3 RETAINING WALL

3.1 Definitions

An earth retaining structure that retains and stabilizes an unstable soil mass by means of lateral support or reinforcement, with a height of 4 feet or greater and the angle of face inclination greater than 70 degrees from horizontal. Retaining walls join end to a soil and the other end to either soil, a bridge abutment, or other structure(s).

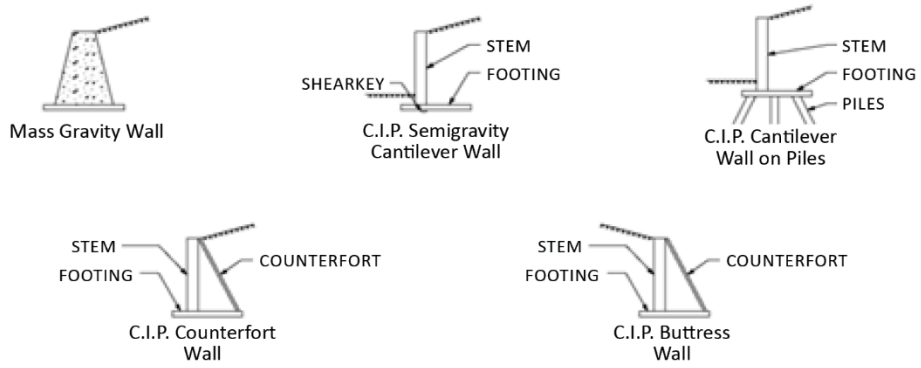
Other common terms which may be used when discussing retaining walls include:

Gravity Walls: A structure that provides lateral support for a mass of soil and owes its stability primarily to its own weight and to the weight of any soil located directly above its base. Examples are mass gravity, reinforced (such as Mechanically Stabilized Earth [MSE]) or modular block.

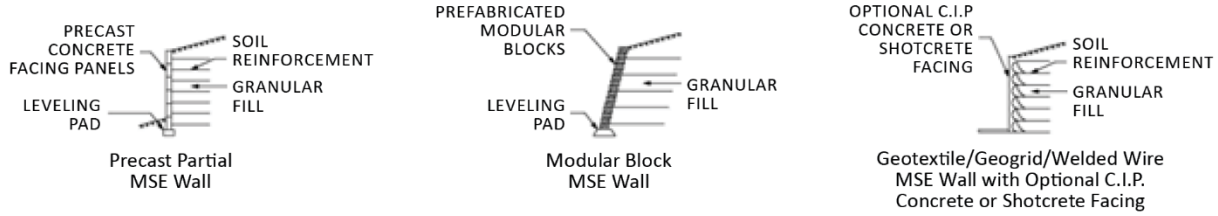
Semi-Gravity Walls: Somewhat more slender than a gravity wall and requires reinforcement consisting of vertical bars along the inner face and dowels continuing into the footings.

Non-Gravity Walls: A soil-retaining system that derives lateral resistance through embedment of vertical wall elements and supports retained soil with facing elements. Examples are walls with tangent or non-tangent walls with structural facing, such as soldier pile and lagging, shotcrete, and sheet pile walls.

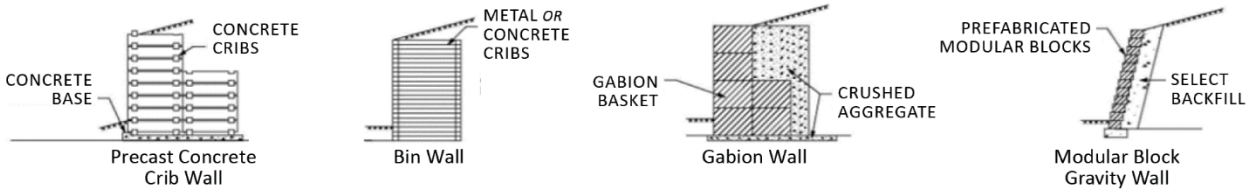
Figure 3-1: Gravity Walls



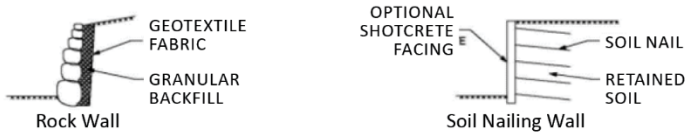
Mass Gravity / Semigravity Walls



Mechanically-Stabilized Earth Walls

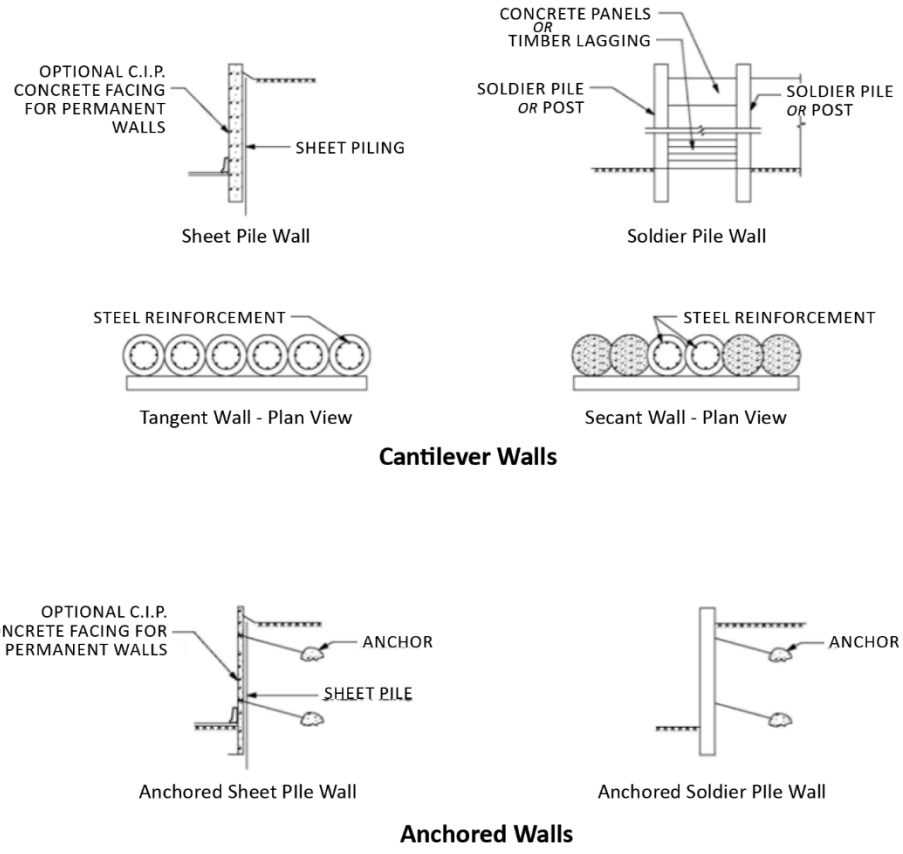


Modular Block Walls



Gravity Walls

Figure 3-2: Non-Gravity Walls



3.1.1 INVENTORY ITEMS

The inspector shall identify the wall type. The different wall types are Reinforced Concrete Stem, Mechanically Stabilized Wall (MSE), Timber, Masonry, Block, Metal, Anchored, Reinforced, (such as a soil nail wall), Gabion, Plastic/Vinyl Lumber, or Other. Sheet pile walls and sea walls may also be present. The inspector shall also identify the architectural wall facing type, foundation type, and features supported or protected by the wall, and confirm the wall's maximum height, minimum height, length, and batter. The slope of backfill behind and in front of the wall should also be identified. Structures attached to the wall and instrumentation placed on the wall should also be noted. Appurtenances and attachments, such as signs or electrical boxes, should be observed and work recommendations or requests for action should be created to address issues, failure, or safety concerns. Appurtenances and attachments are not rated as part of the retaining wall.

Take photos of the required inventory items listed in Section 3.2.

A complete list of inventory items is provided in the Ancillary Structures Data Dictionary.

3.1.2 ELEMENTS

Retaining walls are divided into six elements. Elements are assigned a condition state based on the distresses identified in each element.

The following guidelines for consistent location notation provide the framework for rating a wall element in accordance with the condition rating tables.

Consistent Location Notation Examples:

- ***Wall Facing Area*** – The wall facing area should be calculated by measuring the maximum and minimum height of the wall. The difference in height between maximum and minimum should be multiplied by the wall length to obtain an approximate area.
- ***Wall Length***- In many cases, a retaining wall joins to a bridge. Where a bridge wingwall extends past the nearest expansion or construction joint beyond the abutment and is no longer considered integral with the abutment, the wingwall is then defined as an "independent wingwall", i.e., a retaining wall. Otherwise, a retaining wall is measured from the location where it joins to soil. The location of points on walls, if measured and noted, are from the south or east end of the wall, not along the direction of vehicle travel. The distress(es) observed, if applicable, is assumed to be at any location within the wall height at that lateral point.
- ***Anchors/Connections –*** The total number of anchors may be counted individually or obtained from plan drawings, if available. Alternatively, the number may be estimated by determining the number of anchors per a ten-foot square area. The wall facing area may then be divided by ten and then multiplied by the number of anchors per a ten-foot square area to obtain an estimated number of anchors.
- ***Vertical Support/Columns*** – The total length of vertical support and columns can be obtained by measuring the average height of post multiplied by the number of vertical supports present.
- ***Wall Stability***- Distress locations along the wall length may be referenced by using photographs. If wall stability distress is noted, the length of distress shall be measured along the length of the wall.
- ***Foundation*** – If the foundation is visible, measure distresses along the total wall length.
- ***Drainage*** – The total amount of drainage can be measured as the length of the wall drainage visible. This is likely equivalent to the wall length plus the distance of drainage extending laterally from the wall.

Table 3-1: Retaining Wall Elements and Unit of Measure

Component	Element	Element Code	Unit of Measure
Retaining Wall Conditions	Wall Facing	13101	Area, square feet
Retaining Wall Conditions	Anchors/Connections	13102	Each
Retaining Wall Conditions	Vertical Support/Columns	13103	Each
Retaining Wall Conditions	Wall Stability	13104	Length, ft
Retaining Wall Conditions	Foundation	13105	Length, ft

Retaining Wall Conditions	Drainage Approach	13106	Length, ft

3.1.3 COMPONENTS

Retaining walls are defined by a single component: the retaining wall structure.

The component rating for a retaining wall is based on the following:

- Retaining Wall Structure - The wall's overall rating is based on its structural condition, ability to perform its function, and possible negative impact to the roadway above or below. The wall facing, buried conditions, and overland conditions are all considered.

See Section 1.7 for discussion on component ratings, element ratings, and condition states.

A representation of the rating structure for retaining walls is provided in Figure 3-3.

Figure 3-3: Component-element diagram for Retaining Wall Structures

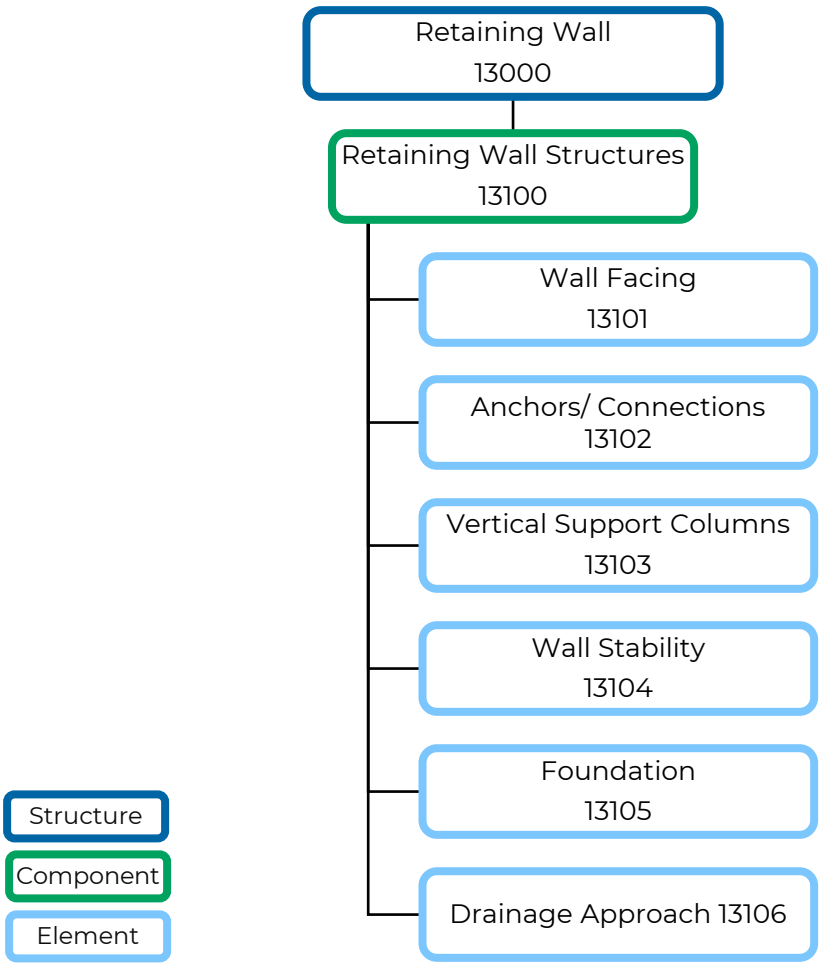
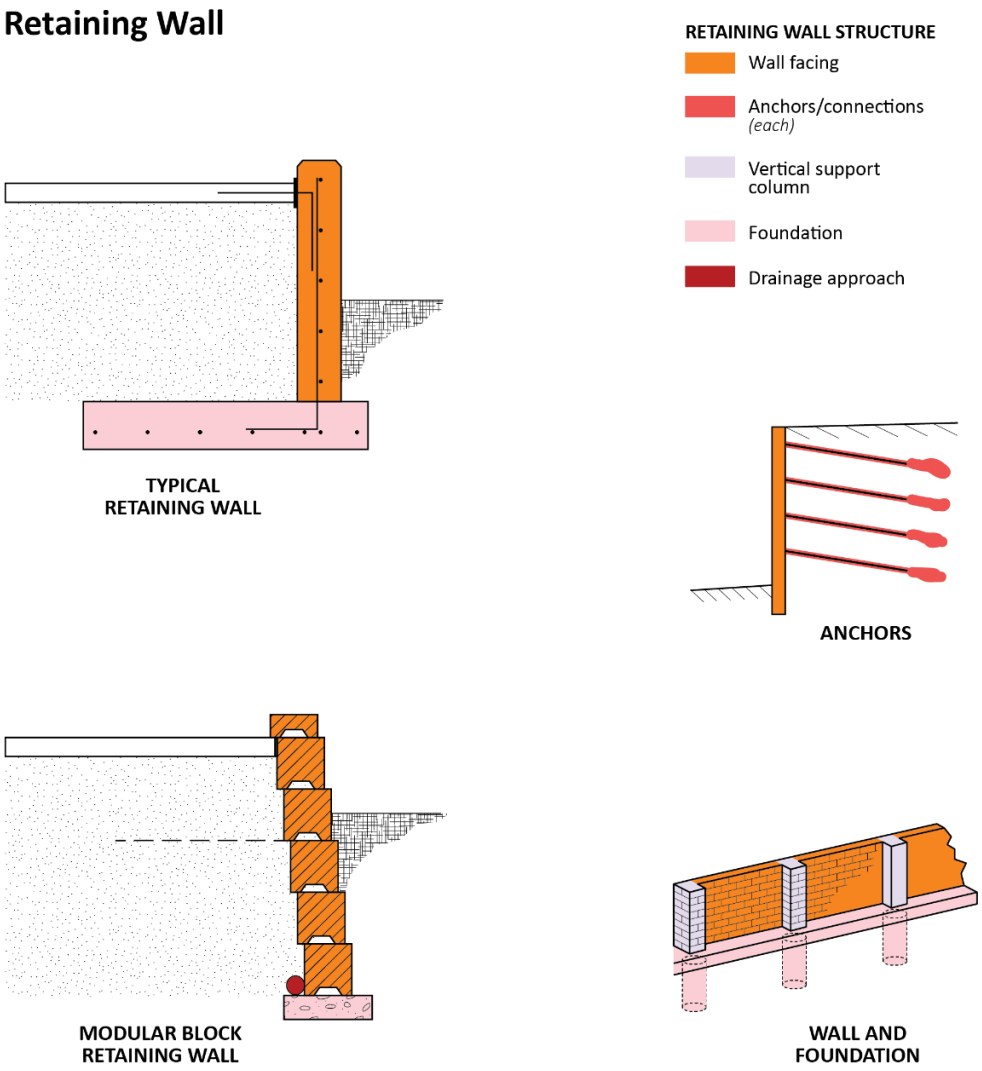


Figure 3-4: Elements and components for Retaining Walls



Note: Wall stability is not represented in the figure. The drainage approach is not fully illustrated. Buried portions of the element(s) will not be inspected.

