

MnDOT Bridge Office 2012 LRFD Workshop - June 12, 2012

Wall Selection, Design and Details

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Outline

- Foundation Analysis and Design Recommendation (FADR)
- Wall Types
- Wall Design Process, Plan and Spec Requirements
- Contacts and References



FADR

- Foundation Analysis and Design Recommendation (FADR)
- Design parameters
- Address global stability
- Document ground water level
- Required for:
 - Proper wall selection
 - Excavation requirements
 - Drainage design
 - Long term performance

FADR

- Service bearing and settlement estimates
- Strength bearing
- Foundation preparation requirements
- Pile type, estimated pile tip elevation and length, pile setup
- Embedment of cantilevered walls
- Verify soils are consistent with assumptions in Standards



Wall Types

- CIP Cantilever (and Counterfort)
- MSE
 - Thin panel
 - Blocks
- Gravity Blocks
- Specialty Walls
 - Sheetpile
 - Anchored
- Noise walls

Common Retaining Wall Types

- Cast In Place Concrete (CIP)
- MSE Walls
 - MSE walls with thin precast panels (5" to 6" structural thickness panels)
 - Prefabricated Modular Block Walls, wet cast "Big Blocks" with soil reinforcement (PMBW)
 - Modular Block Walls, dry cast "small blocks" (MBW) with soil reinforcement
- Gravity Walls
 - Prefabricated Modular Block Walls wet cast "Big Blocks" without soil reinforcement (PMBGW)
 - Modular Block Walls, dry cast "small blocks" (MBW) without soil reinforcement

Proprietary &
Prequalified

Cantilevered CIP walls



5 - 30ft

Benefits:

- Aesthetics
- Durability
- Less Backfill

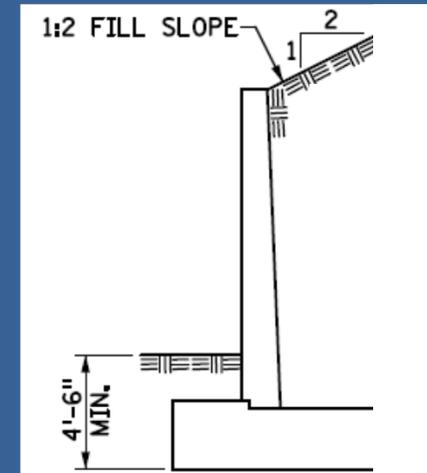
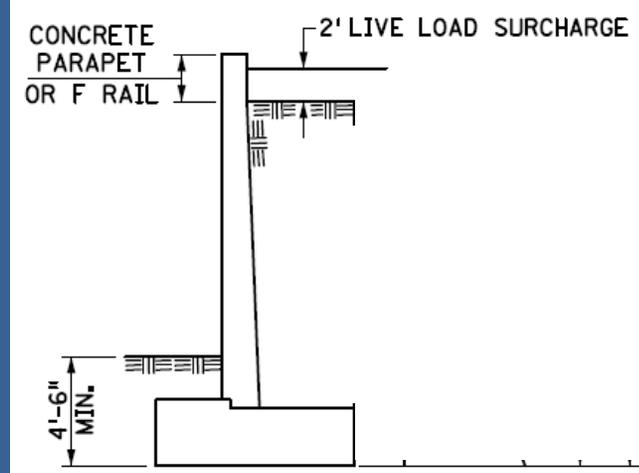
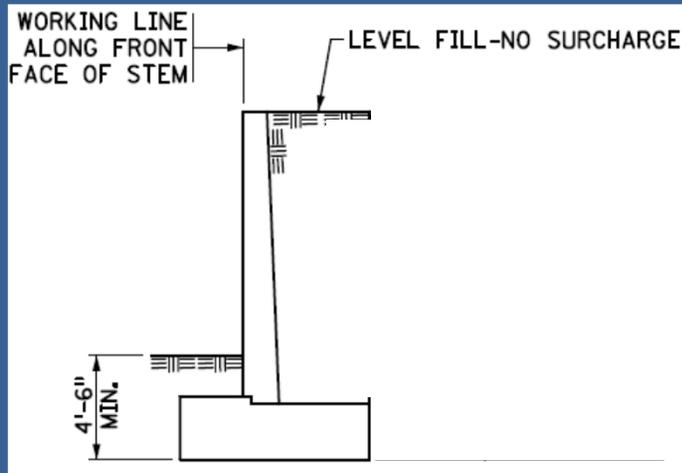
Limitations:

- Piles or large subcut may be required
- Relatively long construction time

Economical in:

- Moderate cuts
- Fills

Cantilevered Wall CIP Standards



Not applicable when:

- High water or non-drained backfills
- Other wall types more cost effective

Cantilever Retaining Wall Standards

- Updated, LRFD standards are being developed
- Eliminating standards for walls supported on timber piles
- Using only 100 ton (CIP and H-Pile) piles
- New standards:
 - Use fewer shear keys for sliding resistance
 - TL-4 barriers
 - Address construction tolerances
 - Refined stem reinforcement



Cantilever Retaining Wall Standards

- Level fill tolerance to 1V:6H backfill slope
- Pile layout guidance
- Spread footings - Service and Strength bearing pressure and effective width given:

UNIFORM PRESSURE DISTRIBUTION						TRAPEZOIDAL PRESSURE DISTRIBUTION		STEM HEIGHT h
SERVICE		STRENGTH 1a		STRENGTH 1b		* STRENGTH		
EFFECTIVE WIDTH B'	EFFECTIVE PRESSURE KSF	EFFECTIVE WIDTH B'	EFFECTIVE PRESSURE KSF	EFFECTIVE WIDTH B'	EFFECTIVE PRESSURE KSF	TOE PRESSURE KSF	HEEL PRESSURE KSF	
7'-10 7/8"	1.103	8'-7/8"	0.910	7'-9 5/8"	1.532	1.062	1.751	5
3'-1/2"	1.452	2'-5/8"	2.125	2'-7 7/8"	2.166	2.888	0.000	6
3'-4 7/8"	1.505	2'-3 1/8"	2.256	2'-11 1/2"	2.260	3.014	0.000	7
3'-8 3/4"	1.683	2'-6 1/4"	2.487	3'-3 1/4"	2.509	3.346	0.000	8
3'-11 3/4"	1.953	2'-9 1/4"	2.829	3'-6 5/8"	2.886	3.848	0.000	9
4'-4 5/8"	2.083	3'-1 1/4"	2.979	3'-11 1/4"	3.064	4.086	0.000	10

Counterfort Retaining Walls



40 - 60ft Fills

Benefits:

- Aesthetics
- Durability
- Less Backfill

Limitations:

- Costly
- More forming and pours
- Piles or large subcut
- may be required
- Relatively long construction time

MSE Thin Panel Walls

10 - 50 ft

(Fill situations)

Benefits:

- Rapid construction
- Relatively low skill labor
- Facing flexibility
- Can accommodate some settlement



Source: Crosstown Project

MSE Thin Panel Wall Limitations

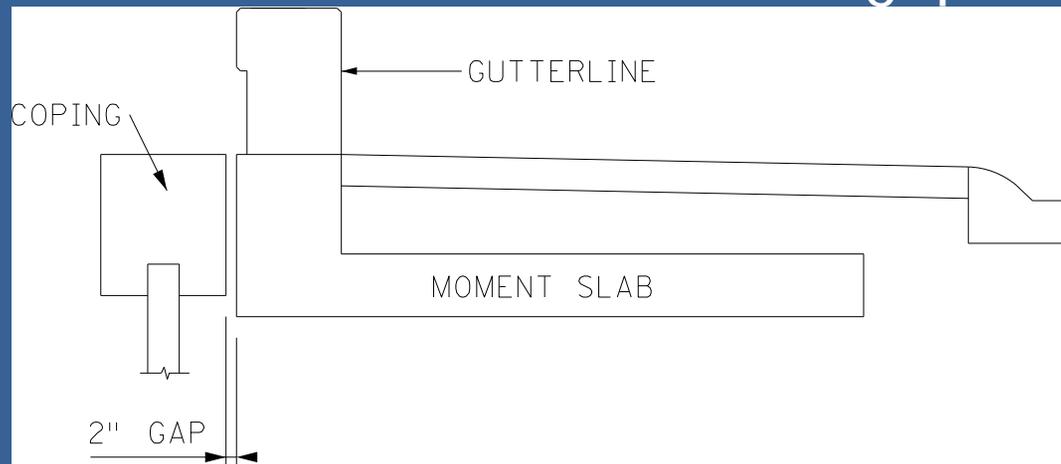
- Water table
- Utility restrictions
- Settlement control
- Large amount select backfill
- Construction season limited
- Corrosion in aggressive environments



