GUIDELINES FOR DEVELOPING DETAILS FOR REPAIR OF MSE WALL FACING

These sample details and notes provide guidance on repair methods for damaged portions of mechanically stabilized earth (MSE) walls with precast concrete panels and steel or geosynthetic reinforcements. The designer should select the appropriate repair method based on the type and level of damage in the wall facing.

DOOT Bridge Design Manual shall be consulted for guidance for appropriate methods for concrete repair and restoration. This information should be used as a guide in developing appropriate plan notes.

If reconstruction is determined to be more feasible in cost and/or time than repair, and if reconstruction is selected, construction shall be preceded by design calculations and be subject to approval by the department. The MSE reinforcement shall be of the same type as the soil reinforcement used in the repair of the wall (steel or geosynthetic) to avoid different wall deformation responses.

REPAIR METHODS LIST

Panel Repair Method 1: Minor cosmetic facing repair by part-depth removal and installation of fresh concrete with dowels and bonding agents. This method does not require details. It only requires removal and replacement limits.

Panel Repair Method 2: Facing repair by part or full-depth grouting or spraying and installation or erection of either a thinner zone of fresh cast-in-place concrete or dowels, bonding agents, and new additional steel, reinforcing bar or a precast panel, with connection to helical anchors. Helical anchors typically are installed either above or below the existing concrete surface.

Reinforcement Repair: Installation of drilled and grouted soil nails with corrosion protection.

Grout Fill: Backfilling of voids produced by loss of reinforcement fill using CMS 613 - low-strength mortar backfill (LSM), type 2.

CAUSES OF MSE WALL DAMAGE AND DETERIORATION

The main causes for damage of the MSE wall shall be identified prior to selecting the repair method.

Damage Types and Repair Methods

Four types of damage are addressed:

Type A: Extensive to moderate damage to facing panels and/or joints and reinforcement or reinforcement connections with partial loss of reinforcement fill through the damaged panels or joints. The damaged reinforcement can be miss-shaped or bent, severely corroded, or deteriorated. Damage may include significant lateral or uneven vertical movements. This type of damage can be caused by impact from vehicles, objects, falling objects, water, foundation issues, excessive settlement, or lateral deformation, overpressuring of the facing due to wall loading and/or eccentric loads on the facing, lack of reinforcement between the panels or damage caused by aggressive chemicals that might be harm to concrete or the reinforcement. This can be a visible single kind of damage or multiple kinds of damage to adjacent panels or groups of panels.

This type requires the following repairs:

1. Panel repair method 2.
2. Panel repair method 2 (where MSE reinforcements are not functional).

Type B: Local, damage limited to facing panels or/and joints which results in partial loss of reinforced fill through the damaged facing panels or panels between panels with no effects on the reinforcement or reinforcement connections.

This type requires the following repairs:

1. Panel repair method 1 or repair method 2.
2. Grout fill.

Type C: Partial loss of reinforced fill due to panel joint widening or uneven settlement of panels without damage to the panel units.

This type requires the following repairs:

1. Panel repair method 1 or repair method 2 to close out joints.
2. Grout fill.

Type D: Damage to the exterior of panels with no loss of reinforced fill and no effects on the reinforcement or reinforcement connections.

This type requires the following repairs:

1. Panel repair method 1.

Sample General Notes for Repair Methods:

Construction Specifications:

Goed Bridge Design Manual and Goed Construction and Material Specifications (CMS).

Materials:

Cast-in-place concrete shall be class C3, f'c=4,000 psi ± 28 days.

Shotcrete shall be in accordance with the CMS CMS list 520 (pneumatically placed mortar), f'c=2,000 psi ± 28 days.

CMS item 613 - Low-strength mortar (LSM), Type 2.

Reinforced steel shall be in accordance with CMS 605, min. yield strength 60 ksi.

Bend and hooks in reinforcing steel shall meet the requirements of the most current edition of the AASHTO LRFD Bridge Design Specifications, Article 5.10.2, unless noted otherwise.

All reinforcing steel shall be a minimum 2 inch concrete cover unless noted otherwise.

Helical anchors shall be grade 60 steel, galvanized per CMS item 171/02 and must be at least 4 feet long with 8 inch broad diameter mounted on a 3/4 inch diameter shaft/proof. See details on Sheet 2 of 8. The nominal yield strength of mechanical resistance holding power of the anchor is 4 kips. The anticipated torque to achieve the 4 kips is 400 ft-lb.