3.2 Inventory Record Photographs

Inventory photos are captured during a routine inspection, saved as part of the inventory database, and follow the naming convention in *Table 3-2*.

Retaining Wall Required Photos:

- General view of the full wall (may require several sequential photos)
- General view at the top of wall (may require several sequential photos)
- Typical joint photo

Table 3-2: Retaining Wall Photograph Naming Convention

Photo Name	Description
Wall_Entire_Front	General view of entire wall
Wall_Top	General view of top of wall
Wall_Joint	Typical joint photo
Wall_Attachment	Typical attachment

Note: Photo sequence should coincide with inspection direction for the walls.

3.3 Inspector Minimum Technical Qualifications

At least one member of the field inspection crew shall possess the following:

- A minimum experience of ten structures combined concrete inspection, steel inspection, or design experience (bridge inspection qualifies). At least three of the ten inspected structures shall be concrete structures.
- Ancillary structures inspection procedures training
- Working knowledge of inspection tools, their use, application, and limitations for the structure type being inspected.
- Inspection Experience with anticipated material types, such as concrete, timber, masonry, or steel. Internal training will address inspection procedures for all anticipated material types.

3.4 Routine Inspection

These inspections should assess highway earth retaining structures with heights of greater than 4 feet and the angle of face inclination greater than 70 degrees from horizontal. Walls that retain earth are assessed separately from noise walls, which are not designed to retain soil. Retaining walls should join one end to soil and the other end to either soil, a bridge abutment, or other structure.

Where a bridge wingwall extends past the nearest expansion or construction joint beyond the abutment and is no longer considered integral with the abutment, the wingwall is then defined as an “independent wingwall,” (i.e., a retaining wall). Where a wingwall walls adjoin to a bridge abutment and is considered integral to that abutment, the wall along the abutment is part of the National Bridge Inspection process and is considered part of the bridge. Therefore, a wall which visually appears to be a single length would be defined as ancillary structure retaining wall, bridge abutment wall, ancillary structure retaining wall, similarly to the below sketch. Typically, the expansion or construction joint is within 40 feet of the abutment face and is easily visually observed.

The acceptable tolerance for intervals of less than 24 months for the next inspection is up to two (2) months after the month in which the inspection was due. The acceptable tolerance for intervals of 24 months or greater for the next inspection is up to three (3) months after the month in which the inspection was due. Exceptions to the inspection interval tolerance due to rare and unusual circumstances should be approved by MDOT’s

Ancillary Structures Program Manager in advance of the inspection due date plus the above tolerances.

It is recognized that severe weather, inspector safety, inspection quality, resource optimization, technological difficulties, or other unique situations may be a reason to adjust the scheduled inspection date. In these situations, the adjusted inspection date should not extend more than two (2) months after the month the inspection was due for any inspection interval less than 24 months and not extend more than three (3) months after the month the inspection was due for any inspection interval 24 months or greater. Inspection interval tolerances are intended to provide some flexibility. When tolerances are applied, the longest time period prescribed between inspections is the applicable interval plus the prescribed tolerance. For example, a routine inspection on a 12-month interval could be performed during the 14th month if the tolerance is applied. Repeatedly applying the tolerance to the next inspection will create inspection date creep and may impact an owner's ability to perform future inspections in a timely manner due to other limitations (e.g. available resources, inspection workload, schedule, seasonal weather conditions, technological difficulties, etc.). Exceptions to inspection interval tolerances due to rare and unusual circumstances should be approved by MDOT's Ancillary Structures Program Manager in advance of the inspection due date, plus the tolerance. For example, if an inspection with an interval of 24 months is due on June 17, an exception request should be approved by MDOT's Ancillary Structures Program Manager before the end of the 3-month tolerance (i.e. September 30). However, a request for exception should be made when the potential for not meeting the tolerance becomes known to provide MDOT's Ancillary Structures Program Manager with adequate time for review and approval.

Figure 3-5: Diagram indicating where retaining walls differ from bridge abutments and wingwalls

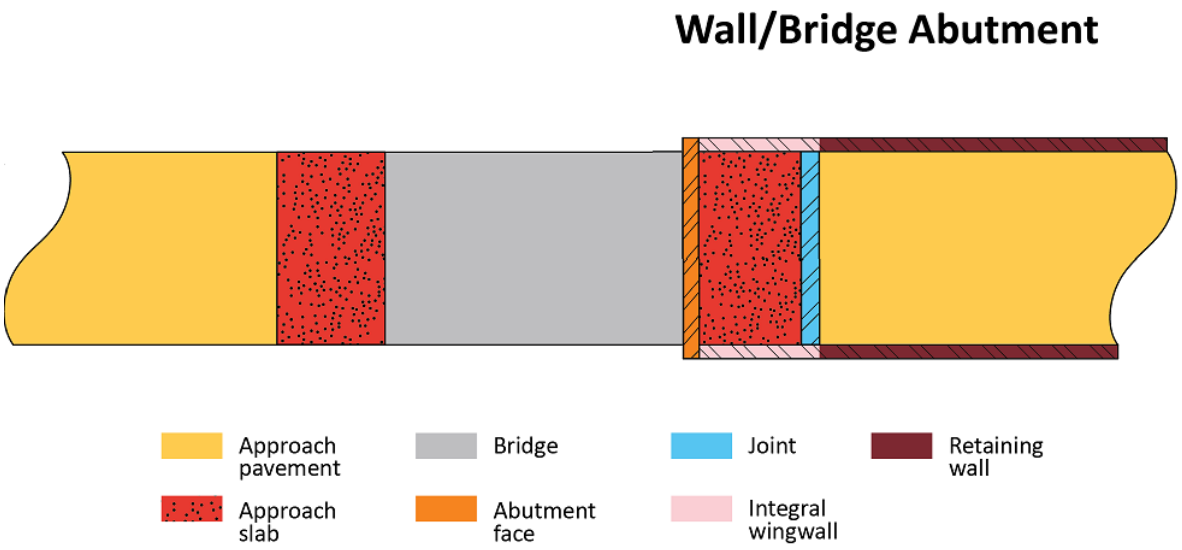
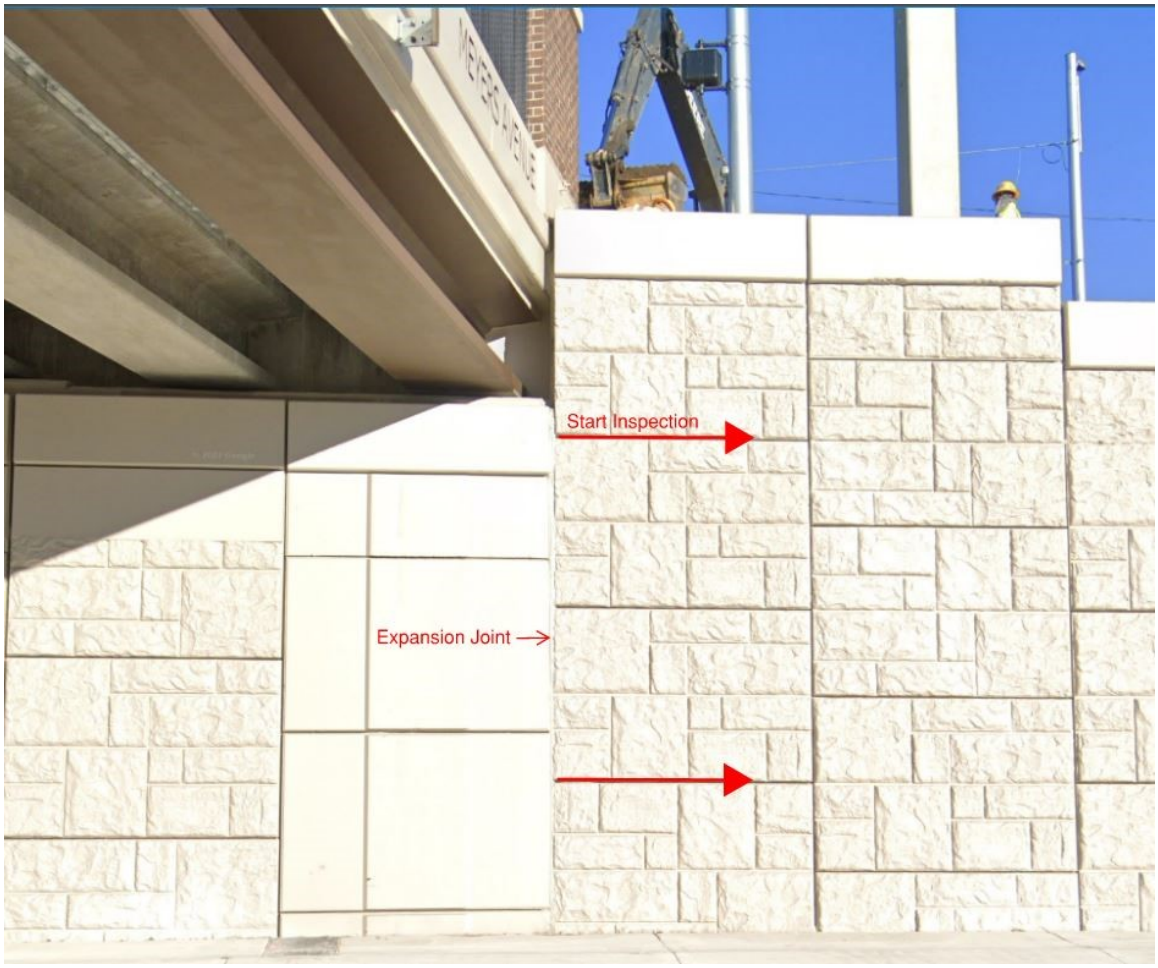


Figure 3-6 Inspection Limits for Retaining Walls



Retaining wall standard inspection frequency is once every 2 years, unless otherwise identified for more frequent inspection.

The routine inspection assesses the retaining wall's ability to safely perform, transfer all loads to the surrounding soil or subsurface material, and assess signs of stability. The inspection of walls for signs of instability (sliding, overturning etc.) is of utmost importance. If safety concerns such as significant erosion, settlement, lateral displacement, etc. are noted, initiate an RFA.

The routine inspection is performed on a regularly scheduled basis, with frequency determined by AS type, and includes the element condition ratings of the wall facing (including joints), vertical support columns, wall stability, foundation, and drainage approach. Walls are typically inspected either from south to north or west to east, similar to bridge inspection procedures.

The purpose of retaining wall inspection is to identify distress indicators related to wall condition and wall stability. It consists of observations and measurements needed to determine the physical and functional condition of the retaining wall. For example, concrete materials might exhibit spalling or cracking, and reinforcing may exhibit corrosion and section loss.

The inspection should identify any changes from initial or previously recorded conditions, and to ensure that the retaining wall continues to satisfy present service requirements. All

elements and the component shall be visually inspected at a distance that is close enough to determine the overall condition and to detect deficiencies.

A sample retaining wall routine inspection would consist of:

- Verify set elevations along the face of the wall for signs of settlement.
- Inspect the vertical alignment of the wall with a plumb-bob. Most retaining walls should be vertical (verify with plans or inventory); however, some retaining walls are built at an angle.
- Examine the opening of the construction joints between sections of the wall.
- Inspect joints for any fill material washing out from between or below the panels.
- Inspect panel joints for differential movement or rotation. Sight down panel face to note individual rotation or tipping out of plane.
- If applicable, inspect for erosion or heaving of the embankment material in front and in back of the wall.
- If applicable, inspect for cracking of pavement or sidewalk materials in front and in back of the wall.
- Inspect sidewalk or roadway along the wall for signs of joint separation, potholes and areas of settlement which may indicate a more global impact on the retaining wall system.
- Inspect for settlement of the fill material behind the wall.
- Examine site grading for any locations that may prohibit proper drainage along the wall.
- Examine and probe drains within the vicinity of the wall for signs of clogging.
- Examine the wall for deterioration of the material, such as cracking, spalling, corrosion, discoloration, etc. noting the width, length, depth, and/or orientation of the deterioration.
- Check wall for evidence of efflorescence or rust staining.
- Examine Panel connections & frame, if applicable.
- Examine post base and anchorage systems if present. Fasteners and connections should be checked for tightness and distress.
- Examine vegetation growth along the wall. Root infiltration may create undesirable stresses on the wall and may induce cracking or failure if left untreated.
- If foundation is visible, note length of foundation exposed and distresses associated with visible foundation.
- Rate Component.
- Rate Elements.
- Provide photographs for all Poor or Severe condition state defects and submit the applicable Work Recs or RFAs.

Table 3-3 provides guidance for inspecting reinforced and prestressed concrete cracking.