Source: TH 169

Additional MSE Considerations

- Barrier cannot contact panel
- Provide 2" min. movement gap



- Details of traffic barriers, moment slabs, coping, fencing and drainage
- Leveling pad at proper depth
- No planting above wall
- No excavation near/into wall

Reinforced Soil Walls

Acute Corner Angles >70 deg.



Source: Monticello I-94 Project 07-2010

PMBW and PMBGW



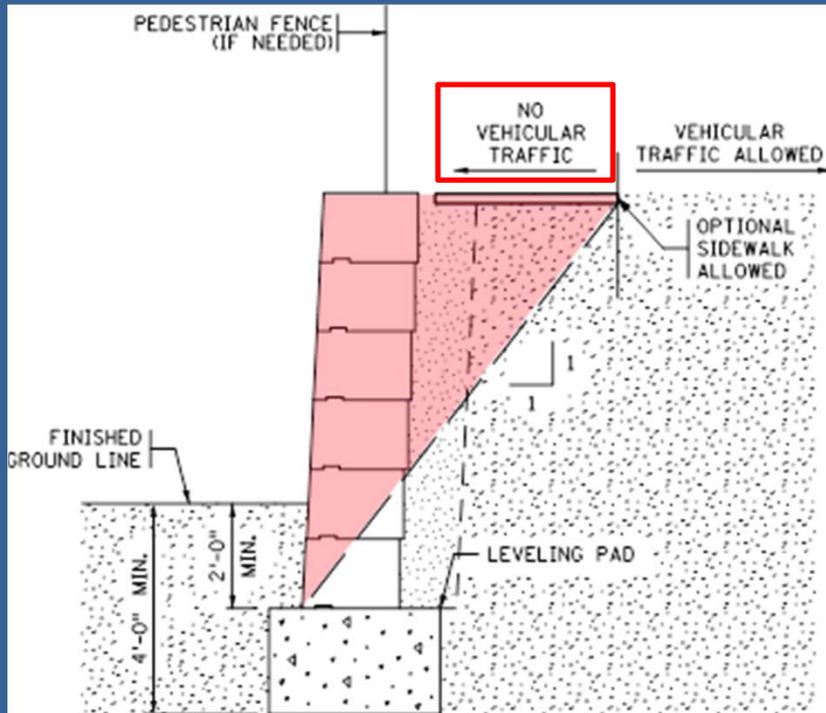
Up to 16" high,
48" wide,
60" deep



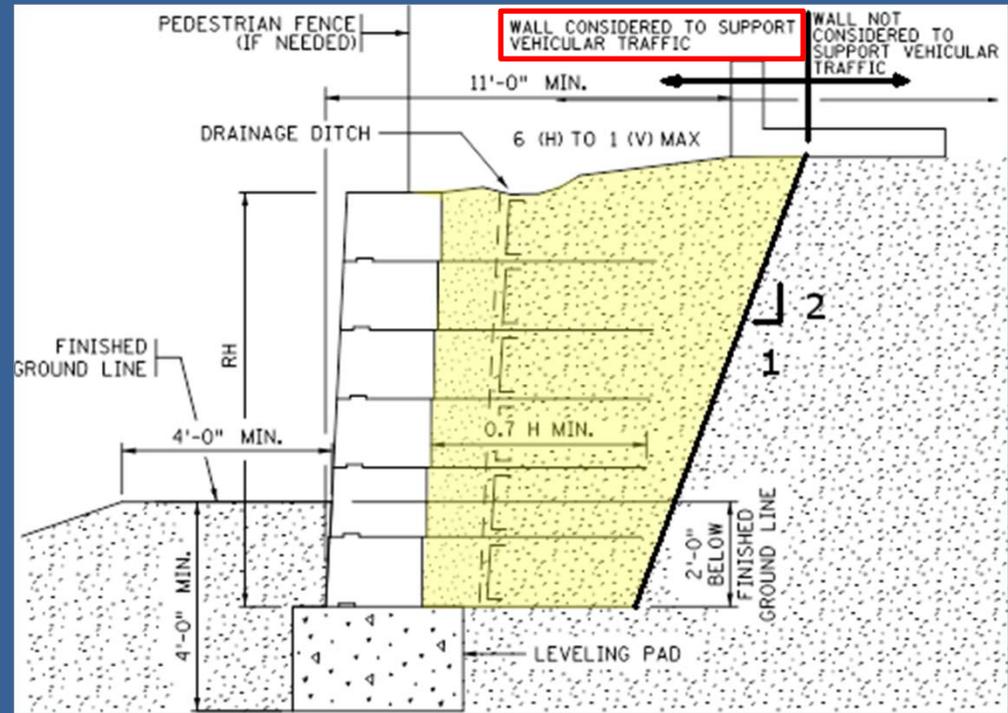
Approved Suppliers:

<http://www.dot.state.mn.us/products/walls/PMBW.pdf>

PMBW and PMBGW



PMBGW



PMBW

(Also applies to MSE with Thin Panel Face)

Prefabricated Modular Block Walls

PMBW and PMBGW



Up to 18 ft general range - limitations for roadway

- Adaptable to site conditions
- Can resist high horizontal pressures

Limitations:

- Soil reinforcement requires permanent easement or ROW
- Settlement $\leq 1/200$

Modular Block Walls (MBW)

- Modular Block Gravity Wall aka “small block” aka “Segmental Concrete Masonry Units”
 - Reinforced \leq 12-ft tall, 10-ft exposed
 - Unreinforced (Gravity only) not permitted to support roadway
 - Termed “MBW” when soil reinforcement added



