INDOT RETAINING WALL INSPECTION MANUAL

RETAINING WALL MANUAL

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RETAINING WALL MANUAL

1.0 INTRODUCTION

Retaining walls are structural assets within Indiana's transportation system that retain soils to both support roads and structures and support the ground adjacent to roads and structures. The proper functioning and long-term serviceability of these structural assets are essential to INDOT's mission to maintain a functioning and serviceable transportation system. There are many different retaining wall types that are designed and constructed for different purposes that include roadway embankment and bridge substructure support, grade separation, landslide remediation, streambank and channel erosion and scour control, and minimizing Indiana's right-of-way.

All retaining walls owned and maintained by INDOT with exposed heights 5 feet or greater at any point along the full length of a retaining wall asset are included in INDOT's asset inventory and inspection program. With some exceptions, LPA owned/maintained retaining wall structures supporting both transportation-related assets and privately owned retaining walls supporting building-type structures are generally not included in this asset inventory and inspection program. Retaining walls built along state owned/maintained roadways that support non-transportation assets are included in this asset inventory and inspection program. In addition, noise walls, culvert headwalls and wingwalls, lined, riprapped, or similarly reinforced embankment slopes, soil nail walls, and temporary construction shoring walls are also not included in this asset inventory and inspection program.

1.01 PURPOSE

There is currently no FHWA mandate or regulation requiring retaining wall inventory, inspection, and condition reporting. If a retaining wall has not been properly designed, constructed, is not performing as designed, or is experiencing premature deterioration, the condition may continue to worsen over time if not detected early and reported for timely corrective actions, putting that segment of the State's transportation system at risk.

It is important for INDOT to know what types of retaining wall assets it has in its inventory, their existing physical conditions, and how they are serving against expectations. Collecting and maintaining this information will allow INDOT to plan appropriate maintenance actions for existing walls, plan future projects, and make informed decisions regarding future retaining wall design standards and specifications, policies, and procedures for retaining walls. This chapter serves as reference for INDOT personnel for the collection of retaining wall inventory and inspection data.

2.0 DEFINITIONS

Anchor – A tendon, tendon bundle, rod, or bar element that is installed into the ground through the wall and anchored into stable material well behind potentially unstable soil, then tensioned and attached to the wall to provide additional resistance to earth pressures. Anchors are also referred to as Tie-Backs or Ground Anchors.

Bin Wall – A type of gravity retaining wall consisting of bins typically fabricated from metal or concrete, filled with granular soil material, and then placed adjacent and atop of one another. The individual bins are typically placed in a non-interlocking manner.

Cantilever Semi-Gravity – A type of retaining wall that has a vertical stem wall that is structurally connected to a base slab, or footing. The base slab may be either bearing directly on underlying foundation soil or supported on piles. The vertical stem wall is typically reinforced concrete or reinforced, solid-grouted concrete masonry block, while the base slab is reinforced concrete. The combined weight of the retaining wall itself and the soil mass on the base slab provides overall stability against earth pressures, while the stem wall behaves as a vertical cantilever member that is reinforced at the base of the wall providing cantilever resistance to lateral earth pressures.

Crib Wall – A type of gravity retaining wall consisting of interlocking elements of timber, metal, or precast concrete arranged in the form of bins (or cribwork) and filled with granular soil material. Crib walls gain their stability not only from their weight but also to some extent from the strength of fill within the bins.

Drilled Shaft – A structural element constructed using an auger to drill into a soil mass to remove soil and then filling the drilled void with concrete. Drilled shafts used for retaining wall construction are typically built as Secant Walls (consisting of overlapping or intersecting drilled shafts), Soldier Walls (consisting of spaced drilled shafts with lagging), or Tangent Walls (consisting of drilled shafts placed side-by-side and touching one another but not overlapping).

Gabion – A cage, wire container, cylinder, or similar type box filled with rocks, broken concrete, or granular soil used in retaining wall and erosion control applications.