Table 3-3: Standard Cracking Widths

Description	Reinforced Concrete	Prestressed Concrete
Hairline (HL)	<1/16" (0.0625")	< (0.004")
Narrow (N)	1/16" to 1/8" (0.0625" to 0.125")	(0" to 0.009")
Medium (M)	1/8" to 3/16" (0.125" to 0.1875")	(0.010" to 0.030")
Wide (W)	>3/16" > (0.1875")	> (0.03")

Note: Cracking width guidelines taken from FHWA Bridge Inspector's Reference Manual (Publication No. FHWA NHI 03-001, October 2002)

3.4.1 STRUCTURE COMPONENT RATING

The retaining wall's overall characteristics are rated on its structural condition, ability to perform its function, and possible negative impact to the entire wall or the roadway above or below. The wall facing, buried conditions, and overland conditions are all considered as part of the component rating. The component rating includes consideration of critical items pertaining to the structural condition of the wall face including anchors or connections. When evaluating cracking or other wall face distresses consider that different distresses are not of equal importance to the wall function. The failure of an anchored wall system may result in serious consequences such as partial or full collapse of retaining wall and surrounding assets, loss of life and significant financial loss. Wall failure may also impact nearby structures behind the wall, including other roadways, bridges, or buildings.

Distresses due to water pressure effects are highly important when rating the overall structure.

The predominant characteristic determining overall condition is stability. Consider if the wall is unstable due to soil movement or foundation issues. Also consider if scour or erosion has created wall instability. Wall backfill or drainage system issues may occur in conjunction with the unstable wall condition.

Table 3-4: Component Rating Guidelines for Retaining Walls

Component Rating	Condition	Material	Description
9	**NEW**	All	No deficiencies in any of the structural components that will affect long term performance.
8	**VERY GOOD**	All	All structural elements are sound and functioning as designed. There may be superficial cracking or weathering and/or dirt contamination of structural elements.

Component Rating	Condition	Material	Description
7	GOOD	All	All elements retain full section properties and function as designed. Minor cracks or moderate cracks that are sealed.
6	SATISFACTORY	Concrete	Unsealed moderate-width or map cracks. Minor delamination, spalling, or efflorescence without build-up or rust staining.
		Timber	Decay or section loss affecting less than 5% of the member section. Splits arrested and concerns mitigated.
		Steel	Protective coating failures is limited to less than 2% of the surface area with no loss of section.
		Masonry	Moderate weathering or cracking (joints may have minor deterioration). Evidence of slight freeze-thaw.
		All	Minor deterioration affecting structural elements. Scour effects have been arrested with countermeasures.
5	FAIR	Concrete	Moderate delamination, spalling, or efflorescence. Reinforcement exposure without section loss.
		Timber	Decay or section loss affecting 5% to 10% of the member section. Checks, shakes, and splits have no effect on capacity.
		Steel	Protective coating failure is limited to less than 5% of the surface area with minor loss of section. Loose fasteners or broken welds present but the connection is in place and functioning as intended.
		Masonry	Extensive weathering or cracking (joints may have slight separation or offset). Evidence of minor freeze-thaw.
		All	Moderate deterioration affecting structural elements including minor settlement, shallow scour, or impact damage. Structure continues to function as designed.
4	POOR	Concrete	Considerable cracking, spalling, and efflorescence with heavy build-up or rust staining.
		Timber	Extensive decay, section loss, checks, shakes, or splits that do not warrant structural review.
		Steel	Protective coating failure affecting between 5% and 10% of the surface area with some loss of section. Cracks that have not been arrested but do not require structural review.
		Masonry	Advanced weathering or cracking (joints may have separation or offset). Evidence of moderate freeze-thaw.
3	SERIOUS	Concrete	Considerable areas of spalling, exposed reinforcement with section loss, or heavy rust staining.

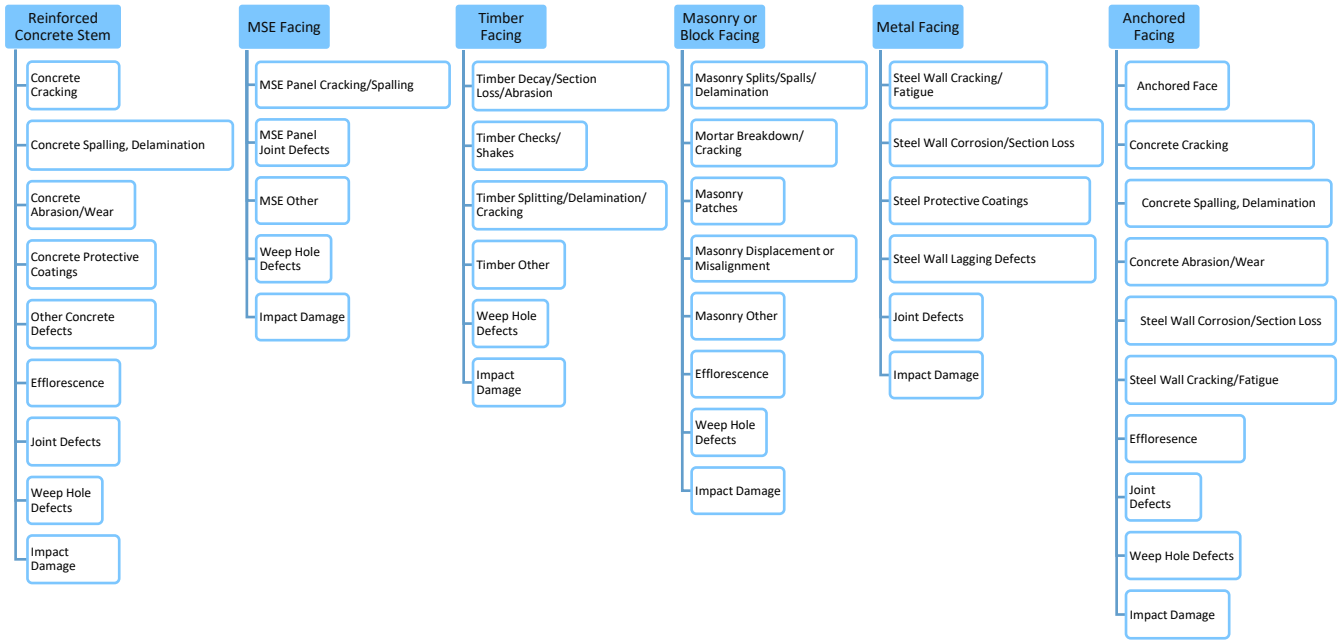
Component Rating	Condition	Material	Description
		Timber	Decay or section loss that affects more than 10% of the member section. Checks, shakes, splits warrant action.
		Steel	Protective coating failure affecting more than 10% of the surface area with measurable loss of section. Missing fasteners or adjacent broken welds present.
		Masonry	Severe cracking, offset or misalignment. Evidence of severe freeze-thaw.
		All	Considerable deterioration or damage affecting structural elements. Structural evaluation, hydraulic, and/or load analysis may be necessary to determine if the structure can continue to function without restrictions or immediate repairs.
2	**CRITICAL**	All	Deterioration has progressed to the point where the structure is not stable and emergency repairs or shoring with structurally engineered temporary supports is required. Inspection frequency may need to be increased.
1	**IMMINENT FAILURE**	All	Road is closed to traffic due to retaining wall failure, but corrective action may put the noise wall back in service.
0	**FAILED**	All	Road is closed due to retaining wall condition.

3.4.1.1 Wall Facing Element Condition States

Start by identifying the wall type: Reinforced Concrete, MSE, Timber, Masonry or Block, Metal, Anchored (such as a soil nail wall), Gabion, or Plastic/ Vinyl Lumber, such as described in section 3.1. Wall type identification is used to identify the distresses applicable to that wall facing type. Where walls are composed of multiple facing types, a separate inspection is performed for each wall face type.

Figure 3-7 provides the wall facing distresses that might be determined for select wall facing types. Other wall types should consider the materials present at the facing and use the distresses typical for those materials.

Figure 3-7: Wall facing distresses



The wall facing element provides the primary restraint to the slope behind the wall by adequately resisting the lateral forces generated by the slope. The wall facing is the exposed portion of the retaining wall. Wall facings can be metal, precast, or reinforced concrete, timber, masonry, or other types of material. This includes modular units such as

MSE panels and concrete panels/blocks or masonry blocks. Barriers and coping at the top of the wall, however, do not count as part of the wall face area.

Some wall facing types have multiple condition states associated with the facing, such as reinforced concrete walls which require assessment for the concrete cracking, spalling, delamination, and efflorescence. Wall facings have elements closely associated with the facing such as joints and weep holes. For ease of inspection, these joints and weep hole distresses are inspected as part of the wall facing element inspection.

The wall facing inspection shall identify the facing type of material and the associated distresses with the facing type. Inspect the wall facing from the top of the wall (below any copings) to the top of the foundation or to the top of finished grade. Embedded and buried portions of walls are not subject to condition inspection since they are not visible.

Figure 3-8: Typical wall facing inspection limits

Reinforced Concrete Stem

The reinforced concrete wall face includes all types and shapes of reinforced concrete. Reinforced concrete exhibits several different types of deterioration and defects, including, reinforcing bar corrosion, concrete cracking, spalling, and delamination, and other deterioration as described in this subsection.

Table 3-5: Reinforced Concrete Stem Element Distresses

Unit of Measure: Area, square feet measured or estimated using average height of facing multiplied by length.

*Applies to all facing types

**Applies to all facing types except MSE wall facings

Element Number	Element Name	Description	Applicable Distresses
13101	Reinforced Concrete Stem	Concrete wall stem exposed above ground.	Concrete Cracking
			Concrete Spalling, Delamination
			Concrete Abrasion/Wear
			Concrete Protective Coatings
			Other Concrete Defects
			Efflorescence*
			Joint Defects**
			Weep Hole Defects*
			Impact Damage*

Details on the condition state rating schema are in Section 3.7, linked below:

Retaining Wall Condition State Tables

Concrete Cracking

Concrete cracking can be either nonstructural or structural and can be caused by many different factors. Nonstructural cracking is most often related to volumetric changes in concrete caused by fluctuations in moisture content and/or temperature during curing or while in service. Nonstructural cracking is typically less than 1/8 inch wide. Structural related cracking is often related to loading on the concrete being beyond its tensile capacity. Concrete can also crack if the embedded reinforcing bars are corroding.

Figure 3-9: Horizontal structural cracking

Inspect the wall face for cracking and investigate whether any observed cracking is non-structural or structural in nature. Document the approximate location, orientation, width, and spacing of the cracking.

Inspect and document the extent and location of exposed reinforcing bar corrosion. Estimate the extent of any section loss.

Figure 3-10: Corroded wall reinforcing

Concrete Spalling and Delamination

Concrete spalling is a surface failure in which concrete breaks off from the underlying concrete substrate. Like cracking, the spalling typically occurs when the steel reinforcing embedded within the concrete member undergoes corrosion. Spalling can also occur at expansion and contraction joints, at rustication and other ornamental non-structural features. It can also occur at cracks that have propagated due to wall deflection or impact damage.

Figure 3-11: Concrete spall with corroded reinforcing

Figure 3-12: Spalled and delaminated concrete

Concrete delamination can be identified as a thin layer of concrete separation from its substrate. Unlike spalling, delaminated concrete does not break away but remains attached to the structure.

Inspect the wall for delamination and spalling. With a sounding hammer or other device, sound any areas that are exhibiting signs of distress to determine the limits of deterioration. Document the approximate location of delamination or spalling while indicating if reinforcement is exposed.

Abrasion/Wear

Damage occurs when the surface of concrete is unable to resist wear caused by rubbing and friction. As the outer paste of concrete wears on wall face, the fine and coarse aggregate are exposed, and abrasion and impact will cause additional degradation that is related to aggregate-to-paste bond strength and hardness of the aggregate. Abrasion of retaining wall faces is most often the result of wind or water-borne particles along the face of the wall.

Inspect the wall for signs of concrete abrasion, including the loss of cement paste and the exposure of the underlying aggregate. Document on the location and extent of any abrasion on the surface of the wall face.

Figure 3-13: Retaining wall concrete abrasion

Concrete Protective Coatings

Inspect concrete surfaces for protective coating failure. Document the approximate location and extent of coating failure. Inspect concrete coating systems for wear due to UV exposure and other deterioration. Some failures are specific to the coating system, (i.e., epoxy systems) are subject to chalking, cracking, and flaking. Note the degree of effectiveness to which the concrete protection system is functioning.

Figure 3-14: Semi-protective concrete protective coating

Other Concrete Defects

Includes distresses otherwise not noted, which may indicate that the wall facing is not functioning as intended or designed. Identify, inspect, and document the type and extent of any problematic deterioration or conditions.

Efflorescence

Efflorescence is caused when soluble salts and other dispersible water materials come to the surface of concrete and mortars. Efflorescence can be identified by the presence of a white powdery solid which appears on the surface of the concrete.

Inspect the wall for the presence of efflorescence, including surface white with built up or heavy build up with rust staining.

Figure 3-15: Efflorescence accumulation

Joint Defects

Wall joints are horizontal or vertical discontinuities in the wall facing, created intentionally to relieve differential movement, as a result of constructure procedures such as concrete pours, or as a characteristic of the wall facing material.

Inspect the wall joints for displacement, evidence of joint material damage or missing material, and seepage of moisture or backfill through the joint. Document any noted problem areas.

Weep Holes Defect

Inspect weep holes in the wall (if applicable) to determine if they are functioning adequately. Document the approximate location of clogged or ineffective drain systems.

Figure 3-16: Weep holes/wall drainage

Impact Damage

Inspect the wall system for vehicular impact damage. Document the location and degree of damage.

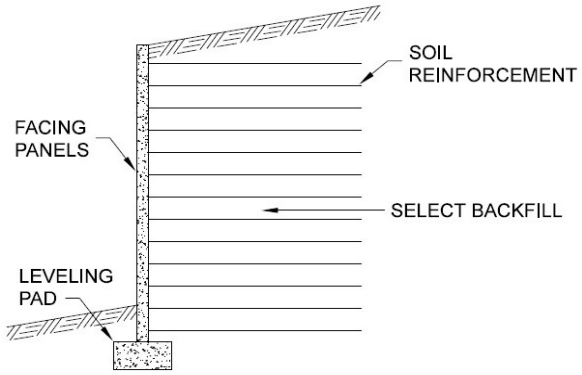
Figure 3-17: Impact damage

MSE Wall Facing (Precast Facing Panels)

MSE walls consist of a reinforced soil mass and a concrete facing which is vertical or near vertical. The facing is often precast panels which are used to hold the soil in position at the face of the wall. The reinforced soil mass consists of select granular backfill. The soil reinforcements and their connections may be proprietary, and may utilize either metallic

(e.g., strip- or grid-type) or polymeric (e.g., sheet-, strip-, or grid-type) reinforcement. The soil reinforcing strips hold the wall facing panels in position and provide reinforcement for the soil. Geotextiles are used to cover the joint between the panels and are placed behind the precast panels to keep the soil from spilling through the joints and to allow excess water to flow out.

