYPICAL DULUTH UTILITIES NEMA 4X ENCLOSURE WITH WINDOW KIT.
27. PROPOSED CROSS CITY TRAIL LOCATION. SEE CITY OF DULUTH PROJECT 0595TR
28. CROSS-SECTION LOCATION, SEE SHEET G-6
29. WP / GFI REC
30. LS17-LP-1
31. NOT USED
32. ENCLOSURE LIGHT
33. FUEL LEVEL TRANSMITTER
34. PROVIDE STANDBY DIESEL FUELED ENGINE GEN-SET W / SUB-BASE TANK
35. PROVIDE TYPICAL GENERATOR PAD
36. PROVIDE TYPICAL GRAVEL BASE AROUND EQUIPMENT. RESTORE AND DRESS ALL GRAVEL AREAS
37. RESTORE WITH EROSION BLANKET



LIFT STATION NO. 17 SITE LAYOUT

PROJECT NO.:	00616118	SCALE:	AS SHOWN	NO.	DATE	REVISION	BY
PROJECT DATE:	7/25/2018	DRAWN BY:	AK	1	03/19/2019	REVISION 1	JJ
F.B.:	.	CHECKED BY:	SRC	.	.	.	.
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PLOT DATE: 3/19/19, P:\610s\616\00616118\CADD - 2016\Construction Drawings\00616119_E3_Electrical Site Plan.dwg

I HEREBY CERTIFY THAT THIS PLAN, REPORT, OR SPECIFICATION WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.

7/25/18 Date — 44287 License No.

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LIFT STATION NO. 9, 17 & 26 IMPROVEMENTS
CITY OF DULUTH, MINNESOTA
CITY OF DULUTH, ST. LOUIS COUNTY, MN

LIFT STATION 17 SITE PLAN
Contract No. L 30784

FILE NO. 00616118
SHEET E-6

SECTION 32 32 23

PREFABRICATED MODULAR BLOCK WALL (PMBW)
WITH AND WITHOUT SOIL REINFORCEMENT

PART 1 GENERAL

1.01 DESCRIPTION OF WORK

A. This work consists of furnishing certified design calculations, shop drawings, fabrication, furnishing and installing a non-structural leveling pad, prefabricated modular block wall, soil reinforcement elements (if applicable), wall construction, excavation and backfill (not included in MnDOT 2451 and 2105) and other services necessary for construction of the wall.

B. The work shall be performed in accordance with the applicable provisions of MnDOT Specifications 3126, 3137, 3149, these Special Provisions, and in close conformity with the lines, grades, standards, design, architectural details, and dimensions shown on the Plans or as otherwise established.

C. Prefabricated modular block wall systems shall be selected from the MnDOT pre-qualified wall system list at the following web site: http://www.dot.state.mn.us/products/index.html

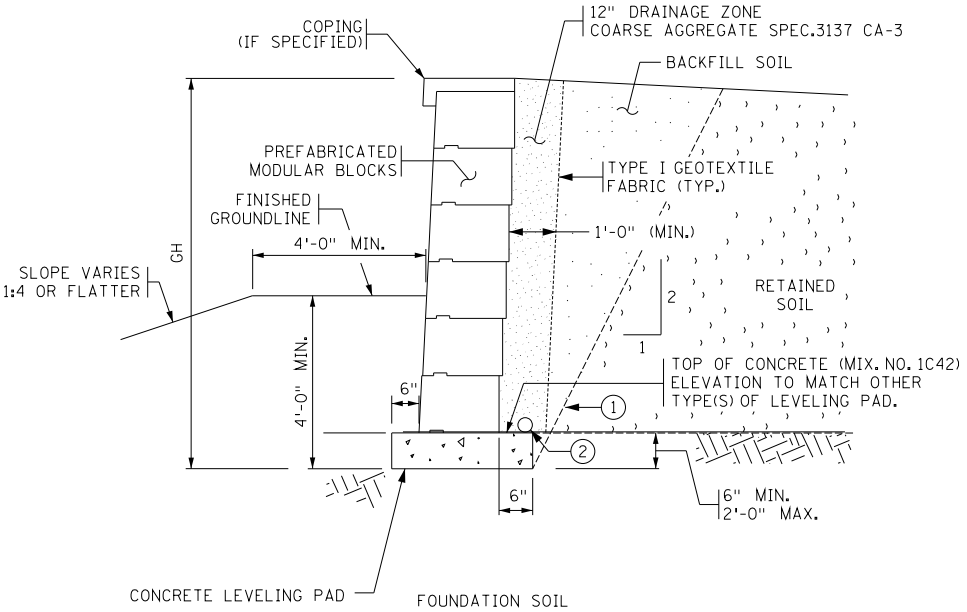
1.02 DEFINITIONS AND DESIGN REQUIREMENTS

A. Definitions:

1. Gravity PMBW: A retaining wall system consisting of wet cast concrete blocks that resists earth pressures and other loads solely by the weight of the blocks, and block infill (if applicable).
2. PMBW with soil reinforcement: A retaining wall system that consists of reinforced soil, soil reinforcement, and wet cast concrete blocks that resists earth pressures and other loads by a reinforced soil mass.
3. Soil Reinforcement: A material placed within a soil mass to increase the strength of the soil.
4. Backfill Soil (for gravity walls only): Soil placed in the backfill zone meeting the requirements of MnDOT 3149 and the "Materials" section of this specification. See Figure 2411-1.
5. Backfill Zone (for gravity walls only): Practical limit for placement of backfill soil. Limit begins at the bottom corner of the concrete portion of the leveling pad and extends at a slope determined by OSHA regulations and the in-situ soils. The pay limit quantity is a line extending at a 2 V:1 H slope from the bottom of the concrete portion of the leveling pad to the finished ground line at the top of the wall. Soil in this zone shall meet the requirements of MnDOT 3149 and the "Materials" section of this specification. See Figure 2411-1.

6. Reinforced Soil (for reinforced walls only): Soil placed in the reinforced zone meeting the requirements of MnDOT 3149 and the "Materials" section of this specification. See Figure 2411-2.
7. Reinforced Zone (for reinforced walls only): Practical limit for placement of reinforced soil. Limit begins near the termini of the bottom layer of soil reinforcement and extends at a slope determined by OSHA regulations and the in-situ soils. The pay limit is a line extending at a 2 V:1 H slope from the intersection of a horizontal line extending at the top of the leveling pad and a vertical line extending at the back of the reinforcing elements. See Figure 2411-2.
8. Retained Soil: Soil retained by the PMBW wall behind the reinforced zone for reinforced walls or backfill zone for gravity walls. See Figures 2411-1 and 2411-2.
9. Foundation Soil: Soil below the leveling pad and beneath the reinforced soil zone. See Figures 2411-1 and 2411-2.
10. Prefabricated Modular Blocks (PMB): Wet cast precast concrete modules used to contain the reinforced soil in position at the face of a reinforced wall. For gravity walls blocks are used to resist horizontal earth forces.
11. Block Depth: The block "depth" is measured from the front face of the block to the back face of the block. The maximum block depth shall be 60", exclusive of face relief.
12. Connection Device: The item used to connect the soil reinforcement to the facing block of a reinforced wall. The connection could either be mechanical or friction.
13. Coping: Attachment placed or cast on top of the wall to tie together the facing blocks and provide an aesthetic finish to the top of the wall.
14. Geotextile Filter: Material placed behind blocks, which prevents migration of fines though the joints, yet still allows for drainage of water through joints.
15. Temporary Shims: Temporary supports used to position the blocks during construction. For permanent shim requirements see Section S-1.4E.
16. Impervious Layer (Geomembrane): A layer of puncture-free and flexible, roughened sheet HDPE, LLDPE or PVC at least 30 mils (0.75 mm) thick placed below the roadway surface to prevent surface water from entering into the wall system. The Impervious Layer (Geomembrane) shall meet the requirements of the materials section of this specification.
17. PMBW System Supplier: The vendor who's name appears on the MnDOT pre-qualified wall system list and is responsible for supplying the PMBW system including the soil reinforcement, blocks and connections. The PMBW System Supplier designs the components of the PMBW system, designs the system for internal stability and prepares the shop drawings.
18. Prequalified PMBW System: A PMBW wall system which has been prequalified by the MnDOT Structural Wall Committee. A list of prequalified PMBW systems can be found at http://www.dot.state.mn.us/products/index.html

19. Gravity PMBW Design Height (GH): For walls with level fill, the wall design height is from the top of block or coping to the bottom of the concrete portion of the leveling pad. For walls containing a parapet with level fill, the wall design height is from the finished ground line at the top of the wall to the bottom of the concrete portion of the leveling pad. Parapets over 6" in height must always contain double sided architectural units. For walls with sloping fills or complex geometries see the AASHTO LRFD Bridge Design Specifications Chapter 11 for design height.
20. PMBW with Soil Reinforcement Design Height (RH): For walls with level fill, the wall design height is from the top of block or coping to the top of the concrete portion of the leveling pad. For walls containing a parapet with level fill, the wall design height is from the finished ground line at the top of the wall to the top of the concrete leveling pad. Parapets over 6" in height must always contain double sided architectural units. For walls with complex geometries see the AASHTO LRFD Bridge Design Specifications Chapter 11 for design height.
21. Supporting Roadway: See Design Section Item H
22. Exposed Height: The distance from the finished ground line at the top of the wall to the finished ground line at the base of the wall. See Design Section B.



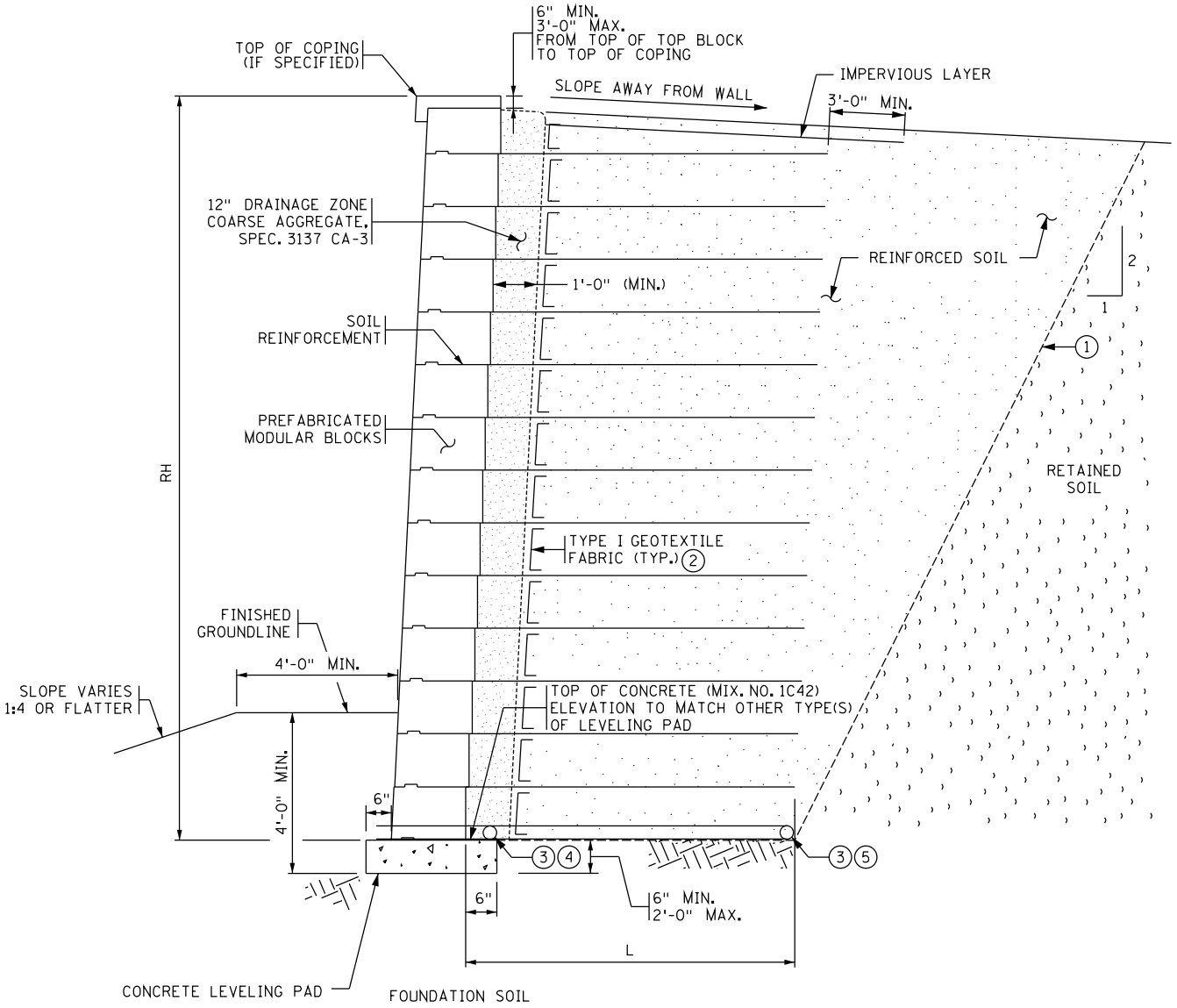
TYPICAL SECTION OF GRAVITY WALL

NOT TO SCALE
LEVEL FILL

(1) PAY LIMIT (2:V TO 1:H) ACTUAL EXCAVATION SLOPE IS DETERMINED BY DESIGNER PREFERENCE OR OSHA REGULATIONS OF IN-SITU SOILS: EXCAVATION BEYOND THESE LIMITS AT CONTRACTORS EXPENSE.

