PROFESSIONAL PRACTICE GUIDELINES

CIVIL AND TRANSPORTATION INFRASTRUCTURE

RETAINING WALL DESIGN

VERSION 1.1
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ENGINEERS &
GEOSCIENTISTS
BRITISH COLUMBIA

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PREFACE

These *Professional Practice Guidelines – Retaining Wall Design* were developed with the support of the City of Nanaimo.

These guidelines will assist Engineering Professionals in undertaking the design of Retaining Walls in a consistent manner, incorporating best practices such as providing complete documentation, and following appropriate quality management procedures. The focus of these guidelines is on the geotechnical aspects of Retaining Walls; however, some regulatory and structural issues are also discussed.

These guidelines were written for the information of Engineering Professionals, statutory decision-makers, regulators, the public, and other stakeholders who might be involved in, or have an interest in, Retaining Wall design in British Columbia (BC).

These guidelines provide a common level of expectation for various stakeholders with respect to the level of effort, due diligence, and standard of practice to be followed when carrying out Retaining Wall design and construction in BC.

This current revision was undertaken to clarify when the assurance statement should be completed, to add field review requirements to the assurance statement, and to clarify other minor items.

These guidelines outline the appropriate standard of practice at the time that they were prepared. However, this is a living document that is to be revised and updated, as required, in the future, to reflect the developing state of practice.

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ABBREVIATIONS

ABBREVIATION	TERM
BC	British Columbia
BCBC	*British Columbia Building Code*
CFEM	Canadian Foundation Engineering Manual
CHBDC	*Canadian Highway Bridge Design Code*
CSA	Canadian Standards Association
FHWA	Federal Highway Administration
MFLNRORD	Ministry of Forests, Lands, Natural Resource Operations and Rural Development
MoTI	Ministry of Transportation and Infrastructure
MSE	mechanically stabilized earth
NBC	*National Building Code of Canada*
VBBL	Vancouver Building By-law

DEFINED TERMS

The following definitions are specific to these guidelines. These words and terms are capitalized throughout the document. Also see Section 1.3 Introduction of Terms for more information and other terms related to Retaining Walls.

TERM	DEFINITION
Act	*Engineers and Geoscientists Act* [RSBC 1996], Chapter 116.
Association	The Association of Professional Engineers and Geoscientists of the Province of British Columbia, also operating as Engineers and Geoscientists BC.
Authority Having Jurisdiction	The jurisdictional body (usually municipal) with authority to administer and enforce the *British Columbia Building Code* (*BCBC*), the City of Vancouver Building By-law (VBBL), the *National Building Code of Canada* (NBC), or a local building bylaw or code.
Bylaws	The Bylaws of the Association made under the *Act*.
Cantilever Retaining Wall	A structure, which is usually either cast-in-place or made of precast concrete but could include reinforced masonry, consisting of a concrete stem and a base (which is typically a concrete foundation slab), and where both the stem and the base are relatively thin and reinforced to resist the applied moments and shear forces resulting from the lateral earth loading.
Engineer of Record	An Engineering Professional: (a) with the appropriate education, training, and experience to provide professional services related to Retaining Wall design and field review, as described in these guidelines; and (b) who takes overall responsibility for all aspects of the design and field reviews for the Retaining Wall.
Engineering Professional(s)	Professional engineers and licensees who are registered or licensed by the Association and entitled under the *Act* to engage in the practice of professional engineering in British Columbia.
Engineers and Geoscientists BC	The business name for the Association.
Geoscience Professional(s)	Professional geoscientists and licensees who are registered or licensed by the Association and entitled under the *Act* to engage in the practice of professional geoscience in British Columbia.
Geotechnical Materials	Soil, rock, mineral ore, and lightweight fill such as pumice or bottom ash.
Gravity Wall	A structure providing lateral support for a mass of soil that owes its stability primarily to its own weight and to the weight of the soil located directly above its base. It depends entirely on the weight of the stone or concrete masonry and of any soil resting on the masonry or concrete foundation slab for its stability, and only a nominal amount of steel is placed near the exposed faces to minimize the risk of surface cracking due to temperature changes.