Figure 3-18: Typical MSE Wall configuration



MSE Walls are inspected for evidence of wall movement, as well as for evidence of bulging, bowing or panel offset. It is noted that MSE walls are intended to accommodate movement within tolerable limits. It is at the discretion/interpretation of the inspector to document and understand the extents of those movements. MSE walls are also inspected for poor or uncontrolled drainage, and for other evidence of damage. Inspect the MSE Wall for the following distresses.

Table 3-6: MSE Wall Facing Element Distresses

Unit of Measure: Area, square feet measured or estimated using average height of facing multiplied by length.

***See the descriptions and discussions under the Reinforced Concrete Wall subsection.

Element Number	Element Name	Description	Applicable Distresses
13101	MSE Wall Facing	MSE wall exposed above ground.	MSE Panel Cracking/ Spalling
			MSE Panel Joints
			MSE Other
			Impact Damage***

Details on the condition state rating schema are in Section 3.7, linked below:

Retaining Wall Condition State Tables

MSE Panel Cracking/Spalling

Check the wall panels for evidence of horizontal or vertical cracking and staining caused by moisture. Structural cracking may be characterized by a separation which penetrates through the full depth of the panel. Wall panels shall also be checked for spalling and other forms of deterioration. Document the location of cracking and other signs of deterioration and the quantity of panels affected.

MSE Panel Joints

The joints between panels of MSE Walls are to be inspected and examined for loss of backfill, change in spacing, and indications of settlement. Check joints for exposure of geotextile fabric, lack of seal adhesion, loss of joint filler material, and leakage through the joints. Check for evidence of backfill seeping through the joints, including backfill piles at the base of the wall. Document the location where fabric is exposed, lack of seal adhesion, loss of joint filler and or loss of fill is occurring. Inspect the wall system for vegetation growth between the panels. Document locations where vegetation is growing.

MSE Other

Drainage systems through or along MSE walls is inspected to verify water is free flowing into and out of the appropriate facility. Ensure that weep holes are free draining. Additionally, associated patterned vertical cracks that propagate at the weep hole and up along the wall facing are often visual indications of excessive hydrostatic pressure or inadequate drainage flow.

Timber Wall Facing

Timber wall facing includes many types and shapes, including timber lagging, slats, and stacked beams.

Wood is a natural engineering material that is prone to deterioration caused by decay, fungi, and insect attack, and through mechanical damage. Typically, areas of high moisture content in timber elements create conditions suitable for biological damage. Mechanical damage might include damaged members or mechanical fasteners.

Walls composed solely or primarily of timber require inspection for insect damage, decay, splitting, and other defects. Since decay often occurs from the inside-out it is important to perform additional investigation when rotting is suspected. Timber walls located in water or saturated soil are also susceptible to advanced loss near the waterline.

Timber members are also susceptible to drying and weathering, which often results in surface and through splits. Checks and splits in members can indicate a weakened member and create an entry for moisture to enter the element.

Table 3-7: Timber Wall Facing Element Distresses

Unit of Measure: Area, square feet measured or estimated using average height of facing multiplied by length.

***See the descriptions and discussions under Reinforced Concrete Wall subsection.

Element Number	Element Name	Description	Applicable Distresses
13101	Timber Wall Facing	Timber wall facing exposed above ground.	Timber Decay/Section Loss/ Abrasion
			Timber Checks/Shakes
			Timber Splitting/ Delamination/ Cracking
			Timber Other
			Impact Damage***

Details on the condition state rating schema are in Section 3.7, linked below:

Retaining Wall Condition State Tables

Decay/Section Loss/Abrasion

Inspect the wall for insect damage, decay, and section loss or abrasion. Surfaces exposed to drainage and other moisture is also documented. Use an awl or sharp knife to penetrate suspected areas to check for decay. When section loss or abrasion is measurable, evaluate the area to determine if an in-depth inspection and subsequent load analysis is warranted. Document the approximate location and estimated amount of section loss, and the location, type of defects, and other deterioration.

Figure 3-19: Section loss at top of wall

Figure 3-20: Timber lagging splitting

Checks/Shakes

Checks and Shakes are natural and are present in most timber members. Inspect the wall for check or shakes. Document the approximate location and the length in respect to member depth.

Splits/Delaminations/Cracking

Inspect the wall for splits and delaminations. Document the approximate location and length in respect to the member depth.

Figure 3-21: Timber lagging is split along top

Timber Other

Inspect the timber walls for loose or failed connections, and other problem areas not noted above. Document the location, and extent of deterioration or damage if present.

Masonry Walls Facing

Stone masonry is seldomly used in new construction today except as facing or ornamentation. However, many old stone walls are still in use and require inspection. Granite, limestone, and sandstone are the most common types of stone that were used and are still seen today. There are three general types of stone masonry construction:

- **Rubble Masonry** consists of rough stones that are un-squared and used as they come from the quarry. They can be constructed to approximate regular rows or courses (coursed rubble) or could be uncoursed (random rubble).
- **Squared-Stone Masonry** consists of stones, that are squared and dressed roughly. They can be laid randomly or in courses.
- **Ashlar Masonry** consists of stones, that are precisely squared and finely dressed. Like square-stone masonry, they can be laid randomly or in courses.

Figure 3-22: Typical square-stone masonry wall

Table 3-8: Masonry Wall Element Distresses

Unit of Measure: Area, square feet measured or estimated using average height of facing multiplied by length.

***See the descriptions and discussions under the Reinforced Concrete Wall subsection.

Element No.	Element Name	Description	Applicable Distresses
13101	Masonry Wall Facing	Masonry wall facing exposed above ground.	Masonry Wall Splits/Spalls/ Delamination
			Masonry exposed reinforcement
			Mortar Breakdown/Cracking
			Masonry Patches
			Masonry Displacement/ Misalignment
			Masonry Other
			Efflorescence***
			Weep Hole Defects***
			Impact Damage***

Details on the condition state rating schema are in Section 3.7, linked below:

Retaining Wall Condition State Tables

Masonry Splits/Spalls/Delaminations

Inspect the wall face for evidence of splitting, spalling and delaminated areas. Document the extent and location of any noted deterioration.

Figure 3-23: Vertical split in modular block

Masonry Exposed Reinforcement

Inspect the wall face for evidence exposed steel reinforcement. Note any section loss or corrosion on exposed steel.

Mortar Breakdown/Cracking

Inspect the masonry joints for cracks, loose or missing mortar, vegetation, and water seepage.

Figure 3-24: Masonry breakdown

Masonry Patches

Inspect any patched areas of masonry for cracking and or spalling. Sound previous patches with a hammer to evaluate the condition of the repair.

Masonry Displacement or Misalignment

Check overall configuration of the wall for vertical or horizontal misalignment, signs of settlement, and bulging or warping of the wall.

Figure 3-25: Wall misalignment

Metal Facing

The Metal Facing element includes steel sheet piling, bin wall construction, corrugated metal panels and other constructions.

Sheeting piling walls are structural units which, that when connected to one another, will form a continuous wall. Sheeting is driven to a depth sufficient for the passive pressure exerted on the embedded portion to resist the lateral active earth pressures acting on the cantilevered section. This type of facing system is not typically constructed with weep holes.

Metal bin walls are a system of adjoining closed-faced bins, approximately 10 ft. wide, comprised of sturdy, lightweight steel members. The overlapping steel members are bolted together to form an integral structure. The closed bins are then backfilled with

granular material. Together, the backfill and the closed-faced bins form a composite gravity wall.

Figure 3-26: Typical sheet pile wall

Figure 3-27: Typical metal bin wall

Table 3-9: Metal Wall Element Distresses

Unit of Measure: Area, square feet measured or estimated using average height of facing multiplied by length.

***See the descriptions and discussions under the Reinforced Concrete Wall subsection.

Element Number	Element Name	Description	Applicable Distresses
13101	Metal Wall Facing	Metal or steel wall facing exposed above ground.	Steel Wall Cracking/Fatigue
			Steel Wall Corrosion/Section Loss
			Steel Protective Coatings
			Steel Other
			Joint Defects***
			Impact Damage***

Details on the condition state rating schema are in Section 3.7, linked below:

Retaining Wall Condition State Tables

Steel walls shall be inspected for corrosion, cracking, collision, coating failures, and other defects. Steel walls located in water or saturated soils are also susceptible to advanced section loss near the waterline.

Sheet pile walls, typical composed of steel, which are located along shorelines are not required to have inspection performed from the water. Water-side inspection would necessitate the use of boat, kayak, or other conveyance. Visual inspection for distresses and the associated condition state defects from the shoreline shall be conducted. Steel sheet piling not visible below the waterline will not be assessed.

Steel Wall Cracking/Fatigue

Inspect the wall for cracking. When cracking has been previously arrested or repairs have been installed observe the surrounding surface area to verify that further propagation is not occurring. Document the approximate location and estimated length of the cracking.

Steel Wall Corrosion/Section Loss

Inspect the wall for corrosion and section loss. Inspect surfaces that are exposed to drainage or other moisture for additional corrosion and section loss. Document the approximate location, type of defect, and cause of the damage and estimate the extent of any section loss.

Figure 3-28: Steel corrosion and section loss

Steel Protective Coatings

Inspect steel surfaces for protective coating failure. Note whether the failure is limited to the top application coat or to bare steel. Create Work Rec and document the approximate location, percentage, and extent of coating failure. Coating failure may be indicated by surface dulling, loss of pigment, exposure of bare metal, oxidation indicated by darkening of the coating, or peeling and curling of the protective coating.

Steel protective coatings are for steel elements that have a protective coating such as paint, galvanization, or other top-coat steel corrosion inhibitor. This element describes all coating systems, including but not limited to paint systems, oxide on weathering steel, metallizing, and galvanization.

Figure 3-29: Steel protective coating missing

Inspect steel coating systems for chalking, peeling, curling, and oxide color. Document on the location and extent of any observed deterioration to coating systems present.

Steel Other

Inspect the wall for defects such as distortion or buckling of the wall or lagging. Check for horizontal or vertical misalignment between sheeting or other panels. Document the location, length of area affected, and estimated extent of damage.

Anchored Wall Facing

Anchored walls generally consist of vertical structural elements, such as soldier piles, sheet pile, caissons or drilled shafts, combined with lateral anchorage elements placed beside or through the vertical structural elements. Anchorage types include ground anchors, soil nails, dead man anchorage, and post tensioned caissons. The anchor typically includes the anchorage visible in front of the wall face and the anchor length installed behind the wall face. In some walls, for aesthetic reasons, the anchorage is covered by lagging.

Anchored walls offer several advantages over more conventional gravity type wall systems. One of the biggest benefits of these types is the wall's ability to withstand relatively large horizontal wall pressures without requiring a significant increase in the wall cross-section area. Additional benefits include the elimination of the need for deep foundation support, and reduced right-of-way (ROW) acquisition. Anchor failures may be the result of excessive loading of an anchor (e.g., surcharge by construction materials or equipment), failure of the soil mass behind the wall, or anchorage material failure.

Distresses applicable to various wall types and materials could all apply to the anchored wall types, depending on the type of exposed face. The anchored wall face element applies to distresses observed on the face of the anchored wall. The anchors themselves are discussed as a separate element in Section 3.4.1.2.

Table 3-10: Anchored Wall Facing Element Distresses

Unit of Measure: Area, square feet measured or estimated using average height of facing multiplied by length.

***See the descriptions and discussions under Reinforced Concrete Wall subsection.

Element Number	Element Name	Description	Applicable Distresses
13101	Anchored Wall Facing	Anchored wall including ground anchors, soil nails, dead man walls, and post-tensioned caissons.	Anchored Face
			Concrete Cracking***
			Concrete Spalling, Delamination***
			Concrete Abrasion/Wear***
			Steel Wall Corrosion/Section Loss***
			Steel Wall Cracking/Fatigue***
			Joint Defects***
			Efflorescence***
			Weep Hole Defects
			Impact Damage***

Details on the condition state rating schema are in Section 3.7, linked below:

Retaining Wall Condition State Tables

Types of anchored wall systems are presented below.

Soldier Pile and Lagging Wall

Soldier pile and lagging walls are a common type of anchored wall system. This wall system uses discrete vertical wall elements spanned by lagging which is typically timber, but which may also be precast panels or reinforced shotcrete.

Figure 3-30: Soldier pile wall with precast lagging (note: anchors not shown)

Continuous Walls

Ground anchors are also used in continuous wall systems, such as sheet-pile walls, tangent or secant pile walls, slurry walls, or soil mixed walls. Unlike soldier pile and lagging walls, continuous walls act as both vertical and horizontal wall elements. Because of the relative continuity of these wall systems, the design also takes the water pressure behind continuous walls into account.

Figure 3-31: Typical continuous wall

Soil Nail Walls

Soil nails are reinforcing, passive elements that are drilled and grouted horizontally in the ground to support excavations in soil or in soft and weathered rock. Unlike ground anchors that are post-tensioned, soil nails contribute to the stability of the earth-resisting systems mainly through tension as a result of the deformation of the retained soil or weathered soil mass. Soil nails also transfer loads to the surrounding ground through shear stresses (i.e., bond stresses) along the grout-ground interface. As with any passive system, some movement of the wall is expected to engage the nails.