Backfill materials placed outside the limits of the new and existing walls shall meet the requirements of the dynamic embankment per CMS item 203.

Backfill placed behind the back of the wall face shall meet the requirements of the dynamic embankment as specified.

Sample Construction Requirements:

All exposed surfaces of cast-in-place concrete shall be finished to match the finish of the remainder of wall unless otherwise specified by the engineer.

Exposed areas of new concrete shall be painted to a minimum of 1/8 inch (0.13 cm) below finished grade. Damaged and/or back-filled areas of existing concrete surfaces shall be painted at the same time as new concrete surfaces. The color of the new paint shall be the color of existing paint.

All concrete sealing shall be in accordance with CMS item 512.

All exposed corners of cast-in-place concrete shall be chamfered 1 inch.

A proposed sequence of construction shall be part of the plan notes. Sample notes are provided below.

Sample Construction Sequence for Repair of Damaged Wall Facing and Reinforcement:

1. Excavate spilled select granular backfill and debris from the outside of the damaged wall area to the limits of the new cast-in-place wall facing.
2. Define the limits of removal for loose concrete, remove concrete and the precast concrete panel reinforcement to the limits shown on the plans. The concrete shall be removed with hand tools that will give satisfactory results in preparing and shaping the areas to provide a clean boundary for forming and placing low-strength mortar (LSM). Exposed reinforcing bars may be served as reinforcement by using epoxy or other corrosion protection.
3. Sandblast existing concrete surfaces behind the new cast-in-place facing to produce surface conditions suitable for bonding with new concrete.
4. Cover the opening in the existing wall with temporary formwork behind the MSE wall precast concrete panels and seal the joints between the panels to the limits noted on the plans. This type 2 low-strength mortar (LSM) backfill, from escaping from behind the existing wall during placement, the placing materials shall be securely braced to existing ground to withstand the hydrostatic pressure of the LSM.
5. Backfill existing precast concrete panels in the damaged area and vicinity to prevent outward movement or rotation during placement of the LSM.
6. Core-drill holes through the concrete of the existing wall or the formwork to permit pumping and venting of the LSM. Entry and vent holes shall be in the locations shown on sheet 6 or B.
7. Pump LSM into the void space behind the existing wall until it exits through the vent holes.
8. Forming materials and bracing may be removed 3 days after placing LSM. No wood shall remain in or around the damaged area.
9. Place reinforcing and construct a shotcrete sub-facade.
10. Install a proof test soil nailing and perform proof testing as specified and shown on sheet 8 or B. The shotcrete sub-facade shall attain a minimum compressive strength of 3,000 psi before performing proof testing.
11. Following the engineer's approval of the proof test results, construct the remaining soil nails in the locations shown on the plans and per the plan details. All details shown on the plans.
12. Construct a new uniform reinforcement footing and permanent cast-in-place concrete facing per details shown on the plans.
13. Paint new and existing concrete surfaces, backfill, and restore the grade in front of the wall to match the adjacent area.
DETAIL OF REPAIR FOR EXTENSIVE TO MODERATE DAMAGE (TYPE I)

1. EXCAVATE SPILLED SELECT GRANULAR BACKFILL AND DEBRIS FROM THE OUTSIDE OF THE DAMAGED WALL AREA TO THE LIMITS OF THE NEW CAST-IN-PLACE WALL FACING.


3. SANDBLAST EXISTING CONCRETE SURFACES BEHIND THE NEW CAST-IN-PLACE FACING TO PRODUCE SURFACE CONDITIONS SUITABLE FOR BONDING WITH NEW CONCRETE.

4. COVER THE OPENING IN THE EXISTING WALL WITH TEMPORARY FORMWORK BEHIND THE MSE WALL PRECAST CONCRETE PANELS AND SEAL THE JUNCTURES BETWEEN THE PANELS TO THE LIMITS NEEDED TO PREVENT ITEM 4 AT TYPE 2 LOW STRENGTH MORTAR (LSM) BACKFILL FROM ESCAPING FROM BEHIND THE EXISTING WALL DURING PLACEMENT. THE FORMING MATERIALS SHALL BE SECURELY BRACED TO EXISTING GROUND TO WITHSTAND THE HYDROSTATIC PRESSURE OF THE LSM.

5. BRACE EXISTING PRECAST CONCRETE PANELS IN THE DAMAGED AREA AND VICINITY TO PREVENT OUTWARD MOVEMENT OR ROTATION DURING PLACEMENT OF THE LSM.