Gravity Wall – A wall typically built with stone masonry, mass concrete, or other heavy material that depends on its overall mass, or weight, to resist earth pressure from behind.

Lagging – Structural members that are typically timber, steel, or concrete that are installed behind, between or in front of piles or drilled shafts to support and retain the soil material between spaced

piles. Timber lagging is typically used for temporary construction while steel or concrete lagging is typically used for permanent construction.

Modular Block Wall – A gravity wall built using interlocking blocks that are typically masonry, concrete, or concrete masonry units (CMU) to resist earth pressure from behind. Some modular block walls may also use artificial reinforcing similar to MSE walls.

MSE – Mechanically stabilized earth, sometimes referred to as reinforced soil, is a soil mass embankment constructed with artificial reinforcing that typically consist of either geosynthetics or steel material. When used as retaining walls, MSE walls are designed as gravity walls built with multiple layers of horizontal reinforcing in granular backfill connected to wall face components.

Pile – A structural element driven or drilled into the ground to resist vertical and/or horizontal loads. Piles are usually rolled steel shapes, concrete, or timber.

Retaining Wall – A permanent, relatively rigid structure that supports a soil mass at slopes steeper than their angle of rest to provide usable space both above and in front of the wall.

Sheet Pile Wall – A cantilever wall built using interlocking plate piles fabricated from pressed or molded steel sheet metal to provide structural resistance to lateral earth pressures. Such walls can be fully cantilevered or include anchors for additional resistance.

Soil Nails – Steel rods providing soil reinforcement into embankments that are either grouted into drilled holes or driven into soil at close spacing.

Soldier Pile Wall – A cantilever wall built using piles, typically rolled steel shapes and installed at regular intervals (nominally 6-foot to 10-foot spacings) to provide structural resistance to lateral earth pressures. Lagging is then placed between the soldier piles to both support and retain the soil material between piles and to transfer those lateral earth pressures to the soldier piles. Such walls can be fully cantilevered or include anchors for additional resistance.

3.0 RETAINING WALL INVENTORY

The retaining wall inventory includes inventory data along with available design plans, geotechnical reports, soil borings, and construction records. Other initial asset information and condition data for retaining walls built and in service on or before 2018 previously resided in the INDOT Collaborative GIS Retaining Walls Map and have since been copied into the INDOT Total Asset Management System (iTAMS). However, for all retaining walls built and put into service on or after 2018, all newly collected inventory and condition data, along with all available design and shop drawing plans, reports, soil borings, and construction records, will be stored in the iTAMS retaining wall asset.

RETAINING WALL MANUAL

The following retaining wall asset inventory information will be maintained in iTAMS and updated as required by inspectors

Item ID	Format	Description
WALL ID	N (5)	Retaining wall asset identification numbers initially assigned by geotechnical department inventory project. For new walls built, identification number will be assigned by iTAMS Admin.
NBI	N (6)	For retaining walls that directly support a bridge asset, report the Bridge Number (NBI Item 8 or SNBI Item B.ID.01). Leave this item blank if not applicable.
Route Name	AN (50)	Route name or description initially provided by geotechnical department inventory project; inspector may update this information as required. For new walls built, Route Name description will be provided by the inspector.
Associated Feature	AN (50)	Descriptions initially provided by geotechnical department inventory project that typically described features such as wing walls, substructure units, or ramps; inspector may update this information as required. For new walls built, the Associated Feature description will be provided by the inspector.
District	N (2)	INDOT District Number (NBI Item 2 or SNBI Item B.L.04).
Latitude	N (9,6)	Retaining wall asset latitude initially assigned by geotechnical department inventory project and will be verified during first inspection done in iTAMS. For newly built walls, latitude will be assigned by iTAMS Admin.
Longitude	N (10,6)	Retaining wall asset longitude initially assigned by geotechnical department inventory project and will be verified during first inspection done in iTAMS. For newly built walls, longitude will be assigned by iTAMS Admin.
Year Built	N (4)	Year of initial construction (new or replacement wall).
Year Rehab	N (4)	Year of last repair or rehabilitation work.
Contract Number	AN (10)	Enter full contract number if known; leave blank otherwise.
DES Number	N (6)	Enter the full DES number for the construction contract if known; leave blank otherwise.