(2) 4" THERMOPLASTIC PERFORATED PIPE, SPEC. 3245. WRAP WITH TYPE 1 GEOTEXTILE, SPEC. 3733, INSTALLATION AS PER SPEC. 2502. CONNECT TO DRAINAGE SYSTEM OR OUTLET THROUGH WALL USING 6" T.P. NON-PERFORATED PIPE WITH RODENT SCREEN. ALL WORK INCIDENTAL.

Figure 2411-1 Gravity PMBW Material Definitions/ Typical Cross Sections



TYPICAL SECTION OF PMBW WITH SOIL REINFORCEMENT

NOT TO SCALE
LEVEL FILL

(1) PAY LIMITS (2V:1H). ACTUAL EXCAVATION SLOPE IS DETERMINED BY OSHA REGULATIONS AND IN-SITU SOILS: EXCAVATION BEYOND THESE LIMITS AT CONTRACTORS EXPENSE.

(2) THE WRAP LENGTH FOR GEOTEXTILE FABRIC SHALL NOT BE MORE THAN 6".

(3) 4" THERMOPLASTIC PERFORATED PIPE, SPEC. 3245. WRAP WITH TYPE 1 GEOTEXTILE, SPEC. 3733. INSTALLATION AS PER SPEC. 2502. CONNECT TO DRAINAGE SYSTEM OR OUTLET THROUGH WALL USING 6" T.P. NON-PERFORATED PIPE WITH RODENT SCREEN. ALL WORK INCIDENTAL

(4) FRONT DRAINTILE.

(5) BACK DRAINTILE.

Figure 2411-2 PMBW with Soil Reinforcement Material Definitions/ Typical Cross Section

PART 2 DESIGN REQUIREMENTS

2.01 The wall designer shall be an engineer licensed by the State of Minnesota and shall prepare, sign, and date the design calculations, shop drawings, and the "PMBW Design Certification Letter" provided herein for each PMBW in the contract. The wall designer shall have experience in the design and construction of a minimum of five PMBW projects of similar size and scope as the project currently under design. This experience shall include PMBWs of equivalent complexity and similar height to the walls being designed as part of this contract. A letter certifying the wall designer's previous design experience shall be submitted to the Engineer. A second engineer shall thoroughly check the design calculations and shop drawings to verify compliance with the specifications and shall also sign and date each "PMBW Design Certification Letter". Both the wall designer and the engineer checking the design shall have taken the NHI course titled "Design of Mechanically Stabilized Earth Wall and Reinforced Soil Slopes" (FHWA-NHI-132042) or equivalent, and shall provide proof of attendance to the Engineer.

2.02 The Contractor shall provide the PMBW designer with a complete set of project plans and specifications, geotechnical reports and all other necessary information to design the wall. The Contractor shall ensure that the wall design is compatible with all other project features that may impact the design and construction of the wall.

2.03 The design shall consider the internal and external stability of the wall mass including eccentricity (overturning), sliding, and bearing pressure including temporary construction slopes or stockpiles. The design shall be in accordance with any restrictions for the chosen PMBW system, the plans, specifications and the PMBW design and construction provisions of the AASHTO LRFD Bridge Design Specifications, latest with all interim revisions. The design shall also be in accordance with the Federal Highway Administration requirements as reported in publication Nos. FHWA-NHI-10-024 and FHWA-NHI-10-025, entitled "Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes - Volumes I and II" and the MnDOT LRFD Bridge Design Manual. If the provisions of the above documents conflict, the designer shall follow the most stringent requirement as determined by MnDOT. The internal stability design of PMBW's with Soil Reinforcement shall be performed using the Simplified Method as defined by the AASHTO LRFD Bridge Design Specifications.

2.04 THE DESIGN SHALL MEET THE FOLLOWING REQUIREMENTS:

A. Only PMBW systems listed on the MnDOT pre-qualified supplier list at the letting date will be allowed. The Contractor shall include in the shop drawing and calculation submittal a copy of the MnDOT pre-qualification letter for the PMBW system, and any deviations of details from the previously submitted pre-qualification shall also be specifically outlined in the letter, including MnDOT approval of the deviations.

B. The exposed height is the distance from finished ground line at the top of the wall to the finished ground line at the base of the wall. The exposed wall height shall

be less than 8’ for gravity walls and less than 18’ feet for walls with soil reinforcement. All walls shall have a minimum of 2’ of block below the finished ground line at the base.

C. This is a phase 2 reinforced PMBW.

D. For internal stability design of PMBW’s with soil reinforcement the reinforced soil shall have a unit weight of 0.120 kcf and friction angle of 34 degrees.

E. For gravity PMBW’s if backfill soil is placed behind the wall at a 1 V: 1 H from the bottom corner of the concrete portion of the leveling pad, a unit weight of 0.120 kcf and friction angle of 34 degrees may be used for design if adequate right of way (ROW) is available and there are no utility conflicts. If backfill soil is placed behind the wall at less than a 1 V: 1 H from the bottom corner of the concrete of the leveling pad or for retained soil (outside of the backfill zone) properties are defined in the Geotechnical Report, but not to exceed a friction angle of 30 degrees. Shop drawings shall show backfill limits consistent with the design assumptions.

F. The contribution from passive resistance in front of the wall shall not be allowed from the finished ground line to a distance of 2’ below the finished ground line.

G. The design life for the wall system other than soil reinforcement and connections shall be 75 years. The design life for geosynthetic soil reinforcement and connections used in the wall system, including long term creep, shall be 100 years.

H. For analysis of corrosion degradation life of metallic components, follow the requirements of “Corrosion/Degradation of Soil Reinforcements for Mechanically Stabilized Earth Walls and Reinforced Soil Slopes” (FHWA-NHI-09-87)

I. For PMBW’s with soil reinforcement the minimum reinforcement length shall be 0.7 x RH (see definitions section regarding PMBW’s with Soil Reinforcement Design Height, RH) but not less than 8’ , measured from the back face of the block. If the length of soil reinforcement is governed by overall stability, the designer shall meet the requirement of overall stability. The depth and weight of the block can be used in external stability calculations, but shall not be used in internal stability calculations.

J. Gravity PMBW’s are not allowed to support traffic. A vehicular roadway or parking lot shall not be situated within a 1V: 1H horizontal distance measured from the front face bottom corner of the bottom block. (see Figure 2411-3). The horizontal distance shall be determined for each wall measured at the highest portion of the wall. Since no vehicular live load is applied, a surcharge must be applied to account for snow loads, future maintenance operations, or future regrading. The surcharge shall be 120 psf with a maximum load factor of 1.35 and a minimum load factor of 1.0.

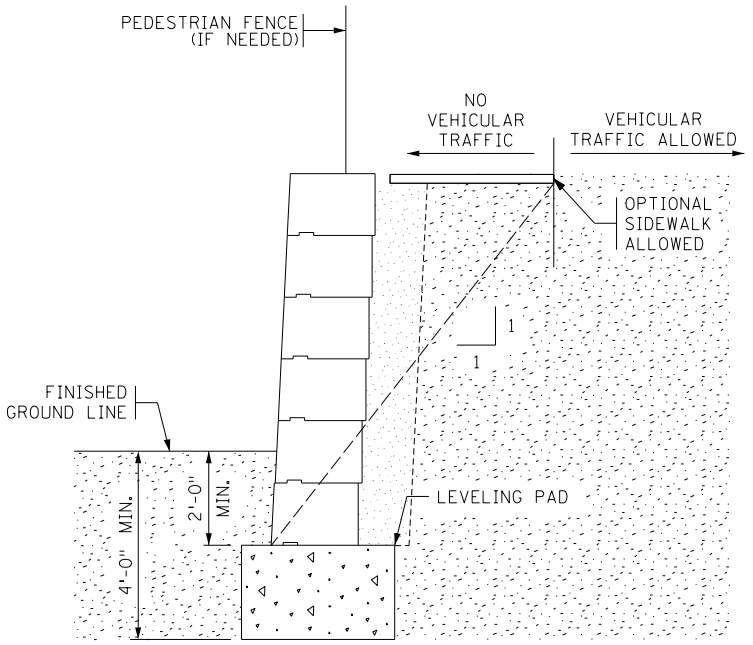


Figure 2411-3 Definition of Supporting Traffic for a Gravity PMBW

1. PMBW's with soil reinforcement are considered to support traffic if a vehicular roadway or parking lot is located within a horizontal distance measured from the front face of the bottom block equal to (Du + L + 0.5 RH) where:

   Du = Depth of the Unit (assume 3' min.)
   L = Length of Reinforcement (Minimum of 0.7 x RH or 8')
   RH = Design Height of PMBW with Soil Reinforcement

2. The horizontal distance shall be determined for each wall measured at the highest portion of the wall.
3. Due to grading, design and visual quality issues between the edge of pavement or roadway and the back of a wall, traffic may not be placed within a horizontal distance of 11' (assumes 3' block depth + 8' behind back of wall) from the front face of the wall, regardless of height. See Figure 2411-4.
4. If a PMBW with soil reinforcement supports traffic, a live load surcharge of 240 psf with a maximum load factor of 1.35 for internal stability and maximum load factor of 1.75 for external stability shall be applied. The live load surcharge shall be placed directly behind the top block and patterned according to the AASHTO LRFD Bridge Design Specifications, Article 11.10.5.2. Since live load surcharge is applied, a surcharge load to account for snow loads, future maintenance operations, or future re-grading need not be applied.

5. If a PMBW with soil reinforcement supports traffic and if noise walls, overhead signs or other items are attached to the traffic barrier, then the wall shall be designed for the both (i) dead load of the barrier and attachments and (ii) dead load of barrier and no attachment loads; with the critical case controlling design. Distribute the dead load to the wall according to AASHTO LRFD Bridge Design Specifications, Article 3.11.6.3.
6. If a PMBW with soil reinforcement supports traffic and the roadway or parking lot is located directly over the soil reinforcement, the top two layers of soil reinforcement shall be designed for a TL-4 vehicular impact load.
7. If a PMBW with soil reinforcement does not support traffic, it does not need to be designed for vehicular live loads. For this case a surcharge load to account for snow loads, future maintenance operations, or future re-grading shall be applied. For PMBW's with soil reinforcement with exposed heights of 8' or less the surcharge shall be 120 psf and placed directly behind the top block with a maximum load factor of 1.35 and a minimum load factor of 1.0 for internal and external stability. For PMBW's with soil reinforcement with exposed heights between 8' and 18' the surcharge shall be 240 psf and placed directly behind the top block with a maximum load factor of 1.35 and a minimum load factor of 1.0 for internal and external stability.