TERM	DEFINITION
Mechanically Stabilized Earth Wall or MSE Wall	A soil-retaining system employing either strip or grid-type, metallic, or polymeric tensile reinforcements in the soil mass, and a Wall Facing element that is either vertical or nearly vertical. These walls are sometimes referred to as "structural earth walls" and "retained soil systems." They typically use a range of proprietary Wall Facing elements and require soil reinforcement for stability. Also included in this category are green walls, in which the Slope Protection supports vegetation growth. For the purpose of these guidelines, geosynthetic reinforced soil technology, which uses a geosynthetic as the reinforcing element in the soil-retaining system, is considered to be a Mechanically Stabilized Earth Wall.
Prefabricated Modular Wall	A soil-retaining system employing interlocking soil-filled timber, synthetic polymer, reinforced or unreinforced concrete, masonry, or steel modules or bins to resist earth pressures by acting as a Gravity Wall.
Retaining Wall	A vertical or near-vertical structure constructed to hold back Geotechnical Materials and safely deal with any hydrostatic pressure. Retaining Walls can be created out of a variety of structural and Geotechnical Materials. Retaining Walls typically stabilize soil and rock against downslope movement and provide lateral support for steep to vertical grade changes.
Segmental Block Gravity Wall	A soil-retaining system utilizing manufactured interlocking blocks, usually of concrete, including lock-block walls and proprietary walls such as Allan block walls. A lower wall may comprise only the blocks retaining soil. A higher wall may use the blocks as Wall Facing elements for a Mechanically Stabilized Earth Wall.
Semi-Gravity Wall	Similar to a Gravity Wall, a structure providing lateral support for a mass of soil that owes its stability primarily to its own weight and to the weight of the soil located directly above its base. However, a Semi-Gravity Wall is more slender and requires reinforcement consisting of vertical bars and dowels continuing into the base.
Slope Protection	Materials placed on the face of a stable slope to minimize the risk of surficial erosion, and sometimes called "revetment." Slope Protection typically refers to vegetation but can also include manufactured products such as erosion-control blankets.
Stacked Rock Wall	A soil-retaining system employing interlocking pieces of rock to resist lateral earth pressures by acting as a Gravity Wall. These walls can be constructed with or without mortar and with or without geogrid. These are also referred to as rockeries, dry-stacked, or dry-stone walls. If a Stacked Rock Wall is used in conjunction with soil reinforcement, it is considered an MSE Wall.
Wall Facing	Materials placed on the face of a stable slope to minimize the risk of surficial erosion, and sometimes called "revetment." Wall Facing typically refers to rock, concrete paving, or other hard surfacing.

VERSION HISTORY

VERSION NUMBER	PUBLISHED DATE	DESCRIPTION OF CHANGES
1.1	February 25, 2020	Clarification of when the assurance statement should be completed, inclusion of field review requirements in the assurance statement, and other minor clarifications.
1.0	November 19, 2019	Initial version.

1.0 INTRODUCTION

Engineers and Geoscientists British Columbia (the Association) is the regulatory and licensing body for the engineering and geoscience professions in British Columbia (BC). To protect the public, the Association establishes, maintains, and enforces standards for the qualifications and practice of its members and licensees.

The Association provides various practice resources to its members and licensees to assist them in meeting their professional and ethical obligations under the *Engineers and Geoscientists Act* (the *Act*). One of those resources are professional practice guidelines, which establish the standard of practice for specific professional activities. The Association works with experts in their fields to develop professional practice guidelines where additional guidance is beneficial or required.

These *Professional Practice Guidelines – Retaining Wall Design* provide guidance on professional practice for Engineering Professionals who design Retaining Walls, including on the issues that must be considered and addressed during Retaining Wall design. Guidance is also provided on how Engineering Professionals can meet their obligations regarding quality management requirements, specifically regarding project documentation and the need for independent structural review.

This current revision was undertaken to clarify when the assurance statement should be completed, to add field review requirements to the assurance statement, and to clarify other minor items.

1.1 PURPOSE OF THESE GUIDELINES

This document provides guidance to Engineering Professionals who carry out a range of professional activities related to the design of Retaining Walls in BC.

Following are the specific objectives of these guidelines:

1. Describe the standard of practice that Engineering Professionals should follow when providing professional services related to Retaining Wall design.
2. Specify the tasks and/or services that Engineering Professionals should complete to meet the appropriate standard of practice and fulfill their professional obligations under the *Act*. These obligations include the Engineering Professional's primary duty to protect the safety, health, and welfare of the public and the environment.
3. Describe the roles and responsibilities of the various participants/stakeholders involved in these professional activities. The document should assist in delineating the roles and responsibilities of the various participants/stakeholders, which may include the Engineer of Record and the owner.
4. Define the skill sets that are consistent with the training and experience required to carry out these professional activities.
5. Provide guidance on the use of the assurance statement (Appendix A: Engineer of Record – Retaining Wall Assurance Statement). The purpose of this assurance statement is to assist Engineering Professionals in considering and addressing relevant regulatory and technical issues.
6. Provide guidance on how to meet the quality management requirements under the *Act* and Bylaws when carrying out the professional activities identified in these professional practice guidelines.