Vendor Name	AN (50)	Retaining wall vendors identified during the geotechnical department inventory project. For newly built walls, enter name of retaining wall vendor.
Comments	AN (300)	Some comments were initially provided by the geotechnical department inventory project; inspector may update this information as required. For newly built walls, comments may be provided by the inspector as warranted.

Code	**Wall Type**
MSE	Mechanically Stabilized Earth (MSE)
CSG	Cantilever Semi-Gravity
G	Gravity
CDS	Cantilever Drilled Shaft
ADS	Anchored Drilled Shaft
CSH	Cantilever Sheet Pile
ASH	Anchored Sheet Pile
CSP	Cantilever Soldier Pile
ASP	Anchored Soldier Pile
MBW	Modular Block Wall
BN	Bin
CB	Crib
O	Other

Code	**Primary Wall Material**
PC	Precast Concrete
CIP	Cast-in-Place Concrete
STL	Steel
MB	Masonry Block
ST	Stone

TM	Timber
O	Other

In addition to the above detailed retaining wall inventory data, the following wall geometric data will be collected by the inspector for all retaining wall inspections first done in iTAMS:

RETAINING WALL GEOMETRY		
Item ID	**Format**	**Description**
Min HT	N (5,1)	Minimum measured height of retaining wall exposed face.
Max HT	N (5,1)	Maximum measured height of retaining wall exposed face.
SSU HT	N (5,1)	Nominal average measured height of retaining wall exposed face along the front face of the bridge substructure unit, as applicable. For retaining walls not associated with a bridge, leave blank.
Total Length	N (5,1)	Total length of retaining wall measured from end to end. For retaining walls associated with a bridge, this measurement shall be the sum of the wingwalls and substructure front face wall.
SSU Length	N (5,1)	Total length of retaining wall segment along the front face of the bridge substructure unit, as applicable. For retaining walls not associated with a bridge, leave blank.
Exposed Wall Facing Area	N (6,1)	Total exposed surface area of retaining wall asset from end to end. For retaining walls associated with a bridge substructure unit, this measurement shall include in totality the wingwalls and substructure front face wall.

4.0 RETAINING WALL INSPECTION

The INDOT retaining wall inspection process is not intended to be a thorough evaluation of a retaining wall's overall structural integrity or geotechnical stability. Rather, the inspection is to report the apparent visible physical condition of the retaining wall and its components, its drainage system as applicable, and the ground and embankment conditions above the retained height and along the exposed face of the wall.

The retaining wall inspector shall provide condition ratings for both the retaining wall as a whole and its components, collect photographs, measurements, and inspections notes documenting both the overall typical conditions and suspect areas exhibiting deterioration or issues, report

maintenance needs and recommendations, and provide a general recommendation of whether the wall condition warrants a more thorough investigation by retaining wall specialists.

4.01 RETAINING WALL INSPECTION TYPES

4.01.01 Initial Inspection

An initial inspection is the baseline inspection that shall be completed on either newly built retaining walls or following any major rehabilitation or repair work, or when the overall geometric configuration of the wall changes. Initial inspections shall be carried out within 90 days following either the creation of a new retaining wall asset in the State's asset inventory database or following completion of construction work. The scope of the initial inspection should be a fully documented investigation that includes the following:

1. Verify accuracy of retaining wall asset inventory information as initially entered into the asset file by the database administrator and collect any missing asset inventory information.

2. Verify accuracy of geometric dimensions and report any missing information.

3. Complete a visual inspection of all accessible surfaces of the retaining wall and appurtenant soil embankment areas to determine the baseline overall retaining wall and applicable retaining wall component condition assessment codes.