6. CORE-DRILL HOLES THROUGH THE CONCRETE OF THE EXISTING WALL OR THE FORMWORK TO PERMIT PUMPING AND VENTING OF THE LSM. ENTRY AND VENT HOLES SHALL BE IN THE LOCATIONS AS SHOWN ON THE PLANS.

7. PUMP LSM INTO THE VOID SPACE BEHIND THE EXISTING WALL UNTIL IT EXITS THROUGH THE VENT HOLES.

8. CONCRETE REMOVAL OPERATION SO THAT THE SOIL REINFORCEMENTS ARE NOT DAMAGED.

9. INSTALL CONCRETE PANELS BETWEEN THE EXISTING MSE WALL PANELS AND SEAL THE JOINTS BETWEEN THE PANELS TO PRODUCE SURFACE CONDITIONS SUITABLE FOR BONDING WITH NEW CONCRETE.

10. PLACE EXPANDED POLYSTYRENE BETWEEN THE EXISTING MSE WALL PANELS AND THE PANEL UNDER REPAIR, AND INSTALL TEMPORARY FORMWORK WITH THE APPROPRIATE ARCHITECTURAL FINISH THAT MATCHES THE ORIGINAL FINISH PROVIDED ON THE EXISTING MSE WALL PANELS.

11. PLACE PREFORMED EXPANSION Joints Fillers (PEJF) AS SHOWN ON THE PLANS WHEN REQUIRED FOR TOP PANELS.

12. PLACE CONCRETE TO THE PANEL UNDER REPAIR TO PRODUCE SURFACE CONDITIONS SUITABLE FOR BONDING WITH NEW CONCRETE.

13. PLACE EXPANDED POLYSTYRENE THAT WAS PLACED BETWEEN THE EXISTING MSE WALL PANELS AND THE PANEL UNDER REPAIR.

14. FILL JOINTS WITH FOAM BACKER ROD OR EXPANDING FOAM. FOLLOW THE MANUFACTURER'S RECOMMENDATIONS FOR APPLICATION. IF USING EXPANDING FOAM, USE A FOAM THAT CAN BE APPLIED IN COLD WEATHER.

15. SEAL JOINTS BY APPLYING A SILICONE SEALANT TO THE FOAM IN THE JOINTS. FOLLOW THE MANUFACTURER'S RECOMMENDATIONS FOR APPLICATION. IF USING EXPANDING FOAM, USE A SEALANT THAT CAN BE APPLIED IN COLD WEATHER, AND THAT COMES IN A COLOR TO MATCH OR COMPLEMENT THE COLOR OF THE MSE WALL PANELS.

16. SMOOTH THE SURFACE OF THE SEALANT.

TYPICAL 5'x5' PANEL

TYPICAL 5'x10' PANEL

NOTE: THE LOCATION OF HELICAL ANCHORS SHALL BE SPECIFIED IN THE DESIGN, DEPENDENT ON THE LOCATION OF SOIL REINFORCEMENT USED IN THE EXISTING MSE WALL. THE HELICAL ANCHOR LOCATIONS SHALL BE SUCH THAT THEY DO NOT CONFLICT WITH THE LOCATION OF EXISTING SOIL REINFORCEMENT.
PANEL JOINT (TYP.)

SCALE: 1" = 1'

GROUT
NONMETALLIC
NONSHRINK,
6"

A
A
B
A
D
A

CONCRETE AND REBAR
REMOVE EXISTING
CONCRETE AND REBAR
#4 REBAR (TYP.)
SOUND CONCRETE)
BEYOND LIMITS OF
LIMIT (MIN. OF 2 INCH
CONCRETE REMOVAL
(DETERMINED IN FIELD)
SOUND CONCRETE
LIMITS OF
ALL REINFORCEMENT SHALL BE EPOXY COATED

DOWEL HOLE
SEE SHEET 5/8
WALL TOP ROW PANELS)
PARAPET (TYP. FOR MSE
MOUNTED DEFLECTOR
BOTTOM OF MOMENT SLAB
MSE WALL)

#4 REBAR TO BE REMOVED (TYP.)
#4 REBAR (TYP.)
#4 REBAR TO BE REMOVED AND REPLACED

REPAIR DAMAGED AREA

AREA TO BE REMOVED

HELICAL ANCHOR
(TYP.)