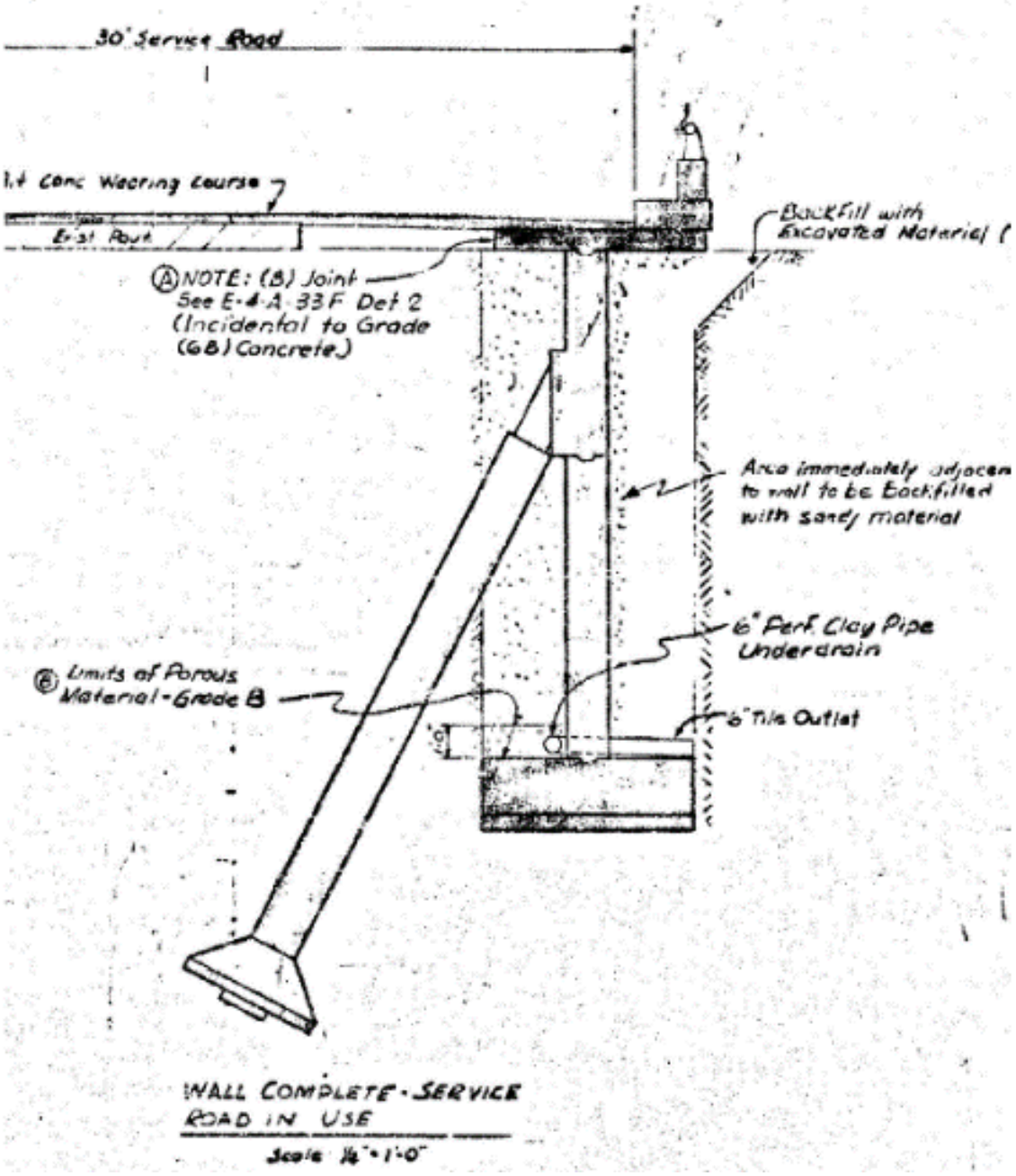
Figure 3-32: Typical soil nail wall

Post Tensioned Caissons

Post tensioned caissons are a method used to provide anchorage for retaining walls to resist overturning and other wall forces. An example of the details used for this design is shown in Figure 3-33. Like other anchorage systems, the caissons and connections on the

fill side of the wall are not directly visible for inspection; however, it is very important to recognize the external indications of potentially serious problems with anchorage systems.

Figure 3-33: Caisson wall detail



Other Wall Types (Gabion, Plastic/Vinyl Lumber, etc.)

Other materials have recently been introduced for use in the construction of retaining walls. These include gabion walls, as well as plastic and vinyl lumber, and other materials.

Table 3-11: Other Wall Type Element Distresses

Unit of Measure: Area, square feet measured or estimated using average height of facing multiplied by length.

***See the descriptions and discussions under the Reinforced Concrete Wall subsection.

Element Number	Element Name	Description	Applicable Distresses
13101	Gabions	Basket or compartmented rectangular containers made of wire mesh filled with rock which comprise a wall.	Gabion Wall Defect Impact Damage***
13101	Plastic/Vinyl Lumber Wall	Wall made of composite materials, typically plastic lumber.	Plastic/Vinyl Lumber Defect Joint Defects*** Impact Damage***

Details on the condition state rating schema are in Section 3.7, linked below:

Retaining Wall Condition State Tables

Gabion Walls

Gabion walls are constructed from rock-filled wire mesh baskets. The gabions typically have a heavy wire mesh with a nominal opening and are formed into rectangular baskets. Individual baskets are placed on the prepared earthen surface, reinforced with internal tie wires, and filled with a select stone.

Succeeding rows of gabions are placed and filled in the same manner. Geotextile fabric is placed behind the baskets to keep the backfill soil from entering the rock filled gabions.

Gabion walls are inspected for the loss of the welded wire section due to corrosion, and loss of stone fill. Additionally, inspect the wall for misalignment including vertical overturning or leaning, settlement and bulging of baskets.

Figure 3-34: Gabion wall

Plastic/Vinyl Lumber

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. Plastics can exhibit ultraviolet deterioration, material incompatibility, corrosion damage, and 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 are inspected for corrosion or other similar material deficiencies. For instance, the tie rod or nuts anchoring a whaler to the outer face of a vinyl sheet piling wall are inspected to ensure they are properly tightened with no signs of corrosion.

Figure 3-35: Plastic/vinyl lumber wall

3.4.1.2 Anchors/Connections Element Condition States

Anchors or connections are used to connect buried structure elements to the wall face.

An inspector will not typically be able to inspect tie-backs or other types of anchorage that are embedded behind a wall for stabilization. Only the visible features of the anchor, anchor head, walers, and bearing plate are typically inspected during a normal routine inspection. The wall facing element and/or discrete vertical elements are reported with their corresponding element and not with the anchor element. Typical tieback spacing ranges along the length of the wall from 5 ft to 15 ft and depends on the height of the wall, retained soil properties, the type of anchorage system and other factors. Vertical anchors may be installed in single or multiple rows depending on the height of the wall and the loads being retained.

It is important to identify the potential issues that may otherwise indicate distress in an anchorage system. These indications might include visual signs of wall movements, panel

deflections, differential displacements, rust staining through panel joints (possible indication of anchorage section loss) material distress and other factors.

Inspect grout pockets, such as those located on tiebacks installed on reinforced concrete stem walls or other walls for stabilization post-construction. Grout pockets shall be inspected for cracking, delamination, or spalling of the grout as well as for separation at the grout and concrete interface. For grout pockets, note if corrosion of conventional steel reinforcement or prestressing steel is present, indicated by corrosion byproduct bleeding through the grout. Note if there is inadequate clear cover.

Visual signs of wall movement and/or deformations and evidence of differential displacement (in plane and out of plane) between wall panels are good indicators for the distress. Additional evidence may include displaced railing and/or distress of overlying fill or pavement. This may be caused by several factors including structural failure of the wall itself, the wale system if present, or the anchor. Additional evidence includes soil failure at the toe or backfill slope, horizontal sliding, or seepage.

Figure 3-36: Wall displacement

Examine anchorage systems, including anchor seals or other fasteners, at connection to the wall for material distress. Signs of distress may include distortion, areas of cracking, spalling, leakage stains, and loss of seal adhesion. Note any corrosion of bars or other anchorage hardware. Identify any damage, looseness or excessive projection of bars or anchorage hardware such as nuts, wedges, collars, or plates. Rotations of anchored retaining walls are often preceded by punching shear or cracking around the area of the anchor attachment to the stem.

Corrosion protection for ground anchor tendons includes either one or more physical barrier layers which protect the tendon from the corrosive environment. The barrier layers include anchorage covers, corrosion inhibiting compounds, sheaths, encapsulations, epoxy coatings, galvanization, and grouts. Inspect the visible portions of the anchors, including tie rods, bolts, or nuts for signs of corrosion and section loss. Document the location and extent of corrosion and section loss in the inspection report.

Table 3-12: Anchor/Connection Element Distresses

Unit of Measure: Each. Total number of anchors to be counted or estimated where visible.

Element Number	Element Name	Description	Applicable Distresses
13102	Anchors/ Connections	Anchors or connections, when present, which are used to connect buried structure elements to the wall face.	Anchor/Connection Defects

Details on the condition state rating schema are in Section 3.7, linked below:

Retaining Wall Condition State Tables

Figure 3-37: Wall anchor

MSE Wall Anchorage

MSE wall panels resist shear loads through the inclusion of attached horizontal reinforcement or anchorage that is distributed throughout the compacted backfill. The anchorage may consist of plastic reinforcement or steel reinforcement such as metallic strips. The MSE wall anchorage will typically not be exposed except in the case of wall failure.

Deadman Anchorage

Deadman anchors are used to anchor a retaining wall in place. Walls using this type of construction include cast-in-place concrete, steel sheeting, timber and other wall construction types. The anchors typically include a steel tie rod attached to the front face of the wall and extending behind the wall to attach to a mass of concrete, and a steel plate, sheeting or other material to provide resistance to lateral wall movement. Deadman anchors could also be used to connect the back face to the wall face.

3.4.1.3 Vertical Support Columns Element Condition States

The Vertical Support/Columns element includes metal, prestressed or reinforced concrete, timber, masonry or other columns or posts that provide structural support to the wall facing element. This also includes any connection hardware present between the vertical supports and adjacent elements. The Vertical Support/Column elements transfer loads from the wall facing elements to the ground or to connected foundation elements. The Vertical Support/Column elements shall be inspected for material specific deterioration and other defects. This element can occur with any wall facing type.

Inspect each of the vertical supports or columns based on the typical defects for the material they are constructed from. In addition, document the location and extent of any misalignment or displacement of the elements, broken connections, damage, erosion or scour at the base of the support, and other defects.

Table 3-13: Vertical Support/Column Element Distresses

Unit of Measure: Each support.

Element Number	Element Name	Description	Applicable Distresses
13103	Vertical Support/ Columns	Vertical Support/Columns provides structural support to the wall facing and includes any connection hardware present between the vertical supports and adjacent elements.	Vertical Support/Column Steel Defects
			Vertical Support/Column Concrete Defects
			Vertical Support/Column Timber Defects
			Vertical Support/Column Masonry Defects
			Vertical Support/Column Other Defects

Details on the condition state rating schema are in Section 3.7, linked below:

Retaining Wall Condition State Tables

Vertical Support/Column Steel

Vertical Support/Column Steel includes all steel columns or vertical supports regardless of size, shape, or protective system. The H-Pile is the most common column type used in retaining wall construction and is commonly used with timber or concrete lagging spanning between the vertical elements. Inspect steel elements for evidence of corrosion and section loss, fatigue cracking, distortion or buckling and misalignment including but not limited to rotation.

Figure 3-38: Vertical support steel

Vertical Support/Column Concrete

Vertical Support/Column Concrete includes all prestressed and reinforced concrete columns/posts regardless of size, shape, or protective system. Inspect concrete elements for delamination, spalling, cracking, efflorescence, exposed reinforcing or prestressing strands and other deterioration. Additionally, inspect the element for evidence of distortion or buckling and misalignment including but not limited to rotation.

Figure 3-39: Vertical support concrete

Vertical Support/Column Timber

Vertical Support/Column Timber includes all timber columns/posts regardless of size, shape or protective system. Inspect timber element for evidence of decay and section loss, checks and shakes, splits and delamination, and other types of deterioration. Additionally, inspect the element for evidence of distortion or buckling and misalignment including but not limited to rotation.

Vertical Support/Column Masonry

Vertical Support/Column Masonry includes all masonry and stone columns/posts regardless of size, shape or protective system. The block or stone may be placed with or without mortar. Inspect the masonry/ stone elements for delaminations, spalling, cracking, efflorescence, exposed reinforcing, mortar deterioration, masonry displacement and other deterioration. Note exposed reinforcing steel as CMU block walls contain vertical steel reinforcement bars. Additionally, inspect the element for evidence of distortion or buckling and misalignment including but not limited to rotation.

Vertical Support/Column Other

Vertical Support/Column Other includes all other material columns/posts regardless of size, shape, or protective system. Inspect other vertical support or column elements for deterioration related to the specific materials used. Additionally, inspect the element for evidence of distortion or buckling and misalignment including but not limited to rotation.

3.4.1.4 Wall Stability Element Condition States

The wall buried conditions elements include the wall foundation element and portions of the wall structure which are not typically visible. These elements also include any evidence (wall sliding, overturning etc.) which may indicate that the underlying foundation element is not functioning as intended or designed.

Table 3-14: Wall Stability Element Distresses

Unit of Measure: Length, ft measured along the wall face, extending behind or below wall for visually observed location of element.

Element Number	Element Name	Description	Applicable Distresses
13104	Wall Stability	Retaining wall subsurface conditions which contribute to the overall wall stability.	Stability- Sliding
			Stability- Overturning, Tilting, Misalignment
			Stability- Settlement
			Other Wall Buried Defects

Details on the condition state rating schema are in Section 3.7, linked below:

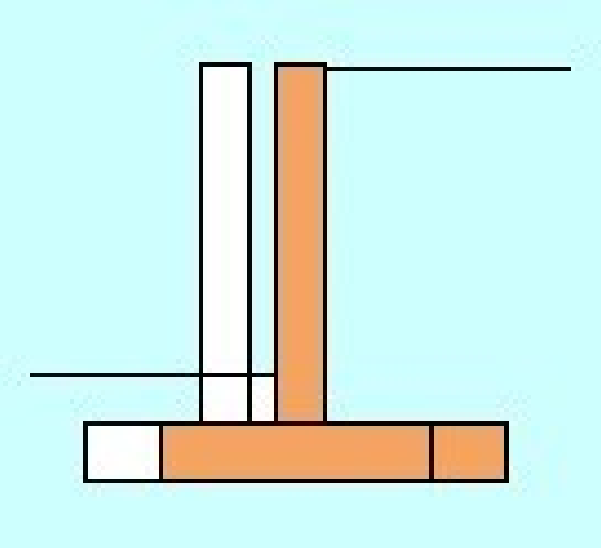
Retaining Wall Condition State Tables

Sliding

Earth retention structures are susceptible to lateral movements or sliding. Lateral movement may occur when the lateral soil pressures exceed the resisting soil frictional and shearing forces, wall anchorage capacities or the capacities of other wall components. In determining condition rating and severity, consider the most common causes of lateral movement which are slope failures (deep shear failures), seepage, changes in soil and water characteristics (e.g., poor drainage, frost action and ice), and settlement 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. A sliding failure is a failure at the soil and wall interface at the base of the wall (e.g., at the base of a reinforced concrete spread footing).

Inspect the wall for visual evidence of a sliding failure including buckling of soil in front of the wall, and in some cases separation of soil at the top of the wall. Document on the location and extent of soil buckling in front of the wall or soil separation on the back face of the wall.