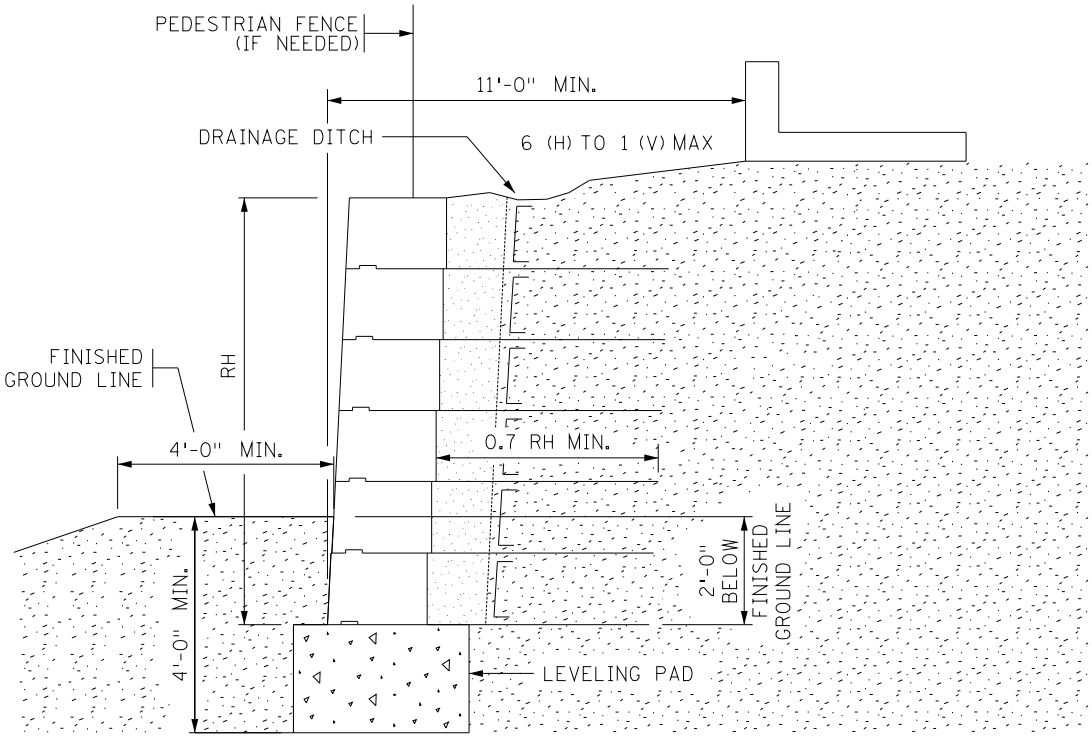


Figure 2411-4 Minimum Traffic Distance for a PMBW with Soil Reinforcement

8. Differential settlement shall be less than 1/200 along the length of the wall and normal to the wall alignment. Adequate joint width/or slip joints shall be provided to accommodate movements without block cracking.
    a. The wall shall be designed and detailed to accommodate differential movements and loads from adjacent structures or structures intercepting the blocks.
    b. All PMBW's shall have 1 foot coarse aggregate per MnDOT Spec 3137 CA-3 behind the block and geotextile fabric per MnDOT Spec 3733 as shown in the Figure 2411-1 or 2411-2.
9. For Gravity PMBW's and PMBW's with soil reinforcement do not place two facing blocks next to each other with interior or exterior angles of less than 90 degrees. Detailed corner block requirements can be found on the MnDOT Approved Products web site.
10. Minimum radius requirements can be found on the MnDOT Approved Products web site.
11. The length of soil reinforcement for the wall shall be constant for all layers. The maximum vertical spacing of soil reinforcement layers shall be 2'-8".
12. Lateral Earth Pressure for gravity PMBW's shall be calculated according to the Coloumb method in AASHTO LRFD Bridge Design Specifications, Article 3.11.5.3. The magnitude and resultant loads and resisting forces shall be calculated according to AASHTO LRFD Bridge Design Specifications, Article 3.11.5.9.
13. If the placement of an obstruction in the soil reinforcement zone such as a catch basin, grate inlet, signal or sign foundation, guardrail post, or culvert cannot be avoided, the design of the wall near the obstruction shall be modified using one the of the following alternatives:
    a. Splay the reinforcement around the obstruction, however geogrid reinforcement may not be splayed unless the connection has been specifically fabricated to accommodate a splay and the connection detail has been approved by MnDOT. Horizontal deviation is referred to as splay. If used, the splay is limited to 15 degrees.
    b. Assuming reinforcement layers must be partially or fully severed in the location of the obstruction, design the surrounding reinforcement layers to carry the additional load which had been carried by the severed reinforcements. The portion of the wall facing in front of the obstruction shall be made stable against a toppling or sliding failure.
    c. Place a structural frame around the obstruction capable of carrying the load from the reinforcements in front of the obstruction to reinforcements connected to the structural frame behind the obstructions. The steel frame and connections shall be designed in accordance with Section 6 of the AASHTO Bridge Design Specifications. The steel frame and connections shall be galvanized, and long-term nominal strength shall consider corrosion losses. If a steel frame is used, an Impervious Layer (Geomembrane) is required

above the steel frame regardless of the system or geogrid reinforcement manufacturer.

14. All ends of the wall shall have corner or radius treatments when they do not abut up to a fixed feature on the project (bridge abutment, other wall, building, etc.). This is to prevent erosion around the end of wall, unsightly exposed ends of blocks and ease of matching in with the existing and fill slopes. The ends are then turned back inward and buried into the soil.

15. All PMBW's with soil reinforcement shall be set on a concrete leveling pad. The minimum width of the pad shall be the depth of the bottom block plus 12 inches. The pad width may need to be increased to accommodate curved wall sections. The minimum height (thickness) of the leveling pad shall be 6 inches (maximum of 2 feet) and the bottom of the leveling pad must extend at least 4' below finished ground line. Vertical steps in the leveling pad shall not be greater than 2.5 feet.

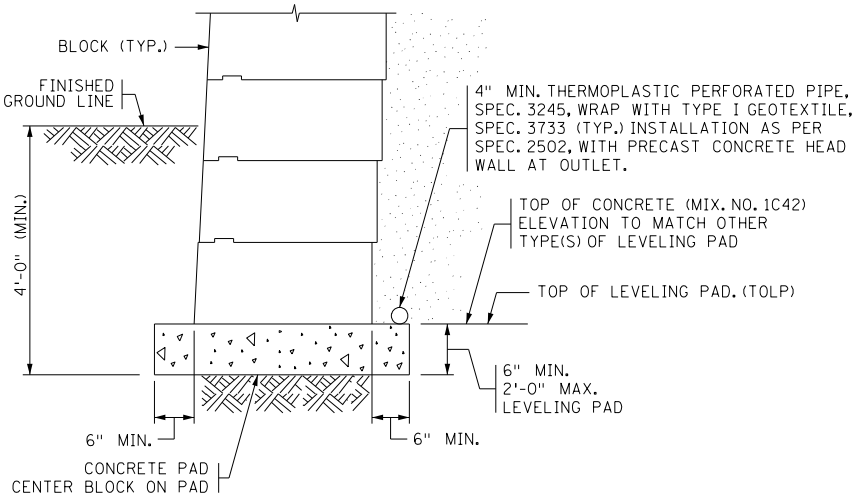


Figure 2411-5 – Full depth concrete leveling pad detail

16. Gravity PMBW's shall be set on either a concrete leveling pad (meeting the minimum requirements above) or a composite leveling pad. The composite leveling pad shall consist of a 6" min. thickness concrete slab over 6" min. thickness of compacted drainable coarse filter aggregate per MnDOT Spec 3149.2H. The coarse filter aggregate shall be completely wrapped with a Type 1 geotextile fabric per MnDOT Spec 3733. (see Figure 2411-6) The bottom of the leveling pad must extend at least 4' below grade. Drains shall be required at the bottom of the coarse filter aggregate and directly above the concrete.

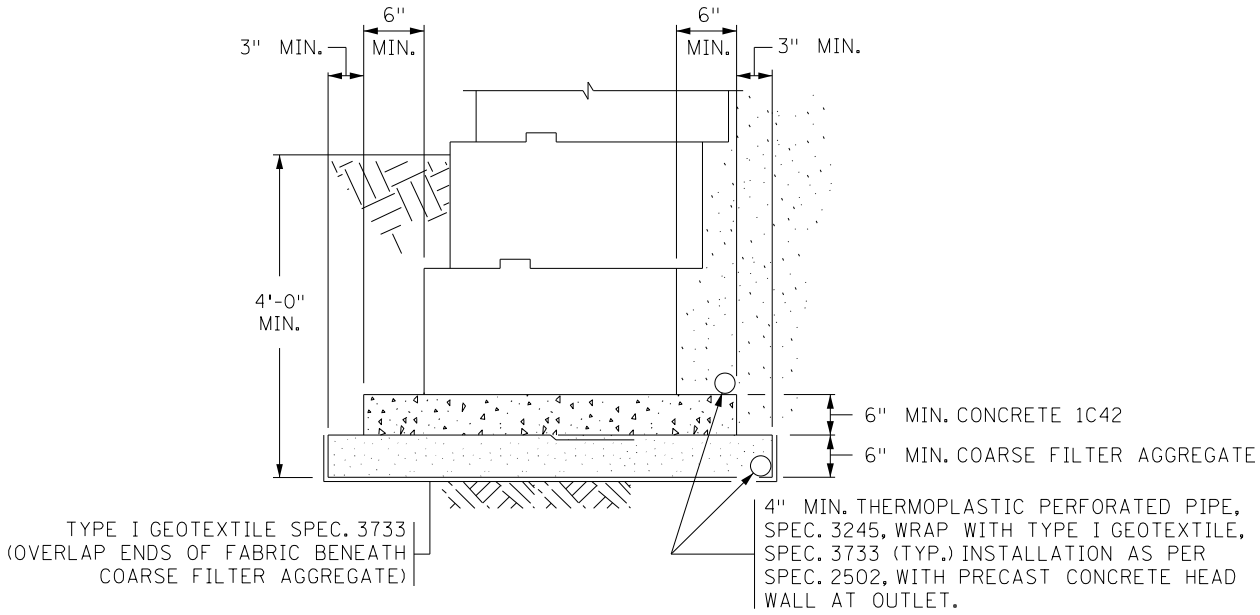


Figure 2411-6 - Composite leveling pad detail (gravity walls only)

17. No drainage systems other than what is required for the wall and highway drainage shall be placed within the reinforced soil zone. The wall design shall include necessary details or design modifications to accommodate the drainage system. The placement of the drainage system shall occur only during construction backfilling of the wall.
18. PMBW's with soil reinforcement shall include a drainage system on top of the concrete leveling pad at the interface of the reinforced and the retained soil (see Figures 2411-2).
    a. Gravity PMBW's with a concrete only leveling pad shall include a drainage system on top of the concrete leveling pad (see Figure 2411-5)
    b. Gravity PMBW's with a composite leveling pad shall include a drainage system on top of the concrete portion of the leveling pad and at the bottom of the coarse filter aggregate (see Figure 2411-6).
    c. The drainage system shall consist of perforated pipe per MnDOT 3245 wrapped with a type I geotextile per MnDOT 3733. The pipe shall be placed such that water drains freely from the pipe, typically a 1% grade and 3 foot minimum radius bends. Provide outlets as required due to expected flow rate with a maximum spacing of 150 feet. Outlet the drainage system through the slope in front of the wall with a concrete headwall per MnDOT Standard Plate 3131 or into a drainage structure (see Figure 2411-1 and 2411-2). The designer shall take into account the location of wall drainage systems in the layout and step locations of wall leveling pads and to ensure the wall drainage system is compatible with the leveling pad step locations. The shop drawings for each wall shall denote the

location of the drainage system components, including the station of each outlet penetration through the wall and whether the flow is outletted through the slope in front of the wall or into a drainage structure.

19. The ground on the exposed side of the wall shall slope away from the wall per Figure 2411-1 or 2411-2. The surface water on the backfill side shall be drained away from the wall to prevent runoff next to the facing blocks and ponding above the reinforced zone or backfill zone. Surface run-off shall not be designed to pass over the top of the wall. A wall coping, drainage system, or a properly designed ditch shall be used to carry run-off water along the wall to be properly deposited.

20. PMBW's with soil reinforcement that are considered to support traffic (see Item H for criteria for supporting traffic) shall have an impervious layer (geomembrane) placed below the roadway surface to prevent any surface water from entering into the wall system and degrading the soil reinforcement. The geomembrane requirement is applicable to all wall systems supporting a roadway unless the prequalified supplier list clearly and specifically states that the wall system is exempted from this requirement. The impervious layer shall be installed at the top of the reinforced zone and shall have a minimum coverage length measured perpendicular to the wall face of at least the length of soil reinforcement plus 3 feet. The impervious layer shall be drained properly to prevent ponding and shall be sloped at 20 (H) to 1 (V) away from the wall unless otherwise approved by the engineer. Contractor submitted shop drawings shall include specific details and dimensions addressing the placement of the geomembrane, soil reinforcement elements, drainage system details, pavement materials, and traffic barrier moment slab (as applicable) at the top of the wall. Notify the project engineer of any required perforations in the geomembrane (if required) for the installation of fence posts, etc., and provide details for sealing around said perforations.