Dry Cast Modular Block Walls (MBW) with Earth Reinforcement



Keystone Retaining Wall Block

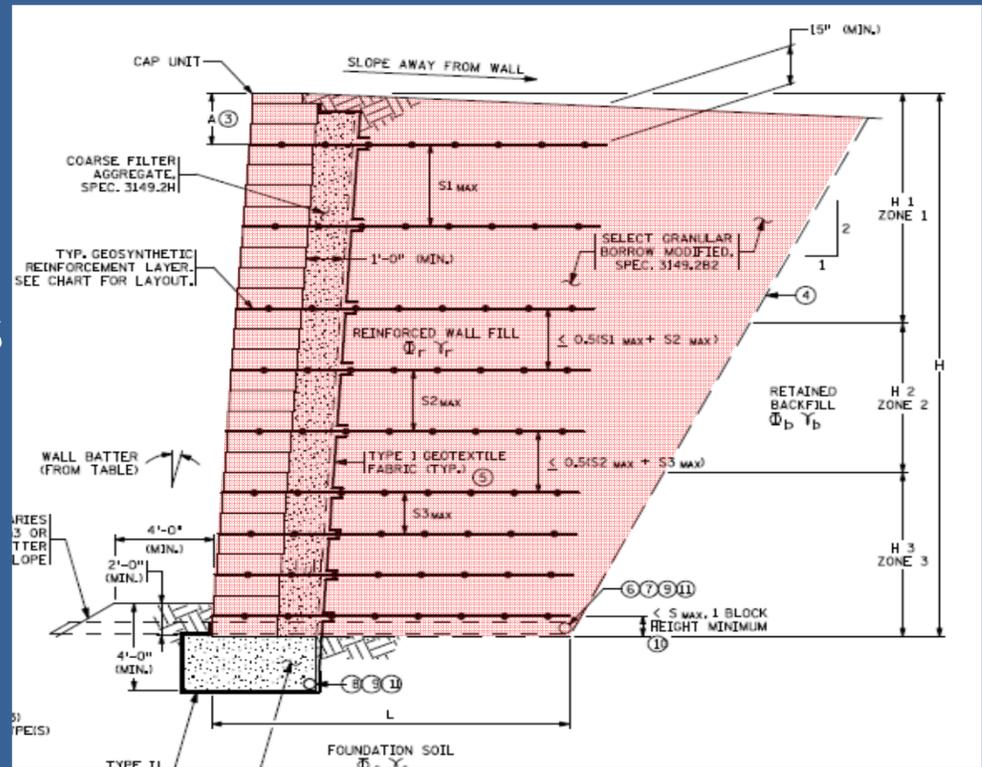


STANDARD II UNIT
Rockface

Width 18"
Depth 18"
Height 8"

Dry Cast Modular Block Walls (MBW) with Earth Reinforcement

- Standard plans 5-297.640, 641, 643, 644, 645
- MnDOT has experienced freeze-thaw durability issues with these block- See tech memo 08-06-MRR-01
- Gutter $\geq 0.5 H$: 1 V from the back of the reinforcement (Tech memo 08-11-MRR-02)



Block Walls

Block type	Suppliers	Soil Reinf.?	Max Wall Height	Support Rdwy
MBW = small block (often dry cast)	Keystone, Anchor Block, Versa-Lok	No	Limited by design	No
		Yes	12' from top of leveling pad	No
PMBW = large block (wet cast)	Oldcastle Recon Redi-Rock Maccaferri London Boulder	No	Up to 8'	No
		Yes	See Pre-qualified notes for height limitations - up to 18-ft	Requires approved barrier details

Cantilevered Sheet Pile Walls

- Usually for temporary situations
- Low aesthetics
- Potential movement



Anchored Walls



15 - 65ft Cuts

Benefits:

- Adaptable to site conditions
- Can resist high horizontal pressures

Limitations:

- Skilled labor required
- Anchors require permanent easement or ROW

Noise Walls

- Timber noise wall standards
- Approved treatments
- New AASHTO Sound Barrier Specifications
 - Wind
 - Crash Requirements
- Design for Strength III
- Supporting Structures consider Strength III and Strength V



Wall Selection



Wall Design Process

- Road profile
- Prelim wall selection
 - Cut or fill
 - Retained height
 - Economy
 - Settlement
 - Utility & ROW
 - Aesthetics
- Contact Foundation Office or hire geotech



Wall Design Process

- Preliminary wall type selected
