Table of Contents

4.4 RETAINING WALLS

4.4.1 Introduction

A retaining wall structure is designed to maintain an abrupt difference in ground surface elevations. These structures support near vertical slopes of soil masses by preventing the soil from sliding and deep shear failure. These structures also provide a means of protecting an earth embankment from erosion, which is common on steep slopes. For instance, a slope can be completely eliminated or constructed at a naturally stable angle by raising the slope's toe elevation with a wall. A steeper slope can be constructed by utilizing soil reinforcement methods or a series of tiered shorter landscape walls.

Roadway proximity to soil cuts and fills necessitate the use of a retaining structure. Typical applications of these structures consist of retaining walls as part of a roadway system, dockwalls along a body of water, and extended wingwalls from a bridge abutment. This chapter contains a comprehensive discussion of the different types of retaining wall structures, types of failure, and element level inspection procedures.

Most newly constructed walls will have an "R" number assigned to it. Refer to Chapter 14 of the Wisconsin Bridge Manual (WBM) for numbering criteria. The ID plaque is generally located at the end of the wall; however, older walls may not necessarily have been assigned numbers and/or may have ID plaques missing. WisDOT inventories all "R" numbered structures within HSI with inspection intervals not to exceed 6 calendar years. This interval may shorten depending on several risk based factors including the overall rating, specific wall type, wall location, defect type, quantity of defect and/or manager preference. Refer to the Structures Inspection Manual (SIM) Part 4 Chapter 1 for more information on interval requirements and recommendations.

Non-integral wingwalls without "R" numbers are evaluated as retaining walls on the bridge inspection report. Therefore, retaining wall elements and appropriate material defects will be used for these wingwalls. Non-integral wingwalls are separated from the abutment footing with a full height joint. In some instances, typically older structures, the bridge plans may need to be reviewed to determine whether a wingwall is integral or not. A wingwall essentially acts as a free standing structure retaining fill. Non-Integral wingwalls with "R" numbers will not be evaluated as part of the bridge inspection but will be inspected as a separate inspection and interval under the inspection program. During bridge inspections, however, it is the inspector's due diligence to perform a cursory inspection of an adjacent "R" numbered retaining wall to ensure that any notable deterioration of the wall does not threaten the integrity of the bridge structure, or endanger the travelling public. Any areas of concern can be captured as maintenance items or through documented communication with the inspection program manager.

4.4.1.1 Wall Types

Retaining walls can be divided into many categories. For inspection purposes, we'll briefly define the common wall types found in Wisconsin in this chapter and refer to Chapter 14 of the WBM for a more in-depth discussion.

Walls can be constructed either bottom-up or top-down. Examples of bottom-up constructed walls include CIP Cantilever, MSE, and modular block walls. If a wall is constructed downward,

from the top of the wall to the bottom, it is a considered a top-down type of wall. Examples include soldier pile and sheet pile walls.

Wall Category	Wall Sub-Category	Typical Construction	Wall Type	Element #
Gravity	Mass Gravity	Bottom Up (Fill)	CIP Concrete Gravity	8600
	Semi-Gravity		CIP Concrete Cantilever	8600
	Reinforced Earth		MSE - Precast Panels	8603
			MSE - Modular Blocks	8603
			MSE - Wire Face	8603
	Modular Gravity		Modular Block	8602
			Gabion	8601
	In-Situ Reinforced	Top Down (Cut)	Soil Nailing	8606
Non - Gravity	Cantilever	Both	Sheet Pile	8605
			Soldier Pile	8604
			Secant/Tangent	8607
Non - Gravity	Anchored	Top Down (Cut)	Sheet Pile	8605
			Soldier Pile	8604
			Secant/Tangent	8607

Table 4.4 1 Wall Categories and Elements

Another category indicates the primary methodology that the wall uses to retain the fill material. Gravity walls are considered externally stabilized as these walls use self-weight to resist lateral pressures. There are numerous sub-categories for this type of wall including mass gravity, semi-gravity, modular gravity, mechanically stabilized reinforced earth (MSE), and in-situ reinforced earth (soil nailing) (see Figure 4.4.1-1). Non-gravity wall are classified into cantilever and anchored wall categories (see Figure 4.4.1-2). These walls are considered externally stabilized and are generally used in cut situations. Typical sub-categories for these walls include sheet pile, soldier pile, and tangent/ secant pile types, either with or without anchors. See WBM Chapter 14 for more information.

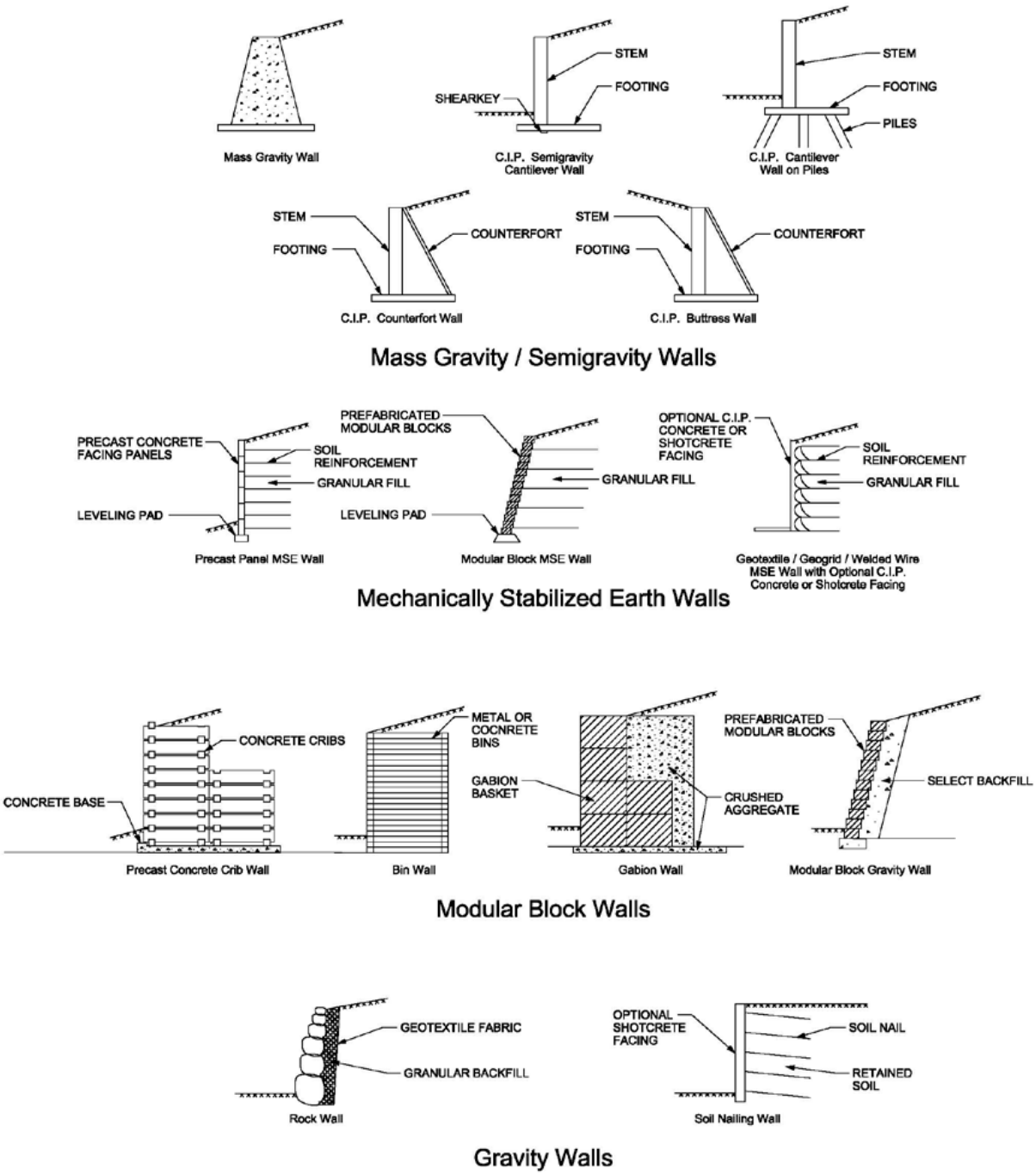
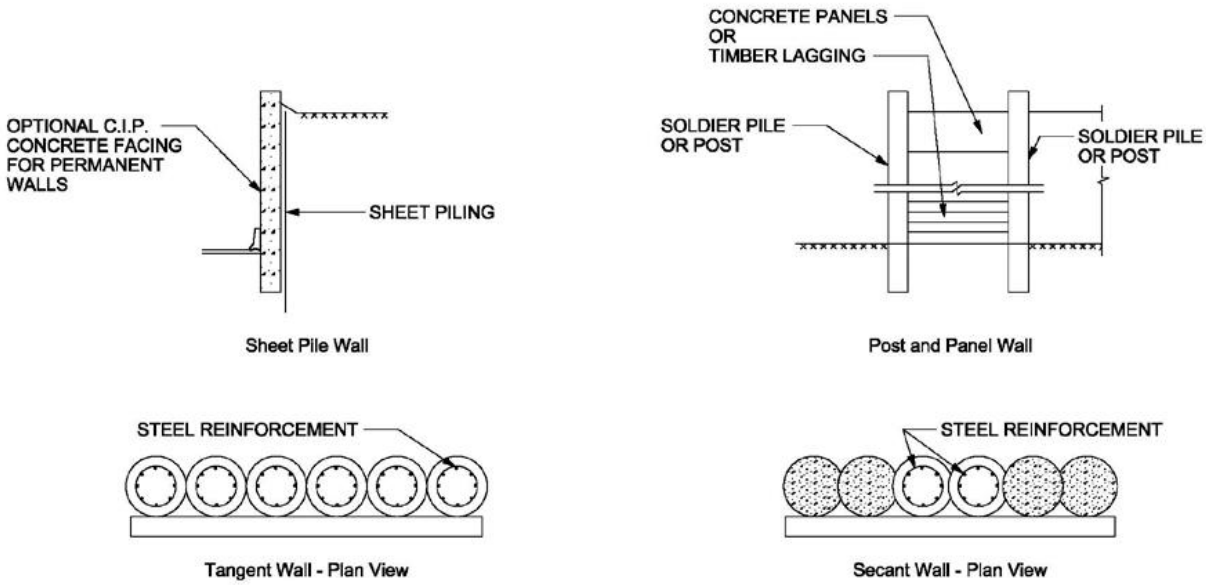


Figure 4.4.1-1: Typical Gravity Walls



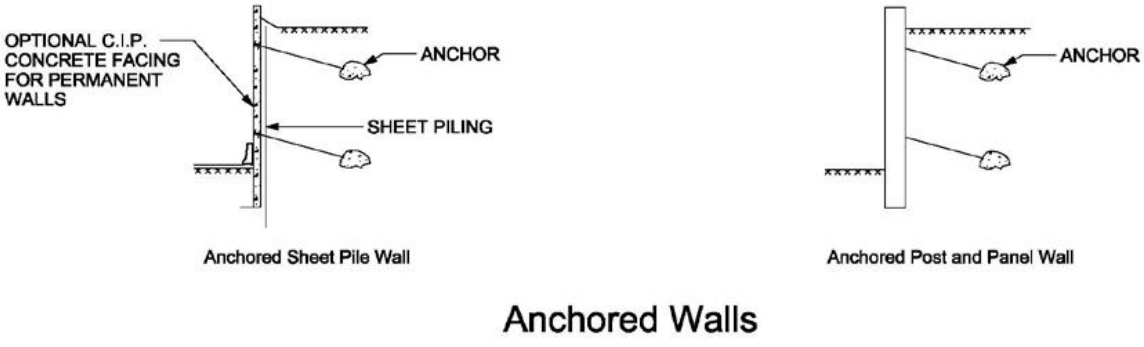


Figure 4.4.1-2: Typical Non-Gravity Walls

4.4.1.2 Wall Classifications

Retaining walls can be divided into three categories of applications: Fill-Section; Cut-Section; and Dockwall. The inspector should identify, if possible, which category of retention structure is present in order to better understand the significance of distress or localized failures. Each wall report within HSI designates whether a wall application is Fill, Cut or Dockwall. This information is located within the inspection report in HSI. Each wall application is elaborated as follows:

1. **Fill-Section Application:** The structure retains a roadway facility at a higher elevation than the adjacent earth. Specific areas of concern for inspection include heavier deterioration at the top and face of the wall from roadway salts washing over the wall, and geotechnical failure due to the added surcharge from traffic.

Figure 4.4.1-1: MSE “Fill” Wall

2. **Cut-Section Application:** The structure retains the adjacent earth at a higher elevation than the roadway facility. Specific areas of concern for inspection include heavier deterioration at the base of the wall from roadway salts washing against the wall, and vehicular impacts.

Figure 4.4.1-2: CIP “Cut” Wall

3. **Dockwall Application:** The structure retains the adjacent earth at a higher level than the waterway channel bottom. The deterioration mechanisms of a dockwall are the same as for a land-based earth retention structure; however, since a portion of the wall exists beneath the water the environment is more severe. This makes the wall more susceptible to scour and accelerated material deterioration. Also, dockwalls are typically associated with portions of the waterway where watercraft traffic and docking occurs, making the dockwall more susceptible to impact and ice flow damage. Underwater inspections are typically required to fully assess the condition of dockwalls. Refer to Part 1, Chapter 3, for a discussion of underwater inspection procedures.

Figure 4.4.1-3: Steel Sheetpile Dockwall

4.4.2 In-Service Retaining Wall Failures

Primary causes of in-service retaining wall failures include poor drainage, corrosion, facing deterioration, inadequate connection details, and latent construction defects. For MSE walls in particular, infiltration due to poor control of external drainage is the most common cause of failure.

Failure of wall construction material is frequently observed in older earth retention structures due to deterioration. Newer walls may exhibit structural material failure due to structural overstresses or poor material properties. Inadequate drainage behind the wall or an unexpected surcharge load can often cause material overstress.

Impact damage may also fail the material, and is typically a result of a collision between a moving object and the earth retention structure. The moving object is typically an errant vehicle or vessel, but may also be smaller objects hurled into the wall due to wind or explosion.

Impact damage is typically confined to an area directly adjacent to the point of contact and is characterized by distortion or crushing of the construction material at the point of contact with cracking, splitting, or splintering radiating from this point. Refer to Figure for a view of an impacted dockwall.

Figure 4.4.2-1: Impact Damage to a Steel Sheet Pile Dockwall.