21. For gravity walls three zones have been identified when utilities are near walls. The zones are referenced in Figure 2411-7.
    a. For purposes of this specification, utilities are defined as any utility requiring a permit as well as State owned utilities and stormwater structures. Dry utilities are defined as facilities that do not carry fluid, examples include power and telephone. Wet utilities are those facilities that carry fluid, but do not include roadway edge drains or subsurface drains associated with the bridge or wall structure.
    b. All wet utilities in zones 1, 2, and 3 require gasketed pipe or joints designed to prevent leakage due to pressurized flow. Casing, where required, shall meet MnDOT requirements for casing. Refer to the MnDOT Policy Statement on Accommodation of Utilities on Highway Right of Way for casing requirements. The following constraints for utilities in any of the three zones describe requirements for parallel installations, skewed, and perpendicular

crossings. The restrictions on utility placement are dependent on their position relative to the structure.

c. In zone 1, during the construction of a new PMBW, utilities are to be placed outside of zone 1 when possible. If relocation is impractical or impossible, new utilities to be installed and existing utilities to remain in place require Bridge Office approval. However, no new wet utilities may be placed longitudinally (i.e., parallel to the PMBW) in zone 1. New utilities may be placed transversely (i.e., perpendicular to the PMBW) to the structure in zone 1, with Bridge Office approval of proposed design and construction sequencing. All pipes and conduits must be designed for any surcharge loading due to structure bearing pressures and possible resulting deformations. All wet utilities must be cased in zone 1; if facilities are too large or cannot be cased effectively, a site specific design is required. Utility owners may choose to case dry utilities to allow for future maintenance or access; however, casing is not required for dry utilities. Future open trench excavation is prohibited in order to protect the wall from potential undermining. Other forms of excavation may be permitted in this zone with Bridge Office approval.

d. In zone 2, new utilities may be installed. Excavation for maintenance or replacement will be permitted with proper sheeting and shoring; no unbraced open cuts will be allowed. Any utilities installed in zone 2 must follow the same casing requirements as in zone 1, with the exception of stormwater facilities. Encasement is required for stormwater pipes with velocities greater than 10 fps, or pipe diameters 54 inches and larger, or pipe materials other than those shown in Standard Plate 3006. Other stormwater facilities need not be cased in zone 2 unless required by contract specifications or as recommended by the Bridge Office.

e. In zone 3, there are no restrictions for utility installations except for the requirement to use gasketed pipe as needed for wet utilities.

f. If these conditions cannot be met, options include relocation or replacement of the utility or placing the substructure on deep foundations. However, pressurized wet utilities placed in zone 1 must be cased due to the risk of significant soil loss. In lieu of casing, a risk analysis approved by the Regional Bridge Construction Engineer is acceptable for PMBW's on deep foundations.

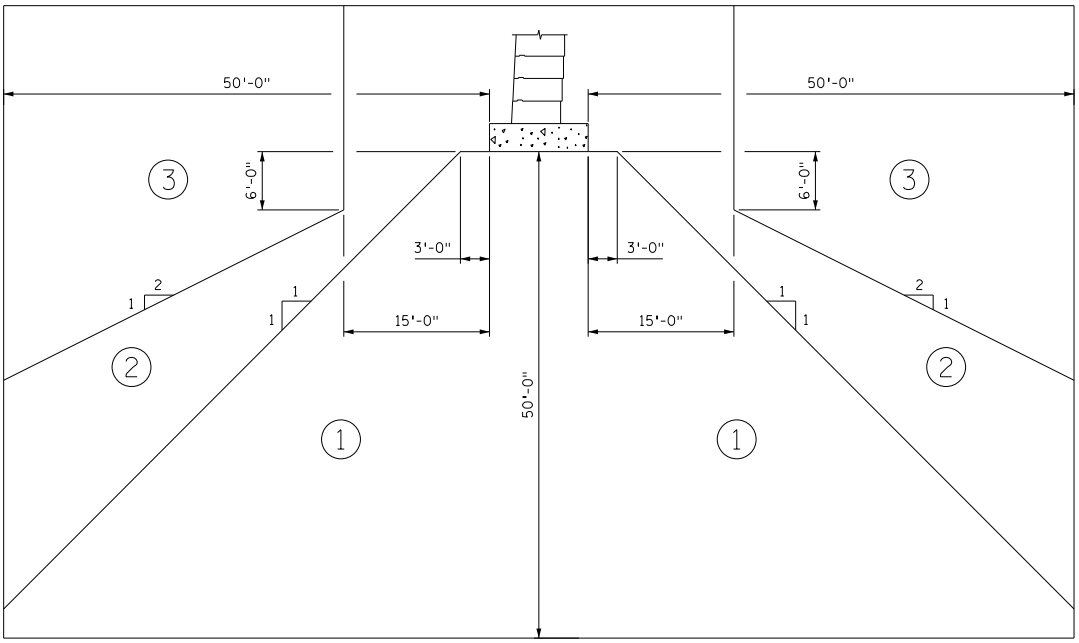


Figure 2411-7 Utilities Near Foundations for PMBW's with Soil Reinforcement

22. For reinforced walls five zones have been identified when utilities are near walls. The zones are referenced in Figure 2411-8.
    a. For purposes of this specification, utilities are defined as any utility requiring a permit as well as State owned utilities and stormwater structures. Dry utilities are defined as facilities that do not carry fluid, examples include power and telephone. Wet utilities are those facilities that carry fluid, but do not include roadway edge drains or subsurface drains associated with the bridge or wall structure.
    b. In zone ①, during the construction of a new PMBW, utilities are to be placed outside of zone ① referenced in Figure 2411-8 when possible. If relocation is impractical or impossible, new utilities installed in zone ① and existing utilities in zone ① require MnDOT approval. However, no new wet utilities (except for utilities that are used for wall drainage) may be placed longitudinally (i.e., parallel to the wall) in zone ① of a new or existing wall. New utilities placed in Zone ① may be placed transversely (i.e., perpendicular to the wall) in zone ① of an existing wall, with Bridge Office approval of proposed design and construction sequencing. All pipes and conduits must be designed for any surcharge loading due to soil or structure bearing pressures and possible resulting deformations. All wet utilities (except for utilities that are used for wall drainage) must be cased in zone ①; if facilities are too large or cannot be cased effectively, a site specific design is required. Utility owners may choose to case dry utilities to allow for future maintenance or access; however, casing is not required for dry utilities. Future open trench excavation is prohibited in order to

protect the wall from potential undermining. Other forms of excavation may be permitted in zone ① with Bridge Office approval.

c. In zone ②, new utilities may be installed. Excavation for utility maintenance or replacement is permitted with proper sheeting and shoring; however, unbraced cuts are not allowed. All utilities installed in zone ② must follow the same casing requirements as in zone ①, except that encasement is required for stormwater pipes with velocities greater than 10 fps, pipe diameters 54 inches and larger, or pipe materials other than design 3006 RCP.

d. In zone ③, future access through excavation areas is permissible and casing is not required for wet or dry utilities.

e. In zone ④, future access through the excavation is permissible and casing is not required for dry utilities. Use gasketed pipe as needed for wet utilities. When excavating within this zone, install shoring or sheet piling, without damaging the geomembrane, to protect the reinforced zone

f. In zone ⑤, utilities are to be placed outside of the zone when possible. Existing utilities cannot remain in place as they will be disturbed during construction. New utilities may be installed in zone ⑤ with Bridge Office approval provided that they are placed during the original construction of the wall and are not wet utilities placed longitudinally. All wet utilities placed transversely must be cased and if utilities are too large or cannot be cased effectively, a site specific design is required. Casing is not required for dry utilities; however utility owners may choose to case dry utilities to allow for future maintenance or access. Future excavation is prohibited.

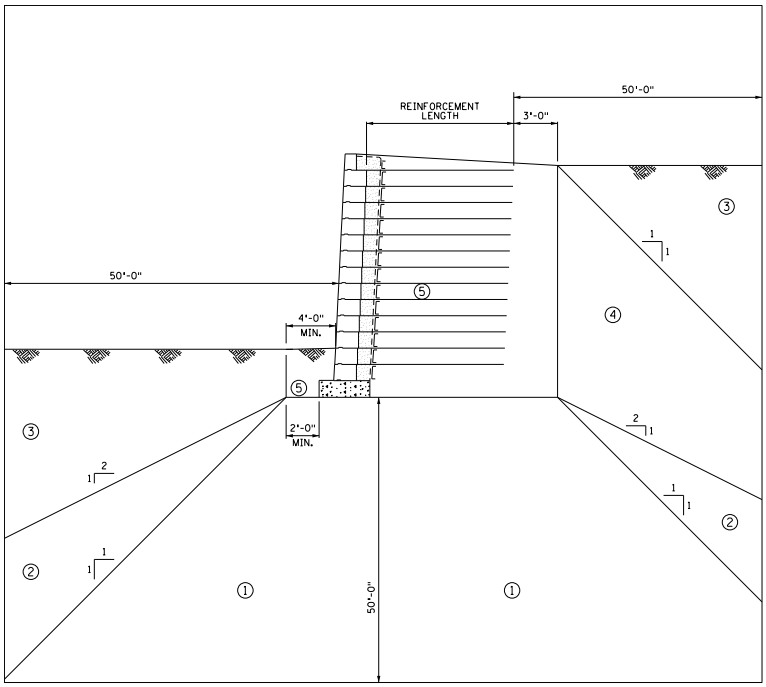


Figure 2411-8 Utilities Near Foundations for PMBW's with Soil Reinforcement

23. No drilling or driving of posts (sign, guardrail, etc.) or other roadside hardware in the reinforced zone shall occur after placement of the reinforced soil. If such roadside hardware is required, the design and plans shall include details such as sleeves to accommodate it. Refer to section S-1.4F regarding penetration of the geomembrane for fence posts.
24. Coping details shall include joints no more than every 20 feet along the length of the wall. Locate coping joints to align with the joints between the blocks.
25. Stability Analysis shall be conducted. All appurtenances behind, in front of, under, mounted on, or passing through the wall such as drainage structures, utilities, noise wall, barrier and moment slab, footings, traffic, slope surcharge or other appurtenances shown on the plans shall be accounted for in the stability analysis. For more detailed stability analysis requirements see Section L.8
26. The wall parapet or freeboard height shall be a maximum of 2' measured from the finished ground line at the top of wall to the top of block or coping. Walls with parapets shall be designed to resist the appropriate pedestrian and/or railing loads specified in the AASHTO LRFD Bridge Design Specifications. Parapet units shall be rigidly connected together to prevent overturning and separation.
27. This PMBW system requires pedestrian railings or barriers. For walls that include pedestrian railings or barriers, the Contractor shall coordinate all design and detailing, including the connection between the railing and the wall, and all construction procedures, with the wall system supplier. All of the necessary details shall be included in the shop drawings. It is also the

responsibility of the Contractor to ensure that all railings including connection details, are constructible and compatible with the specific PMBW system and meet the plans, design requirements and specifications for the project. No payment shall be made for additional rail quantities or work.

28. Pedestrian railings and connections attached to units shall be designed to resist loads per AASHTO LRFD Bridge Design Specifications, Article 13.8. The units shall be designed to fully resist the pedestrian live load with no contribution of the load carried by the earth reinforcement.
29. Gravity PMBW's with open core "bin" type units shall be designed according to AASHTO LRFD Bridge Design Specifications, Articles 11.11.4.3 and 11.11.4.4 with 100% of the soil-fill inside the units for applied bearing and a maximum of 80% of the soil-fill inside the units as effective in resisting overturning. The soil-fill inside the units shall meet the requirements of MnDOT Spec 3137 CA-3 with Class A aggregates (crushed quarry aggregates) and a friction angle of 36 degree's shall be assumed for design.
30. At a minimum, sliding and eccentricity shall be checked between all block interfaces below grade, at the top and bottom of the concrete portion of the leveling pad, and at all transitions in block sizes (depth) above grade. Bearing shall be checked at the top and bottom of the concrete portion of the leveling pad. The eccentricity limit at the interface between the bottom block and the concrete portion of the leveling pad and the interface between the concrete portion of the leveling pad and the base soil shall be L/4. If the concrete portion of the leveling pad is 18" or greater the eccentricity limit at the interface between the bottom block and the concrete portion of the leveling pad shall be 9L/20. The eccentricity limit at the interface between blocks shall be 9L/20.
31. PMBW walls with earth reinforcement may utilize the friction between the lowermost PMBW unit and the leveling pad to reduce the tributary lateral load area on the lowest geogrid layer. The lowest geogrid must be placed on the top of the first row of PMBW units, or lower, to utilize this base friction. The tributary load height for the lowermost geogrid may be measured from halfway between the geogrid above it to halfway to the base of the wall; if the facing element-to-leveling pad interface strength demonstrates sufficient lateral resistance. Sliding resistance at the bottom of the PMBW unit and the cast-in-place concrete leveling pad shall be calculated with a strength limit resistance factor, φ, of 0.9. The factored sliding resistance shall be greater than the factored lateral load computed on the tributary height from the base of the wall to one-half the distance to the lowest geogrid layer.
32. Stacking blocks front to back to achieve a greater wall depth is not permitted.
33. The Resistance Factors, Φ, for Tensile and Pullout Resistance for PMBWs shall be according to Table 2411-1:

Table 2411-1: Tensile and Pullout Resistance Factors

Reinforcement Type and Loading Condition			Resistance Factor Φ
Geogrid reinforcement and connector tensile resistance		Static loading	0.90
		Combined static/traffic barrier impact(A)- PET Geogrid	0.75
		Combined static/traffic barrier impact(A)- HDPE Geogrid	1.00
Geogrid reinforcement pullout resistance		Static loading	0.90
		Combined static/traffic barrier impact PET Geogrid (A)	1.00
		Combined static/traffic barrier impact HDPE Geogrid (A)	1.00
Notes: (A.) Combined static/traffic barrier impact resistance factors are not presented in the AASHTO LRFD Bridge Design Specifications.			