1.2 ROLE OF ENGINEERS AND GEOSCIENTISTS BC

These guidelines were prepared by subject matter experts and reviewed at various stages by a formal review group. The final draft of the guidelines underwent a final consultation process with various committees and divisions of the Association. These guidelines were approved by the Association's Council and, prior to publication, underwent final legal and editorial reviews. These guidelines form part of the Association's ongoing commitment to maintaining the quality of professional services that Engineering Professionals provide to their clients and the public.

An Engineering Professional must exercise professional judgment when providing professional services; as such, application of these guidelines will vary depending on the circumstances, including where site-specific conditions need to be addressed or in the event that there are changes in legislation or regulations subsequent to the publication of these guidelines. Where an Engineering Professional intends to substantially deviate from applying these guidelines, consideration should be made to obtain a second opinion on the merits of the deviation.

The Association supports the principle that appropriate financial, professional, and technical resources should be provided (i.e., by the client and/or the employer) to support Engineering Professionals who are responsible for carrying out professional activities, so they can comply with the standard of practice outlined in these guidelines. These guidelines may be used to assist in the level of service and terms of reference of an agreement between an Engineering Professional and a client.

These guidelines are intended to assist Engineering Professionals in fulfilling their professional obligations, especially regarding the first principle of the Association's Code of Ethics, which is to "hold paramount the safety, health and welfare of the public, protection of the environment and promote health and safety in the workplace." Failure to meet the intent of these guidelines could be evidence of unprofessional conduct and lead to disciplinary proceedings by the Association.

1.3 INTRODUCTION OF TERMS

The following terms should be noted for these guidelines. Also see the Defined Terms section at the front of the document for formal definitions specific to these guidelines.

1.3.1 ENGINEER OF RECORD

The Engineer of Record is an Engineering Professional with the appropriate education, training, and experience to provide professional services related to Retaining Wall design and field review, as described in these guidelines. The Engineer of Record takes overall responsibility for all aspects of the design and field reviews for the Retaining Wall.

1.3.2 RETAINING WALLS

The following are expanded definitions and additional terms related to Retaining Walls.

1.3.2.1 Overview of Retaining Walls

A Retaining Wall is a vertical or near-vertical structure constructed to hold back Geotechnical Materials and safely deal with any hydrostatic pressure. Retaining Walls can be created out of a variety of structural and Geotechnical Materials. Geotechnical Materials include soil, rock, mineral ore, and lightweight fill such as pumice or bottom ash. Retaining Walls typically stabilize soil and rock against downslope movement and provide lateral support for steep to vertical grade changes.

A reinforced slope is a constructed earth slope (an inclined surface, either natural or constructed) containing reinforcing elements (for example, geogrid) within the soil mass and Slope Protection and/or Wall Facing to provide erosion protection. A reinforced slope steeper than 45° (1H:1V) should be treated as a Retaining Wall, for the purposes of these guidelines.

Slope Protection and Wall Facing are materials placed on the face of a stable slope to minimize the risk of surficial erosion, sometimes called "revetment." Slope Protection typically refers to vegetation but can also include manufactured products such as erosion-control

blankets. Wall Facing typically refers to rock, concrete paving, or other hard surfacing. Slope Protection and Wall Facing are not considered Retaining Walls if slope stability analysis shows the slope is stable with and without the Slope Protection and Wall Facing.

A Retaining Wall is considered critical to the stability of a building foundation when any part of it lies within the zone of influence of the foundation, typically defined as being below a 1H:1V plane extending downwards from the outside of a building footing. The zone of influence should be confirmed with stability analysis for foundations within or near the 1H:1V plane or for soil conditions that merit it (for example, fissured clay). If the 1H:1V plane is encroached by a temporary slope excavated to facilitate Retaining Wall construction, the stability of this temporary slope, including the influence of building loads, should be assessed.

1.3.2.2 Types of Retaining Walls

Table 1: Types of Retaining Walls below describes the types of Retaining Walls for the purposes of these guidelines.

1.3.2.3 Characteristics of Typical Retaining Walls

Figures B-1, B-2, and B-3 in Appendix B: Illustrations of Terminology for Retaining Walls depict various characteristics of typical Retaining Walls, as discussed in these guidelines.

Table 2: Characteristics of Typical Retaining Walls below provides more detailed explanations of these characteristics and other terminology.