4. Document any observed deficiencies, defects, construction errors and anomalies, large gaps or joint openings (with or without visible backfill leakage), alignment problems, issues that could cause drainage or runoff problems, and embankment irregularities.

5. Presence or absence of drainage curbs and turnouts directing water away from the retaining wall backfill areas, noting the apparent condition and effectiveness of such components.

6. Document any observed pavement deficiencies, such as dips, depressions, paving irregularities, and major cracking that could suggest embankment voids within soils retained by the wall.

7. Gather available information, such as design plans, shop drawings, geotechnical reports, soil borings, and construction records necessary to maintain an accurate and complete wall asset file. Scan and upload information to the wall asset file in the state's inventory database.

4.01.02 Routine Inspections

Routine inspections are inspections scheduled and completed at defined regular intervals to collect observations, photographs, and measurements necessary to document the visible physical and functional condition of the retaining wall at the time the inspection is done and identify any changes from previously reported conditions. The routine inspection also verifies that the wall appears able to satisfy present service conditions.

Routine inspections are generally done from the ground level along the wall face and from the embankment retained by the wall. Routine inspections require a complete walk-around visual inspection of all primary and secondary wall components. Tactile inspection means through use of hammers, probes, measuring devices, and similar such hand tools shall also be used to assess the apparent physical condition of the wall components. The scope of retaining wall routine inspections should include the following:

1. Verify accuracy of reported retaining wall asset inventory information.

2. Assess the current physical condition of all primary and secondary components of the retaining wall visible and accessible. Assess current visible conditions against previously reported sizes, locations, and severity of defects and deficiencies.

3. Take sufficient elevation photographs of the retaining wall to document the overall physical condition.

4. Take sufficient photographs, measurements, and notes of the retaining wall primary and secondary components to document typical conditions and apparent defects or issues. All apparent defects, deterioration, collision damage, large gaps or joint openings (with or without visible backfill leakage), alignment problems, or similar issues must be documented by type, size, location, and severity.

5. Take additional photographs along with dimensional measurements of retaining wall components identified to be in poor physical condition; sufficient photographs of poor condition components must be taken to fully document the visible defects, deterioration, collision damage, or other issues.

6. Document and take sufficient photographs of any dips, depressions, heaving or erosion along the retaining wall front fascias, erosion of the backfill areas behind the wall tops, and locations of soil grading abnormally.

7. Document and take sufficient photographs of any pavement or approach slab defects, such as cracking, settlement, or underlying void, for pavements or approach slabs located behind the retaining walls.

8. Report on any required maintenance work needs through the INDOT Work Management System.

9. Report as a critical finding any retaining wall that exhibits any major defects, significant movements, or visible embankment settling or displacements. The inspector shall take sufficient photographs and field measurements to document the conditions observed and include this field information in the critical finding notification.

4.01.03 Damage Inspection

Damage inspections are unscheduled inspections done to assess either structural damage resulting from environmental factors or human actions, or apparent geotechnical instability from ground settlement, soil heave, or soil erosion. The scope of a damage inspection should be sufficient to determine whether there is a need for either a restriction or a full closure of the nearby bridge or roadway asset that are on or along the embankments supported by the retaining wall.

The amount of effort expended on damage inspections may vary significantly and is highly dependent on the extent and severity of the damage. However, in all instances, the inspector shall fully document the type, size, location, and severity of the damage done to the retaining wall using photographs and field measurements. Vehicle collision incidents or sudden, adverse ground/embankment movements.

Damage reports shall be completed as soon as possible, but no later than seven (7) days after the field inspection is completed. Damage inspections and reports shall be done for all retaining walls in which the damage incident has left permanent physical evidence. If possible, the inspector should include any police report or accident number in the damage report. This information shall be included in the damage report and will be used by INDOT to collect financial reimbursements from the appropriate insurance companies for damages to state property.

4.02 RETAINING WALL INSPECTION TERMS

Inherent Defect: Not indicative of damage or deterioration but is either a characteristic of the material or the result of normal construction practices. Examples include insignificant width fabrication, shrinkage, and temperature cracks, pop-outs, or shallow edge chips and spalls.