While impact damage is typically expected above ground, utility operations and other similar activities may damage buried elements of an earth retention system. For instance, installation of utility poles behind a mechanically stabilized earth (MSE) wall often severs anchor strapping leading to wall movement. Therefore, it is important to note new construction on or adjacent to earth retention structures and record any distress, deterioration or movement in subsequent inspections.

During retaining wall inspections, geotechnical or structural defects found shall be quantified in their entirety and placed under the appropriate structural defect. While these material

defects may eventually compound or expand, structural defects are more global in nature with effects that may require more immediate attention. The following sections inform inspectors to the various material defects for each construction material used in earth retention structures.

4.4.2.1 Geotechnical Failure Modes

During the design phase, engineers check the wall for anticipated failure mechanisms relating to external stability, internal stability, movement and overall stability. The following figures give some examples of common geotechnical failure types (See WBM Chapter 14 for more information). Defects for wall movements used in the Element based inspection will be discussed in Section 4.4.3.4 and 4.4.3.6.

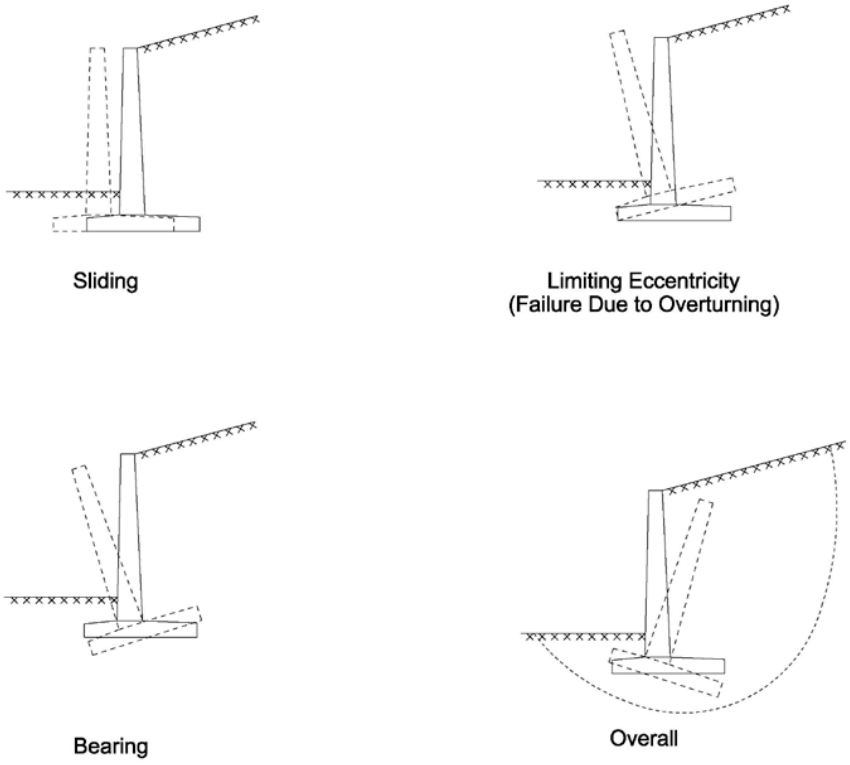


Figure 4.4.2-2: External Stability Failure of a CIP Semi-Gravity Wall

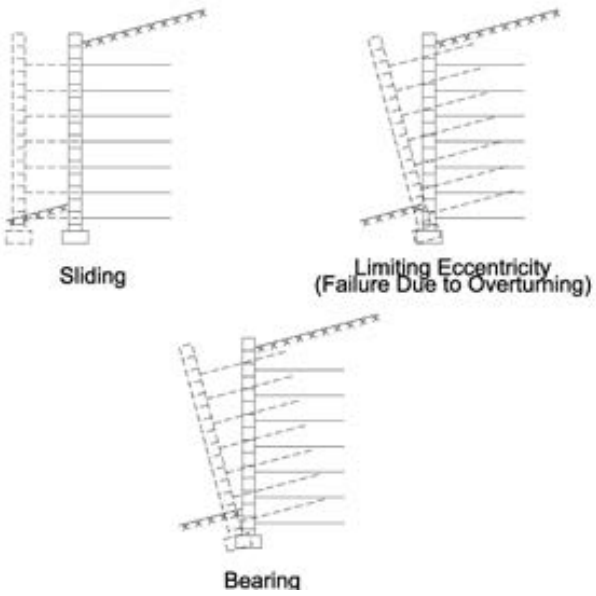


Figure 4.4.2-3: External Stability Failure of MSE Walls

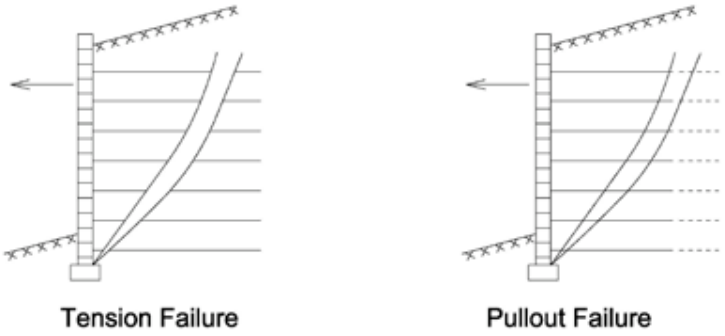


Figure 4.4.2-4: Internal Stability Failure of MSE Walls

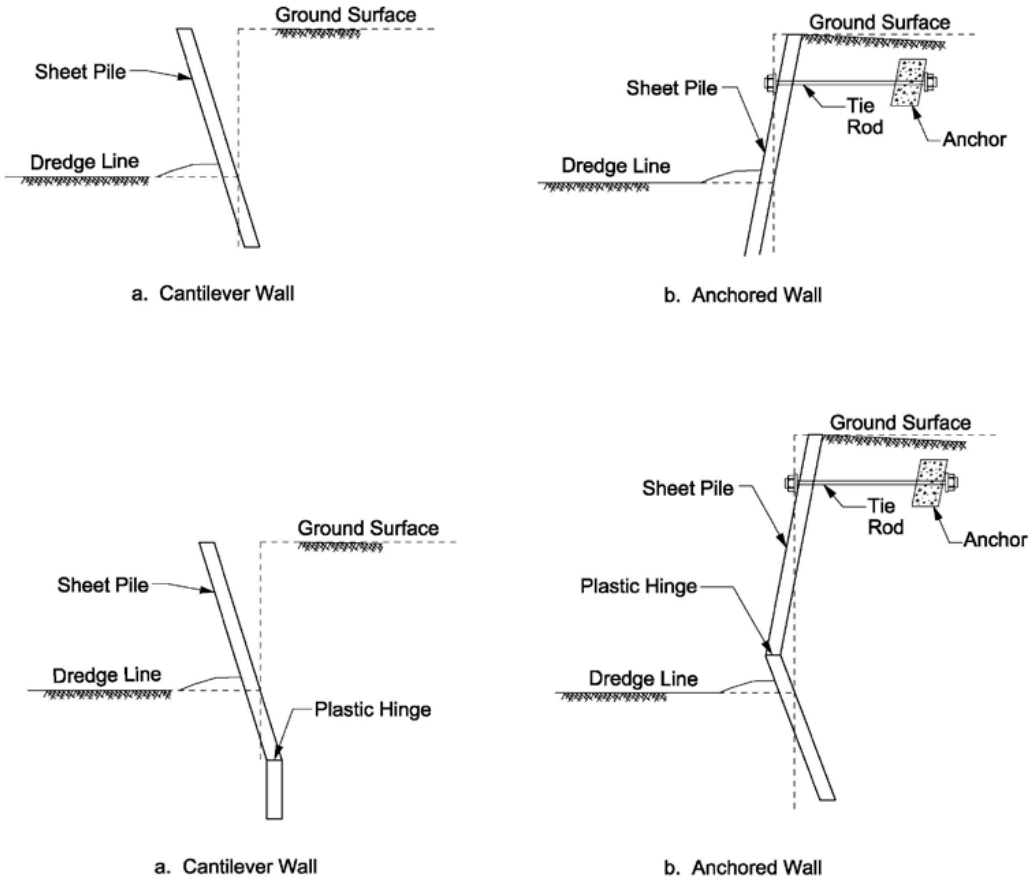


Figure 4.4.2-5: Flexural Failure of Non-Gravity Walls

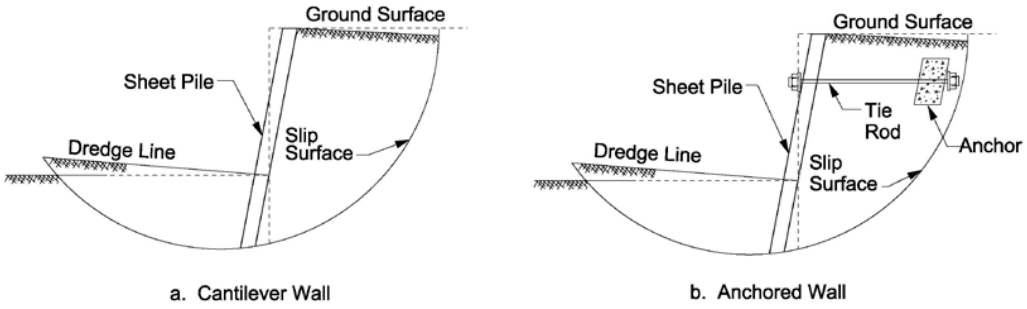


Figure 4.4.2-6: Deep Seated Failure of Non-Gravity Walls

Vertical movement can occur in the form of uniform settlement or differential settlement. Uniform settlement will have little effect on the structural stability of the wall; however, overtopping of the wall may occur if the settlement is significant. Differential settlement, on the other hand, can create serious problems in the wall. Differential settlement may cause the

opening of joints or cause wall cracking or transverse tipping. Refer to Figure 4.4.2-7, Figure 4.4.2-8 and Figure 4.4.2-9 for a diagram and view of differential settlement under a retaining wall.

The most common causes of vertical movement consist of soil bearing failure; soil consolidation; erosion; and foundation material deterioration.

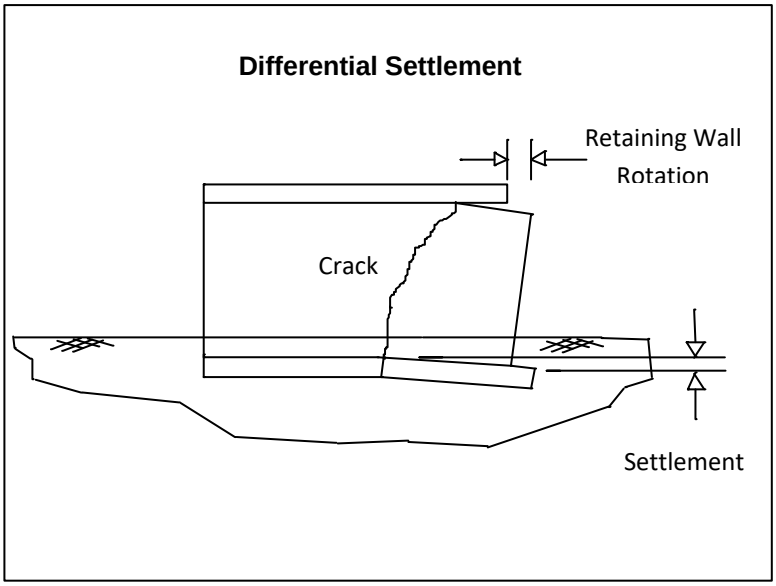


Figure 4.4.2-7: Differential Settlement Under a Retaining Wall.

Figure 4.4.2-8: View of Differential Settlement between Precast Concrete Panels. Note Misalignment in Rustication.

Figure 4.4.2-9: Settlement as Seen from Bridge Rail at Top of Wall.
Note, Settlement was Reflected in Adjacent HMA Pavement.

Earth retention structures are also susceptible to lateral movements or sliding. Lateral movement may occur when the lateral soil pressures exceed the resisting soil frictional and shearing forces, wall anchorages that hold the wall in place or the self weight of different wall components.

The most common causes of lateral movement are slope failures (deep shear failures); seepage; changes in soil characteristics (e.g., frost action and ice); and consolidation of the original soil. Deep shear failures occur along a cylindrical surface when there is a weak layer of soil under the wall at a depth of approximately 1.5 times the width of the base of the wall. Refer to Figure 4.4.2-10 for a diagram depicting lateral movement of a wall due to deep shear failure. Refer to Figure 4.4.2-11 for a view of a mechanically stabilized earth (MSE) wall with extensive lateral movement.

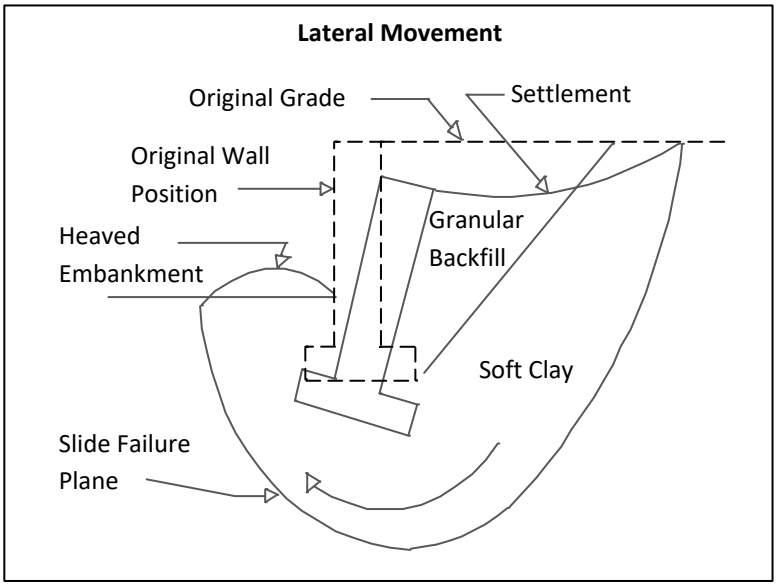


Figure 4.4.2-10: Lateral Movement and Rotation of a Retaining Wall Due to Slope Failure.

Figure 4.4.2-11: Lateral Movement of an Individual Panel of a MSE Wall.

Rotational movement, or overturning, is generally the result of asymmetrical settlements or lateral movements; however, it may result from increased soil pressure behind the wall. Refer to Figure 4.4.2-12 for a diagram of rotational wall movement.