- Geotech performs site investigation (FADR)
- Wall designer reviews FADR or Geotechnical Report
- Confirm wall choice
- Design wall and/or Prepare Bid Documentation
- Structural review
- Review foundation preparation notes and spec

Wall Plan and Spec Information

- Wall height and plan geometry
- Top of wall profile
- Plan and cross section views showing:
 - ROW
 - Easement limits
 - Utilities
- Slopes
- Aesthetics
- Construction staging requirements
- Soil conditions with ground water
- Design criteria and loading conditions

Nonstandard or Proprietary Walls

- List of acceptable wall types and systems for each wall
- Consult with Bridge Architect i.e. Dave Hall for architectural considerations
- Any special structures on wall i.e. large signs, noise wall, lighting- these can affect resistance in the design
- Planning for fencing on wall - document completely in the design, or install sleeves during construction

Resource Links

- MnDOT LRFD Manual
- MnDOT Road Design Manual:
 - <http://roaddesign.dot.state.mn.us/roaddesign.aspx>
- Roadway Design Scene:
 - <http://www.dot.state.mn.us/pre-letting/scene/index.html>
- Standard Retaining Wall Presentation:
 - <http://www.dot.state.mn.us/metro/finaldesign/sampleplan.html>
- Standard Plans
 - <http://standardplans.dot.state.mn.us/>
- Materials and Road Research Tech Memos
 - Tech memo 08-06-MRR-01 “Use of Mechanically Stabilized Earth (MSE) Walls with a Segmental Precast Concrete Panel Facing”
 - Tech memo 08-11-MRR-02 “Use of Dry-Cast Segmental Masonry Retaining Wall Units”
- Approved Products:
 - <http://www.dot.state.mn.us/products/walls/>



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