Figure 3-40: Wall sliding



Overturning, Tilting, Misalignment

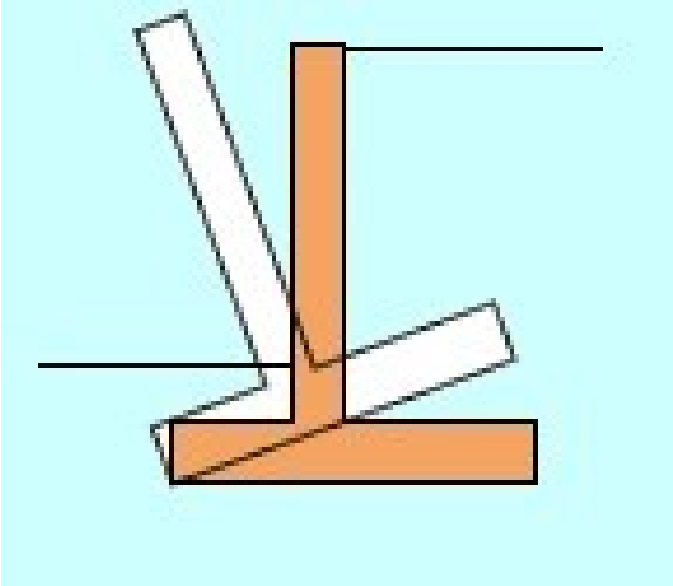
Wall stability issues may be indicated from rotational movement also referred to as overturning. Overturning is generally the result of asymmetrical settlements or lateral movements; however, it may result from increased soil pressure behind the wall. The most common causes of rotational movement are saturation of backfill due to clogged drains, embankment erosion along the front of the wall, or in some cases improper design. The rotation of retaining walls can occur either inward or outward depending on whether it is overcome by passive or active earth pressures. Outward wall rotations are often preceded and accompanied by sinkholes and/or tension cracks at the top of the wall. Inward wall rotation might also be accompanied by the swelling of the backfill soil at the top of the wall. Alternatively, soil may slope downward towards the wall near its base.

Overturning may be indicated by tilt of the wall above the ground level. A small amount of tilt is typical of most retaining walls over time and is not necessarily a cause for concern. This tilt from vertical can be measured with a 4-foot level.

Wall misalignment may also indicate a stability issue. Prior to checking alignment and if construction plans or shop drawings are available, review the plans or drawings review the to determine if the wall was built vertical or has a setback. Inspect the vertical alignment of the wall with a plumb bob. Examine panel joints for differential movement or rotations might indicate rotation between adjacent wall segments. Inspect for heaving of embankment material in front of the wall which would indicate inward rotation of the wall.

Inspect the wall for evidence of excessive deflections. Deflection is considered excessive if it could allow the fill behind the wall to spill or wash out, causing settlement of the retained material above. Document the location of excessive deflections and evidence of fill loss if any.

Figure 3-41: Wall overturning



Settlement

Vertical movement can occur in the forms of uniform settlement or differential settlement. Depending on the magnitude of the settlement realized, uniform settlement will have limited impact on the structural stability of the wall; however, overtopping of the wall may occur if the settlement is significant. Differential settlements, on the other hand, may lead to serious problems in the wall. Differential settlements may cause the opening of joints or cause wall cracking or transverse tipping. The most common causes of vertical movement consist of soil bearing failure; soil consolidation; erosion; and foundation material deterioration.

Inspect the wall for evidence of vertical differential settlement. Settlement issues within the retained fill and backfill are also captured within this defect. Inspect sidewalks or roadway components above the wall for signs of joint separation, potholes, and areas of settlement. It is recommended that the roadway and other elements above the wall be inspected within an area of 1.5 times the height of the wall (the surcharge influence loading zone) for any signs of settlement or other distress.

Figure 3-42: Wall settlement

3.4.1.5 Foundation Element Condition States

Retaining wall foundations may fail when the bearing capacity of the soil supporting the foundation is exceeded. The bearing capacity of soil depends upon the type and consistency of soil.

Foundations are critical to maintain the stability of the wall since the foundation ultimately supports the entire structure. The foundation component provides load bearing capacity to the base of the retaining wall by transferring vertical and lateral forces from the wall to soil below. The foundation component can be comprised of varying foundation elements including footings, piles, and caissons of various construction materials. The foundation elements provide support to the wall facing components and any secondary elements.

The wall foundation includes all the wall elements below the bottom of the wall stem. The wall foundation elements are most often not visible. Often the retaining wall foundations are exposed when undermining or erosion of the foundation occurs. Rate only the visible portions of the foundation. Often the foundations are only visible when distresses are present. Consider the external evidence of the foundation's adequacy to support the wall.

Table 3-15: Wall Foundation Element Distresses

Unit of Measure: Length, ft measured along the wall face

Element Number	Element Name	Description	Applicable Distresses
13105	Foundation	Retaining wall foundation conditions	Foundation Defects
			MSE Reinforced Concrete Stub Cracking

Details on the condition state rating schema are in Section 3.7, linked below:

Retaining Wall Condition State Tables

Various retaining wall foundation types may be encountered and are briefly described in the following sections.

Deep Foundations

Piles can be partially exposed and are made of steel, concrete (cast-in-place or precast), or timber. Caisson, drilled shafts, and piles are other types of deep foundation used when the soil is not competent to support a spread footing.

Shallow Foundations

Shallow foundations are the most common foundation type to experience bearing failure since the foundations are directly supported by the underlying soil. Visual evidence of soil bearing failure may include heaving of the soil at the base of the wall or vertical settlement of the wall. Inspect the wall for signs of vertical settlement and heaving of the soil at the base of the wall. Evaluate the base of the wall perimeter to determine if the foundation is exposed or undermining has occurred due to erosion or other cause. Document the location of foundation exposure.

MSE Reinforced Concrete Stub

MSE walls typically are built on a non-reinforced concrete pad used to provide a level, consistent surface at the proper grade to place the first row of MSE panels. This consistent surface is typically referred to as a "leveling pad." If visible, inspect the leveling pad for signs of concrete deterioration including, cracking, spalling and delaminations. Additionally, check the leveling pad for erosion or undermining. Significant undermining or loss of soil bearing support could have a serious impact on the wall function, including footing failure, loss of retained backfill, and other distress.

3.4.1.6 Drainage Approach Element Condition States

This element defines the drainage along the backside of the retaining wall, as well as drainage through the wall. This element includes area drainage, such as underdrains, which convey water from the backfill to an outfall such as drainage swales, weep holes in the wall facing as well as storm sewer pipes, drainage flumes and other behind the wall drainage features. All drainage elements associated with the wall should adequately divert water from the structure. Internal elements such as subsurface pipes and sheet drains connected to weep holes should prevent water accumulation within the slope behind the wall. It is noted that a weep hole's condition state is rated as part of the Wall Facing element and not with the Drainage Approach element.

Table 3-16: Drainage Approach Element Distresses

Unit of Measure: Length, ft

Element Number	Element Name	Description	Applicable Distresses
13106	Drainage Approach	Drainage approach for retaining wall both behind and in in front of wall	Drainage Approach Defects Streambank Defects Vegetation Defects

Details on the condition state rating schema are in Section 3.7, linked below:

Retaining Wall Condition State Tables

Drainage Approach

Inspect the backside of the retaining wall for evidence of erosion along the embankment directly above or below the wall or in the drainage ditches or flumes. Note whether run off is able to properly drain away or through the wall. Also note any erosion or loss of fill due to drainage at the ends of the walls.

Inspect all inlets to verify water is draining into the inlet and flowing freely to the inlet and out of the outlet. Inspect swales above the wall. Verify rock fall or other materials (trees, etc.) are not blocking, redirecting, or restricting the flow of water through any drainage ditch above wall to the appropriate receptacle.

Storm sewer pipes, including inlets or field inlets, along the wall are inspected and noted if clogged. Flow from seepage sources, including weep holes and horizontal drains etc., is examined for signs of migration of solid particles or fines to check whether there is any internal erosion of the fill behind the wall. Document any signs of abnormal seepage observed on the wall face and any clogs in the drainage system. If applicable compare in-

field drainage structures to available design plans to ensure proper drainage systems have been installed.

Figure 3-43: Drainage outlet is partially clogged with leaves and debris

Streambank

In some cases, water features such as lakes, rivers, or streams may be at the base of the wall. Inspection of the wall from a conveyance such as kayak or boat is not required as part of the AS program. Scour countermeasures or channel protection devices are typical at the base of the wall to protect the wall from undermining or damage due to causes such as erosion, channel widening, local scour and downstream scour. Scour countermeasures may include items such as riprap placed at the base of the wall. Probe with a rod to determine loss of riprap or other protection.

Vegetation

The presence of plant foliage and other vegetation may be interfering with the function of the wall. The penetration of plant roots behind the wall or into wall facing elements may accelerate the deterioration of the wall. The lack of vegetation may also indicate other element defects, such as lack of drainage or wall movement.

Inspect the wall for evidence of vegetation or root growth on the back and front sides of the wall. Document the location and extent of any roots that are penetrating the structure through cracks or other means.

3.4.2 REFERENCES

Michigan Earth Retaining Structure Element Inspection Manual (2020 Draft, unpublished)

AASHTO LRFD Bridge Design Specifications (2020, 9th edition)

3.5 Work Recommendation Guidance

Retaining wall Work Recs are recorded to initiate preventive maintenance actions. Preventive maintenance needs are determined for each ancillary structure and the corresponding actions are identified on the Work Recs documentation.

Work Recs include maintenance, such as cleaning, painting, or re-sealing with protective coatings or paint due to condition defects in efflorescence, corrosion rust staining, or other causes. Repair procedures include patching of concrete or repair of concrete coping or pilasters. Drainage recommendations may consist of filling of erosion and scour holes, or

drainage installed around the wall. Other Work Recs may consist of tightening of facing or expansion joints. Repair of facing (including joint repair), foundation, vertical supports, anchors, or drainage may also be Work Recs.

The following work recommendations are not meant to be all-inclusive and other work recommendations may be added to supplement those noted below.

Photographs should include sufficient information to determine the relationship of the defect to the element or component or entire structure. Close-up photos of each defect with deficiencies marked on the photo should be provided.

Table 3-17: Retaining Wall Work Recommendations

Number	Description of Work Recommendation	Material Involved	Quantity/Unit of Measure
1	Clean and/or paint/re-seal wall	Concrete	Square Foot
2	Tighten/repair timber wall facing	Wood	Square Foot
3	Patch Spalls: Patch delaminations or spalls on concrete or masonry wall facing	Concrete	Square Foot
4	Repair damaged wall facing	Concrete	Square Foot
5	Metal/Corrosion: Remove corrosion and overlay protective coating on metal wall facing	Metal Coating System	Square Foot
6	Fill erosion/scour holes around wall	Stone	Cubic Foot
7	Repair concrete foundation	Concrete	Cubic Foot
8	Clean and/or paint vertical support members	Paint	Square Foot
9	Repair vertical support member	Concrete	Lineal Foot
10	Stabilize vertical supports re-stabilize vertical support member (insert grout plugs, anchors, etc.)	Vertical Support	Each
11	Repair/replace anchors	Steel/Concrete Anchor	Each
12	Repair Wall Railing	Steel	Lineal Foot
13	Paint Coping: Clean and/or paint coping/pilaster	Paint	Square Foot
14	Replace coping/pilaster	Concrete	Square Foot
15	Repair concrete coping/pilaster	Concrete	Square Foot
16	Backfill Erosion: Fill erosion/voids/scour holes in backfill	Earth/Stone	Cubic Yard
17	Re-stabilize Slope	Earth/Stone/Other	Cubic Yard
18	Seal Open Joint (non-expansion)	Joint Filler	Lineal Foot

Number	Description of Work Recommendation	Material Involved	Quantity/Unit of Measure
19	Repair Barrel (non-expansion) e.g., "D" cracking.	Concrete	Square Foot
20	Repair/replace expansion Barrel and seals	Sealant, variable types	Lineal Foot
21	Tighten Expansion Joint	N/A	Lineal Foot
22	Repair/replace Weep Holes	Concrete	Each
23	Repair/replace drain swales/area drains/other drains	N/A	Lineal Foot
24	Install weep holes (for walls with no prior drainage)	N/A	Each
25	Install drainage swales/area drains/other drains	N/A	Lineal Foot
26	In-Depth Inspection	N/A	N/A
27	Remove Vegetation Growth	N/A	Square Foot
99	Other		

3.6 Request for Action Guidance

Priority 1 Level items for Retaining Walls consist of a condition that is compromising the wall's structural capacity and is progressing toward an impending wall failure. Priority 2 Level items for retaining wall consist of a condition that threatens wall functionality and structural capacity.

Examples of applicable priority level items include, but are not limited to:

Priority 1 Level Items

a. Undermining of the foundation or MSE wall leveling pad through erosion, scour, or other ground loss that threatens the integrity of the retaining wall

b. Joints with differential deflection that exhibit major active movement

c. Major wall or panel movement evident, whether rotational or horizontal, such as tilting, sliding, buckling, or heaving of soil at the base of retaining wall, or other evidence of misalignment which indicates a loss of wall stability

d. Retained materials showing major settlement, distortion, rotation, or erosion, potentially occurring in conjunction with a major amount of water or backfill leaking through the wall or wall joints

e. Wall materials showing deterioration that would impact the strength of the structure causing failure of the wall, which could consist of concrete fractures, reinforcement loss, MSE panel cracking, timber cracking, or metal corrosion or deflection

f. Wall constructed with tiebacks that have failed anchor components or distortion impacting strength or function of the structure

g. Multiple loose, missing, or damaged parts, or major deterioration, related to attachments or appurtenances that results in major impact to capacity or durability

Priority 2 Level Items

a. Significant corrosion or section loss at the base of a steel cantilever wall (e.g., sheet pile walls, soldier pile walls, etc.)

b. Concrete wall with significant cracking or spalling resulting in exposed reinforcement with significant section loss

c. Concrete walls with active structural cracking

d. Differential joint deflection where movement is not active but affects stability

e. Masonry with significant shifting out of alignment that impacts stability of the structure, typically indicated by cracking or block misalignment

f. MSE walls showing significant deterioration such as wall misalignment, panel bowing, or cracking that impacts stability of the structure

g. Timber walls showing loss from decay or abrasion, shakes, active cracks, splitting, or delamination

h. Incident resulting in significant structural damage

i. Walls constructed with tiebacks that contain compromised anchor components showing significant deterioration impacting structural functionality

j. Significant water leakage through the wall at locations other than weep holes containing soil particles indicating significant piping is occurring in conjunction with improper drainage

k. Significantly loose parts, or significant deterioration or wear, related to attachments or appurtenances that results in significant impact to capacity or durability

Priority 3 Level Items

a. Concrete exhibiting moderate cracking, spalling, or delamination resulting in exposed reinforcement with moderate section loss

b. Concrete reinforcement exposure with moderate section loss or major staining

c. Masonry showing moderate cracking, spalling, delamination, splitting, or shifting

d. MSE walls with connections visible at isolated locations where panels show bowing or with moderate structural cracking of panels

e. Steel walls with protective coating failure with moderate section loss

f. Timber walls exhibiting moderate decay, cracks, or abrasion

g. Settlement with moderate impact to wall stability

h. Loose or misaligned parts, or moderate deterioration or wear, related to attachments or appurtenances that results in moderate impact to capacity or durability