The most common causes of rotational movement are saturation of backfill due to clogged drains; embankment erosion along the front of the wall; and improper design.

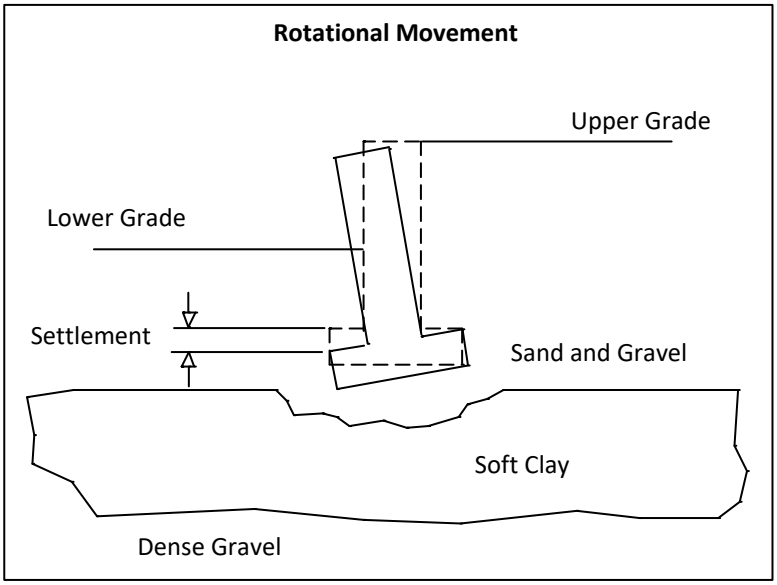


Figure 4.4.2-12: Rotational Movement of a Retaining Wall.

4.4.2.2 Material Deterioration

This section will give a brief description of common material flaws that will be observed during retaining wall inspections. Specific defect condition states will be addressed with specific language for each wall type in Section 4.4.4.

Stone Masonry and Concrete Masonry Units

The following is a discussion of different types of material defects that may be found when inspecting Masonry units. Unreinforced concrete masonry units are commonly used in the construction of segmented block retaining walls.

- **Construction Defects:** Construction flaws are often characterized by damage to the blocks that appear to be due to poor construction technique or errors. Examples might include evidence of cracked units, open joints in locations other than a bend, or evidence of improper design or construction, such as improper block alignment. Refer to Figure 4.4.2-13 for a view of construction defects as shown by the open joint.

Figure 4.4.2-13: Poor Construction Methods Resulting in Block Separation.

- **Corner Breaks:** One or more of the block corners are cracked or broken off. The plane of fracture is approximately 45 degrees from vertical, and the size of the fracture exceeds 2 inches along all three major axes. Smaller breaks should be considered to be fraying or edge spalls. Refer to Figure 4.4.2-14 for a view of a corner break as well as cracking in the top face.

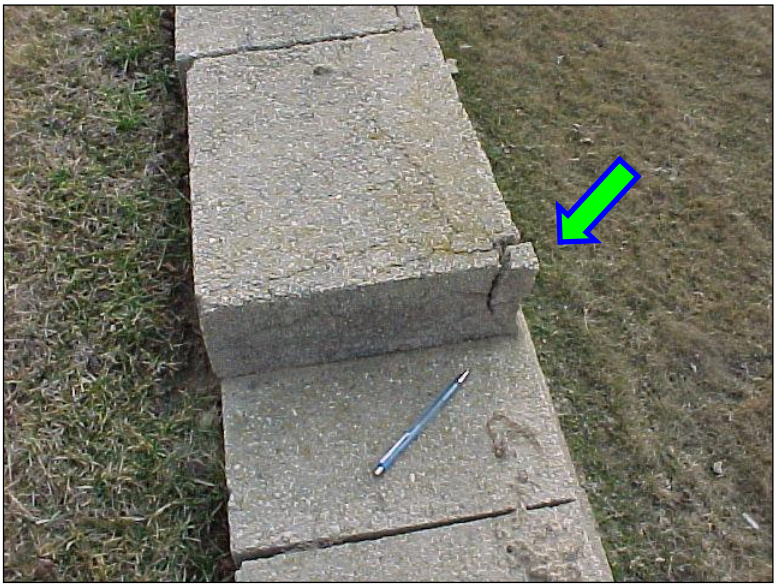


Figure 4.4.2-14: Corner Break with Cracking on the Top Face.

- **Cracked Block:** Randomly cracked block units. The direct cause of the crack development is uncertain. Examples might include diagonal or straight crack propagation across the capstone, or vertical crack propagation along the face of the

stone. Refer to Figure 4.4.2-15 for a view of a transverse crack through the front face of a block.

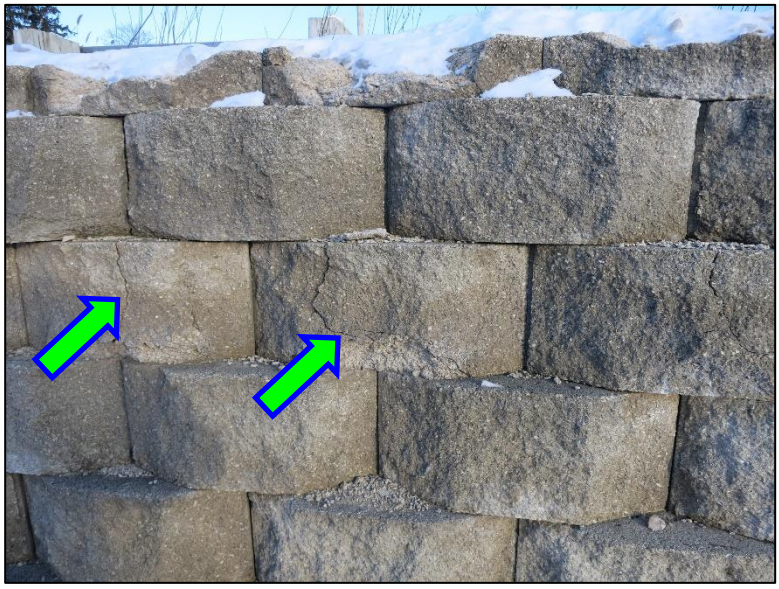


Figure 4.4.2-15: Vertical Cracking through the Front Face of a Block Unit.

- **Efflorescence:** Efflorescence, informally referred to as leaching, is a white deposit on the concrete surface caused by the crystallization of soluble salts (calcium chloride, calcium hydroxide) contained within the cement paste. Water traveling through the concrete dissolves these salts and usually deposits them along cracks where the water exits. Efflorescence indicates that water and dissolved chemicals are able to pass through and contaminate the concrete. This is primarily an aesthetic problem, but can serve as evidence of increased block porosity and weakness in extreme cases. Refer to Figure 4.4.2-16 for a view of efflorescence.

Figure 4.4.2-16: White Precipitate Formed due to Efflorescence.

- **Embedded Vegetative Growth:** This is the presence of plant foliage growing from between the block units or in wash-through deposits. The penetration of plant roots into the blocks may cause units to crack either through root growth into pores and small flaws or by extensive plant growth between block units. Neither exposed fine tree and plant roots that have grown through the wall from behind, nor plants present as architectural enhancements are considered Embedded Vegetative Growth.

- **Abrasion:** Abrasion is the loss of surface material due to the action or water or wind-blown abrasives. This distress may be easily confused with surface scaling and freeze-thaw damage because the latter two are generally more severe in areas of water flow and saturation. Abrasion is typically evidenced by relatively uniform loss of surface mortar along the paths of water flow. Surface scaling and freeze-thaw damage is generally greater in depth.

- **Fraying/Spalling (Block Edges):** Fraying or spalling is the presence of minor chipping along block edges and corners. Occasionally fraying or spalling will be the result of improper handling and placement during construction. Other causes include thermal expansion, or the placement of blocks on uneven surfaces. The presence of a large number of spalls in the same place on each block may indicate a problem in manufacturing. Refer to Figure 4.4.2-17 for a view of spalling and fraying along the block edges.

Figure 4.4.2-17: Spalling and Fraying on the Top Edge of the Block.

- **Freeze-Thaw Damage:** This is the progressive internal deterioration of saturated block material in the presence of freezing and thawing temperatures. The expansion of water during freezing periods can produce significant internal damage. Resulting defects will appear as areas of crumbling or general deterioration. This type of damage is most often found in areas that are frequently saturated and exposed to freezing conditions. Note if this type of damage is occurring on a vertical or horizontal surface. Refer to Figure 4.4.2-18 for a view of typical freeze-thaw damage.

Figure 4.4.2-18: Freeze-Thaw Damage at a Corner.

- **Manufacturing Flaws:** These flaws are evidence by systematic flaws in the block units that are due to a design or manufacturing problem.

- **Popouts:** Aggregate particles near the surface of the block units that have expanded and caused concrete to flake or chip-off.

- **Positioning-Guide Damage:** Some block designs include a small vertical concrete "lip" near the back edge of the block. This lip provides guidance in the positioning of each block to ensure a uniform rate of setback. They are susceptible to manufacturing flaws, or damage due to poor handling.

- **Scaling:** This is a special type of freeze-thaw damage. It is generally characterized by significant exterior damage and crumbling, more so than typical freeze-thaw damage.

- **Staining:** This is the discoloration of block units caused by exposure to elements such as surface runoff containing dark clays or organic material, deicing chemicals, mold growth, moss, and other sources. Refer to Figure 4.4.2-19 for a view of staining.

Figure 4.4.2-19: Typical Staining Evidenced by the Brown Discoloration of the Blocks.

Figure 4.4.2-20: Excessive Gap Forming At Base of Stone Block.

- **Wash Through:** This is the erosion of retained material through the wall. Check for evidence of deposits of retained material on flat surfaces of the exposed side of the wall. Minor deposits are generally cosmetic problems, but can promote vegetative growth. Larger deposits could indicate severe erosion of the retained material.

Concrete

The following is a discussion of different types of material defects that may be found when inspecting Concrete Earth Retention Structures. This includes cast-in-place and precast

concrete wall components. Refer to the SIM Part 2, Chapter 1 for further discussion on concrete deterioration.

- **Cracking:** Random cracks in the structure. The direct cause of the crack development is uncertain and may be attributed to movement, shrinkage or temperature. Examples might include diagonal, straight, or horizontal crack propagation. Refer to Figure 4.4.2-21 for a view of typical vertical cracking found in precast concrete panels.

Figure 4.4.2-21: Vertical Crack Through Precast Concrete Panel.

- **Scaling**: This is a special type of freeze-thaw damage. It is generally characterized by significant exterior damage and crumbling, more so than typical freeze-thaw damage.

- **Spalling/Exposed Reinforcing Steel:** Spalling is the presence of minor chipping along concrete edges and corners. Occasionally spalling will be the result of improper handling and placement during construction but most cases it is caused by the increase in section of reinforcing steel due to corrosion, causing concrete to delaminate from the reinforcing steel and spall. Other causes include thermal expansion, or the placement of concrete panels on uneven surfaces. The presence of a large number of spalls in the same place on each panel may indicate a problem in manufacturing. Consistent spalling over time can result in exposed reinforcing steel. Refer to Figure 4.4.2-22 for a view of spalled concrete with exposed reinforcing steel.

- **Abrasion:** Abrasion is the loss of surface material due to the action or water or wind-blown abrasives. This distress may be easily confused with surface scaling and freeze-thaw damage because the latter two are generally more severe in areas of water flow and saturation. Abrasion is typically evidenced by relatively uniform loss of surface mortar along the paths of water flow. Surface scaling and freeze-thaw damage is generally greater in depth.

Figure 4.4.2-22: Concrete Spalling with Exposed Reinforcing Steel.

Timber

The following is a discussion of different types of material defects that may be found when inspecting Timber Retention Structures. Refer to the SIM Part 2, Chapter 1 for further discussion on timber deterioration.

- **Decay:** This is the breaking down of a material as a result of bacteria or fungi attack. Signs include discolored wood with a soft rotted texture. Look also for fruiting bodies and depressed areas of the wood surface.

- **Insect Infestation:** Often, insects such as termites use timber as food and shelter. These and other insects can be detrimental to the integrity of a timber wall and can cause significant internal damage. Signs can include piles of sawdust, small holes in the surface, insects themselves, or hollows sounds when tapping timber with an inspection hammer.

- **Vermin Damage:** Damage by small animals and birds using the timber for shelter can also be significant.

- **Fire Damage:** This item is generally self-explanatory. If the structure appears black, a piece of it has disappeared, or a large amount of ashes are present at the site, it is likely the structure was damaged by fire.

Metal

The following is a discussion of different types of material defects that may be found when inspecting Metal Retention Structures. Refer to the SIM Part 2, Chapter 1 for further discussion on metal deterioration.

- **Corrosion:** This type of deterioration is the slow, steady material deterioration due to chemical reactions between the material and outside elements. Refer to Figure 4.4.2-23 for a view of steel corrosion.

- **Cracking:** Cracks can occur due to fatigue and or brittle fracture. Cracks are arrested by drilling mouse holes at the tips, or sometimes with bolted splices.

Figure 4.4.2-23: Severely Corroded Steel Sheeting Cantilever Wall.

Other Materials

Several other materials have recently been introduced for use in the construction of retaining walls. These include plastic lumber, vinyl, and geotextile fabrics and grids.

Plastic composites come in a variety of forms including plastic lumber, which is typically formed from recycled high-density polyethylene (HDPE) plastic, vinyl sheet piling, and integrated hybrid composites of plastic and steel. Refer to Figure 4.4.2-24 and Figure 4.4.2-25 for views of plastic, vinyl, and geotextile grid cell retention structures.

Plastics typically exhibit the following types of deterioration:

- Ultraviolet deterioration
- Material Incompatibility
- Corrosion Damage
- Overstress Damage

Plastics will typically exhibit discoloration when undergoing ultraviolet deterioration. The material may also begin to fray when under constant sunlight.

Connections for securing, supporting or bracing other material components should be inspected for corrosion or other similar material deficiencies. For instance the tie rod or nuts anchoring a waler to the outer face of a vinyl sheet piling wall should be inspected to ensure they are properly tightened with no signs of corrosion.

Figure 4.4.2-24: Plastic Lumber Retaining Wall.