REMOVE EXISTING
CONCRETE AND REBAR

LIMITS OF
SOUND CONCRETE
(DETERMINED IN FIELD)

CONCRETE REMOVAL
LIMIT (MIN. OF 2 INCH
BEYOND LIMITS OF
SOUND CONCRETE)

HELICAL ANCHOR
(TYP.)

Temporary Formwork

Temporary Formwork

Temporary Formwork

Temporary Formwork

PARTIAL REPLACEMENT OF TYPICAL MSE PANEL REPAIR METHOD-2

FULL REPLACEMENT OF TYPICAL MSE PANEL REPAIR METHOD-2

SCALE: 1" = 1'/"
PARTIAL AND FULL REPLACEMENT OF 5' x 10' PANEL

**Panel Repair Method 2**

**Partial Replacement of Typical MSE Panel Repair Method-2**

**Full Replacement of Typical MSE Panel Repair Method-2**

**Panel Joint (Typ.)**

**Scale:** 1" = 1'

**Grout**

**Nonmetallic Nonshrink**, 6"

**Concrete and Rebar**

Remove existing concrete and rebar beyond limits of sound concrete (determined in field)

**Dowel Hole**

See sheet 5/8 wall top row panels)

**Parapet (Typ. for MSE Mounted Deflector)**

Bottom of moment slab mounted deflector panel, (typ. for MSE wall top row panels). See sheet.

**Helical Anchor (Typ.)**

Remove existing concrete and rebar

Place 3/4" expanded Polystyrene before placing the concrete for the panel.

**Panel Joint (Typ.)**

**Temporary Formwork**

**Limits of Sound Concrete**

Concrete removal limit min. of 2 inch beyond limits of sound concrete.

**Expanded Polystyrene**

**Helical Anchor (Typ.)**

**Area to be Removed**

**Temporary Formwork**

**Remove Existing Concrete and Rebar**

**Plate 3/4" Expanded Polystyrene Before Placing the Concrete for the Panel**

**Temporary Formwork**

**All MSE Panel Reinforcement shall be epoxy coated**

**Epoxy Coated**

**Designed & Drawn by:**

**GEO-TECHNICAL ENGINEERING OF ICICE**

**Prepared by:**

**GEO-TECHNICAL ENGINEERING OF ICICE**

**Date:**

**ADMINISTRATOR**

**DESIGNER**

**E.L. ROBINSON**

**ORIGINALLY DESIGNED & PREPARED**

**X - X - X - X**

**JUNE X - X - X X**

**GEO-TECHNICAL ENGINEERING OF ICICE**
MISCELLANEOUS DETAILS

MISCELLANEOUS REPAIR DETAILS ARE SHOWN TO PROVIDE GUIDANCE FOR SPECIFIC DETAILS THAT MAY BE PART OF OVERALL REPAIRS REQUIRED. THESE DETAILS WILL REQUIRE MODIFICATION TO ACCOMMODATE PROJECT SPECIFIC REQUIREMENTS.

DEFLECTOR PARAPET ON MSE WALL DETAIL

INSTALL 5/8" P.E.J.F. TO THE REMOVAL LIMITS AS SHOWN ON SHEET A OF 10

DETAIL A

SLIP JOINT

SCALE 1"=2'
**SAMPLE REINFORCEMENT REPAIR**

**PLAN SHEET 1 - INSTALLATION OF SOIL NAILS**

**LOW STRENGTH MORTAR (LSM) NOTES:**

1. **CONTRACTOR**
   - **CONSTRUCT FORMWORK WITHIN EXISTING WALL OPENING AND INSTALL WALL BRACING PRIOR TO PLACING THE CMS ITEM 613 - LOW-STRENGTH MORTAR (LSM), TYPE 2. THE DESIGN OF FORMWORK AND BRACING SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR.**

2. **DRILL HOLES NUMBER 1, 2 AND 3 THROUGH THE EXISTING PRECAST PANELS. HOLE 2 WILL BE THE GROUT PAD HOLES AND HOLES 1 AND 3 WILL BE THE VENT HOLES.** IF NEEDED, CREATE A PASSAGE THROUGH THE ENERGIZED FILL INTO THE EXISTING VAPORIZED AREA USING A DRILL, REINFORCING BAR OR OTHER MEANS TO ENSURE CLEAR PASSAGE OF THE LSM INTO AND OUT OF THE VAPORIZED AREA. THE PASSAGE THROUGH THE BACKFILL SHALL HAVE A MINIMUM DIAMETER OF 2 INCHES. ADJUST DRILLED HOLES TO AVOID CONFLICT WITH REINFORCEMENT CONNECTORS.