34. Traffic barriers and moment slabs shall meet the requirements of Test Level 4 (TL-4) There are three possible methods for approval of traffic barriers:
    a. Test Method: The barrier, connection, wall, backfill, and soil reinforcement shall be crash tested as a system per NCHRP Report 350 or MASH (08) requirements.
    b. Analytical Method: The FHWA allows the use of bridge barrier designs that are similar to a crash tested design based on an analytic comparison using the methodology outlined in Section 13 of the AASHTO LRFD Bridge Design Specifications. The FHWA policy and an example comparison can be obtained at: http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/ctrmeasures/bridge_railings/
        1) For either method (a) or (b), FHWA acceptance is necessary and shall include a cross section detail of the barrier and slab, including all dimensions and reinforcement sizes and spacing requirements.
        2) Calculations validating the AASHTO LRFD Bridge Design Specifications Article 13 provisions must be included. No variation in the details will be allowed without written approval of the FHWA.
    c. Test and Analytical Method: The barrier shall be crash tested per NCHRP Report 350 or MASH (08) requirements and connection, moment slab, wall, reinforced soil and soil reinforcement shall be designed analytically per NCHRP Report 663 "Design of Roadside Barrier Systems Placed on MSE Retaining Walls" and this specification.

1) Regardless of what barrier approval method is used, traffic barriers and moment slabs shall be detailed to allow at least 2 inches of horizontal movement prior to making contact with PMBW block. The traffic barrier shall also meet the following requirements:

2) The barrier is cast integrally with a reinforced concrete slab that is placed on reinforced soil (does not sit overtop of the wall). The slab shall be at least 12 inches thick and have a minimum width (normal to the wall alignment) of 8 feet and shall meet the requirements of NCHRP report 663 "Design of Roadside Barrier Systems Placed on MSE Retaining Walls". There shall be a minimum clearance of 2 inches from the back of slab to the back of the wall facing block or coping.

3) All joints in the moment slab must be doweled to maintain continuity. The minimum spacing between the dowel joints in a moment slab and the barrier shall be 35 feet for TL-4 and the moment slab shall be continuously reinforced between the joints.

35. Strength and Service Limit States for PMBW's with and without Traffic Barriers Loads and Load Factors for Strength and Service

Table 2411-2: Maximum and Minimum PMBW Load Factors

Force Effect, Q_i	Load Factor γi	
	Max	Min
Vehicular Live Load (LL) for External Stability*	1.75	
Vehicular Live Load (LL) for Internal Stability*	1.35	
Dead Load of Structural Components and Nonstructural Attachments (DC)	1.25	0.90
Dead Load of Wearing Surfaces and Utilities (DW)	1.35	0.65
Horizontal Earth Pressure, Active (EH)	1.50	0.90
Vertical Pressure from Dead Load of Earth Fill (EV)	1.35	1.00
Earth Surcharge Load (ES)**	1.50	0.75

* There are no maximum or minimum values. Either apply or do not apply the transient live load with the single load factor.

**Earth Surcharge Loads such as stockpiles of fill shall have a load factor of 1.5. The minimum surcharge load to account for roadways, snow loads, future maintenance operations, or future re-grading shall use the maximum Earth Vertical (EV) load factor of 1.35 and minimum load factor of 1.0.

The vertical component of stress, σ_v used in the horizontal load calculation, for soil reinforced walls, consists of several loads including, Earth Vertical, Dead Load, Dead

Load Surcharge, and Live Load Surcharge. An equation for the factored vertical component of stress, σ_{vf} in ksf shall be taken as:

$$\sigma_{vf} = \gamma_p(\gamma H + \Delta\sigma_{vDL} + \Delta\sigma_{vLL}) \qquad \text{(Equation 1)}$$

where:

γ = unit weight reinforced soil (0.120 kcf)
H = height of soil column behind wall (ft.)
$\Delta\sigma_{vDL}$ = Dead Load Surcharge (ksf)
$\Delta\sigma_{vLL}$ = Live Load Surcharge (ksf) where $\Delta\sigma_{vLL} = 2\gamma$
γ_p = the applicable load factor from Table 2411-2

The corresponding factored horizontal component of stress σ_{hf} in ksf, acting on the wall shall be taken as:

$$\sigma_{hf} = \gamma_p \Delta\sigma_h + k_r(\sigma_{vf}) \qquad \text{(Equation 2)}$$

where:

γ_p = the applicable load factor from Table 2411-2.
Δσh = horizontal stress at reinforcement level resulting from any applicable concentrated horizontal load as specified in AASHTO LRFD Bridge Design Specifications Article 11.10.10 (ksf), or loads from signs, noise wall, etc.
k_r = horizontal pressure coefficient (dim.)
σ_{vf} = factored vertical component of stress in (ksf) from Equation 1.

Pullout Resistance Load Combinations for Strength and Service Limit States

For pullout resistance, the loads Earth Vertical, EV, Dead Load Surcharge, $\Delta\sigma_{vDL}$ and Live Load Surcharge, $\Delta\sigma_{vLL}$ shall be defined and applied according to Table 2411-3.

Table 2411-3: Load Definitions and Applications Related to Pullout Resistance for Strength and Service Limit States

Load	Pullout Resistance
Earth Vertical, EV	May be included in the pullout resistance calculations.
Dead Load Surcharge, (Due to barrier and attachments) $\Delta\sigma_{vDL}$	Shall be excluded from the pullout resistance calculations.

Live Load Surcharge, (Traffic loading) $\Delta\sigma_{vLL}$	Shall be excluded from the pullout resistance calculations.

The PMBW strength loading and design shall include live load surcharge resulting from traffic loads. The live load surcharge for this case shall be equivalent to a 2 foot soil surcharge. (Use the load factors for Vehicular Live Load from Table 2411-2)

The vertical component of stress used in the pullout resistance calculations σ_v^* in ksf may be taken as:

$$\sigma_v^* = y\,H \qquad \text{(Equation 3)}$$

where:

H = height of soil column behind wall, i.e., to the top of wall (ft.)

γ = unit weight of reinforced soil (0.120 kcf)

36. Extreme Event II Limit State for Walls Supporting Traffic

a. Walls supporting traffic shall include computations showing that the Extreme Event II limit state due to traffic impact has been met. The requirements for the Extreme Event II limit state consist of AASHTO LRFD Bridge Design Specifications, FHWA, NCHRP Report 663 and MnDOT requirements.

b. The total factored force effect, Q shall be taken as:

$$Q_i = \sum \gamma_i Q_i \le \varphi R_n \qquad \text{(Equation 4)}$$

where:

Q_i = force effects from loads specified herein

γi = load factors specified in Table 2411-5

Rn = nominal resistance

φ = resistance factor specified in Table 2411-1 applied to nominal resistance

1) Loads and Load Factors for Extreme Event II :The PMBW design for the Extreme Event II limit state shall include static loads due to horizontal earth pressure and dead load due to the barrier and attachments and a dynamic load due to the traffic impact. For the Extreme Event II case, the live load surcharge effects on the reinforcement are incorporated in the reinforcement loads presented in Table 2411-4. As a result for the Extreme Event II case the live load surcharge is not included again as an additional load. The loads for the Extreme Event II limit state are defined as:

a) Horizontal Earth Pressure

The static load due to horizontal earth pressure shall be obtained from the static earth pressure times the tributary area of the reinforcement unit.

b) Barrier and Attachments

The weight of the barrier and attachments above the top of the wall, such as noise walls, signs, etc., shall be included in the reinforcement tensile load calculations and treated as a dead load. For the vertical component of the stress due to dead load surcharge the load distribution width (normal to the wall alignment) shall be equal to the width of the bottom of the barrier denoted as "bb" in Figure 2411-9.

The factored vertical component of stress, σ_{vf} consists of Earth Vertical and Dead Load due to the barrier and attachments. An equation for the factored vertical component of stress, σ_{vf} in ksf shall be taken as:

$$\sigma_{vf} = \gamma_p(\gamma H + \Delta\sigma_{vDL}) \quad \text{(Equation 5)}$$

where:

γ = unit weight of reinforced soil (0.120 kcf)
H = height of reinforced soil column behind wall (ft.)
$\Delta\sigma_{vDL}$ = Dead Load Surcharge (ksf)
γ_p = the applicable load factor from Table 2411-5

The corresponding factored horizontal component of stress σ_{hf} in ksf, acting on the wall shall be taken as:

$$\sigma_{hf} = \gamma_p \Delta\sigma_h + k_r(\sigma_{vf}) \quad \text{(Equation 6)}$$

where:

γ_p = the applicable load factor from Table 2411-5.
Δσh = horizontal stress at reinforcement level resulting from any applicable concentrated horizontal load as specified in AASHTO LRFD Bridge Design Specifications Article 11.10.10 (ksf), or loads from signs, noise wall etc.
k_r = horizontal pressure coefficient
σ_{vf} = factored vertical component of stress in (ksf) from Equation 5.

c) Horizontal Traffic Impact Load

The horizontal traffic impact load shall be distributed to the upper 2 layers of soil reinforcement, as specified in Table 2411-4.

Table 2411-4: Maximum Nominal Rupture and Pullout Impact Loads

Layer	Rupture impact load	Pullout impact load
1st Top layer	2300 lb/ft	1300 lb/ft
2nd Top layer	600 lb/ft	600 lb/ft

d) Extreme Event II Load Factors
For the loads included in Extreme Event II limit state the following load factors shall be used.

Table 2411-5: Maximum and Minimum PMBW Load Factors for Extreme Event II.

Force Effect, Q_i	Load Factor γi	
	Max	Min
Vehicular Collision Force (CT)	1.00	NA
Dead Load of Structural Components and Nonstructural Attachments (DC)	1.25	0.90
Dead Load of Wearing Surfaces and Utilities (DW)	1.35	0.65
Vertical Pressure from Dead Load of Earth Fill (EV)	1.35	1.00

NA= Not Applicable

2) Pullout Resistance for Extreme Event II
For pullout resistance, the loads Earth Vertical, EV and Dead Load Surcharge, $\Delta\sigma_{vDL}$ shall be defined and applied according to Table 2411-6. As described, permanent barrier and attachment loads shall be included in the pullout loading calculation.

Table 2411-6: Load Definitions and Applications Related to Pullout Resistance for Extreme Event II.

Load	Pullout Resistance
Earth Vertical, EV	Shall be included in the pullout resistance calculations.
Dead Load Surcharge, (Due to barrier and attachments) $\Delta\sigma_{vDL}$ (See "a" below)	Shall be excluded from the pullout resistance calculations.
Live Load Surcharge, (Traffic loading) $\Delta\sigma_{vLL}$	Shall be excluded from the pullout resistance calculations.

a) The pullout resistance, the vertical component of stress used in the pullout calculations σ_v^* in ksf may be taken as:

$$\sigma_v^* = y\,H \qquad \text{(Equation 7)}$$

where:

H = height of soil column behind wall, i.e., to the top of wall (ft.)

γ = unit weight of reinforced soil (0.120 kcf)

b) Resistance Factors for Extreme Event II
The resistance factors shall be taken from the resistance factor Table 2411-1

For geosynthetic reinforcements, the nominal strength used to structurally size the reinforcements to resist the impact load may be increased by eliminating the reduction factor for creep, as allowed for the internal stability in seismic design.