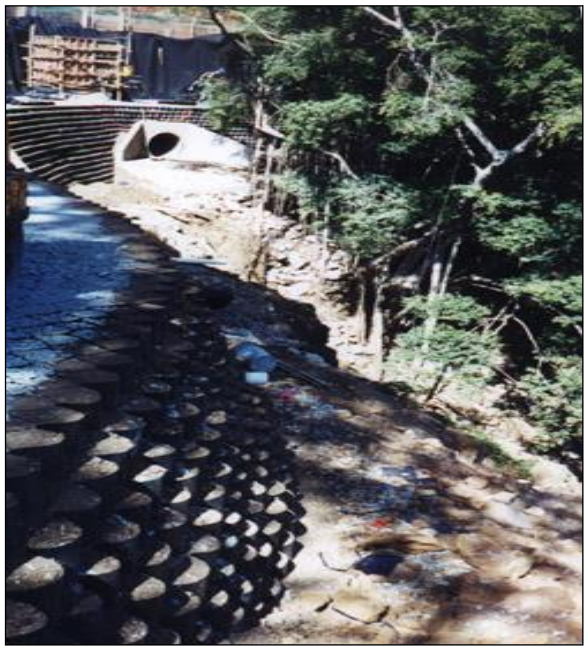


Figure 4.4.2-25: Geotextile Grid Cell Retaining Wall.

4.4.3 Retaining Wall Inspections

A wall inspection consists of observations and/or measurements to determine the condition of wall elements and to identify changes in the condition from previous inspections to ascertain potential maintenance needs and more importantly, assess the ability of the structure to safely serve its intended function.

Walls will be inspected using the applicable WisDOT Elements and Assessments discussed later in this Chapter.

An inspector will not typically be able to inspect tie-backs or other types of anchorages that are embedded behind a wall for stabilization. Only the visible features of the wall including the front face (facade), top, and sides of a wall will typically be inspected during a normal routine inspection. It is the inspector's duty to discern from distress through the observable components if other unseen issues are at play.

4.4.3.1 Inspection Types

Routine

All retaining walls will require a routine visual inspection to be conducted under the inspection interval guidelines set forth in Part 4 Chapter 1 of this manual. In addition, if portions of the wall are submerged where the routine inspector cannot adequately assess the condition of the structure, then an underwater dive inspection will also be required on the same interval as the routine.

In-Depth

In-Depth inspections can also be utilized on retaining wall structures if needed to assess one or more structural elements not readily detectible using routine inspection procedures. These are hands-on, close-up inspections. Each element under investigation should be within arm's reach of the inspector. Non-Destructive Evaluation equipment and/or other material tests may need to be performed.

The inspection may include a request for a structural evaluation to assess the residual capacity of the damaged or deteriorated members, depending on the extent of damage or deterioration.

For large MSE structures (more than 20' in exposed height) where movements are suspected, three dimensional (Lidar) surveys may be requested at 10 year intervals to ascertain movement by the WisDOT survey crew.

This type of inspection is usually on an as needed basis, and scheduling of such an inspection is at the discretion of the ancillary regional program manager.

Damage or Special

Unscheduled inspections are to be performed after a significant event, such as a vehicular impact, extreme weather that could compromise the structure, or indications of significant wall movements.

4.4.3.2 Recommended Routine Inspection Procedures

The following is a list of common inspection procedures when conducting a routine inspection on a retaining wall. For procedures when utilizing NDE/NDT technologies, consult Part 5 of this manual.

1. Arrive at site and set-up traffic control (if required).

2. Identify & Verify Structure Number (Note location within Structure Specific Notes)

3. Perform Inspection.

Due to the similar function of retaining wall types, the following list should be used when inspecting retaining walls to verify proper material function and wall stability.

- Check wall for signs of settlement, rotation, or bulging.

- Inspect the vertical alignment of the wall with a plumb-bob. (Note: Most walls are constructed with a battered or sloped face, therefore this must be taken into account and noted).

- Examine the opening of the construction joints between sections of the wall.

- Inspect joints near ground line for any fill material washing out from between panels or joint.

- Inspect panel joints for differential movement or rotation. Sight down panel face to note individual rotation or tipping out of plane.

- Inspect for erosion of the embankment material in front of the wall.

- Inspect for heaving of the embankment material in front of the wall.

- Inspect for settlement of the fill material behind the wall.

- Examine the wall for deterioration of the material, such as cracking, spalling, and/or corrosion, noting the width, length, depth, and/or orientation of the deterioration. Provide photographs for Condition State 3 (Poor) and 4 defects.

- Some wall types (post and panel, for example) may require the inspector to randomly select a few posts and dig down 3~6” below groundline to see if piling is deteriorating at the soil level.

- Lagging or cribbing should be checked for excessive deflections. Excessive deflections may allow the soild behind to spill or wash out, causing settlement in the retained material above.

- Examine previous areas of repair for soundness.

- Check wall façade for evidence of water seepage, efflorescence or rust staining.

- Examine anchorage systems if present. Fasteners and connections to the wall components should be checked for tightness and distress.

- Examine and probe drains for signs of clogging. Examine drainage around ends of wall and note if embankments have been experiencing erosion.

- Examine site grading for any locations that may prohibit proper drainage from behind the wall. Look for evidence of ponding above the wall, such as debris accumulation in the lower spots. Attempt to ascertain why water is not draining properly, and note in the inspection.

- Inspect sidewalk or roadway components above wall for signs or joint separation, potholes and areas of settlement.

- Examine vegetation growth along and above the wall. Root infiltration may create undesirable stresses on the wall and may induce cracking, bulging or failure.

- Examine the wall system for vehicular damage. Document the location and degree of damage.

4. Determine and record the overall rating of structure based on inspection findings.

5. Determine and record all applicable maintenance items and a level of priority.

6. Determine if an underwater dive inspection or an in-depth inspection needs to be scheduled to supplement the routine inspection and provide more information on the condition and performance of the wall. If determined to be needed, schedule in the HSI System.

7. Review of inspection notes to ensure completeness and correctness.

8. Document all CS3 and CS4 defects with a photo and/or a sketch.

9. Remove any traffic control.

4.4.3.3 Element/Assessment Inspections

For all structure types, WisDOT uses concepts adapted from the AASHTO Manual for Bridge Element Inspection to record condition of the components of a structure. Components are divided into Elements (Primary) and Assessments (Secondary). Both require that the inspector quantify specific conditions states, but Elements take it a step further and also require that the inspector define Defects specific to each Element for asset management purposes.

- Elements – Elements are the main structural components of the wall, including the wall face, vertical supports, foundations, anchors, etc. They are subject to distress, movement, and deterioration on a daily basis. They are considered the most important features rated during the inspection and thus, require thorough descriptions of any defects. All wall type elements are recorded in units of linear feet. Each linear foot includes the vertical projection of the exposed height of the wall element. This area is

inspected and evaluated for any distress with deficiencies captured and quantified under the appropriate wall defects.

- Assessments – Assessments include secondary components such as attachments, appurtenances, and surrounding features that can impact the performance of the wall. They include copings, drainage elements, joints, sidewalks, roadways, slopes and backfill. Quantities may either be in units of each, or Lineal feet depending on the specific assessment.

- Defects - WisDOT simplifies wall inspection into these defects:

    - 8903 Wall Deterioration
    - 8902 Wall Movement
    - 1640 Masonry or Panel Displacement
    - 8000 Scour

The defect 8903 Wall Deterioration essentially acts as an umbrella defect which refers the inspector to the unique defects of the material the wall is constructed. While there is only one material defect to code within the inspection report, it is required that the inspector note the specific material defect observed and measured under the defect note. A detailed description of this defect is included for each wall element in the subsequent sections.

For all walls, any lateral, vertical or rotational movement involving more than one pane or panel shall be coded under the defect 8902 Wall Movement. This defect captures the global movement of the wall as discussed in 4.4.2.1. The term global represents a length or portion of wall greater than a single pane or panel of a retaining wall structure. Similar to a cast-in-place or gravity wall, secant walls are essentially monolithic walls. That is, they are poured together with the intent to work integrally, even with precast or cast-in-place panels placed in front of the secant wall. Movement includes lateral movement (whether in or out along the plane of the wall), differential settlement or global settlement. The major function of all retaining walls is to effectively keep soil from movement in order to allow safe passage of the travelling public either on top or along the wall. Therefore, movement is an immediate concern and shall be measured noted and captured within the inspection reports. The inspector shall note the type, location and length of movement that is occurring under the defect notes (e.g. overturning, settlement, sliding, etc.). A detailed description of this defect is included for each wall element in the subsequent sections.

Localized (individual or small groups) panel or masonry block movement and rotation of MSE or Masonry block walls shall be captured under the defect 1640 Masonry or Panel Displacement. In the instance of several MSE panels or masonry blocks exhibiting movement, the inspector should utilize the material defect 8902 Wall Movement. Refer to section 4.4.2.1 for modes of geotechnical failure. A detailed description of this defect is included for each relevant wall element in the subsequent sections.

There may arise the necessity to quantify scour for a retaining structure abutting a body of water. The Scour (8000) is a structural defect. Structural defects shall be coded in their entirety on the inspection report regardless if overlapping with the other wall defects (i.e. structural

defects do not fall under the defect hierarchy). Structural defects represent global or external deterioration that adversely affects the wall. The scour defect should be used to capture the erosion of material along the base of a wall due to a stream or body of water. The defect shall be coded under the primary wall element (i.e. MSE Wall, Sheet Pile Wall, etc.).

4.4.4 Retaining Wall Elements

Retaining wall components are designed to restrain soil and can be made out of steel, concrete, timber, masonry/stone, and other materials. A variety of elements are available for the inspector to utilize during an inspection to best capture the type of wall being evaluated.

The quantity for wall elements is the length of the wall in lineal feet measured from end to end with each linear foot capturing the defects over the entire height of the wall element. Other elements that may be part of the wall, such as bridge railings and copings, are also evaluated as linear feet. All visible portions of the wall shall be considered during the inspection, including all assessments found on the wall.

4.4.4.1 CIP Concrete Wall (Element 8600)

Cast-in-place (CIP) concrete walls are made by placing ready-mix concrete into removable forms that are built around reinforcing steel at the final intended position of the wall. A CIP wall can incorporate tie-backs or prestressed soil anchors for stabilization depending on the height of the wall and characteristics of the soil that is being restrained. Footings with piles may also be used. The weight of the soil on the inner half of the footing slab (heel) provides additional vertical weight for stability. The wall is fully reinforced and relatively thin, allowing for an economical use of materials.

Figure 4.4.4-1: Cast-in-Place Concrete Cantilever Wall.

Figure 4.4.4-2: Cast-in-Place Concrete Cantilever Wall.

The exposed concrete stem may be plain, textured and/or colored. The height on these types of walls is typically less than 28 feet. Walls higher than 28 feet typically require counterforts or tie-backs for additional strength and deflection control. Refer to Figure 4.4.4-1 and **Error! Reference source not found.** for a typical cast-in-place concrete gravity cantilever wall.

Use the below definition(s) to record Defect 8903 Wall Deterioration for this element:

- ***Condition State 1 (Good)***: No spalls, delaminations, abrasions, or patched areas. Cracks, if they exist, have been sealed or are less than 0.012".

- ***Condition State 2 (Fair)***: Delaminations may be present. Spalls, if present, are 1" or less in depth or less than 6" in diameter. Patched areas that are sound. If rebar is exposed, there is no section loss. Cracks, if they exist, are between 0.012" - 0.05". Where efflorescence is present, it's minor and no evidence of rust staining. Abrasions, if they exist, have exposed course aggregate but the aggregate remains secure in the concrete.

- ***Condition State 3 (Poor)***: Spalls greater than 1" deep, or greater than 6" in diameter. Patched areas that are unsound. Exposed rebar, if present, has measurable section loss. Cracks, if present, are greater than 0.05" wide. Where efflorescence is present, there is heavy build-up and/or rust staining. If abrasions are present, the course aggregate is loose or has popped out of the concrete matrix. Conditions are not sufficient to warrant structural review.

- ***Condition State 4 (Severe)***: The condition warrants a structural review to determine the effect on strength or serviceability of the wall, or the wall has failed due to deterioration.

Use the below definition(s) to record Defect 8902 Wall Movement for this element:

- ***Condition State 1 (Good)***: Wall elements are as constructed, and/or show no signs of settlement, bulging, bending, heaving, or distortion/deflection beyond normal prescribed post-construction limits. Wall elements are fully bearing against retained soil/rock units.

- ***Condition State 2 (Fair)***: Wall movement has started to occur. Wall shows signs of settlement, bulging, bending, heaving, misalignment, distortion, deflection and/or displacement beyond normal prescribed post construction limits (i.e. wall face rotation, basket budging, anchor head displacement, bin displacement). Wall may be strapped or anchored to prevent further movement, or movement has been arrested through countermeasures. Wall elements are mostly bearing against retained soil/rock units.

- ***Condition State 3 (Poor)***: Wall rotation/sliding/settlement is active and extensive and well beyond normal post-construction limits; sloughing of retained material behind wall is evident. Wall may have been strapped, anchored or stabilized to prevent further movement, but this device has failed. Many or key wall elements are no longer bearing against retained soil/rock units.

- ***Condition State 4 (Severe)***: Wall has failed.

It is important to note that these condition states are for the linear foot unit of measure. Therefore condition states 3 and 4 shall have representative measurements and photographs within the report.

4.4.4.2 Gabion Wall (Element 8601)

Gabion gravity crib walls are constructed from rock-filled wire mesh baskets. The gabions typically have a heavy wire mesh with a nominal 3-inch opening and are formed into rectangular baskets, normally 1.5 to 3 feet in height. Individual baskets are placed on the prepared earthen surface, reinforced with internal tie wires, and filled with a select stone ranging from 4-inch to 10-inch diameter. After the baskets are filled, the wire lids are closed and wired shut to form a relatively rigid block. Succeeding rows of gabions are laced onto the filled underlying gabions and filled in the same manner. Manufacturers typically provide details for the wires, lacing, and lid closure. As wall heights increase, more baskets are wired together to increase the wall depth into the slope. Gabion walls are typically less than 18 feet tall. Geotextile fabric is placed behind the baskets to keep the backfill soils from entering the rock filled gabions. Gabion gravity crib walls are often used in fill sections of a roadway and/or adjacent to waterways. For water installations, the wall typically needs additional protection from scour by the use of riprap or other suitable material.

There are a variety of different types of gabion gravity crib walls on the market. They can be easily constructed without the use of skilled labor or specialized equipment, and they are often built rapidly. Unfortunately, it is difficult to make height adjustments to the wall once in place. Refer to Figure 4.4.4-3 and Figure 4.4.4-4 for views of gabion gravity crib walls.