3.7 Element Condition States

Element Number	Element	Condition States Defects Note	Link to Discussion in Section 3
13101	Wall Facing	Use the appropriate condition state table based on material (Reinforced Concrete, MSE, Timber, Masonry, Metal/Steel, or Other).	Wall Facing Element Condition States
13102	Anchors/Connections	Use the appropriate condition state table	Anchors/Connections Element Condition States
13103	Vertical Supports/Columns	Use the appropriate condition state based on material (Reinforced Concrete, Timber, Masonry, Metal/Steel, or Other).	Vertical Support Columns Element Condition States
13104	Wall Stability	Use the appropriate condition state table	Wall Stability Element Condition States
13105	Foundation	Use the appropriate condition state based on foundation type.	Foundation Element Condition States
13106	Drainage	Use the appropriate condition state table	Drainage Approach Element Condition States

Element 13101 (Wall Facing) – Reinforced Concrete Stem

Description	This element defines wall facing, regardless of facing material type.			
Quantity Calculation	Area, square feet measured or estimated using average height of facing multiplied by length. Retaining walls adjacent to bridge abutments are measured beginning from the nearest expansion or construction joint between the abutment and the start of the retaining wall.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Concrete Cracking	Insignificant cracks or moderate-width cracks that have been sealed. No exposed reinforcing.	Unsealed moderate-width cracks or unsealed moderate pattern (map) cracking. No exposed reinforcing.	Wide cracks (>3/16" or 0.1875 inches) or heavy pattern (map) cracking. Some reinforcing may be exposed. Incidental loss of section of reinforcing may be present but does not affect the function.	Major deterioration due to cracking impacting strength of wall. Substantial amounts of water or backfill may be leaking through cracks or joints. Major corrosion of exposed reinforcing.
Concrete Spalling, Delamination, Patching	None present.	Delaminations or spalls ≤ 1 inch in depth and ≤ 6 inches in diameter. Patch present and functioning.	Delaminations or spalls > 1 inch in depth or > 6 inches in diameter. Patches partially functioning or showing distress. Cracks ≤1/2-inch width may be present. Patches partially functioning or showing distress.	Major deterioration due to spalling, or delamination impacting strength of wall. Failed patches.
Concrete Abrasion/Wear	None present	Abrasion or wearing has exposed coarse aggregate.	Abrasion or wearing has caused coarse aggregate to be loose and/or lost from the concrete matrix.	Major deterioration of concrete due to abrasion or wear. Wall strength may be impacted.
Other Concrete Defects	Other Concrete is present and does not exhibit deterioration or distress.	Minor deterioration or distress of Other Concrete.	Moderate deterioration or distress of Other Concrete.	Major deterioration or distress of Other Concrete.

Description	This element defines wall facing, regardless of facing material type.			
Quantity Calculation	Area, square feet measured or estimated using average height of facing multiplied by length. Retaining walls adjacent to bridge abutments are measured beginning from the nearest expansion or construction joint between the abutment and the start of the retaining wall.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Concrete Protective Coatings	Protective coatings functioning.	Minor peeling/ bubbling/ cracking present.	Protective coatings partially effective. Major peeling, bubbling, or cracking is present.	Does not create a critical condition.
Efflorescence	None	Surface white without build-up or leaching without rust staining.	Heavy build-up with rust staining present.	Does not create a critical condition.
Joint Defects	No damage present	Joints are slightly misaligned between units. Joints may have irregular spacing and be too wide or narrow. Joint with seals showing minor damage, cracking, or loss of seal adhesion. Debris is impacted into joints.	Joints are moderately misaligned between units. Joints may have irregular spacing and be too wide or narrow. Debris is impacted into joints. Joints allowing water leakage or backfill migration. Joints with seals showing moderate damage, cracking, or loss of seal adhesion.	Joints allowing major water leakage or backfill migration. Joints with seals are non-functioning.
Weep Hole Defects	No issues present.	Minor amount of debris build up in weep holes. Wall surface in weep hole vicinity have none to minor cracking or mortar deterioration.	Major accumulation of debris in weep holes. Moderate amounts of cracking extending through weep hole vicinity. Minor spalls adjacent to weep holes. Vegetation may impact wall drainage functions.	Drainage functions plugged and have major deterioration. Extensive cracking extending through weep holes. Major spalling adjacent to weep holes.
Impact Damage	Not applicable.	The element has minor damage caused by vehicular impact.	The element has moderate damage caused by vehicular impact.	Major impact damage from vehicular or vessel collision.

Element 13101 (Wall Facing) – MSE

Description	This element defines wall facing, regardless of facing material type.			
Quantity Calculation	Area, square feet measured or estimated using average height of facing multiplied by length. Retaining walls adjacent to bridge abutments are measured beginning from the nearest expansion or construction joint between the abutment and the start of the retaining wall.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
MSE Panel Cracking/Spalling	Like new condition	Minor non-structural cracks without surface staining. Hairline cracks (less than 1/16 inch) or moderate-width cracks that have been sealed.	Structural cracks or cracking with surface staining. Unsealed moderate-width cracks or unsealed moderate pattern map) cracking. Wide cracks (>3/16" or 0.1875 inches) or heavy pattern (map) cracking. Moderate amounts of water or small amounts of backfill may be leaking through cracks or joints	Cracks greater than ½ inch wide. Major amounts of water or moderate/major amounts of backfill may be leaking through cracks or joints.
MSE Panel Joint Defects	Wall panel joint spacing is substantially uniform.	Wall panel joint width exceeds as-built spacing without geotextile fabric exposure.	Wall panel joint width exceeds as-built spacing or is irregular with exposed geotextile fabric.	Wall panel joints showing differential deflection and major active movement.
MSE Other Defects	Other MSE is present and does not exhibit deterioration or distress.	Minor deterioration or distress of Other MSE.	Moderate deterioration or distress of Other MSE.	Major deterioration or distress of Other MSE.
Impact Damage	Not applicable.	The element has minor damage caused by vehicular impact.	The element has moderate damage caused by vehicular impact.	Major impact damage from vehicular or vessel collision.

Element 13101 (Wall Facing) – Timber

Description	This element defines wall facing, regardless of facing material type.			
Quantity Calculation	Area, square feet measured or estimated using average height facing multiplied by length. Retaining walls adjacent to bridge abutments are measured beginning from the nearest expansion or construction joint between the abutment and the start of the retaining wall.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Timber Decay/ Section Loss/ Abrasion	None present.	Decay or section loss affects less than 10% of the member. Abrasion affects less than 10% of the member thickness.	Decay or section loss affects more than 10% of the member. Abrasion affects more than 10% of the member thickness.	Major decay, section loss, or abrasion of wall. Wall strength may be impacted.
Timber Checks/ Shakes	None present.	Checks affect less than 5% of the member thickness.	Checks/shakes affect 5% to 50% of the member thickness. Larger checks/shakes have been repaired.	Checks and shakes of timber affect more than 50% of member thickness. Wall strength and stability may be impacted.
Timber Splitting/ Delamination/ Cracking	No splitting or delamination present. Sealed cracks may exist.	Cracking affects less than 5% of the member thickness.	Delamination or splitting length equal to or greater than the total member depth, but only present away from connections. Cracking penetrates 5% to 50% of the member thickness. Larger cracks have been repaired.	Delamination or splitting near connections; imminent collapse of member or structure. Severe deterioration due to cracking impacting strength of wall.
Timber Other	Other Timber is present and does not exhibit deterioration or distress.	Minor deterioration or distress of Other Timber.	Moderate deterioration or distress of Other Timber.	Major deterioration or distress of Other Timber.
Impact Damage	Not applicable.	The element has minor damage caused by vehicular impact.	The element has moderate damage caused by vehicular impact.	Major impact damage from vehicular or vessel collision.

Element 13101 (Wall Facing) – Masonry

Description	This element defines wall facing, regardless of facing material type.			
Quantity Calculation	Area, square feet measured or estimated using average height of facing multiplied by length. Retaining walls adjacent to bridge abutments are measured beginning from the nearest expansion or construction joint between the abutment and the start of the retaining wall.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Masonry Splits/Spalls/ Delamination	None present.	Delaminations or spalls ≤ 1 inch in depth and ≤ 6 inches in diameter. Hairline cracks may be present. Block or stone has split or spalled with no shifting.	Delaminations or spalls > 1 inch in depth or > 6 inches in diameter. Cracks ≤1/2-inch width may be present. Block or stone has split or spalled with shifting.	Major deterioration such as spalling/delamination or splitting. May affect structure strength or performance.
Masonry Exposed Reinforcement	No exposed reinforcing.	Reinforcement may be exposed with no measurable section loss.	Incidental loss of section of reinforcing may be present but does not affect the function.	Major corrosion of exposed reinforcing.
Mortar Breakdown/ Cracking	No mortar breakdown.	Cracking or voids in less than 10% of the mortar joints.	Cracking or voids in greater than 10% or more of the mortar joints.	Mortar joints with cracks or voids in more than 50% of the mortar joints. Substantial amounts of water or backfill may be leaking or migrating through cracks. May affect structure strength or performance.
Masonry Patches	Not applicable.	Patch is present and functioning as intended to arrest original deterioration.	Unsound patches or patches showing distress.	Patch has failed.
Masonry Displacement/ Misalignment	None present.	Block or stone has shifted slightly out of alignment.	Block or stone has shifted moderately out of alignment or is missing.	Major displacement of block or stone with missing blocks and stones. May affect structure strength or performance.

Description	This element defines wall facing, regardless of facing material type.			
Quantity Calculation	Area, square feet measured or estimated using average height of facing multiplied by length. Retaining walls adjacent to bridge abutments are measured beginning from the nearest expansion or construction joint between the abutment and the start of the retaining wall.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Masonry Other	Other Masonry is present and does not exhibit deterioration or distress.	Minor deterioration or distress of Other Masonry.	Moderate deterioration or distress of Other Masonry.	Major deterioration or distress of Other Masonry.
Efflorescence	None	Surface white without build-up or leaching without rust staining.	Heavy build-up with rust staining present.	Does not create a severe condition.
Weep Hole Defects	No issues present.	Minor amount of debris build up in weep holes. Wall surface in weep hole vicinity have none to minor cracking or mortar deterioration.	Moderate accumulation of debris in weep holes. Moderate amounts of cracking extending through weep hole vicinity. Minor spalls adjacent to weep holes. Vegetation may impact wall drainage functions.	Drainage functions plugged and have major deterioration. Extensive cracking extending through weep holes. Major spalling adjacent to weep holes.
Impact Damage	Not applicable.	The element has minor damage caused by vehicular impact.	The element has moderate damage caused by vehicular impact.	Major impact damage from vehicular or vessel collision.

Element 13101 (Wall Facing) – Metal/Steel

Description	This element defines wall facing, regardless of facing material type.			
Quantity Calculation	Area, square feet measured or estimated using average height of facing multiplied by length. Retaining walls adjacent to bridge abutments are measured beginning from the nearest expansion or construction joint between the abutment and the start of the retaining wall.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Steel Wall Cracking/ Fatigue	None present.	Steel cracking is self-arrested or arrested with holes, doubling plates, or similar. Fasteners are performing as intended.	Steel cracking is progressing.	Major deterioration due to cracking impacting strength of wall. Substantial amounts of water or backfill may be leaking through cracks or joints.
Steel Wall Corrosion/ Section Loss	None present.	Freckle rust on steel and minor corrosion.	Moderate section loss due to corrosion.	Major wall section loss due to corrosion. Wall strength may be impacted.
Steel Wall Lagging Defects	No issues present.	Minor splitting of lagging.	Moderate splitting or deterioration of lagging. Some lagging may be non-functional.	Lagging missing or non-functioning.
Steel Wall Protective Coatings	Protective coatings functioning.	Minor peeling/bubbling/cracking present.	Protective coatings on steel partially effective. Major peeling, bubbling, or cracking is present. Chalking or oxide films may be present.	Does not create a critical condition.
Impact Damage	Not applicable.	The element has minor damage caused by vehicular impact.	The element has moderate damage caused by vehicular impact.	Major impact damage from vehicular or vessel collision.
Joint Defects	No damage present	Joints are slightly misaligned between units. Joints may have irregular spacing and be too wide or narrow. Joint with seals showing minor damage, cracking, or loss of seal adhesion. Debris is impacted into joints.	Joints are moderately misaligned between units. Joints may have irregular spacing and be too wide or narrow. Debris is impacted into joints. Joints allowing water leakage or backfill migration. Joints with seals showing moderate damage, cracking, or loss of seal adhesion.	Joints allowing major water leakage or backfill migration. Joints with seals are non-functioning.

Element 13101 (Wall Facing) – Anchored

Description	This element defines wall facing, regardless of facing material type.			
Quantity Calculation	Area, square feet measured or estimated using average height of facing multiplied by length. Retaining walls adjacent to bridge abutments are measured beginning from the nearest expansion or construction joint between the abutment and the start of the retaining wall.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Anchored Wall Face	Anchored wall such as soil nail wall is present and does not exhibit deterioration or distress.	Minor deterioration or distress of Anchored Wall.	Moderate deterioration or distress of Anchored Wall.	Severe deterioration or distress of Anchored Wall.
Concrete Cracking	Minor or moderate-width cracks that have been sealed. No exposed reinforcing.	Unsealed moderate-width cracks or unsealed moderate pattern (map) cracking. No exposed reinforcing.	Wide cracks (>3/16" or 0.1875 inches) or heavy pattern (map) cracking. Some reinforcing may be exposed. Incidental loss of section of reinforcing may be present but does not affect the function.	Major deterioration due to cracking impacting strength of wall. Significant amounts of water or backfill may be leaking through cracks or joints. Severe corrosion of exposed reinforcing.
Concrete Spalling, Delamination, Patching	None present.	Delaminations or spalls ≤ 1 inch in depth and ≤ 6 inches in diameter. Patch present and functioning.	Delaminations or spalls > 1 inch in depth or > 6 inches in diameter. Patches partially functioning or showing distress. Cracks ≤1/2-inch width may be present. Patches partially functioning or showing distress.	Major deterioration due to spalling, or delamination impacting strength of wall. Failed patches.
Concrete Abrasion/Wear	None present	Abrasion or wearing has exposed coarse aggregate.	Abrasion or wearing has caused coarse aggregate to be loose and/or lost from the concrete matrix.	Major deterioration of concrete due to abrasion or wear. Wall strength may be impacted.