Table 1: Types of Retaining Walls

TYPE OF WALL	DESCRIPTION
Cantilever Retaining Wall	A structure, which is usually either cast-in-place or made of precast concrete but could include reinforced masonry, consisting of a concrete stem and a base (which is typically a concrete foundation slab), and where both the stem and the base are relatively thin and reinforced to resist the applied moments and shear forces resulting from the lateral earth loading.
Gravity Wall	A structure providing lateral support for a mass of soil that owes its stability primarily to its own weight and to the weight of the soil located directly above its base. It depends entirely on the weight of the stone or concrete masonry and of any soil resting on the masonry or concrete foundation slab for its stability, and only a nominal amount of steel is placed near the exposed faces to minimize the risk of surface cracking due to temperature changes.
Mechanically Stabilized Earth Wall or MSE Wall	A soil-retaining system employing either strip or grid-type, metallic, or polymeric tensile reinforcements in the soil mass, and a Wall Facing element that is either vertical or nearly vertical. These walls are sometimes referred to as “structural earth walls” and “retained soil systems.” They typically use a range of proprietary Wall Facing elements and require soil reinforcement for stability. Also included in this category are green walls, in which the Slope Protection supports vegetation growth. For the purpose of these guidelines, geosynthetic reinforced soil technology, which uses a geosynthetic as the reinforcing element in the soil-retaining system, is considered to be a Mechanically Stabilized Earth Wall.
Prefabricated Modular Wall	A soil-retaining system employing interlocking soil-filled timber, synthetic polymer, reinforced or unreinforced concrete, masonry, or steel modules or bins to resist earth pressures by acting as a Gravity Wall.

TYPE OF WALL	DESCRIPTION
Segmental Block Gravity Wall	A soil-retaining system utilizing manufactured interlocking blocks, usually of concrete, including lock-block walls and proprietary walls such as Allan block walls. A lower wall may comprise only the blocks retaining soil. A higher wall may use the blocks as Wall Facing element for a Mechanically Stabilized Earth Wall.
Semi-Gravity Wall	Similar to a Gravity Wall, a structure providing lateral support for a mass of soil that owes its stability primarily to its own weight and to the weight of the soil located directly above its base. However, a Semi-Gravity Wall is more slender and requires reinforcement consisting of vertical bars and dowels continuing into the base.
Stacked Rock Wall	A soil-retaining system employing interlocking pieces of rock to resist lateral earth pressures by acting as a Gravity Wall. These walls can be constructed with or without mortar and with or without geogrid. These are also referred to as rockeries, dry-stacked, or dry-stone walls. If a Stacked Rock Wall is used in conjunction with soil reinforcement, it is considered an MSE Wall.

Table 2: Characteristics of Typical Retaining Walls

CHARACTERISTIC	DESCRIPTION
backslope	Average ground inclination measured from the top of the Retaining Wall to the crest of the slope of retained soil (see Figure B - 1a).
blanket drain or chimney drain	A vertical drain located directly against the back of a Retaining Wall (as shown in Figure B - 1a), or an inclined or horizontal drain on the surface of a cut slope or toe area, as shown in see Figure B - 1b, where seepage is occurring or may occur, to reduce water flow into the Retaining Wall backfill zone. A blanket drain provides full coverage along the length of the wall while a chimney drain provides intermittent coverage.
broken backslope	Backslope that reduces to a flatter/horizontal grade (see Figure B - 1b).
drainage system	An engineered system consisting of a permeable medium, hydraulically connected to subsurface pipes or weep holes through the Retaining Wall or beyond the end(s) of the wall, which collects, conveys, and discharges water; intended to reduce hydrostatic pressures and minimize the risk of erosion.
embedment depth	Depth from finished grade level in front of the Retaining Wall to the base of the wall footing; the minimum embedment depth is typically greater than the frost considerations and may also provide stability (see Figure B - 1a and Figure B - 1b).
external stability	Stability of the Retaining Wall relating to rotation (overturning), sliding (translation), and bearing capacity failure modes. (see Figure B - 3a and Figure B - 3b for rotation and sliding)
Geotechnical Materials[a]	Soil, rock, mineral ore, and lightweight fill such as pumice or bottom ash.
global stability	Stability against deep-seated failure that encompasses a Retaining Wall, or, in the case of terraced Retaining Walls, one or more of the individual walls.
internal stability	Stability against failure of materials comprising the Retaining Wall (for example, reinforced concrete in the case of cast-in-place Cantilever Retaining Walls, soil reinforcing in the case of Mechanically Stabilized Earth Walls).
reinforced fill zone	The composite backfill and reinforcement zone in a Mechanically Stabilized Earth Wall.