Figure 4.4.4-3: Gabion Gravity Crib Wall Under Construction.

Use the below definition(s) to record Defect 8903 Wall Deterioration for this element:

- ***Condition State 1 (Good)***: No Defects Noted.
- ***Condition State 2 (Fair)***: Freckled rust with corrosion of the steel basket initiating. Loose fasteners without distortion are present but the connection is in place and functioning as intended. Stones are split, but no shifting.
- ***Condition State 3 (Poor)***: Section loss of the steel basket is evident. Broken or missing fasteners have caused localized distortions. Stones are splitting and spalled with some differential movement but does not warrant a structural review.
- ***Condition State 4 (Severe)***: The condition warrants a structural review to determine the effect on strength or serviceability of the wall, or the wall has failed due to deterioration.

Use the below definition(s) to record Defect 8902 Wall Movement for this element:

- ***Condition State 1 (Good)***: Wall elements are as constructed, and/or show no signs of settlement, bulging, bending, heaving, or distortion/deflection beyond normal prescribed post-construction limits. Wall elements are fully bearing against retained soil/rock units.
- ***Condition State 2 (Fair)***: Wall movement has started to occur. Wall shows signs of settlement, bulging, bending, heaving, misalignment, distortion, deflection and/or displacement beyond normal prescribed post construction limits (i.e. wall face rotation, basket budging, etc). Wall elements are mostly bearing against retained soil/rock units.
- ***Condition State 3 (Poor)***: Wall rotation/sliding/settlement is active and extensive and well beyond normal post-construction limits; sloughing of retained material behind wall is evident. Wall may have been stabilized to prevent further movement, but this device

has failed. Many or key wall elements are no longer bearing against retained soil/rock units.

- ***Condition State 4 (Severe)***: Wall has failed.

It is important to note that these condition states are for the linear foot unit of measure. Therefore condition states 3 and 4 shall have representative measurements and photographs within the report.

Figure 4.4.4-4: Tiered Gabion Gravity Crib Wall.

4.4.4.3 Gravity (Block & Rubble) Wall (Element 8602)

A gravity wall is a large monolithic structure, which depends entirely on its self-weight and the weight of the soil that rests upon it for stability. The large mass needed to develop adequate weight requires a substantial footprint; therefore available space may limit its use. The walls are typically constructed of concrete with very little, if any, steel reinforcement, masonry or stone block. Concrete gravity walls are typically less than 10 feet tall, and segmented modular block gravity walls are limited by design to an exposed height of 4'-0" without the use of geosynthetic reinforcement behind the wall. Masonry or stone block gravity walls will have varying heights and are entirely dependent on the available footprint. The blocks of these gravity walls are freestanding with joints that may or may not be mortared. Therefore taller walls of this type will require a significant footprint at the base to retain the soil. Refer to Figure 4.4.4-5 for a view of a segmented modular block gravity wall.

Use the below definition(s) to record Defect 8903 Wall Deterioration for this element:

- ***Condition State 1 (Good)***: No Defects Noted.

- ***Condition State 2 (Fair)***: If using mortar, cracking or voids in less than 10% of the joints. Block or stone has split or spalled with no shifting. Patched areas are sound.

- ***Condition State 3 (Poor)***: If using mortar, cracking or voids in 10% or more of the joints. Block or stone has split or spalled with shifting. Patched areas are not sound. Does not require a structural review.

- ***Condition State 4 (Severe)***: The condition warrants a structural review to determine the effect on strength or serviceability of the wall, or the wall has failed due to deterioration.

Figure 4.4.4-5: Segmented Modular Block Gravity Wall.

Figure 4.4.4-6: Lannon Stone (Limestone) Block Gravity Wall.

Use the below definition(s) to record Defect 8902 Wall Movement for this element:

- ***Condition State 1 (Good)***: Wall elements are as constructed, and/or show no signs of settlement, bulging, bending, heaving, or distortion/deflection beyond normal prescribed post-construction limits. Wall elements are fully bearing against retained soil/rock units.

- ***Condition State 2 (Fair)***: Wall movement has started to occur. Wall shows signs of settlement, bulging, bending, heaving, misalignment, distortion, deflection and/or displacement beyond normal prescribed post construction limits (i.e. wall face rotation, basket budging, anchor head displacement, bin displacement). Wall may be strapped or anchored to prevent further movement, or movement has been arrested through countermeasures. Wall elements are mostly bearing against retained soil/rock units.

- ***Condition State 3 (Poor)***: Wall rotation/sliding/settlement is active and extensive and well beyond normal post-construction limits; sloughing of retained material behind wall is evident. Wall may have been strapped, anchored or stabilized to prevent further movement, but this device has failed. Many or key wall elements are no longer bearing against retained soil/rock units.

- ***Condition State 4 (Severe)***: Wall has failed.

Use the below definition(s) to record Defect 1640 Masonry or Panel Displacement:

- ***Condition State 1 (Good)***: None. No movement is observed or measured.

- ***Condition State 2 (Fair)***: Block, stone or panel has shifted slightly out of alignment.

- ***Condition State 3 (Poor)***: Block, stone or panel has shifted significantly out of alignment or is missing but does not warrant a structural review.

- ***Condition State 4 (Severe)***: The condition warrants a structural review to determine the effect on strength or serviceability of the element, or a review has been completed and it has been found that the defects impact strength or serviceability.

It is important to note that these condition states are for the linear foot unit of measure. Therefore condition states 3 and 4 shall have representative measurements and photographs within the report.

4.4.4.4 MSE Wall (Element 8603)

An MSE wall is based on the principle of integrating reinforcing into a granular backfill via means such as metal strips or rods, geosynthetic sheets, or wire grids. This reinforces the soil against shear failure, and allows the soil to act as a single large mass. The friction stresses developed between the granular backfill and the reinforcement resists bond pullout. The reinforcing is tied to precast concrete facing units, which form the vertical face of the wall. The facing units are relatively small and piece together in a geometric pattern. The reinforcing is attached at regular intervals throughout the width and height of the wall.

MSE Walls can be constructed with different materials including precast concrete panel facings (classic vertical faced MSE walls), Modular Block facings (battered segmental retaining walls), and Wire faced walls.

The Segmented Modular Block Retaining Wall is the most common of MSE structure in Wisconsin. Although these walls can act as Gravity walls, they are usually constructed as MSE walls. When constructed as gravity or crib walls, these retention structures are limited to an exposed height of 4'-0" and are embedded 1'-6". Consequently, most of these walls fall under the MSE category. The height to which they can be constructed is a function of the block width, site geometry, setback angle of the wall, angle of the back slope behind the wall, and the design parameters of the retained and foundation soils. Refer to Figure 4.4.4-7 for a view of a Segmented Modular Block Wall. These walls are proprietary and the wall supplier provides their design. Since placement of reinforcing is required, these walls are best used in fill sections. They require good foundation material where little differential settlement is expected.

Use the below definition(s) to record Defect 8903 Wall Deterioration for segmented modular block MSE walls:

- ***Condition State 1 (Good)***: No Defects Noted.
- ***Condition State 2 (Fair)***: If using mortar, cracking or voids in less than 10% of the joints. Block or stone has split or spalled with no shifting. Patched areas are sound.
- ***Condition State 3 (Poor)***: If using mortar, cracking or voids in 10% or more of the joints. Block or stone has split or spalled with shifting. Patched areas are not sound. Does not require a structural review.
- ***Condition State 4 (Severe)***: The condition warrants a structural review to determine the effect on strength or serviceability of the wall, or the wall has failed due to deterioration.

Figure 4.4.4-7: Segmented Modular Block MSE Wall.

For the Precast Concrete Panel Facing MSE wall, metallic strips, or wire grids are used to reinforce the soil mass and act as a gravity retaining structure. This type of MSE Wall is best used in fill sections. Refer to Figure 4.4.4-8 for a View of a Precast Concrete Panel MSE Wall. These walls cannot be built over existing utilities, and new utilities cannot be located within the reinforced soil. All reinforcement must lie within the permanent right of way. Foundation materials must have adequate bearing capacity to support the loads. Differential settlement limitations vary based on height and construction. Refer to the WisDOT Bridge Manual Chapter 14 for the maximum differential settlements.

Precast concrete panel faced MSE walls are very competitive economically with other walls when heights exceed 20 feet. They can be used as bridge wingwalls and in conjunction with sill abutments. However, they require a specific type of backfill with non-corrosive properties since there is corrosion potential for metallic strips. The MSE precast panels are founded on an unreinforced concrete leveling pad to provide a level base. However, as the pad is unreinforced, any exposure or undermining of the pad can have major implications to the stability of the fill behind the panels.

Another type of MSE Wall is the MSE Wall with Modular Block Facing. The same general principles apply as the previous type of MSE Wall with some slight variations. These walls typically are not used in the following situations: as a component of an abutment structure; or where traffic barriers/roadway pavements must be vertically supported by the wall. Differential settlement limitations vary based on height and construction. These walls typically have a maximum height of 18 feet.

Use the below definition(s) to record Defect 8903 Wall Deterioration for precast concrete panel facing MSE walls:

- ***Condition State 1 (Good)***: No spalls, delaminations, abrasions, or patched areas. Cracks, if they exist, have been sealed or are less than 0.012”.

- ***Condition State 2 (Fair)***: Delaminations may be present. Spalls, if present, are 1” or less in depth or less than 6” in diameter. Patched areas that are sound. If rebar is

exposed, there is no section loss. Cracks, if they exist, are between 0.012" - 0.05". Where efflorescence is present, it's minor and no evidence of rust staining. Abrasions, if they exist, have exposed course aggregate but the aggregate remains secure in the concrete.

- ***Condition State 3 (Poor)***: Spalls greater than 1" deep, or greater than 6" in diameter. Patched areas that are unsound. Exposed rebar, if present, has measurable section loss. Cracks, if present, are greater than 0.05" wide. Where efflorescence is present, there is heavy build-up and/or rust staining. If abrasions are present, the course aggregate is loose or has popped out of the concrete matrix. Conditions are not sufficient to warrant structural review.

- ***Condition State 4 (Severe)***: The condition warrants a structural review to determine the effect on strength or serviceability of the wall, or the wall has failed due to deterioration.

Figure 4.4.4-8: MSE Precast Concrete Panel Facing Wall.

Use the below definition(s) to record Defect 8902 Wall Movement for this element:

- ***Condition State 1 (Good)***: Wall elements are as constructed, and/or show no signs of settlement, bulging, bending, heaving, or distortion/deflection beyond normal prescribed post-construction limits. Wall elements are fully bearing against retained soil/rock units.

- ***Condition State 2 (Fair)***: Wall movement has started to occur. Wall shows signs of settlement, bulging, bending, heaving, misalignment, distortion, deflection and/or displacement beyond normal prescribed post construction limits (i.e. wall face rotation, basket budging, anchor head displacement, bin displacement). Wall may be strapped

or anchored to prevent further movement, or movement has been arrested through countermeasures. Wall elements are mostly bearing against retained soil/rock units.

- ***Condition State 3 (Poor)***: Wall rotation/sliding/settlement is active and extensive and well beyond normal post-construction limits; sloughing of retained material behind wall is evident. Wall may have been strapped, anchored or stabilized to prevent further movement, but this device has failed. Many or key wall elements are no longer bearing against retained soil/rock units.

- ***Condition State 4 (Severe)***: Wall has failed.

Use the below definition(s) to record Defect 1640 Masonry or Panel Displacement:

- ***Condition State 1 (Good)***: None. No movement is observed or measured.

- ***Condition State 2 (Fair)***: Block, stone or panel has shifted slightly out of alignment.

- ***Condition State 3 (Poor)***: Block, stone or panel has shifted significantly out of alignment or is missing but does not warrant a structural review.

- ***Condition State 4 (Severe)***: The condition warrants a structural review to determine the effect on strength or serviceability of the element, or a review has been completed and it has been found that the defects impact strength or serviceability.

It is important to note that these condition states are for the linear foot unit of measure. Therefore condition states 3 and 4 shall have representative measurements and photographs within the report.

4.4.4.5 Post & Panel Wall (Element 8604)

Post and Panel Walls are comprised of vertical elements (typically H piles) and panels (concrete or timber) which extend between the vertical elements. The panels resist lateral soil pressures by spanning horizontally between the posts. The panels are usually constructed of precast reinforced concrete although precast/prestressed concrete and timber are also possibilities. Refer to Figure 4.4.4-9 and Figure 4.4.4-10 for typical views of post and panel walls using concrete panels and timber panels respectively. The use of Post and Panel walls should be considered if minimal environmental damage or disturbance to the site from construction procedures is critical. These walls also function well in a cut section, where right of way is limited.

Use the below definition(s) to record Defect 8903 Wall Deterioration steel posts with concrete panels:

- ***Condition State 1 (Good)***: No spalls, delaminations, abrasions, or patched areas. Cracks, if they exist, have been sealed or are less than 0.012”.

- ***Condition State 2 (Fair)***: Delaminations may be present. Spalls, if present, are 1” or less in depth or less than 6” in diameter. Patched areas that are sound. If rebar is exposed, there is no section loss. Cracks, if they exist, are between 0.012” - 0.05”. Where efflorescence is present, it’s minor and no evidence of rust staining. Abrasions,

if they exist, have exposed course aggregate but the aggregate remains secure in the concrete. Freckle rust on the posts. Corrosion of the steel has initiated. Cracking of the steel has self-arrested, or has been arrested with effective holes, doubling plates, or similar. Fasteners may be loose, but are performing the intended function.

- ***Condition State 3 (Poor)***: Spalls greater than 1” deep, or greater than 6” in diameter. Patched areas that are unsound. Exposed rebar, if present, has measurable section loss. Cracks, if present, are greater than 0.05” wide. Where efflorescence is present, there is heavy build-up and/or rust staining. If abrasions are present, the course aggregate is loose or has popped out of the concrete matrix. Section loss of the posts is evident. Cracks exist in the steel that have not been arrested. Missing bolts, broken welds, or other fastener damage with some distortion. Conditions are not sufficient to warrant structural review.

- ***Condition State 4 (Severe)***: The condition warrants a structural review to determine the effect on strength or serviceability of the wall, or the wall has failed due to deterioration.

Figure 4.4.4-9: Post and Panel Cantilever Wall with Precast Panels and Steel "H" Piles.

Figure 4.4.4-10: Post and Panel Cantilever Wall with Timber Planks and Steel "H" Piles.