3. **ONLY HOLES 1, 2 AND 3 SHOULD BE DRILLED PRIOR TO PLACING THE LSM. ADDITIONAL HOLES (HOLES 8 AND 9) MAY BE DRILLED TO PROVIDE ADDITIONAL VENTING AND MONITORING OF GROUT FILLING.**

4. **PUMP THE LSM INTO THE SPACE BEHIND THE EXISTING WALL THROUGH HOLE NO. 2 UNTIL SLURRY EXITS AT THE VENT HOLES.**

5. **THE FORMING MATERIALS AND WALL BRACING SHALL REMAIN IN PLACE FOR A MINIMUM 3 DAYS AFTER PLACING THE LSM.**

**TYPICAL SOIL NAIL LOCATION IN PRECAST PANEL**

**NOTE:**

THE LOCATIONS OF THE SOIL NAILS MAY BE ADJUSTED AS NECESSARY TO FACILITATE DRILLING.

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EXISTING MSE WALL

#4 DOWEL, SEE NOTES THIS SHEET

NEW CIP CONCRETE FACING WALL

#4 @ 12" EACH WAY

UNREINFORCED FOOTING

8" DEEP x 12" WIDE

BASE OF RUSTICATION

1" (TYP.)

1" RUSTICATION

ANCHOR PLATE TO BASE OF RUSTICATION EXCEEDS 10"

ANCHOR PLATE TO BASE OF RUSTICATION EXCEEDS 10"

HAIRPIN NOTE:

HAIRPIN BARS ARE TO BE BENT IN THE FIELD & USED WHERE WALL THICKNESS OUTSIDE FACE OF ANCHOR PLATE TO BASE OF RUSTICATION EXCEEDS 10"

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ELEVATION

SECTION A-A

SECTION B-B

SECTION C-C

SECTION D-D

#4 DOWEL, SEE NOTES THIS SHEET

NEW CIP CONCRETE FACING WALL

#4 @ 12" EACH WAY

UNREINFORCED FOOTING

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REVISIONS TO READOUT

1. Soil nails shall have a minimum 28-day compressive strength of 3,000 psi, and a minimum 3-day compressive strength of 1,500 psi. Soil nail grout may be neat-cement grout or ready-mix grout. Type S Portland cement conforming to ASTM C595/ASTM C618 shall be used for soil nail grout. Submit wet design to the engineer for review and approval prior to construction.

2. Soil nails shall be hollow bar nails of either 

(a) HOLLOW BAR NAIL DIAMETER 3/4 IN.
(b) CONCRETE-SEAL TYPE 30/16
MIN. YIELD STRENGTH 60 KSI

3. Soil nails shall not be epoxy coated.

4. Structural steel for bearing plates shall be in accordance with ASTM A36, YS=36,000 psi.

5. Welded stud shear connectors shall be in accordance with CMS Item 93.

6. High strength threaded bolts, nuts and washers shall conform to ASTM 95.

INSPECTION AND MONITORING:

1. Services for work inspection, material testing, and surveying and monitoring of soil nail installation will be provided by the contractor. The drilling contractor shall cooperate with the inspection and testing agencies selected by the contractor, and shall furnish equipment, tools, and labor on site as required to facilitate such tasks.

2. The drilling contractor shall take photographs to document conditions of adjacent existing structures, walls, street pavements, utilities, etc., prior to commencement of work. One set of these photos shall be submitted to the engineer before commencing any work.

3. The contractor shall survey every other nail in the top row of nails to monitor horizontal and vertical ground movements. The survey shall be done on a daily basis until wall construction is complete, and the daily results shall be made available to the engineer by the following work day.

4. Should excessive movement greater than 1/8 inch or a sudden increase in ground settlement, lateral deformation, or soil nail movement be detected, the soil nail contractor shall notify the engineer immediately.

5. The soil nails shall have a minimum 28-day compressive strength of 3,000 psi, and a minimum 3-day compressive strength of 1,500 psi. Soil nail grout may be neat-cement grout or ready-mix grout. Type S Portland cement conforming to ASTM C595/ASTM C618 shall be used for soil nail grout. Submit wet design to the engineer for review and approval prior to construction.

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