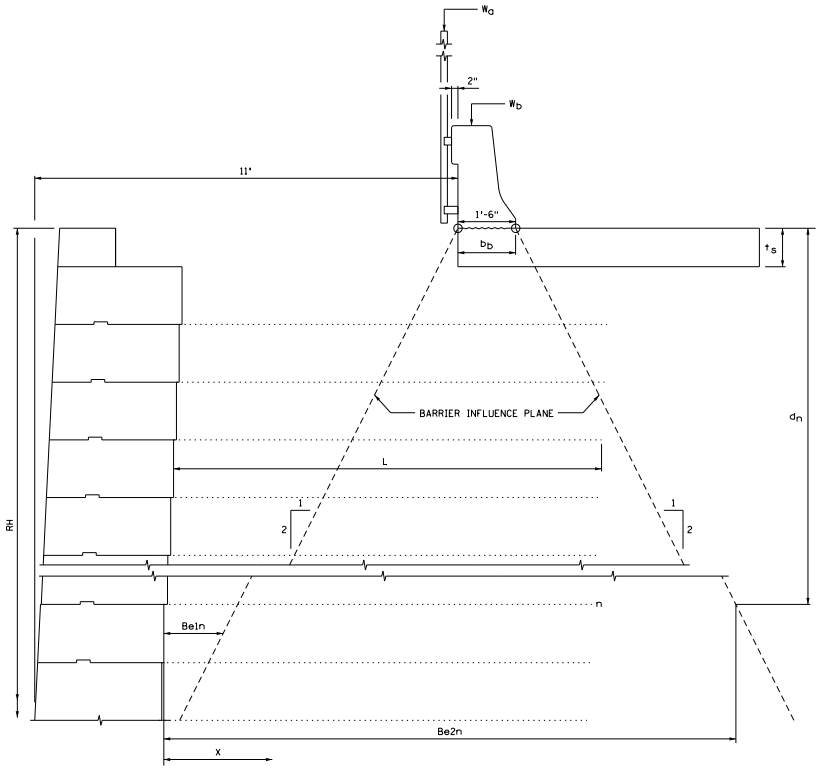


Figure 2411-9 Distribution of loading from barrier, moment slab and attachments used in reinforcement tensile load calculations for Extreme Event II.

2.05 SUBMITTAL REQUIREMENTS AND MnDOT QUALITY ASSURANCE (QA) REVIEW

A. Shop Drawing and Calculation Submittal:

1. The Contractor shall be responsible to review all available geotechnical investigation reports, and the Contractor's signature on the proposal shall certify that this review has been performed and that any relevant geotechnical information has been provided to the designer and PMBW System Supplier of the PMBWs.
2. For each wall the PMBW system supplier shall submit two sets of complete, certified and independently checked design computations, five sets of certified shop drawings, and one "PMBW Design Certification Letter" to the Engineer for quality assurance (QA) review allowing at least 30 calendar days for review before beginning the fabrication and construction of the wall system. The shop drawings shall comply with the design plans, and include all details, dimensions, quantities and any information required to lay out and construct the wall.
3. The submitted information shall include, but not be limited to, the following:
    a. Plan shop drawing for the full length of EACH wall containing the following:
        1) Beginning and ending stations of wall relative to roadway centerline and any changes in wall alignment.
        2) Locations of bridges, piles, existing and other proposed retaining walls, slopes or other objects.
        3) Locations of all drainage structures, pipes, signs, light poles and other conflicting existing and planned structures or obstructions as provided in the contract documents. Additional typical sections shall be provided whenever changes happen to the wall such as the addition or change in moment slab or coping, transition to approach span of bridge, etc.
        4) Limits of soil reinforcement and location where changes in length and/or size of reinforcement occur.
        5) Location of existing and planned utilities as provided in the contract documents.
        6) Existing and proposed ground elevations.
        7) Limits for any construction constraints such as right-of-way, easements, staged construction, etc.
        8) Horizontal and vertical curve data for curved walls.
        9) Limits of bottom of wall and top of wall, for wall system submitted.
    b. Cross section drawing for EACH wall and design change identifying:
        1) Location and batter of the wall face.
        2) Reinforcement type, dimensions, and vertical spacing.

3) Wall treatment, including impervious geomembrane, traffic barrier(s), cast-in-place moment slab (including potential interference with soil reinforcement), runoff collection, subsurface and surface drainage pipes & structures.
4) Elevation of leveling pad.
5) Depth of wall embedment below finished grade.
6) Limits of excavation and backfill.
7) Block joint cover (geotextile filter fabric) location and generic material type.

c. Elevation view in equal horizontal and vertical scale for the full length of EACH wall showing:
1) Top and bottom wall elevations, in-place ground line, and finished grade elevation at top and bottom of wall.
2) Details and dimensions for foundation and leveling pad, including steps and setbacks in the leveling pad.
3) Location of drainage structures and construction details around these structures. Locations and details of any penetrations in the facing blocks,
4) Dimension, grade, and location of reinforcements.
5) Maximum applied bearing pressure (Strength and Service) under the wall for each reinforcement length and owner specified Service and Strength nominal bearing resistance.
6) Manufacturer name, block type and "depth" dimension for each block.
7) Block configuration for standard and special cut blocks.
8) Summary of quantities for each wall.
9) Block dimensions.

d. Horizontal and vertical curve data affecting the wall. Match lines or other details to relate wall stationing to centerline stationing.

e. Connection details and dimensions between facing blocks, embedded devices and soil reinforcement.

f. Details for construction, including but not limited to:
1) Termination at cast-in-place structures and any adjacent slope construction.
2) Connection details and reinforcement placement requirements around all obstructions including light and sign supports.
3) Details for constructing blocks lock and soil reinforcement at corners.
4) ALL internal drainage pipes, systems, and facilities.
5) Other details such as coping or barrier, guardrail, fencing, or noise wall.
6) Impervious geomembrane to block connection detail, and construction sequencing notes.
7) Location of ALL subdrains and outlets of the internal drainage system.

8) Locations and details of any required penetrations in the blocks.
9) Locations and placement details including minimum overlap(s) dimension(s), for geotextile filters.

g. Architectural details including surface pattern and texture, joint layout and details, and surface finish and color. (See the Project Aesthetic Guidelines for requirements)

h. Name of PMBW System Supplier and their QA/QC documents.

i. Test wall construction and details, when specified.

j. General notes required for constructing the wall:
1) Design properties and assumptions regarding material properties, material qualities and construction method.
2) Wall layout information.
3) Requirements for reinforced soil compaction.
4) Materials used in construction.
5) Geotextile filter fabric locations
6) Reinforcement handling, storage, preparation, and placement information and requirements.
7) Angle of internal friction used for the design.

k. Copy of geotechnical report showing:
1) Plan view of sampling and field-testing locations across project site.
2) Subsurface profile across project site.
3) Boring logs.
4) All laboratory test data and results.
5) Engineering properties of the foundation soil, the reinforced soil, and the retained soil as appropriate to ensure the proper long-term performance of the PMBW structure.
6) Required soil modification, if any
7) Overall stability analysis.
8) Service and Strength bearing pressure beneath the wall footing and the reinforced soil mass.
9) Settlement analysis and anticipated differential settlement for the foundation soil beneath the wall and the reinforced soil mass.
10) Groundwater, any free water conditions, anticipated high water conditions and any required drainage schemes.
11) Recommendations concerning items that may be appropriate to ensure the proper long-term performance of the PMBW structure.
12) Internal friction angle and unit weight of the retained soil.

l. Copy of calculations showing:
1) Table of contents page for design computations.
2) List of all assumptions used for all calculations and rationale for each assumption.

3) Design notes page with explanation of symbols and details of any computer programs used. Summary table of design parameter inputs for computer program. Tabulate all calculated capacity to demand ratios to ensure internal, external and compound stability.

4) Block design including the design of reinforcement connectors and internal reinforcement.

5) Calculations and test results verifying the design life of the soil reinforcement.

6) Computed applied bearing pressure and factored bearing resistance beneath the wall and the reinforced soil mass assuming an estimated total settlement of 1 inch. The computed applied bearing pressure shall be compared explicitly to the owner specified factored bearing resistance.

7) Barrier/slab detail above wall, when applicable, including all reinforcement.

8) Stability analysis shall include internal and external stability. External stability consists of evaluating sliding, limiting eccentricity (overturning), and bearing resistance. All appurtenances behind, in front of, under, mounted on, or passing through the wall such as drainage structures, utilities, noise wall, barrier and moment slab, footings, traffic, slope surcharge or other appurtenances shown on the plans shall be accounted for in the stability analysis.

   a) The Contractor, his supplier and/or subcontractor shall provide compound stability check and submit supporting calculations and drawings. This work shall include any required geotechnical testing required to perform the analysis and be completed by a licensed engineer in the State of Minnesota. Supporting calculations and drawings shall be submitted for the Engineer and Owner's review.

9) Provide a copy of calculations showing magnitude, direction, and location of the forces from any external loads such as traffic surcharge, traffic barrier, moment slab and attachments including impact loading, lighting, signs, bridges, slope surcharge, etc. The design and detailing of the wall system shall take into account these external loads. Walls supporting traffic barriers shall provide complete details and calculations showing conformance with the requirements listed above for Extreme Event II traffic impacts.

   a) Provide connection details for all reinforcements interfered with by obstructions. Provide design computations demonstrating that the details and wall

system meets all design and construction requirements in the obstruction area.

10) A set of project-typical hand calculations verifying computer generated output.

11) Verification of the design properties/parameters including results from creep, durability, construction induced damage, junction strength tests, and any other applicable tests from MnDOT pre-approval documentation. Indicate the appropriate standardized test designation followed for each test.

12) Friction angles used in design for reinforced and retained soil.

13) Soil reinforcement length based on overall stability.

14) All design calculations shall be based on assumed conditions at the end of the design life.

m. Indicate the following performance requirements:

1) Anticipated and tolerable movement of the wall for both horizontal and vertical settlements or movements both along and perpendicular to wall.

2) Tolerable block movement.

3) Monitoring and measurement requirements, if any.

4) All other appropriate design computations.

5) As built drawings: As-built profiles and plans shall be submitted. Unless otherwise specified, the coordinates shall conform to City of Duluth requirements.

n. Shop Drawing and Calculation Submittal Review:

1) The above information shall be submitted to the Engineer for QA review. Engineer and/or Owner QA review of the computations and shop drawings shall not relieve the Contractor of sole responsibility for the wall design, details, computations, and the submission of complete shop drawings for the accurate construction and performance of the wall. The Contractor shall be solely responsible for ensuring that the information submitted by the wall designer and the PMBW System Supplier is in accordance with all contract plans and shall contain all material, fabrication and construction requirements for erecting the wall system complete in place. (For more information about routing and review of submittals see Technical Memorandum No.: 08-11-MRR-02)

2.06 MATERIALS

A. All Materials for the wall system shall conform to requirements of these Special Provisions.

B. Acceptance of Materials:

1. Unless stated otherwise, at least 3 weeks prior to construction of the PMBW the Contractor shall furnish the Engineer Certificates of Compliance for each material listed below, certifying that all materials comply with the applicable contract specifications, including a copy of all test results. All tests shall be performed by an independent testing laboratory. A Certificate of Compliance shall be provided by the Contractor for each material source. A new Certificate of Compliance shall be provided any time the Contractor changes the source of materials.
2. Acceptance will be based on the Certificate of Compliance, accompanying test reports, visual inspection, and/or tests ordered or performed independently by the Engineer. The Engineer retains the right to order or perform independent tests to verify information.

C. Reinforced and Backfill Soil: Soil used in the reinforced and backfill zones shall comply with MnDOT 3149 and shall meet the following additional requirements:

1. Contractor Certificate of Compliance: At least 3 weeks prior to construction of the PMBW the Contractor shall furnish the Engineer a Certificate of Compliance certifying that reinforced or backfill soil complies with the applicable contract specifications listed below, including a copy of all test results. A Certificate of Compliance shall be provided by the Contractor for each source at a rate of 1 per 50,000 yd3. A new Certificate of Compliance shall be provided any time the Contractor changes the source of the reinforced or backfill soil materials or the material within a given source changes.
    a. Screened virgin aggregate material meeting the requirements of 3137.2B3, Class C.
    b. Angle of Friction Requirements:
        1) Determine angle of friction with direct shear testing (MnDOT Lab Manual method 1309) assuming consolidated drained conditions. Tests to be performed on portion of sample passing the #10 sieve and compacted at optimum moisture content to 95% determined by MnDOT Lab Manual method 1305.