Use the below definition(s) to record Defect 8903 Wall Deterioration steel posts with timber planks:

- ***Condition State 1 (Good)***: No spalls, delaminations, abrasions, or patched areas. Cracks, if they exist, have been sealed or are less than 0.012".

- ***Condition State 2 (Fair)***: Decay or section loss of the timber affects <10% of the member section. Checks/Cracks penetrate <5% of the timber member thickness. Timber members do not have splits/shakes/delaminations. Section loss of the timber due to abrasion is < 10% of the member thickness. Freckle rust on the steel posts. Corrosion of the steel has initiated. Cracking of the steel has self-arrested, or has been arrested with effective holes, doubling plates, or similar. Fasteners may be loose, but are performing the intended function.

- ***Condition State 3 (Poor)***: Decay or section loss of the timber affects 10% or more of the member. Checks/cracks penetrate 5%~50% of the member thickness. Timber member has splits/shakes with length less than member depth. Larger cracks/splits/shakes have been arrested with effective repairs. Section loss of the timber member due to abrasion is 10% or more of the member thickness. Section loss of the steel posts is evident. Cracks exist in the steel that have not been arrested. Missing bolts, broken welds, or other fastener damage with some distortion. Conditions are not sufficient to warrant structural review.

- ***Condition State 4 (Severe)***: The condition warrants a structural review to determine the effect on strength or serviceability of the wall, or the wall has failed due to deterioration.

Use the below definition(s) to record Defect 8902 Wall Movement for this element:

- ***Condition State 1 (Good)***: Wall elements are as constructed, and/or show no signs of settlement, bulging, bending, heaving, or distortion/deflection beyond normal prescribed post-construction limits. Wall elements are fully bearing against retained soil/rock units.

- ***Condition State 2 (Fair)***: Wall movement has started to occur. Wall shows signs of settlement, bulging, bending, heaving, misalignment, distortion, deflection and/or displacement beyond normal prescribed post construction limits (i.e. wall face rotation, basket budging, anchor head displacement, bin displacement). Wall may be strapped or anchored to prevent further movement, or movement has been arrested through countermeasures. Wall elements are mostly bearing against retained soil/rock units.

- ***Condition State 3 (Poor)***: Wall rotation/sliding/settlement is active and extensive and well beyond normal post-construction limits; sloughing of retained material behind wall is evident. Wall may have been strapped, anchored or stabilized to prevent further movement, but this device has failed. Many or key wall elements are no longer bearing against retained soil/rock units.

- ***Condition State 4 (Severe)***: Wall has failed.

4.4.4.6 Sheet Pile Wall (Element 8605)

A common type retention structure found in Wisconsin is the Steel Sheet Pile Wall. These walls can either be temporary or permanent walls and they may or may not be anchored (often depends on exposed height of wall). Temporary walls can be used in construction to retain fill materials while construction adjacent to the wall is performed. Permanent sheet pile walls will typically be found along rivers and shorelines to protect the shoreline from erosion. Another permanent use for sheet pile walls is around boat docks to allow for proper water depths for boat to draft. The corrosion potential for these walls is high, and site conditions should be taken into account. These walls should not be used in areas where there is shallow bedrock. A steel sheet pile wall can be a maximum of approximately 15 feet high without tiebacks being required. Only the connections at the face of the wall for tiebacks are accessible for inspection. Therefore the inspector should carefully note any distress in fasteners. Refer to Figure 4.4.4-11 and Figure 4.4.4-12 for a view of an anchored sheet pile dockwall and a failed tie-rod, respectively.

Protective coatings, such as paint or impervious water membranes, are provided on steel members, shall be captured under the assessment 9010 Aesthetic Treatments. If, under the inspector's discretion, the coating has become compromised and should be replaced to prevent corrosion, the inspector may create an appropriate maintenance item.

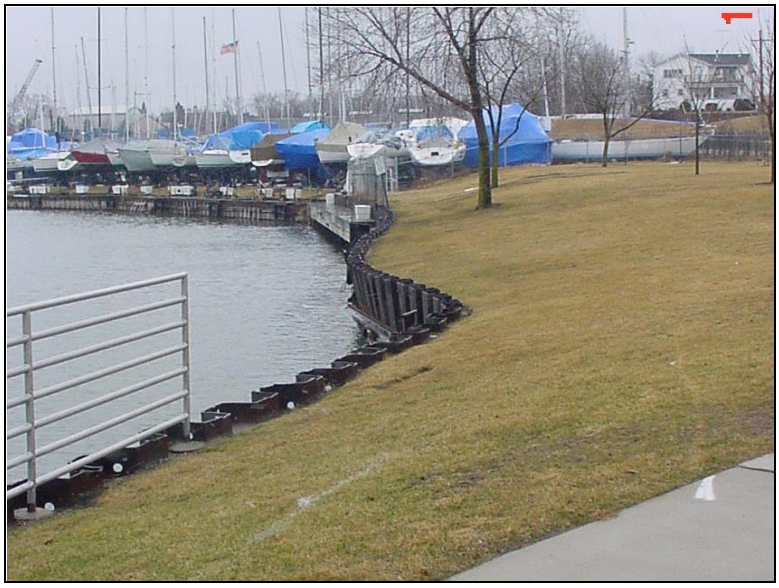


Figure 4.4.4-11: Tilted and Deformed Sheet pile Dockwall.

Use the below definition(s) to record Defect 8903 Wall Deterioration for Steel Sheet Pile Walls:

- ***Condition State 1 (Good)***: No Defects
- ***Condition State 2 (Fair)***: Freckle rust on the steel. Corrosion of the steel has initiated. Cracking of the steel has self-arrested, or has been arrested with effective holes, doubling plates, or similar. Fasteners may be loose, but are performing the intended function.
- ***Condition State 3 (Poor)***: Section loss of the steel posts is evident. Cracks exist in the steel that have not been arrested. Missing bolts, broken welds, or other fastener damage with some distortion. Conditions are not sufficient to warrant structural review.
- ***Condition State 4 (Severe)***: The condition warrants a structural review to determine the effect on strength or serviceability of the wall, or the wall has failed due to deterioration.

Figure 4.4.4-12: Failed Tie-rod Along a Sheet Pile Dockwall.

Use the below definition(s) to record Defect 8902 Wall Movement for this element:

- ***Condition State 1 (Good)***: Wall elements are as constructed, and/or show no signs of settlement, bulging, bending, heaving, or distortion/deflection beyond normal prescribed post-construction limits. Wall elements are fully bearing against retained soil/rock units.

- ***Condition State 2 (Fair)***: Wall movement has started to occur. Wall shows signs of settlement, bulging, bending, heaving, misalignment, distortion, deflection and/or displacement beyond normal prescribed post construction limits (i.e. wall face rotation, basket budging, anchor head displacement, bin displacement). Wall may be strapped or anchored to prevent further movement, or movement has been arrested through countermeasures. Wall elements are mostly bearing against retained soil/rock units.

- ***Condition State 3 (Poor)***: Wall rotation/sliding/settlement is active and extensive and well beyond normal post-construction limits; sloughing of retained material behind wall is evident. Wall may have been strapped, anchored or stabilized to prevent further movement, but this device has failed. Many or key wall elements are no longer bearing against retained soil/rock units.

- ***Condition State 4 (Severe)***: Wall has failed.

4.4.4.7 Reinforced Soil Slope (Element 8606)

Reinforced soil slope are used when designers are required to maximize the amount of land used on a project. Due to certain slope material conditions, the unreinforced slope is too shallow, thus using too much land to obtain a stable slope. Reinforced soil slops add tensile inclusions with soil to create a composite material. The tensile inclusions are typically

geosythetic reinforcement. Vegetation can be used as the facing of the composite material for slopes less than 45 degrees but more significant armoring may be needed for steeper slopes such as high strength concrete, emulsified asphalt, riprap, stone veneer or articulating modular units. These are not common in Wisconsin and thus no discussion of the defect condition states are available at this time.

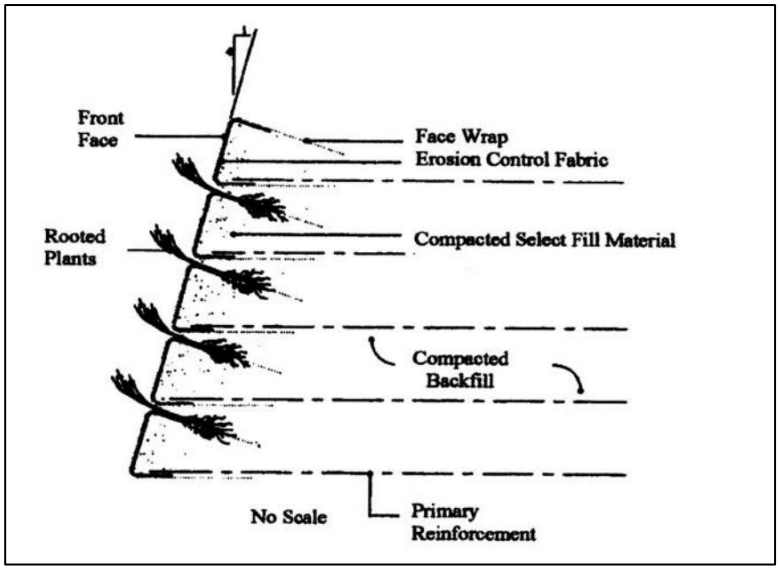


Figure 4.4.4-13: Schematic of a Reinforced Soil Slope with Vegetation Facing.

4.4.4.8 Secant or Tangent Shaft Wall (Element 8607)

Secant and Tangent walls are a series of interlocking concrete drilled shafts. These walls are constructed by drilling a series of reinforced shafts filled with concrete spaced at intervals less than the diameter of the shaft. After the concrete has hardened but before it has completely cured, a reinforced shaft is drilled through both adjacent drilled shafts, thus locking them together. In some instances steel H-piles are placed in the drilled shaft for additional reinforcement. The shafts act together to retain the soil. Once the wall is fully cured, one side of the wall is excavated. Typically precast concrete panels are placed in front of the secant pile wall as an aesthetic façade.

In Wisconsin, Secant Pile Walls used in tunnel construction may be covered with a reinforced shotcrete façade, precast concrete panel façade or other aesthetic feature. Regardless, visual inspection of the secant piles is typically not possible and must be evaluated by distress on the façade paneling. The inspector should look for signs of water seepage, panel distortion, cracking and alignment to gauge how the wall is performing. Refer to Figure 4.4.4-14 for a photo of a Secant Wall being installed and Figure 4.4.4-15 for a photo of the finished wall. Refer to Figure 4.4.4-16 for a photo of distress in a Secant Wall.

Use the below definition(s) to record Defect 8903 Wall Deterioration for this element:

- ***Condition State 1 (Good)***: No spalls, delaminations, abrasions, or patched areas. Cracks, if they exist, have been sealed or are less than 0.012”.

- ***Condition State 2 (Fair)***: Delaminations may be present. Spalls, if present, are 1” or less in depth or less than 6” in diameter. Patched areas that are sound. If rebar is exposed, there is no section loss. Cracks, if they exist, are between 0.012” - 0.05”. Where efflorescence is present, it’s minor and no evidence of rust staining. Abrasions, if they exist, have exposed course aggregate but the aggregate remains secure in the concrete.

- ***Condition State 3 (Poor)***: Spalls greater than 1” deep, or greater than 6” in diameter. Patched areas that are unsound. Exposed rebar, if present, has measurable section loss. Cracks, if present, are greater than 0.05” wide. Where efflorescence is present, there is heavy build-up and/or rust staining. If abrasions are present, the course aggregate is loose or has popped out of the concrete matrix. Conditions are not sufficient to warrant structural review.

- ***Condition State 4 (Severe)***: The condition warrants a structural review to determine the effect on strength or serviceability of the wall, or the wall has failed due to deterioration.

Figure 4.4.4-14: Secant Wall Construction.

Figure 4.4.4-15: Secant Wall Constructed as Tunnel Wall.

Figure 4.4.4-16: Excessive Cracking within Secant Wall Facade Concrete Panel.

Use the below definition(s) to record Defect 8902 Wall Movement for this element:

- ***Condition State 1 (Good)***: Wall elements are as constructed, and/or show no signs of settlement, bulging, bending, heaving, or distortion/deflection beyond normal prescribed post-construction limits. Wall elements are fully bearing against retained soil/rock units.

- ***Condition State 2 (Fair)***: Wall movement has started to occur. Wall shows signs of settlement, bulging, bending, heaving, misalignment, distortion, deflection and/or

displacement beyond normal prescribed post construction limits (i.e. wall face rotation, basket budging, anchor head displacement, bin displacement). Wall may be strapped or anchored to prevent further movement, or movement has been arrested through countermeasures. Wall elements are mostly bearing against retained soil/rock units.

- ***Condition State 3 (Poor)***: Wall rotation/sliding/settlement is active and extensive and well beyond normal post-construction limits; sloughing of retained material behind wall is evident. Wall may have been strapped, anchored or stabilized to prevent further movement, but this device has failed. Many or key wall elements are no longer bearing against retained soil/rock units.

- ***Condition State 4 (Severe)***: Wall has failed.

4.4.4.9 Other Wall (Element 8608)

This element is intended to be used for any type of earth retention wall that does not fit into any of the previously mentioned elements. Some of the wall types that may be encountered under this element would be Concrete Crib Wall and Timber Crib Wall. Welded wire walls should be evaluated under the MSE Wall element as these are typically vertical walls with attached panel façade. As these are not typical, defects will not be discussed in this section.

Figure 4.4.4-17: Vinyl Sheet Piling Retaining Wall.

4.4.5 Retaining Wall Assessments

Assessments allow for the evaluation of secondary components not necessarily impacting the structural integrity of the structure. The inspector must be familiar with all the available assessments within the HSI system and appropriately capture them within the inspection report for each retaining wall structure. Evaluating assessments provides a more accurate picture of the structure being inspected and alerting the Department of potential future issues including traffic hazards or functionality of the wall. The following section describes all the available assessments that may be reported within HSI.

4.4.5.1 Drainage Approach (9001)

This assessment captures the condition of the soil and slopes at the ends of the retaining structure. The inspector shall note any erosion or loss of fill due to drainage at the ends of the walls. The inspector shall note any remediation recommendations under the maintenance items on the inspection report as well as noting the assessment state of the Drainage Approach. This assessment is quantified as 1 EA for each end of the wall. For unit walls, the inspector shall note this fact, and evaluate the condition of the sidewalk/soils at the walls' interface.