CHARACTERISTIC	DESCRIPTION
restrained (non-yielding) walls	Retaining Walls that are prevented from moving sufficiently to develop active pressures behind the wall.
retained soil	Fill (typically compacted mineral soil) immediately behind Gravity Walls or cast-in-place Cantilever Retaining Walls, and the backfill behind the reinforced fill zone in Mechanically Stabilized Earth Walls, as well as the *in-situ* Geotechnical Materials that require the Retaining Wall for stability.
Slope Protection[a]	Materials placed on the face of a stable slope to minimize the risk of surficial erosion, and sometimes called "revetment." Slope Protection typically refers to vegetation but can also include manufactured products such as erosion-control blankets.
toe slope	Average ground inclination measured from the exposed bottom of the wall to the toe of the slope in front of the wall.
unrestrained (yielding) walls	Retaining Walls that are able to move sufficiently to allow active pressures to develop behind the wall in the limiting condition.
wall batter	Slope of the front and/or back face of a Retaining Wall. Negative wall batter is when the top of the front face overhangs the bottom of the exposed wall.
wall height	Distance from the bottom of the exposed wall to the top of the Retaining Wall (see Figure B - 2a). Where the backslope above the wall or a toe slope below the wall is steeper than 2H:1V, the wall height should include the height of that slope (see Figure B - 2b). The wall height does not include the height of a parapet or guard where one is utilized.
wall movement	Rotational and/or sliding movement (as shown in Figure B - 3a and Figure B - 3b). Rotational movement results in an increase or decrease in the wall batter, whereas sliding movement does not significantly impact the wall batter.
Wall Facing[a]	Materials placed on the face of a stable slope to minimize the risk of surficial erosion, and sometimes called "revetment." Wall Facing typically refers to rock, concrete paving, or other hard surfacing.

NOTE

[a] These terms are capitalized because they are formally defined terms. See the list of Defined Terms at the beginning of these guidelines.

1.4 SCOPE OF THE GUIDELINES

These guidelines apply to the types of Retaining Walls discussed in Section 1.4.1 Retaining Walls Covered In These Guidelines below. The focus of these guidelines is on the geotechnical aspects of Retaining Wall design; however, some regulatory and structural issues are also discussed.

These guidelines are not intended to be prescriptive, nor are they intended to serve as a substitute for engineering judgement and experience. The Association recognizes that professionals and contractors may pursue innovative Retaining Wall design and construction. In such instances, it must be demonstrated that the proposed Retaining Wall will meet or exceed safety and performance expectations as outlined in these guidelines.

Where wall types are not specifically covered in these guidelines, Engineering Professionals should refer to the Association's professional practice guidelines entitled *Guidelines for Geotechnical Engineering Services for Building Projects* (Engineers and Geoscientists BC 1998) and *Guidelines for Legislated Landslide Assessments for Proposed Residential Developments in BC* (Engineers and Geoscientists BC 2010), and should use their own professional judgment.

1.4.1 RETAINING WALLS COVERED IN THESE GUIDELINES

These guidelines apply to the following types of Retaining Walls:

- Cantilever Retaining Wall
- Gravity Wall and Semi-Gravity Wall
- Segmental Block Gravity Wall
- Mechanically Stabilized Earth Wall (MSE Wall)
- Stacked Rock Wall

Retaining Walls, as described in the *BC Building Code* (*BCBC*) or the City of Vancouver Building By-law (VBBL) Part 9, Division B, Sentence 9.3.2.9.(4) and Appendix A, must be built in accordance with the applicable requirements of the *BCBC* or VBBL, and the guidance as provided in these guidelines.

For terraced Retaining Walls other than those described in Section 1.4.2 Retaining Walls Not Covered In These Guidelines, the design aspects covered in these guidelines should be considered for each wall, both individually and in combination.

1.4.2 RETAINING WALLS NOT COVERED IN THESE GUIDELINES

These guidelines do not apply to the following Retaining Wall types:

- Retaining Walls less than 1.2 m high, unless failure would impact a structure or impact life safety.
- Terraced Retaining Walls less than 1.2 m high, with:
  - average slope angles less than 45 degrees to the horizontal (1H:1V);
  - step-back distances (distances between successive walls when used in a series) greater than the wall height; and
  - an acceptable global factor of safety (consistent with established norms for each load case under consideration) for the entire terraced slope.
- Where Slope Protection and/or Wall Facing is not required for stability (i.e., factor of safety of the slope without the Slope Protection and/or Wall Facing is greater than 1.5 for static conditions).
- Retaining Walls for which specialized design is typically required (for example, soil nail walls, shotcrete and anchor walls, sheet pile walls, shoring systems).
- Retaining structures that are part of excavation and foundation systems for buildings, as identified under Division B, Section 4.2. of the *BCBC* or VBBL.
- Retaining structures for temporary excavations and trenches.
- Structures intended to retain water or to provide a protective barrier to dynamic/impact forces.