Minor Defect: Damage or deterioration has initiated but is not considered significant. Examples include minimal to moderate width cracks with no efflorescence or rust stains, shallow depth spalls with no exposed reinforcing steel, or speckled surface rust.

Moderate Defect: Damage or deterioration is significant, but the strength or performance is not yet adversely affected. Examples include moderate width cracks with either efflorescence or rust stains, spalls with exposed reinforcing steel, or more pronounced surface rust and corrosion with either pitting or delamination. Defects or deterioration at this level may not yet warrant a structural or geotechnical review.

Major Defect: Damage or deterioration is significant, and the strength or performance is adversely affected. Examples would be similar in type to moderate defects but of greater magnitude and severity that, upon reporting, would require a structural or geotechnical review.

Isolated: Defect is visible in one or few incident locations.

Widespread: Defect is visible across many incident locations.

Some: Defect visibility is more than isolated and less than widespread.

4.03 RETAINING WALL CONDITION RATINGS

The following condition ratings shall be used to evaluate the overall retaining wall condition from a holistic frame of reference.

Code	Condition	Description
9	EXCELLENT	None or isolated inherent defects. Appears stable.
8	VERY GOOD	Some inherent defects. Appears stable.
7	GOOD	Some minor defects. Appears stable. Isolated insignificant movements, separations, or distortions.
6	SATISFACTORY	Widespread minor or isolated moderate defects. Appears stable, but widespread insignificant or isolated minor movements, separations. or distortions visible.
5	FAIR	Some moderate defects. Some minor movements, separations, or distortions are visible. Overall apparent strength and functionality of the wall is not affected.
4	POOR	Widespread moderate or isolated major defects. Widespread movements, separations, or distortions are visible. Overall apparent strength and functionality of the wall is affected.
3	SERIOUS	Widespread major defects. Widespread movements, separations, or distortions visible. Strength and functionality detrimentally affected and local failure appears likely.
2	CRITICAL	Strength and functionality detrimentally affected and isolated local failures present. Restrictions behind or in front of the wall are either warranted or in place, and corrective actions are needed to keep the wall in service.
1	IMMINENT FAILURE	Wall essentially failed. Areas behind and in front of the wall must be closed off due to serious material movement and loss of retainment. Repair or rehabilitation may return wall to service.
0	FAILED	Wall failed. Areas behind and in front of the wall must be closed off due to serious material movement and loss of retainment. Wall is beyond corrective action and must be replaced to restore service.

4.04 RETAINING WALL COMPONENT CONDITION RATINGS

Retaining walls typically consist of primary and secondary components. Primary components directly provide the structural strength and geotechnical stability that retain the soil mass and allow the wall to function as designed. Secondary components are non-structural features that contribute to the overall aesthetics, integrity, and functionality of a retaining wall system. Assigning separate condition ratings to the applicable primary and secondary retaining wall components will assist the inspector in assigning the retaining wall condition rating. The following condition ratings shall be used to evaluate the below defined primary and secondary components.

Primary components:

1. Wall fascia elements: panels or lagging.
2. Wall vertical elements: drilled shafts, caissons, soldier piles, or MSE corner panels.
3. Wall anchorages: ground anchors, tiebacks, or soil nails.

Secondary components:

1. Wall coping caps.
2. Drainage elements.
3. Soil embankment or pavement conditions along top of wall.
4. Soil embankment or pavement conditions along base of wall.
5. Vegetation.

Code	Condition	Description
7	GOOD	Appears predominantly sound, intact, and functioning as intended with little to no visible deterioration, defects, movements, or adverse issues. Drainage elements where visible appear open and functioning. Ground surfaces are well graded with no visible deformation or erosion. Little to no vegetation growth either adversely affecting the wall or prohibiting access for inspection.