Figure 4.4.5-1: Concrete Flume at End of Wall. Condition State 2 (Fair) – No Erosion Evident, with wide crack.

Refer to the following condition states:

- ***Condition State 1 (Good)***: No slope erosion is evident off the ends of the wall or in the associated ditches.
- ***Condition State 2 (Fair)***: Minor erosion of slopes around the wall. Drainage systems at the end of the wall are plugged or have minor deterioration.

- ***Condition State 3 (Poor)***: Moderate erosion of slopes around the bridge. Drainage systems at the end of the wall are plugged or have moderate deterioration.

- ***Condition State 4 (Severe)***: Major erosion of wall end slopes. Drainage systems at the end of the wall are plugged and have major deterioration.

Deficiencies shall be reported under the assessment notes and state the type, size and location of the defects. This assessment is quantified as 1 EA for each end of the structure.

4.4.5.2 Aesthetic Treatments (9010)

Similar to the bridge inspection assessment, this item is used to evaluate the condition of all the aesthetic treatments located on the retention structure. In certain settings, a structure may contain several aesthetic components, from concrete staining, stamped concrete façade, obelisks, etc. It is necessary for an inspector to review the plan set to determine the type of structure being inspected to determine whether the façade is an aesthetic feature or integral structural component. For instance, secant walls are comprised of main load retaining secant piles typically installed behind precast concrete paneling. During an inspection only the precast paneling can be inspected. The inspector shall use visible distress in the precast panels to determine the condition of the secant piling behind. A similar inspection would be performed with an MSE wall. In this case, any distress noted in the paneling would be noted in the secant pile defects. Any stained concrete or form-lined features would be accounted for under the Aesthetic Treatments assessment.

Figure 4.4.5-2: Failed Concrete Stain.

Figure 4.4.5-3: Aesthetic Treatment Form-Lined Precast Concrete Panels.

Refer to the following condition states:

- ***Condition State 1 (Good)***: System is in good condition, with no notable issues.
- ***Condition State 2 (Fair)***: Aesthetic system is in fair condition, with some fading or discoloration. Minor issues.
- ***Condition State 3 (Poor)***: Aesthetic system is in poor condition, with significant fading or discoloration.
- ***Condition State 4 (Severe)***: Aesthetic system is in severe condition and is not functioning as intended.

Aesthetic deficiencies shall be reported under the assessment notes and state the size and location of the defect. This assessment is quantified as 1 EA for the entire structure. It is the inspector's discretion, based on the assessment's condition over the structure as a whole, to codify the appropriate assessment state.

4.4.5.3 Utilities (9011)

Any utilities noted on the retaining earth structure, not including sign structures. This may include the quantification and evaluation of light poles, luminaires, electrical conduits, or other mechanical/electrical devices that may be attached to or in the earth retaining structure. Drainage pipes, inlets and outlets shall be assessed under 9340 Drainage System.

Refer to the following condition states:

- ***Condition State 1 (Good)***: Utility is in excellent condition, no problems noted.

- ***Condition State 2 (Fair)***: Utility is in fair condition. Some minor problems are noted, but they do not affect the serviceability of the utility.

- ***Condition State 3 (Poor)***: Utility is in poor condition, with moderate problems.

- ***Condition State 4 (Severe)***: Utility is in severe condition. Failures have occurred.

Material deficiencies shall be reported under the assessment notes and state the type, size and location of the defect. This assessment is quantified as 1 EA for an individual component/system. Conduit packages may be quantified as 1 EA or as each individual conduit within the package. It is at the inspector's discretion as to quantify the package or individual conduits. Regardless, the inspector shall note the utilities present on the retaining structure within the assessment notes.

4.4.5.4 Signs Other (9035)

All signs located on the retaining earth structure shall be accounted for, quantified and evaluated under this assessment. This assessment does not includes the Name ID Plaque typically located at the end of a wall. Refer to section 4.4.5.5 Structure ID Plaque (9208) for Name ID plaque assessment. Furthermore, this assessment does not include the quantification or evaluation of any signs located on a sign structure that may be founded on the retaining earth structure.

Refer to the following condition states:

- ***Condition State 1 (Good)***: Sign is present and is in good condition (there may be superficial damage or deterioration).

- ***Condition State 2 (Fair)***: Sign is present – sign may have some damage or deterioration (slightly bent or fading), but remains readable.

- ***Condition State 3 (Poor)***: Sign is present, but is deteriorated to the point that replacement or repair should be considered in next inspection cycle.

- ***Condition State 4 (Severe)***: Sign is absent, or incorrect, or existing sign is damage or deteriorated to the extent that repair or replacement is required as soon as possible.

Material deficiencies shall be reported under the assessment notes and state the type, size and location of the defect. This assessment is quantified as 1 EA for each sign, not including sign structure signs, observed on the structure.

4.4.5.5 Structure ID Plaque (9208)

All new retaining walls should have a name plaque located on the visible face of the wall at an approach end. This assessment shall be utilized to note the location and condition of the plaque.

Refer to the following condition states:

- ***Condition State 1 (Good)***: Sign is present and is in good condition (there may be superficial damage or deterioration).

- ***Condition State 2 (Fair)***: Sign is present – sign may have some damage or deterioration (slightly bent or fading), but remains readable.

- ***Condition State 3 (Poor)***: Sign is present, but is deteriorated to the point that replacement or repair should be considered in next inspection cycle.

- ***Condition State 4 (Severe)***: Sign is absent, or incorrect, or existing sign is damage or deteriorated to the extent that repair or replacement is required as soon as possible.

Material deficiencies shall be reported under the assessment notes and state the type, size and location of the defect. This assessment is quantified as 1 EA.

Figure 4.4.5-4: Retaining Wall Name ID Plaque.

4.4.5.6 Decorative Rail (9335)

All extensions fastened to a bridge railing element or horizontal coping on a retaining earth structure and not considered comprised of chain-link fencing shall be quantified and evaluated under the Decorative Rail assessment.

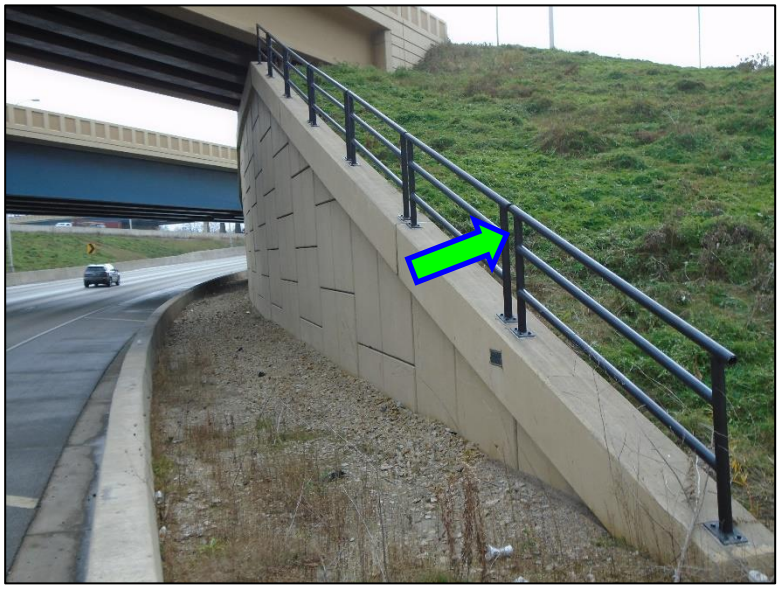


Figure 4.4.5-5: Decorative Rail atop a Horizontal Coping.

Figure 4.4.5-6: Decorative Rail atop a Bridge Rail Element.

Refer to the following condition states:

- ***Condition State 1 (Good)***: Rail has little or no deterioration. Galvanizing or protective coating is sound.
- ***Condition State 2 (Fair)***: Rail has minor deterioration. Coating may have minor failure – surface rust may be present.

- ***Condition State 3 (Poor)***: Rail has moderate deterioration. Coating may have moderate failure – surface rust may be prevalent. Components may be slightly bent or misaligned – connections may be slightly loose.

- ***Condition State 4 (Severe)***: Rail has extensive deterioration. Coating may have extensive failure – there may be section loss. Components may be bent or misaligned connections may be loose.

Material deficiencies shall be reported under the assessment notes and state the type, size and location of the defect. This assessment is quantified as 1 EA for the entire length of the structure. It is the inspector's discretion, based on the assessment's material condition over the whole length, to codify the appropriate assessment state.

4.4.5.7 Luminaire Bases (9336)

Luminaire bases are the bump-outs located along a retaining earth structure that support vertical light posts. These will typically poured monolithic with the bridge railing element atop the horizontal copings. Note that these bases do not include sign structure foundation bump outs. Sign structure bump outs are inspected under a separate inspection for the sign structure itself.

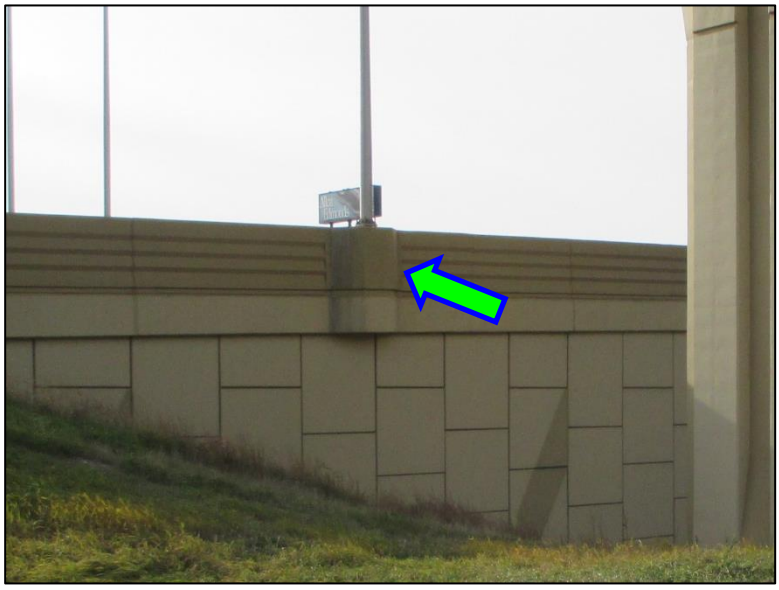


Figure 4.4.5-7: Luminaire Base Placed in Coping and Barrier Wall.

Refer to the following condition states:

- ***Condition State 1 (Good)***: Good condition, with no problems noted.

- ***Condition State 2 (Fair)***: Fair condition, with superficial spalls and/or cracking.

- ***Condition State 3 (Poor)***: Moderate deterioration, with cracking and spalls.

- ***Condition State 4 (Severe)***: Base has failed. Major deterioration noted.

Material deficiencies shall be reported under the assessment notes and state the type, size and location of the defect. This assessment is quantified as 1 EA for each base located along the structure. It is the inspector's discretion, based on the assessment's material condition of each base, to codify the appropriate assessment state.

4.4.5.8 Protective Screening (9337)

In contrast to the Decorative Rail assessment, the Protective Screening assessment shall be utilized for any extension above a bridge railing element or coping that is comprised of chain-link fencing. This is regardless if the screening is the active barrier between the leading edge of a sidewalk or simply on top of the coping/railing.

Figure 4.4.5-8: Protective Screening Fastened to a Horizontal Coping. Note the Screening is Not Adjacent to a Sidewalk.

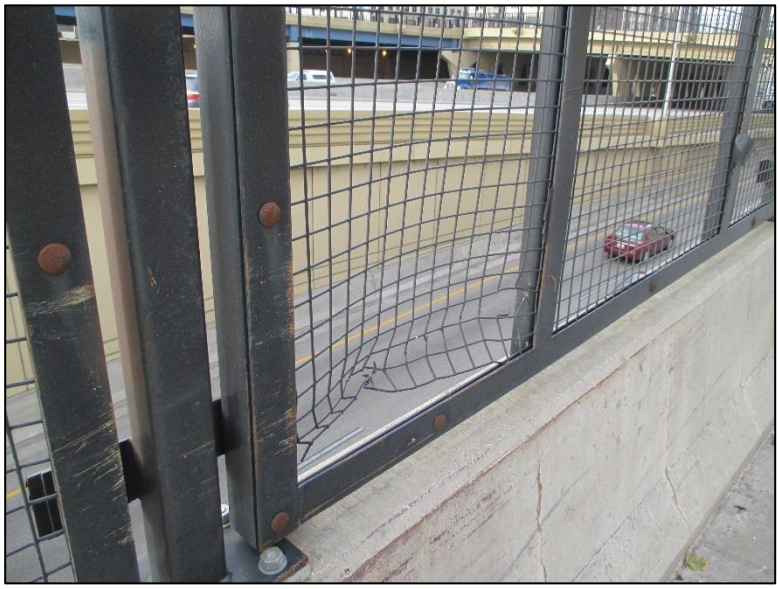


Figure 4.4.5-9: Assessment State 3 Protective Screening atop Bridge Rail. Note Chain-link Fence Deformation but Function Remains.

Refer to the following condition states:

- ***Condition State 1 (Good)***: Chain-link fence has little or no deterioration. Galvanizing or vinyl coating is sound.

- ***Condition State 2 (Fair)***: Chain-link fence has minor deterioration. Coating may have minor failure- surface rust may be present. Fence components are properly aligned (all connections are sound).

- ***Condition State 3 (Poor)***: Chain-link fence has moderate deterioration. Coating may have moderate failure – surface rust may be prevalent. Components may be slightly bent or misaligned – connections may be slightly loos. Fabric may have snags or holes (areas may be slightly stretched or deformed).

- ***Condition State 4 (Severe)***: Chain-link fence has extensive deterioration. Coating may have extensive failure – there may be section loss. Components may be bent or misaligned – connections may be loose. Fabric may have numerous snags or holes (areas may be stretched or deformed).

Material deficiencies shall be reported under the assessment notes and state the type, size and location of the defect. This assessment is quantified as 1 EA for the entire length of the structure. It is the inspector's discretion, based on the assessment's material condition over the whole length, to codify the appropriate assessment state.

4.4.5.9 Horizontal Copings (9338)

This assessment captures the deficiencies associated with the component that is commonly found along the top of a retention structure. This assessment may contribute to the aesthetics of the structure, however it also serves the structural purpose of tying adjacent panels together

at the top of the wall and providing a sound base for placing bridge railing elements. The coping provides protection from deterioration caused by water runoff, snow, freeze/thaw and ice by diverting water away from vertical seams, the top of the wall, and the wall facing. These assessments will typically be comprised of cast-in-place concrete or in some instances precast concrete.