Note that the first two wall types listed above (Retaining Walls and terraced Retaining Walls less than 1.2 m high) would still benefit from engineering design, especially if future access to replace these walls will be limited. In addition, various Authorities Having Jurisdiction specify various wall heights above which retention of an Engineering Professional is required. Engineering Professionals should check the requirements of the jurisdiction in which they are working.

1.5 APPLICABILITY OF THE GUIDELINES

These guidelines provide guidance on professional practice for Engineering Professionals who carry out design of Retaining Walls. These guidelines are not intended to provide systematic instructions for how to carry out these activities; rather, these guidelines outline considerations to be aware of when carrying out these activities.

An Engineering Professional's decision not to follow one or more aspects of the guidance provided in these guidelines does not necessarily mean a failure to meet his or her required professional obligations. Such judgments and decisions depend upon weighing facts and circumstances to determine whether other reasonable and prudent Engineering Professionals, in similar situations, would have conducted themselves similarly.

1.6 ACKNOWLEDGEMENTS

These guidelines were prepared by Garry Stevenson, P.Eng., P.Geo., M.Eng., FGC, on behalf of Engineers and Geoscientists BC.

This document was reviewed by a group of technical experts, as well as by various committees and divisions of the Association. Authorship and review of these guidelines does not necessarily indicate the individuals and/or their employers endorse everything in these guidelines.

Engineers and Geoscientists BC would like to thank the City of Nanaimo for their initial work upon which these guidelines were based.

2.0 ROLES AND RESPONSIBILITIES

2.1 COMMON FORMS OF PROJECT ORGANIZATION

Retaining Walls are used for a wide variety of purposes, including building projects, bridge projects, or landscaping projects. Project organization and makeup of the project team will vary according to the needs of the project and the parties involved.

Regardless of the project organization, the various participants have particular responsibilities for Retaining Wall projects, as described below.

2.2 RESPONSIBILITIES

The following responsibilities of various potential project team members ensure the design and construction of a Retaining Wall meets the appropriate standards of public safety and the appropriate regulatory requirements.

2.2.1 OWNER

The owner should:

- retain the appropriate Engineering Professionals, as required, to complete the scope of the project;
- establish or agree to serviceability requirements equal to or more stringent than those shown in Table 3: Retaining Wall Design Guide;
- establish a design life greater than or equal to the minimum shown in Table 3: Retaining Wall Design Guide;
- obtain required approvals, licenses, and permits from the Authority Having Jurisdiction or other jurisdictional body;
- identify appropriate scopes of work and realistic schedules of work and enter into contracts with all Engineering Professionals whose expertise and services will be required;
- recognize that drawings, specifications, and other documents prepared by Engineering Professionals are for the project and should not be used or copied for other projects without the consent of the Engineering Professionals; and
- receive the assurance statement from the Engineer of Record upon completion of the design and field reviews for the Retaining Wall, as outlined in these guidelines.

After construction of the Retaining Wall is completed, the owner should:

- ensure periodic assessments are taking place to assess whether performance criteria continue to be met;
- maintain the drainage system;
- undertake any remedial measures identified during these assessments; and
- have a qualified Engineering Professional who is familiar with the design and construction of the Retaining Wall review any proposed changes to the wall, such as increasing the wall height, removing fill from in front of the wall, alterations to the drainage system, changes to loading conditions, and construction of a structure above or below the wall.

2.2.2 ENGINEER OF RECORD

The Engineer of Record takes overall responsibility for all aspects of the design and field reviews for the Retaining Wall.

The Engineering Professional who is acting as the Engineer of Record must determine what expertise is required for the project based on the type of wall and the site conditions. The Engineer of Record must then determine if he or she has the appropriate education, training, and experience to undertake all aspects of the design and field reviews (see Section 5.2 Education, Training, and Experience). If not, the Engineering Professional must engage one or more appropriate Engineering Professionals or Geoscience Professionals to assist with the project.

The Engineer of Record must:

- develop a scope for the project and review it with the owner;
- consider whether a structural engineer, geotechnical engineer, or Geoscience Professional should be retained to assist with the project;
- follow Section 3.0 Guidelines for Professional Practice of these guidelines when undertaking design and field review of the Retaining Wall;
- where applicable, coordinate, integrate, and review the work of any Engineering Professionals or Geoscience Professionals providing specialized services; and
- sign and seal the assurance statement located in Appendix A: Engineer of Record – Retaining Wall Assurance Statement.