5	FAIR	Appears predominantly sound and functional. Minor to moderate deterioration, defects, local minor movement and rotation, or issues visible that are consistent with the wall age. Drainage elements where visible appear open and functioning with little drainage erosion. Ground surfaces exhibit some minor to moderate erosion or heave. Vegetation growth is measurable but is not visibly affecting the wall or prohibiting access for inspection.
4	POOR	Widespread deterioration, defects, or issues visible such that the apparent strength and functionality is adversely affected. Major movement or rotation visible. Drainage elements appear visibly damaged or not functioning. Backfill leaking from behind the wall. Ground surfaces noticeably deformed, heaved, or eroded. Vegetation growth is measurable and visibly affects the wall or prohibiting access for inspection.
3	SERIOUS	Significant deterioration and issues; major movement or rotation visible; apparent strength and functionality are detrimentally affected and local failures either appear likely or are already present. Major loss of backfill apparent. Drainage elements are not functional. Ground surfaces exhibit significant distortion, heave, or erosion. Vegetation growth is excessive, impacting wall serviceability, or prohibiting inspection access.
N	NOT APPLICABLE	Retaining wall component is not present.

4.05 RETAINING WALL INSPECTION FREQUENCIES

The overall retaining wall condition rating shall be used to set inspection frequency. The following maximum inspection frequencies shall be assigned. Based upon inspection conditions and at the discretion of the inspector, and as approved by the district bridge inspection supervisor, a more frequent inspection interval may be assigned.

Condition Rating 7 or higher: 72 months for stand-alone retaining walls not part of bridge.

Condition Rating 7 or higher: 48 months for retaining walls integral to bridge substructures.

Condition Rating 6 or 5: 24 months.

Condition Rating 4 or less: 12 months

To promote the overall efficiency of the agency's labor efforts, retaining wall inspections shall be scheduled and done as either part of routine bridge inspections or along corresponding route-based inspection cycles.

5.0 CRITICAL FINDINGS

A critical finding is defined as being either a structural or public safety deficiency that represents an immediate hazard to either the structural stability of the retaining wall or an immediate public safety danger and requires immediate corrective action. A structural deficiency is one that disrupts the load path and does not allow loads acting on the retaining wall to be supported and transferred as designed, causing either overstress or instabilities that could potentially lead to either a partial or total collapse of the wall. A public safety danger may also be non-structural but poses a hazard to the safety of motorists or pedestrians.

Upon identifying a potential critical finding, the inspector shall report the critical finding to the INDOT bridge inspection statewide program manager (SPM) verbally via phone and in writing via email (Microsoft Outlook or equivalent). This notification must be done within 24 hours following discovery of the retaining wall critical finding. Critical Finding Incident Reports in iTAMS (as are done for bridge critical findings) are **not required** for retaining wall critical findings, as such assets are not under FHWA reporting mandates or regulations. Written notifications of critical findings shall include the following information:

1. Retaining wall asset identification and location.

2. Date critical finding was discovered.

3. Photographs and field measurements documenting the observed critical finding conditions.

4. Assessment of critical finding priority. Urgent Priority requires corrective action be done within 3 days of discovery. Severe Priority requires corrective action be done within 30 days of discovery.

5. Inspector's recommendations for immediate corrective actions. When making immediate corrective action recommendations, the inspector must consider who will be responsible for carrying out any corrective actions, as well as if the corrective actions can be reasonably done within the critical finding priority requirements.

The SPM will maintain critical finding incident notifications for tracking and follow up, and will work with the inspector, district bridge inspection supervisor, and other INDOT personnel (that will likely include the responsible district system asset manager and INDOT geotechnical department) to ensure that appropriate corrective actions are completed and documented. Once the immediate hazards are addressed, the SPM will formally close the critical finding incident.

6.0 EXAMPLES

Retained for future use.

The intention of this final section is to provide drawings and photographs showing the types of typical retaining walls that the inspectors are likely to encounter in the field and the types of defects or deficiencies that are particular to retaining walls. Wherever possible, the drawings should be ones taken from INDOT's design manuals and the photographs should be ones of INDOT retaining walls.