Description	This element defines wall facing, regardless of facing material type.			
Quantity Calculation	Area, square feet measured or estimated using average height of facing multiplied by length. Retaining walls adjacent to bridge abutments are measured beginning from the nearest expansion or construction joint between the abutment and the start of the retaining wall.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Steel Wall Cracking/ Fatigue	None present.	Steel cracking is self-arrested or arrested with holes, doubling plates, or similar. Fasteners are performing as intended.	Steel cracking is progressing.	Major deterioration due to cracking impacting strength of wall. Substantial amounts of water or backfill may be leaking through cracks or joints.
Steel Wall Corrosion/ Section Loss	None present.	Freckle rust on steel and minor corrosion.	Moderate section loss due to corrosion.	Major wall section loss due to corrosion. Wall strength may be impacted.
Joint Defects	No damage present	Joints are slightly misaligned between units. Joints may have irregular spacing and be too wide or narrow. Joint with seals showing minor damage, cracking, or loss of seal adhesion. Debris is impacted into joints.	Joints are moderately misaligned between units. Joints may have irregular spacing and be too wide or narrow. Debris is impacted into joints. Joints allowing water leakage or backfill migration. Joints with seals showing moderate damage, cracking, or loss of seal adhesion.	Joints allowing major water leakage or backfill migration. Joints with seals are non-functioning.
Efflorescence	None	Surface white without build-up or leaching without rust staining.	Heavy build-up with rust staining present.	Does not create a critical condition.
Weep Hole Defects	No issues present.	Minor amount of debris build up in weep holes. Wall surface in weep hole vicinity have none to minor cracking or mortar deterioration.	Moderate accumulation of debris in weep holes. Moderate amounts of cracking extending through weep hole vicinity. Minor spalls adjacent to weep holes. Vegetation may impact wall drainage functions.	Drainage functions plugged and have major deterioration. Extensive cracking extending through weep holes. Moderate spalling adjacent to weep holes.

Description	This element defines wall facing, regardless of facing material type.			
Quantity Calculation	Area, square feet measured or estimated using average height of facing multiplied by length. Retaining walls adjacent to bridge abutments are measured beginning from the nearest expansion or construction joint between the abutment and the start of the retaining wall.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Impact Damage	Not applicable.	The element has minor damage caused by vehicular impact.	The element has moderate damage caused by vehicular impact.	Major impact damage from vehicular or vessel collision.

Element 13101 (Wall Facing) – Other – Reinforced Face, Gabion, Plastic/Vinyl, Lumber, etc.

Description	This element defines wall facing, regardless of facing material type.			
Quantity Calculation	Area, square feet measured or estimated using average height of facing multiplied by length. Retaining walls adjacent to bridge abutments are measured beginning from the nearest expansion or construction joint between the abutment and the start of the retaining wall.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Gabion Wall Defect	Gabion wall is present and does not exhibit deterioration or distress.	Minor deterioration or distress of Gabion Wall.	Moderate deterioration or distress of Gabion Wall.	Severe deterioration or distress of Gabion Wall.
Plastic/Vinyl Lumber Wall Defect	Plastic or Vinyl Lumber Wall is present and does not exhibit deterioration or distress.	Minor deterioration or distress of Plastic or Vinyl Lumber Wall.	Moderate deterioration or distress of Plastic or Vinyl Lumber Wall.	Major deterioration or distress of Plastic or Vinyl Lumber Wall.

Description	This element defines wall facing, regardless of facing material type.			
Quantity Calculation	Area, square feet measured or estimated using average height of facing multiplied by length. Retaining walls adjacent to bridge abutments are measured beginning from the nearest expansion or construction joint between the abutment and the start of the retaining wall.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Joint Defects	No damage present	Joints are slightly misaligned between units. Joints may have irregular spacing and be too wide or narrow. Joint with seals showing minor damage, cracking, or loss of seal adhesion. Debris is impacted into joints.	Joints are moderately misaligned between units. Joints may have irregular spacing and be too wide or narrow. Debris is impacted into joints. Joints allowing water leakage or backfill migration. Joints with seals showing moderate damage, cracking, or loss of seal adhesion.	Joints allowing major water leakage or backfill migration. Joints with seals are non-functioning.
Impact Damage	Not applicable.	The element has minor damage caused by vehicular impact.	The element has moderate damage caused by vehicular impact.	Major impact damage from vehicular or vessel collision.
Anchors/ Connections Defects	No damage present	Anchor heads may show minor displacement. Anchors show minor rust spots or corrosion. Tie rods or nuts should be snug tight with no signs of corrosion. Debris may be impacted into connections. Anchor seals or other fasteners showing minor damage, cracking, or loss of seal adhesion.	Anchor heads may show moderate displacement with exposure past the anchor head. Tie rods, bolts, or nuts may be loose or show corrosion. Anchor seals or other fasteners showing moderate damage, cracking, or loss of seal adhesion.	Wall connections showing failure. Missing tie rods, bolts, or nuts. Wall strength or stability may be impacted.

Element 13102 (Anchors/Connections)

Description	This element includes anchors or connections which are used to connect buried structure elements to the retaining wall face.			
Quantity Calculation	The quantity for this element is collected as each anchor or connection unit. Anchors and connections are frequently covered by the wall facing element and are not visible.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Anchors/ Connections Defects	No damage present	Anchor heads may show minor displacement. Anchors show minor rust spots or corrosion. Tie rods or nuts should be snug tight with no signs of corrosion. Debris may be impacted into connections. Anchor seals or other fasteners showing minor damage, cracking, or loss of seal adhesion.	Anchor heads may show moderate displacement with exposure past the anchor head. Tie rods, bolts, or nuts may be loose or show corrosion. Anchor seals or other fasteners showing moderate damage, cracking, or loss of seal adhesion.	Wall connections showing failure. Missing tie rods, bolts, or nuts. Wall strength or stability may be impacted.

Element 13103 (Vertical Support/Columns)

Description	This element is defined by vertical supports and connection hardware which provide structural support to the wall facing and adjacent elements.			
Quantity Calculation	The quantity is collected as each.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Vertical Support/ Column Steel Defects	No deterioration present	Steel cracking is self-arrested or arrested with holes, doubling plates, or similar. Fasteners are performing as intended. Freckle rust on steel and minor corrosion. Wall movement is occurring with signs of bulging, bending, misalignment, distortion, or deflection of vertical support.	Steel cracking is progressing. Moderate loss due to corrosion.	Major deterioration due to cracking, corrosion, section loss, or misalignment impacting strength of wall. Wall movement is active with sloughing behind and major wall misalignment.
Vertical Support/ Column Concrete Defects	Hairline cracks may be present. Minor cracks or moderate-width cracks that have been sealed. No exposed reinforcement.	Unsealed moderate-width cracks or unsealed moderate pattern (map) cracking. Delaminations or spalls ≤ 1 inch in depth and ≤ 6 inches in diameter. Reinforcement exposed without measurable section loss. Freckled rust may be present. Corrosion has initiated.	Wide cracks (>3/16” or 0.1875 inches) or heavy pattern (map) cracking. Delaminations or spalls > 1 inch in depth or > 6 inches in diameter. Cracks ≤1/2-inch width may be present. Exposed reinforcement with measurable section loss. Pack rust may be present.	Major deterioration due to cracking, spalling, reinforcement corrosion, section loss or other deterioration impacting strength of wall.

Description	This element is defined by vertical supports and connection hardware which provide structural support to the wall facing and adjacent elements.			
Quantity Calculation	The quantity is collected as each.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Vertical Support/ Column Timber Defects	No deterioration present	Decay or section loss affects less than 10% of the member. Abrasion affects less than 10% of the member thickness. Checks affect less than 5% of the member thickness. Cracking affects less than 5% of the member thickness. Wall has shifted slightly out of alignment.	Decay or section loss affects more than 10% of the member. Abrasion affects more than 10% of the member thickness. Checks/ shakes/cracks affect 5% to 50% of the member thickness. Larger checks/ shakes/cracks have been repaired. Delamination or splitting length equal to or greater than the total member depth. Wall has shifted moderately out of alignment.	Severe decay, section loss, or abrasion of wall. Checks and shakes of timber affect more than 50% of member thickness. Delamination or splitting near connections. Severe shift in alignment. Wall strength may be impacted.
Vertical Support/ Column Masonry Defects	No splits or spalls, mortar breakdown present. No displacement or misalignment of stones present. No exposed reinforcing.	Delaminations or spalls ≤ 1 inch in depth and ≤ 6 inches in diameter. Hairline cracks in stones may be present. Cracking or voids in less than 10% of the mortar joints. Block or stone has shifted slightly out of alignment. Reinforcement may be exposed with no measurable section loss.	Delaminations or spalls > 1 inch in depth or > 6 inches in diameter. Cracks ≤1/2-inch width may be present. Cracking or voids in greater than 10% or more of the mortar joints. Block or stone has shifted moderately out of alignment or is missing. Incidental loss of section of reinforcing may be present but does not affect the function.	Major spalling, delamination cracking or splitting of masonry. Mortar joints with cracks or voids in more than 50% of the mortar joints. Major displacement of block or stone with missing blocks and stones. May effect structure strength or performance. Major corrosion of exposed reinforcing.
Vertical Support/ Column Other Defects	Vertical Support /Column Other is present and does not exhibit deterioration or distress.	Minor deterioration or distress of Vertical Support/Column Other.	Moderate deterioration or distress of Vertical Support/ Column Other.	Major deterioration or distress of Vertical Support/Column Other.

Element 13104 (Wall Stability)

Description	This element defines the adjacent soil movement caused by vertical or lateral pressures such as settlement, global stability, wall tilt, which affects the wall stability. The wall buried conditions elements include the wall foundation element and portions of the wall structure which are not typically visible. These elements also include any evidence (wall sliding, overturning etc.) which may indicate that the underlying foundation element is not functioning as intended or designed.			
Quantity Calculation	The quantity is collected in length of feet measured along the wall face.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Stability – Sliding	Wall shows no signs of movement.	Wall movement has occurred. Signs of bulging, bending, heaving, misalignment, distortion, deflection, or displacement are present. Wall may have had preventative or countermeasures installed such as straps or anchors.	Sloughing of retained material behind wall is evident. Previous stabilization measures, if present, are failed.	Major wall sliding either along the base of a wall or a slip surface cutting through the wall. Wall movement is active and extensive. Wall considered failed. Threat to wall structural capacity and overall stability. The condition warrants a structural review to determine the effect on strength or functionality of the element or wall.
Stability – Overturning, Tilting, or Misalignment	Wall shows no signs of movement.	Wall movement has occurred. Signs of bulging, bending, heaving, misalignment, distortion, deflection, or displacement are present. Wall may have had preventative or countermeasures installed such as straps or anchors.	Moderate rotation, misalignment, tilting, or vertical or horizontal movement has occurred. Previous stabilization measures, if present, are failed.	Major wall rotation, misalignment, or tilting. MSE wall geotextile (if applicable) may be exposed. Wall considered failed. Threat to wall structural capacity and overall stability. The condition warrants a structural review to determine the effect on strength or functionality of the element or wall.

Description	This element defines the adjacent soil movement caused by vertical or lateral pressures such as settlement, global stability, wall tilt, which affects the wall stability. The wall buried conditions elements include the wall foundation element and portions of the wall structure which are not typically visible. These elements also include any evidence (wall sliding, overturning etc.) which may indicate that the underlying foundation element is not functioning as intended or designed.			
Quantity Calculation	The quantity is collected in length of feet measured along the wall face.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Stability – Settlement	Facilities behind wall, such as pavement, are smooth and show no signs of settlement. No indications of retained material/ backfill loss.	Facilities behind wall, such as pavement, may have minor settlement, cracking, or deterioration. If settlement is present the structure has no other associated distress.	Facilities behind wall, such as pavement, may have moderate settlement, cracking, or deterioration. Structural distress due to settlement is present.	Facilities behind wall, such as pavement, may have moderate settlement, cracking, or deterioration. Retained materials showing major settlement, distortion, or erosion. Substantial amounts of water or backfill may be leaking through joints.
Other Wall Buried Defects	Other Wall Buried is present and does not exhibit deterioration or distress.	Minor deterioration or distress of Other Wall Buried.	Moderate deterioration or distress of Other Wall Buried.	Major deterioration or distress of Other Wall Buried.

Element 13105 (Foundation)

Description	This element defines a foundation, regardless of foundation type			
Quantity Calculation	The quantity is collected in length of feet measured along the wall face.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Foundation Defects	Wall shows no signs of movement. Wall foundation elements are in place.	Wall movement has occurred. Signs of settlement, deflection, or displacement are present. Foundation may be exposed. Wall is still attached to foundation.	Moderate wall settlement, rotation, or movement indicating possible foundation damage. Wall may be partially disconnected from its foundation.	Major loss of wall bearing capacity which is a threat to wall structural capacity and stability. Wall may not be attached to foundation elements.
MSE Reinforced Concrete Stub Cracking	No damage present	Unsealed moderate-width cracks or unsealed moderate pattern (map) cracking. Stub exposed due to erosion.	Stub highly exposed and undermined. Wide cracks (>3/16” or 0.1875 inches) or heavy pattern (map) cracking.	Cracks greater than ½-inch wide.

Element 13106 (Drainage Elements)

Description	This element defines the drainage along the backside of the retaining wall, as well as drainage through the wall.			
Quantity Calculation	The quantity is collected in length of feet measured along the wall face.			
	Condition State Descriptions			
Defect Type	**Good**	**Fair**	**Poor**	**Severe**
Drainage Approach Defects	Wall flume end and associated ditches in good condition.	Minor rill erosion of slope below wall. Minor sheet erosion (up to 10% bare ground), indications of storm water runoff down embankment below wall.	Evidence of piping. Moderate sheet erosion of slopes below retaining wall requiring protection and investigation. Drainage functions plugged or with moderate deterioration.	Major erosion of slopes at ends of retaining wall. Drainage functions plugged and have major deterioration. Soil tension cracks perpendicular/semi-circular to slope indicating shifting or settlement. Sloughing of embankment causing loss of support to wall above. Slope stability failure likely.
Streambank Defects	No indications of bank erosion or scour.	Wall remains stable but has intermittent bank erosion or local scour that does not expose or undermine wall. Countermeasures are substantially effective. Extensive minor to isolated advanced defects present.	General bank erosion leading to channel widening, local scour or head cutting or signs of downstream scour. Trees and brush may restrict stream channel. Extensive advanced to major defects.	Countermeasures or channel protection devices are unstable, missing, or no longer effective. Bank, wall, and/or roadway weakened by scour. Foundation has lost support and is undermined sufficiently to threaten the wall integrity. Danger of collapse with next flood event.
Vegetation Defects	Minor vegetation growth through or around elements. No evidence of damage from growth.	Moderate vegetation growth through or around element and/or evidence of minor to moderate damage to the element caused by the growth. Structural elements are still sound.	Heavy vegetation growth through or around elements and/or severe damage or deterioration of the element due to growth.	Not applicable.