3.0 GUIDELINES FOR PROFESSIONAL PRACTICE

3.1 OVERVIEW

Formally defined words and terms are capitalized throughout the document (see the list of Defined Terms).

Additional terms that should be noted for these guidelines are in Section 1.3 Introduction of Terms under

Table 1: Types of Retaining Walls and

Table 2: Characteristics of Typical Retaining Walls.

3.1.1 DESIGN LIFE

The design life of an engineered structure is the period of time (post-construction) over which the structure is expected to remain serviceable based on the intended design loads and site factors. The design, construction, environmental conditions, and maintenance of a specific structure greatly influences its useful design life.

Table 3: Retaining Wall Design Guide provides guidance on design issues, including typical maximum allowable static plus seismic wall movement, typical minimum design life, and design requirements. The guidance is based on wall height and the wall's potential to impact the structural integrity of adjacent facilities or structures.

The design life of a Retaining Wall includes both stability and serviceability aspects. For stability considerations, the design life depends on the consequence of a failure (see Table 3). For serviceability considerations, a minimum design life of 20 years for Wall Facing materials should be used for all types and categories of Retaining Wall. This implies that some reconstruction or replacement of the Wall Facing may be acceptable after 20 years, and access to do the work should be available.

Note that Table 3: Retaining Wall Design Guide is a general guide, but bylaws of Authorities Having Jurisdiction and other jurisdictional bodies may include requirements that supersede those described in the table.

3.1.2 FAILURE

For the purposes of these guidelines, "failure" implies that a Retaining Wall has not met its intended serviceability within its design life. This intended serviceability is specific to each Retaining Wall and must be identified at the time of design. Types of failure include the following:

- Collapse
  - Retaining Walls must be designed for "no collapse" under both static loading and the design earthquake loading. For these guidelines, "collapse" is defined as a failure that could endanger human life or cause damage to one or more adjacent structures. Some examples include a Retaining Wall falling over as a result of slow creep, blocks dislodging, or the wall toppling.
- Repairable damage
  - The owner may elect to have the Retaining Wall designed to experience repairable damage during the design earthquake. This means that the Retaining Wall can be repaired following an earthquake without complete reconstruction.

- Extreme damage
  - This normally applies to a severe loading event in which the Retaining Wall may suffer damage requiring complete reconstruction, but collapse does not occur.
- Excessive movement
  - A Retaining Wall may displace or rotate sufficiently to impact the function of the area above the retained soil. Examples are cracking of pavement and displacement of structures founded on the retained soil.

Table 3: Retaining Wall Design Guide

WALL HEIGHT (m)[a]	POTENTIAL TO IMPACT STRUCTURAL INTEGRITY OF ADJACENT FACILITIES OR STRUCTURES	TYPICAL MAXIMUM ALLOWABLE STATIC PLUS SEISMIC WALL MOVEMENT (mm)		TYPICAL MINIMUM DESIGN LIFE (years)[b]	DESIGN REQUIREMENTS	INDEPENDENT REVIEW REQUIRED
		ROTATIONAL	SLIDING			
<1.2	No impact	No restriction	No restriction	No restriction	• No design typically required[a] • No restrictions • No building permit typically required[c] • No field reviews required	No
≥1.2 to <3	No impact	Prevent negative wall batter	No restriction	20	• Building permit typically required • Field reviews required • Use either yielding or non-yielding lateral earth pressure calculation methods • No collapse, damage allowed	No
≥3 to 9	No impact	Prevent negative wall batter	<150	30	• Building permit typically required • Field reviews required • Use either yielding or non-yielding lateral earth pressure calculation methods • No collapse, damage allowed • Limit Stacked Rock Walls to 3.7 m high (and 4.6 m for Stacked Rock Walls designed as MSE Walls[d])	Yes
<9	Will impact	<25[e]	<50	50	• Building permit typically required • Field reviews required • No collapse, damage allowed	Yes
≥9 and special designs[f]	All cases	Special design[f]	Special design[f]	50	• Building permit typically required • Field reviews required • No collapse, damage allowed	Yes

NOTES

Abbreviations: m = metres; mm = millimetres; MSE = mechanically stabilized earth

[a] Various Authorities Having Jurisdiction and other jurisdictional bodies may specify their own wall heights, above which retention of an Engineering Professional is required. Engineering Professionals should check the requirements of the jurisdictions in which they are working. In the case of terraced walls, the wall height specified in this table would be the total height of all terraces, except in the case described in Section 1.4.2 Retaining Walls Not Covered In These Guidelines.