Figure 4.4.5-10: Cast-In-Place Horizontal Coping

Refer to the following condition states:

- ***Condition State 1 (Good)***: No issues. If cracks exist, they are <1/16" in width or sealed.

- ***Condition State 2 (Fair)***: Delaminations or spalls 1" or less, or less than 6" diameter. Patches, if they exist, are sound. HL or narrow cracking may be present. Minor efflorescence may exist, but no rust staining. Abrasion, if present, is minor.

- ***Condition State 3 (Poor)***: Spall greater than 1" deep, or 6" diameter. Patched areas are unsound or showing distress. Medium width cracks. When efflorescence is present, there is heavy build-up and/or rust staining. Abrasion, if it exists, is moderate.

- ***Condition State 4 (Severe)***: The condition warrants a structural review to determine the effect on strength or serviceability of the wall; or a structural review has been completed and the defects impact the strength and/or serviceability of the wall.

Material deficiencies shall be reported under the assessment notes and state the type, size and location of the defect. This assessment is quantified in lineal feet LF for the entire length of the structure. It is the inspector's discretion, based on the assessment's material condition over the whole length, to codify the appropriate assessment state for the unit of measure.

4.4.5.10 Features (Roadway/Sidewalk/Etc.) to Wall (9339)

Typically, fill and cut section walls will have roadways, sidewalks, driveways or other facilities adjacent or carried by the wall. Regardless if these features are along the face or along the top of the wall, the inspector shall perform a visual inspection of the features paying particular attention to any settlement, joint separation or excessive cracking. These deficiencies may indicate wall movement or wall distress in the adjacent wall. The slope behind the wall should be stable and adequately supported by the wall. Any backfill losses, indication of water retention, or other defects may indicate performance issues with the wall and should be noted.

Figure 4.4.5-11: Concrete Sidewalk Along Top of Retaining Wall.

Figure 4.4.5-12: Pothole Due to Loss of Fill Within Shoulder Gutter Pan Along Top of Retaining Wall.

Refer to the following for condition states:

- ***Condition State 1 (Good)***: No issues with retained material. The facilities, if they exist, are generally smooth and show no signs of settlement.

- ***Condition State 2 (Fair)***: Settlement exists but within tolerable limits with no structural distress observed. The facility, if they exist, may have minor settlement and/or may be cracked and deteriorated.

- ***Condition State 3 (Poor)***: Settlement exists that exceeds tolerable limits with no structural distress observed, nor structural review required. The facilities, if they exist, may have moderate deterioration and/or may be cracked and deteriorated.

- ***Condition State 4 (Severe)***: The condition warrants a structural review to determine the effect on strength or serviceability of the wall; or a structural review has been completed and the defects impact the strength and/or serviceability of the wall.

Only quantify the assessment if the facility has a direct impact on the wall. Deficiencies shall be reported under the assessment notes and state the type, size and location of the defect. This assessment is quantified as 1 EA for along the top of the wall and 1 EA for along the face of the wall. It is the inspector's discretion, based on the assessment's material condition over the whole length, to codify the appropriate assessment state.

4.4.5.11 Drainage System (9340)

This assessment defines the drainage along the retaining wall, both on top and along the face. Typically systems to note during inspection include vegetation or lack thereof along the wall and whether run off is able to properly drain away or through the wall. Storm sewer pipes including inlets or field inlets along the wall should be inspected and noted if clogged. Debris preventing adequate drainage should be noted or removed by the inspector. The inspector should note any settlement of fill along or above the wall. Settlement localized in the vicinity of storm sewer inlets and outlets may be an indication that the drainage system is not functioning properly or may be broken and eroding fill material away from behind the wall.

The inspector should assess and evaluate fill settlement and erosion in front and along the top of the wall under 9340 Drainage System.

Figure 4.4.5-13: Drainage System Along Top of Retaining Wall. Note Vegetation Exhibits No Signs of Erosion or Settlement.

Figure 4.4.5-14: Drainage System Located along Top of Retaining Wall.

Refer to the following assessment states for Drainage System

- ***Condition State 1 (Good)***: Drainage systems are functioning properly. No slope erosion is evident, nor are any signs of settlement of the slope.
- ***Condition State 2 (Fair)***: Minor erosion of slope. Drainage system is plugged or has minor deterioration.

- ***Condition State 3 (Poor)***: Moderate erosion of the slope. Drainage system is plugged or has moderate deterioration. Minor slope failures have occurred either removing or adding material from the wall area.

- ***Condition State 4 (Severe)***: Major erosion of slopes. Drainage system is plugged and has major deterioration. Substantial slope failures have occurred either removing or adding material to the wall area.

Deficiencies shall be reported under the assessment notes and state the type, size and location of the defect. This assessment is quantified as 1 EA for along the top of the wall and 1 EA for along the face of the wall. It is the inspector's discretion, based on the assessment's material condition over the whole length, to codify the appropriate assessment state.

4.4.5.12 Stairwell (9341)

This assessment defines the treads, risers, nosing, and hand rails that make up the stairway within a retaining wall structure. The sides of the stairwell will be evaluated as part of the retaining wall element.

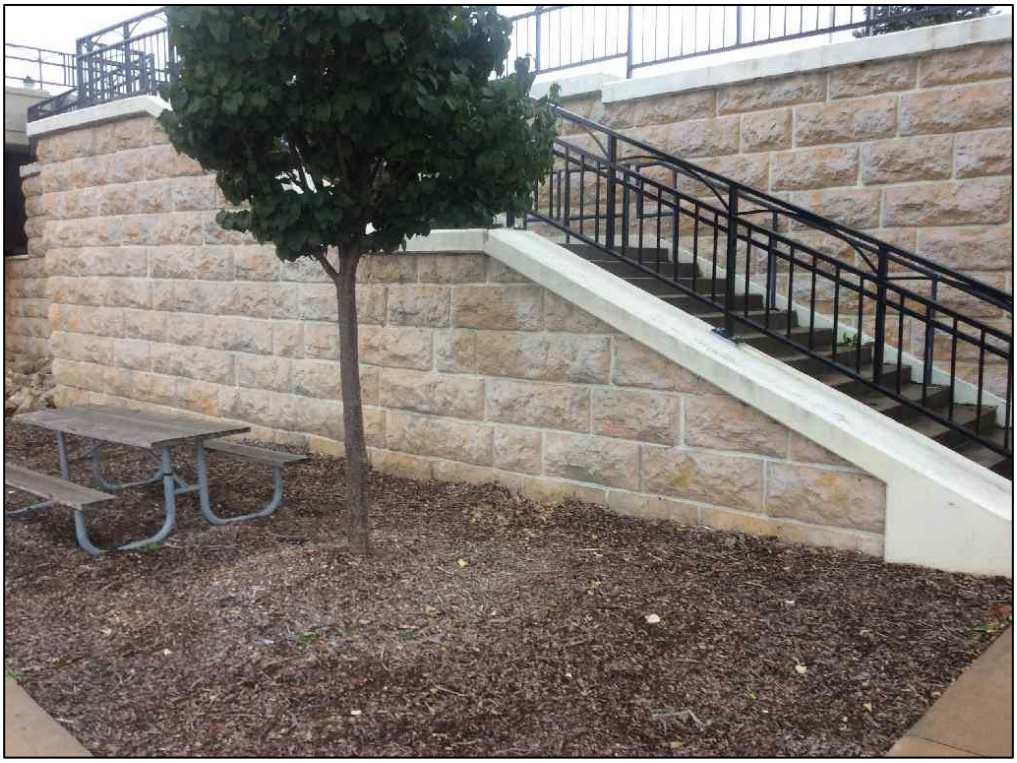


Figure 4.4.5-5: Stairwell integral to Retaining Wall.

Refer to the following assessment states for Stairwell:

- ***Condition State 1 (Good)***: Good condition without defects and functioning as intended. Stairwell may have superficial or cosmetic cracks, spalls, or stains.

- ***Condition State 2 (Fair)***: Fair condition with superficial or cosmetic cracks, spalls, stains, or light corrosion; defects are present, but are not a structural concern.

- ***Condition State 3 (Poor)***: Moderate deterioration or defects that may be a structural issue such as settlement, heaving, tipping, misalignment, scaling, heavy corrosion, etc. Early signs of structural defects.

- ***Condition State 4 (Severe)***: Stairwell has major deterioration or defects that are structurally concerning. Evaluate and close stairwell, as necessary, to restrict access.

Deficiencies shall be reported under the assessment notes and state the type, size and location of the defect. This assessment is quantified as 1 EA for each stairwell. It is the inspector's discretion, based on the assessment's material condition over the whole length, to codify the appropriate assessment state.

4.4.6 Overall Wall Condition Rating

Upon completion of a wall inspection, the inspector is tasked with assigning an overall condition rating to the structure. This is a global evaluation and is used to determine inspection interval and other asset management functions. Therefore the inspector must take into account all elements and assessments noted during the inspection and the functionality of the entire structure. There are four rating levels. The following performance definitions should be reviewed to aid the inspector in assigning the appropriate overall rating for a wall:

- ***Good***: No, or very low distress observed in the wall elements and assessments. Defects are minor, and within the normal range for newly constructed or fabricated elements. Highly functioning wall that is only beginning to show the first signs of distress or weathering.

- ***Fair***: Overall, the condition is satisfactory. Distress is present in wall elements and/or assessments, but does not compromise the wall function. Localized drainage issues, settlement, staining, washing of fines from backfill material that are minor.

- ***Poor***: Overall condition of the wall is poor. Distress is present, but does not pose an immediate threat to wall stability and closure of facilities adjacent to structure is not necessary. Repair and/or replacement is needed in the near future.

- ***Severe***: Critical condition. Major structural defects, or components have rotation, sliding, settlement, and/or overturning that is close to possible collapse. Wall is no longer serving the intended function, or is unstable and needs repair/replacement as soon as possible. Facilities adjacent to wall may need to be closed.

When attempting to rate a significantly long wall (greater than 500 ft) it is important for the inspector to note the functionality of the wall as a whole. Areas of localized severe material distress that do not appear to be affecting the function of the structure will not have as severe an impact on the overall rating. Only when material defects eventually result in large scale wall deterioration, movement or loss of fill from behind the wall should those localized areas be taken into such large consideration when assigning the overall rating.

4.4.7 Maintenance & Repair Items

Upon completion of the inspection report the inspector is relegated to determining the appropriate maintenance & repair actions that should be performed on the structure in order to keep it functioning properly. This includes determining the priority of each particular action. Each maintenance item priority is viewed by the structure owner and provides information for budgetary purposes.

Maintenance activities include items that are of a cyclic or reoccurring nature such as cleaning drains, removing debris, replacing dislodged chinking, painting soldier piles, sealing concrete, etc. Repair activities include non-routine fixing and restoring of wall elements to their intended function: resetting dislodged stonework, repointing stone masonry, grading/reseeding adjacent slopes, patching concrete spalls, mending damaged wire baskets, etc.

Determining the priority level for each item depends significantly on how the functionality of the wall is impacted. Those areas of distress that have a minimal impact should be categorized under a low or medium priority while those areas of distress that are or are eminently impacting the functionality of wall, such as measureable wall movement or global wall failure, should be set at high or critical priority. The following table describes the repair timeline associated with each priority level.

Priority Level	Timeline Expectations
Low	Repair prior to next inspection, as funding allows.
Medium	Repair within one year as funding allows.
High	Repair within 90 days.
Critical	Repair within the timeline specified by the inspector in the notes, but not to exceed 30 calendar days.

The following is the list of all available Maintenance, Repair, and Monitoring Items at the inspector's disposal:

Category	Repair/Maintenance Item	Default Priority
Aesthetics	Aesthetics – Apply Anti-Graffiti Coating	Low
	Aesthetics – Other Work	---
	Aesthetics – Power Wash	Medium
	Aesthetics – Re-paint/ Re-stain	Medium
	Aesthetics – Remove Graffiti	Medium
Drainage	Drainage – Clean Inlets	Medium
	Drainage – Fill Voids in Retained Material	High
	Drainage – Install Riprap/ Geotextile Fabric	Medium
	Drainage – Install/Replace Weep Hole	Medium
	Drainage – Repair Erosion/Scour	Medium
	Drainage – Repair or Replace Inlets	Medium
	Drainage – Repair/Reconnect Drain Tile	High
	Drainage – Seal Horizontal Joints or Cracks	Medium

	Drainage – Seal Vertical Joints or Cracks	Medium
	Drainage – Tuckpoint Inlets	Medium
	Drainage – Unclog Weep Hole	High
	Drainage – Uncover Drain Tile Outfall	Medium

Category	Repair/Maintenance Item	Default Priority
Improvement	Imp – Rehab/Major Repair	---
	Imp – Replace Structure	---
Miscellaneous Maintenance	Misc. – Cut Brush	Low
	Misc. – Other Work	---
	Misc. – Remove Vegetation (Spray)	Low
	Misc. – Remove/Monitor Loose Concrete	Medium
	Misc. – Repair/Replace Fence or Railing	Medium
	Misc. – Sign Remove/Reset/Replace	Low
	Misc. – Utility Repair/Notify Utility	Low
Structural	Structural – Joint Repair or Replacement	Low
	Structural – Other Work	---
	Structural – Patch Concrete Delams/Spalls	Low
	Structural – Repaint Steel Posts or Connections	High
	Structural – Repair Footing	High
	Structural – Repair Timber	High
	Structural – Repair/Replace Steel Connections/Anchors	High
	Structural – Replace Damaged Wall Panel	Critical
	Structural – Replace Deteriorated Modular Block	Medium
	Structural – Replace Shims/ Reset Panels	High
	Structural – Replace Tie-Back	Critical
	Structural – Reset Displaced Masonry/Block	Medium
	Structural – Stabilize Wall	Critical
	Structural – Tighten/Replace Bolts and Nuts	Medium
	Structural – Tuck Point Masonry	Medium
Investigating or Monitoring	Monitor – MSE Wall Settlement	---
	Monitor - Rotation/Tipping	---
	Monitor – Steel Corrosion / Section Loss	---
	Investigate - Cause of MSE Fill Loss	---
	Investigate – Recommend In-Depth Inspection	---
	Investigate – Recommend NDT or MIC Testing	---