Table 2411-7: Friction Angle:

TEST	SPEC. RANGE	TEST METHOD	TESTING RATE
Angle of Friction	≥ 34 Degrees	MnDOT Lab Manual Method 1309	1/50,000 cu. yd. per source

Table 2411-8: Electrochemical Requirements of Reinforced or Backfill Soil:

Base Polymer	TEST	SPEC. RANGE	TEST METHOD	TESTING RATE
High Density Polyethylene (HDPE) and Polypropylene (PP)	pH	3≤ pH	AASHTO T 289	1/50,000 cu. yd. per source
Polyester (PET)	pH	3≤ pH ≤ 8	AASHTO T 289	1/50,000 cu. yd. per source

2. Contractor Certificate of Compliance for Sieve Analysis: At least 3 weeks prior to construction of the PMBW the Contractor shall furnish the Engineer a Certificate of Compliance certifying that reinforced or backfill soil complies with the applicable contract specifications listed below, including a copy of all test results. Certificate of Compliance for Sieve Analysis shall be provided by the Contractor for each source at a rate of 2 per 50,000 yd3. A new Certificate of Compliance shall be provided any time the Contractor changes the source of the reinforced or backfill soil materials or the material within a given source changes.
   a. Sieve Analysis Requirements:
      1) Sieve analysis tests shall be performed according to MnDOT lab manual methods 1202 and 1203 or in the field according to MnDOT Grading and Base Manual method 5-692.215 and meet the requirements in Table 2411-9 and Table 2411-10.

Table 2411-9 Reinforced or Backfill Soil Sieve Analysis Requirement

Sieve Size	Percent Passing
¾ in	100

Table 2411-10 Reinforced Soil or Backfill Sieve Analysis Ratio

Percent Passing Ratio	Requirement
No. 40 / No. 10	0 – 0.65
No. 200 / No. 10	0 – 0.10

D. Soil Reinforcement: At least three weeks prior to the start of construction the Contractor shall furnish the Engineer a Certificate of Compliance certifying that all soil reinforcement complies with the applicable contract specifications listed below, including a copy of all test results. A Certificate of Compliance shall be provided with each additional shipment of reinforcement and any time the Contractor changes the source of reinforcement.
   1. Geogrid reinforcement shall be oriented, drawn, long chain high-density polyethylene containing stabilizers and inhibitors added to the base plastic

for resistance to ultraviolet and heat degradation. Geogrid reinforcements and their connection devices shall be the same connection devices and reinforcement as approved by MnDOT in the pre-qualification application of the MSE wall system. Geogrid reinforcement manufacturer's certification shall include ultimate tensile strength ASTM D6637 quality assurance test results, at a minimum rate equal to, or greater than, the sampling rate defined in Table 2411-11 (ASTM D4354) for each type of geogrid used. Additionally, the Contractor shall provide ultimate tensile strength ASTM D6637 specification conformance test results, by an independent laboratory, at a minimum rate equal to, or greater than, the sampling defined in Table 2411-12 (ASTM D4354) for each type of geogrid used.

Table 2411-11 (ASTM D4354) Geosynthetic Manufacturer Quality Assurance Testing Rates

Number of Rolls in Lot*	Number of Tests
1 to 2	1
3 to 8	2
9 to 27	3
28 to 64	4
65 to 125	5
126 to 216	6
217 to 343	7
344 to 512	8
513 to 729	9
730 to 1000	10
1001 or more	11

Table 2411-12 (ASTM D4354) Geosynthetic Contractor Quality Assurance Testing Rates

Number of Rolls in Lot*	Number of Tests
1 to 200	1
201 to 500	2
501 to 1000	3
1001 or more	4

* A lot is defined as a group of rolls from an individual production run.

E. Lifting Devices, Connectors, and Joint Materials: At least 3 weeks prior to the start of construction the Contractor shall furnish the Engineer a Certificate of Compliance certifying that all connectors and joint materials comply with the applicable contract specifications listed below, including a copy of all test results. Flexible cable lifting devices shall be galvanized per MnDOT 3394, except for the finely stranded cable type which shall be stainless steel. Lifting devices cast into the back surface of the block and which do not extend into the block more than eight inches may be fine-stranded galvanized steel. The requirements of S-H.2 (below) shall also apply.

F. Geotextile: At least three weeks prior to the start of construction the Contractor shall furnish the Engineer a Certificate of Compliance certifying that all geotextiles comply with the applicable contract specifications listed below, including a copy of all test results. The Certificate of Compliance shall include a manufacturer's certificate stating the furnished geotextile meets the requirements of the specifications, as evaluated by the manufacturer's quality control program. (suitable for use on concrete surfaces in cold weather application) to ensure that it doesn't move out of place during backfilling operations. Geotextiles shall be tested at rate equal to, or greater than, the sampling rate defined in Table 2411-11 (ASTM D4354).

G. Impervious Layer: At least three weeks prior to the start of construction the Contractor shall furnish the Engineer a Certificate of Compliance certifying that all impervious geomembrane material complies with the applicable contract specifications listed below. A copy of all test results shall be provided by the Contractor to assure contract compliance. A new Certificate of Compliance shall be provided any time the Contractor changes the source of material or at a rate of 1 test per 50,000 yd2 for each type of impervious layer.

1. The impervious layer material shall be a puncture-free and flexible, roughened sheet HDPE, LLDPE or PVC geomembrane. The geomembrane shall have both sides textured with a rough finish and have a minimum thickness of 30 mils (0.75 mm) in accordance with ASTM D5994 for Textured Geomembranes. The geomembrane manufacturer shall certify that the geomembrane properties have been tested by lot and meet the minimum specification property requirements for 30 mil (0.75 mm) material as specified in the following industry standards:

Table 2411-13: Geosynthetic Testing Standards:

Material Type	Organization	Standard
HDPE	Geosynthetic Institute	GRI Test Method GM13 Standard Specification for "Test Properties, Testing Frequency and Recommended Warranty for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes"
LLDPE	Geosynthetic Institute	GRI Test Method GM17 Standard Specification for "Test Properties, Testing Frequency and Recommended Warranty for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes"
PVC	American Society of Testing and Materials	ASTM D7176 - 06 Standard Specification for Non-Reinforced Polyvinyl Chloride (PVC) Geomembranes Used in Buried Applications, and

		ASTM D7408 - 08 Standard Specification for Non Reinforced PVC (Polyvinyl Chloride) Geomembrane Seams

2. In addition to the standard specification requirements, the following minimum properties shall be required regardless of the type of geomembrane. Samples of the geomembrane will be collected upon delivery to the site and, at the engineer's discretion, sent to an independent laboratory for verification testing.
   a. Minimum Thickness, 30 mils
      Tested per ASTM D5199 or ASTM D5994 for Textured
   b. Minimum Tear (Die C), 10 lbs
      Tested per ASTM D1004
   c. Minimum Puncture Resistance, 32 lbs
      Tested per ASTM D4833
3. The geomembrane manufacturer's certification shall include quality assurance test results at a rate equal to, or greater than, the sampling rate defined in Table 2411-11 (ASTM D4354) for each type of geomembrane used.

H. Prefabricated Modular Blocks: The precast concrete blocks shall be wet cast and conform to the following requirements:
   1. Concrete reinforcement (if any) shall conform to MnDOT 2472 and shall be galvanized per MnDOT 3394, or epoxy coated per MnDOT 3301. All reinforcing and attachment devices shall be carefully inspected by the Contractor to insure they are true to size and free from defects that may impair their strength and durability.
   2. Steel connection elements, tie strip guides or other galvanized devices shall not contact or be attached to the facing block reinforcement steel, unless the block reinforcement is also galvanized.
   3. The minimum rebar cover requirement is 1.5 inches.
   4. The manufacturer's name, plant identification (if manufacturer has multiple plants) and date of manufacture shall be stenciled with waterproof ink or clearly scribed on the back face of each block. If soil reinforcement is embedded into the block, the soil reinforcement type and strength shall be clearly scribed or stenciled with waterproof ink on the back face of each block.
   5. Block colors shall be consistent and free of stains, and blocks should be free of defects, cracks or chips. Blocks that contain visible defects such as, but not limited to, vertical or horizontal seams, conspicuous stains, form marks or color streaks shall be repaired to the satisfaction of the Engineer or removed and replaced at the Contractor's expense.
   6. All units used shall be manufactured within the following tolerances:
      a. Height: +/- 3/16 inch
      b. Width: +/- 1/2 inch unless field cut for fitting purposes
      c. Depth: No less than the unit design depth (i.e. 24", 26", 48")

d. Squareness shall be determined by measuring diagonally across the face; the difference between the two diagonals shall not exceed ½ inch.

e. Formed patterns or textures designed to be oriented horizontally or vertically shall be aligned with both the horizontal and vertical edges of the block, and the pattern/texture shall cover the entire face of the block.

f. If required, allowance shall be made for texture relief up to 2 inches in depth measured from the front face of the block.

7. The block shall be cast on a level surface and shall be fully supported until a compressive strength of 2500 psi or specific written permission from the State Materials Engineer has been attained. A random sample of the concrete shall be taken in accordance with AASHTO T141.

8. Concrete shall be mix number 3Y43 or an air-entrained mix with a minimum compressive strength of 4300 psi, using an approved design meeting the requirements of 2461. Coarse aggregate shall meet the requirements of 3137.2D1. If the system requires a higher strength concrete, the mix design shall meet the requirements of MnDOT 2461 for that higher strength.

9. All units shall be handled, stored, and shipped in a manner to eliminate the risk of chipping, discoloration, cracks, fracture, and excessive bending stresses. Blocks shall be stored on firm blocking or on a paved or otherwise compacted surface so as to protect any block connection devices and the exterior finish. Blocks shall reach 100% of design strength before shipment, as demonstrated by control cylinders kept with the product.

10. The wall supplier shall provide a technical representative in the plant during the first three days of production or ensuing production period if needed or until the Materials Engineer determines that the plant has demonstrated the ability to fabricate the blocks without technical assistance or MnDOT oversight. When so directed by the Materials Engineer, the technical representative shall return to oversee manufacture of blocks, and shall remain until relieved of that responsibility by MnDOT.

I. Block Rejection: Blocks may be rejected because of failure to meet any of the requirements specified above. In addition, any or all of the following defects shall be sufficient cause for rejection:

1. Defects that indicate imperfect molding, including imperfections of the form liner, if there is one.
2. Bending or misalignment of connections.
3. Defects indicating honeycombing or open texture concrete.
4. Any defect on the visible face larger than 1 square inch, cracks on any face, severe chips or other defects caused by defective materials or workmanship.
5. Color variation on front face of block due to excess form oil or other reasons.
6. Tie strips, connecting pins, PVC pipe, or lifting devices set to improper dimensions or tolerances shown on the plans and specified above.

7. Any damage that would prevent making a satisfactory joint.

J. Gabion basket's used in gabion walls shall conform to MnDOT 3602 and shall be galvanized per MnDOT 3394 and epoxy coated per MnDOT 3301.

1. The Contractor shall furnish only durable, quarried carbonate rock from the Prairie du Chien Group, that is free from defects such as: silt or shale seams on which the rock will break or separate due to environmental weathering; excessive internal silt or clay content (exceeding 10% by mass); natural or production induced fractures; or any other visible defects that will cause rapid or excessive deterioration or degradation during service. Source rock for the project shall be approved by the MnDOT Geologist prior to the filling of any gabion baskets. Rock may only be supplied from specific layers or ledges that have been approved. The Contractor shall be required to verify that rock is being supplied only from the approved layers or ledges.

PART 3 CONSTRUCTION REQUIREMENTS

3.01 GENERAL REQUIREMENTS:

A. An PMBW Preconstruction Meeting shall be held at least 15 days before wall construction begins and after the Owner has completed the QA review of the shop drawings and design calculations. At a minimum this meeting shall be attended by the Engineer, Contractor, the Contractor who will erect the wall, and a technical representative from the PMBW system supplier. The Contractor shall provide a complete written sequence of PMBW construction at the meeting and review the sequence, any construction issues, the specifications and the PMBW system requirements and determine any issues that need to be resolved prior to construction.

B. The wall supplier shall provide a documented Field Construction Manual specific to MnDOT requirements and describing in complete details the sequence of construction steps. The PMBW system supplier shall also provide an experienced technical representative on the project site during the erection of the first full height section, and the following sections if needed until the Engineer determines that the Contractor has demonstrated the ability to construct the wall system on his own meeting all project construction requirements. The PMBW system supplier technical representative shall be available to provide instructions, guidance in pre-construction activities, and on-site technical assistance anytime during construction at no additional cost to MnDOT. Every step in the sequential construction of the PMBW system shall comply with the construction requirements and tolerances. All instructions from the PMBW system supplier that are not contrary to these special provisions shall be followed unless otherwise directed in writing by the Engineer.

C. The Contractor shall be solely responsible to coordinate construction of PMBWs with bridge, roadway, and other construction and ensure that resulting or existing obstructions shall not impact the construction or performance of the wall.

D. All PMBW system blocks shall be constructed in accordance with the QA reviewed shop drawings, including the architectural features specified.

3.02 FOUNDATION PREPARATION:

A. The following statements shall apply to MnDOT 2451: The foundation for the structure shall be graded level for a width equal to the length of the soil reinforcement element plus PMBW width or as shown on the plans. The entire graded area shall be compacted according to MnDOT 2451 before wall construction begins.

B. Prior to wall construction and subsequent to clearing and grubbing any unsuitable foundation material shall be excavated and replaced with granular fill per these specifications, and compacted with a smooth wheel steel vibratory drum roller. If the PMBW bears on a rocky foundation or on bedrock, place 6 inches of reinforced soil per the Materials section of these specifications, under the soil reinforcement. Compact as specified above.

C. The Contractor shall develop and implement a plan to protect the open excavation from surface drainage during construction and until the wall is placed. The Contractor shall protect the excavation against collapse.

3.03 REINFORCED AND BACKFILL SOIL PLACEMENT:

A. Soil placement shall closely follow erection of each row of blocks. Soil shall be placed in a way that does not cause damage or disturbance to the wall or soil reinforcement. Soil reinforcement shall be maintained in a horizontal position along its length and shall be placed perpendicular to the wall face, except as shown in the plans.

B. Compaction beyond 3 feet of the back face of the prefabricated modular blocks shall be compacted to a density of not less than 100 percent of maximum density using the specified density method in accordance to MnDOT 2105.3.F.1. or the granular penetration index method in accordance with MnDOT 2105.3.F.3. The maximum lift size shall be 12 inches loose.

C. Compaction within 3 feet of the back face of the concrete blocks shall be achieved by means of a minimum of 3 passes with a lightweight mechanical tamper, roller or vibratory system. The number of passes needed for the compaction within the 3 foot zone shall be determined using a test strip with the proposed compactor and lift height(s) for this zone. The maximum lift size within 3’ shall be 8 inches loose and it shall be compacted to a density of not less than 95 percent of maximum density using the specific density method in accordance to MnDOT 2105.3.F.1.

D. Sieve analysis testing for quality control shall be performed according to section S-1.3B.2 of this specification. Sieve analysis testing for quality assurance shall be performed according the MnDOT Grading and Base Manual method 5-692.215.

E. The PMBW system supplier may require the Contractor to perform quality control density tests. The contractor shall perform the PMBW system suppliers required tests and submit the test results to the Engineer at no additional cost.

F. No drilling or driving of piles, posts (sign, guardrail, etc.) or other roadside hardware through the reinforced soil shall occur after placement of fill.

G. At the end of each day's operations, slope the last lift of reinforced soil to direct surface runoff away from the wall. Do not allow surface runoff from adjacent areas to enter the wall construction area.

H. The area in front of the wall and around the leveling pad should be backfilled as soon as practically possible. Tamping type (sheep's foot) rollers shall not be used for compaction of the reinforced soil.

I. At no time shall construction equipment come in direct contact with the soil reinforcement. A minimum reinforced soil thickness of 6 inches above geosynthetic soil reinforcement shall be required prior to operation of vehicles. Each course or layer shall be compacted up to or slightly above the location of the next connection for the soil reinforcement prior to placing the next layer of reinforcement as designated in the erection sequence provided by the manufacturer of the wall system.

J. If the reinforced soil material changes or a new source or material is used, construction of the PMBW shall be halted until the Contractor provides a new Certificate of Compliance and accompanying test reports.

K. Leveling Pad: For PMBW's with soil reinforcement an unreinforced cast-in-place concrete leveling pad shall be provided at the foundation level for each base unit of the wall system and shall be continuous at all steps. The leveling pad shall be concrete Mix Number 1C42 and have minimum dimensions as shown in Figure's 2411-5 and 2411-6.

L. Gravity PMBW's shall be set on either a concrete leveling pad (meeting the minimum requirements above) or a composite leveling pad.

M. A wider leveling pad shall be used for walls with curves or corners to ensure blocks fully bear on the leveling pad. The bottom of pad elevation shall be a minimum of 4 feet below finished ground line. Construct the leveling pad so that the surface does not vary more than ¼ inch in 10 feet along the length of the wall nor more than 1/8" across the width of the leveling pad from plan dimensions. The leveling pad shall have a compressive strength of at least 1500 psi and cured a minimum of 24 hours before blocks are placed. During erection blocks shall not extend more

than 6 inches beyond the end of the leveling pad at steps. Fill the void with reinforced soil immediately after the first row of blocks are set.

N. Wall Erection: Storage, handling and transportation shall avoid damage or discoloration of the blocks. If water has ponded in front of the wall; pump the water out prior to constructing the wall and reinforced zone. All PMBW's shall be constructed in accordance with approved shop drawings and in conformance with this specification, including the architectural features specified. PMB's shall be placed so that their final position is vertical or battered as shown on the plans. Construction should always begin from existing structures toward the open end of the wall. For erection, blocks which are handled by means of lifting devices inset in the top surface of the block. After placing the blocks, the depressions for lifting devices in the top course of blocks shall be completely filled with MnDOT Spec 2506.2B mortar. Depressions do not need to be filled if the lifting device is stainless steel. Place the initial row of blocks on the centerline of the leveling pad and level the block. Permanent bearing pads to level the blocks (between the leveling pad and bottom course of blocks) are prohibited. Blocks should be placed in successive horizontal lifts in the sequence shown on the plans as reinforced soil placement proceeds.

O. Permanent shims may be used to level or position successive courses of blocks provided:

P. The shim is made of a plastic material that will not rust, stain, rot or leach onto the concrete;

Q. The shim has a minimum compressive strength of 4300 psi;

R. The shim shall not exceed 3/16" in thickness;

S. No shim shall be used between the concrete leveling pad and the base course of the block wall, regardless if such wall is a Gravity PMBW or a PMBW with Soil Reinforcement;

T. With respect to a PMBW with Soil Reinforcement, a shim shall not be used between blocks that are also being used for a frictional geogrid connection;

U. Shims shall be limited to no more than 3 percent of the blocks in a wall.

V. If blocks overhang the leveling pad transversely reconstruct the leveling pad. After setting the batter of the blocks, horizontal and vertical alignments shall be checked by the Contractor with surveying methods, using suitable measuring points. The maximum vertical joint spacing between blocks of the constructed wall shall be 3/16 inch. Placement of a block on top of a block not completely backfilled shall not be permitted.

W. Concrete block vertical and horizontal alignment tolerances shall not exceed ¾ inch per 10 feet. Do not construct any block more than ½ inch out of vertical or horizontal alignment from the adjacent blocks. The completed wall shall have (cap or top of wall) overall horizontal and vertical tolerance not to exceed ½ inch per 10 feet of the planned location. Blocks out of alignment shall not be pulled or pushed into proper place, as that may cause damage to the soil reinforcement. If misalignment occurs, the reinforced soil and the soil reinforcement shall be removed and the facing blocks reset to the proper alignment.

3.04 IMPERVIOUS LAYER (GEOMEMBRANE):

A. The installation of the impervious layer (geomembrane) shall be in accordance with manufacturer's recommendations and as approved by the Engineer. Before geomembrane installation, it shall be assured that the area that is to be lined shall be smooth and free of sharp objects or debris of any kind. Atmospheric exposure of the geomembrane to the elements following lay down shall be a maximum of fourteen (14) days. The Contractor shall install a geomembrane liner free of tears. Notify the project engineer of any perforations placed in the geomembrane for the installation fence posts, etc. The geomembrane shall be placed below the pavement, above the first row of reinforcement and under the parapet moment slab (where present) and over specified areas as shown on the plans. The geomembrane shall be sloped to drain away from the blocks as shown on the plans. HDPE shall not be installed during periods of precipitation or in conditions of excessive moisture such as fog or dew in accordance with the geomembrane manufacturer's recommendations and as approved by the Engineer.

B. All seams of the HDPE geomembrane liner system shall be welded or bonded, as per the manufacturer's specifications, such that a water tight seal is formed to prevent leakage. Seams shall be oriented parallel to the line of maximum slope. Seams shall have a minimum finished overlap of 4 in. unless a greater overlap is specified by the geomembrane manufacturer. Field testing of seams, according to the manufacturer's specifications, shall be conducted to verify satisfactory seaming conditions. When backfilling, care shall be taken to prevent damage to the geomembrane. Any tears, punctures or holes incurred during the installation process shall be assessed by the Engineer and the membrane shall either be repaired in accordance with recommendations of the membrane manufacturer or replaced at the Engineer's discretion at no additional cost.

C. Perforations through the liner shall be limited. Where penetrations are necessary, the Contractor shall provide details demonstrating the method(s) of sealing the penetration for approval by the Engineer.

3.05 SOIL REINFORCEMENT INSTALLATION:

A. Soil reinforcement shall be placed in accordance with the shop drawings. Reinforcement shall generally be placed perpendicular to the back of wall unless

shown otherwise on shop drawings. Pretension flexible reinforcement to remove any slack in the reinforcement. Bar mat soil reinforcement shall not be skewed. No alteration or cutting of reinforcement is permitted unless clearly detailed in the approved shop drawings. Connections must be made in accordance with the manufacturer's recommendations. Reinforcement placement elevations shall not vary more than 1 inch from a horizontal line through the block connection.

B. Any wall system material that becomes damaged or disturbed during the installation of the wall system shall be removed, replaced or corrected at the Contractor's expense, as directed by the Engineer. Walls may be rejected due to failure to meet any of the requirements of the above specifications that will require future maintenance or will impact aesthetics, function, performance or life of the wall.

3.06 CAP BLOCK, COPING AND BARRIER CONSTRUCTION:

A. This final construction sequence shall be undertaken after the final wall blocks have been placed, and the reinforced soil has been completed to its finished ground line. Pedestrian rail anchors shall be placed at least 5 inches from a top block edge or coping joint (measured from the center on the anchor to the edge of the block).

3.07 METHOD OF MEASUREMENT:

A. PMBW's shall be measured by the square foot of face on a vertical plane between a line 2 feet below the finished ground line in front of the wall and the top of the wall or coping as shown on the plans. The Department will not adjust pay quantities for variations in concrete leveling pad elevations required to accommodate actual block placement.

3.08 PAYMENT METHOD:

A. Payment for PMBW's constructed at the Contract price per square foot of completed wall surface will be compensation in full for all costs of design and construction including blocks, soil reinforcement, connection devices, joint materials, leveling pad, technical representatives, excavation and backfill, and other items which do not have separate pay items but are necessary to complete the PMBW. The pay item for PMBW's is 2503.601 LS 17 Engineered Modular Block Wall, Lump Sum.

PMBW Certification Letter

State Project No. (S.P. or S.A.P.)	
Wall No.	
Name of Pre-Qualified PMBW System	

Design Data	
The design life for the wall system other than soil reinforcement and connections.	75 years
The design life for geosynthetic reinforcement and connections used in the wall system, including long term creep.	100 years
Angle of Internal Friction - Reinforced Soil/Backfill	____ Degrees
Maximum Applied Bearing Pressure at Base	
Factored Bearing Resistance at base (located in Geotechnical or foundation report)	
Length of reinforcement to satisfy overall stability (located in Geotechnical or foundation report, Reinforced walls only)	
Compound stability check satisfied (if required by these special provisions)	

I hereby certify that the design calculations for the internal stability of the mechanically stabilized earth retaining structure and the detail drawings included in this construction submission are in complete conformance with the AASHTO LRFD Bridge Design Specifications, the project special provisions and meet the foundation report recommended overall stability soil reinforcement length. I further certify that the design data provided above and data assumed for the design calculation submitted herein is accurate for the above referenced wall.

Engineer of Record I hereby certify that this plan was prepared by me or under my direct supervision and that I am a duly licensed professional engineer under the laws of the State of Minnesota.
Signature:
Date:
Registration Number:

Engineer Performing Design Check I hereby certify that this plan was checked by me and that I am a duly licensed professional engineer under the laws of the State of Minnesota.
Signature:
Date:
Registration Number:

(Provide a PMBW Certification Letter for each wall in the project plans)