[b] The Ministry of Forests, Lands, Natural Resources Operations and Rural Development calls for a minimum design life of 45 years for permanent Retaining Walls.

[c] Refer to the bylaws of the Authority Having Jurisdiction or other jurisdictional body for specific requirements regarding permits.

[d] Guidance comes from Technical Circular T-01/10, Rock Stacked Retaining Walls (BC MoTI 2010). Engineering Professionals should carefully consider the use of stacked rock for walls greater than those limits.

[e] Horizontal movement measured at the top of the Retaining Wall (see Appendix B: Illustrations of Terminology for Retaining Walls, Figures B-3a and B-3b).

[f] Special design refers to Retaining Wall types not specifically covered by these guidelines; for example, soil nail walls, sheet pile walls, and other walls used as permanent Retaining Walls.

3.2 REGULATORY REQUIREMENTS

3.2.1 REQUIREMENTS OF AUTHORITIES HAVING JURISDICTION

Retaining Walls are regulated under various regulatory regimes. Engineering Professionals should review the applicable building codes, bylaws of the relevant Authority Having Jurisdiction, and requirements of other jurisdictional bodies to ensure conformance of the Retaining Wall design with all applicable requirements. Regulations for the following may influence Retaining Wall design:

- Required clearances
- Limits on wall height
- Limits on slopes of excavations and fills
- Aesthetic considerations
- Requirements for structural design

3.2.2 CANADIAN HIGHWAY BRIDGE DESIGN CODE

The design of Retaining Walls for highway projects is regulated by *CAN/CSA-S6-14 Canadian Highway Bridge Design Code* (*CHBDC*) (CSA 2014). See below for highway projects under the jurisdiction of the BC Ministry of Transportation and Infrastructure (BC MoTI).

3.2.3 MINISTRY OF TRANSPORTATION AND INFRASTRUCTURE

For highway projects under the jurisdiction of the BC MoTI, Retaining Wall design is regulated by the Supplement to CAN/CSA-S6-14 Bridge Standards and Procedures Manual (BC MoTI 2016). The Supplement specifies maximum heights for MSE Walls of 9 m for walls using extensible (geogrid) reinforcing elements and 12 m for walls using inextensible (steel) reinforcing elements.

The BC MoTI has further requirements in Technical Circular T-01/10, Rock Stacked Retaining Walls (BC MoTI 2010). This document applies to Stacked Rock Walls proposed under the MoTI subdivision process, and includes guidance specific to where these walls can be used, height restrictions, and specific design and construction requirements.

3.2.4 MINISTRY OF FORESTS, LANDS, NATURAL RESOURCES OPERATIONS AND RURAL DEVELOPMENT

The BC Ministry of Forests, Lands, Natural Resources Operations and Rural Development (MFLNRORD) has guidance on design life requirements and minimum factors of safety in its Engineering Manual (BC MFLNRORD 2019).

3.2.5 ENGINEERS AND GEOSCIENTISTS BC GUIDELINES

Engineering Professionals may also refer to the Association's professional practice guidelines, particularly where wall types are not specifically covered in these guidelines:

- *Guidelines for Geotechnical Engineering Services for Building Projects* (Engineers and Geoscientists BC 1998)
- *Guidelines for Legislated Landslide Assessments for Proposed Residential Developments in BC* (Engineers and Geoscientists BC 2010)

3.2.6 OTHER CODES AND GUIDELINES

Other codes and guidelines are available that may be used for additional guidance. Some examples include the following:

- Canadian Foundation Engineering Manual (CFEM), 4th Edition (Canadian Geotechnical Society 2006)
- American Association of State Highway and Transportation Officials (AASHTO) Standard Specifications for Highway Bridges, 17th Edition (including interim revisions) (AASHTO 2002)
- AASHTO LRFD [Load and Resistance Factor Design] Bridge Design Specifications, 8th Edition, (AASHTO 2017)
- United States (US) Department of Transportation, Federal Highway Administration (FHWA) Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes - Volume 1 (Publication No. FHWA-NHI-10-024) (FHWA 2009)
- Chapter 4 of FHWA Geosynthetic Reinforced Soil Integrated Bridge System, Interim Implementation Guide (Publication No. FHWA-HRT-11-026) (FHWA 2012)

3.3 RETAINING WALL PERFORMANCE REQUIREMENTS

3.3.1 PERFORMANCE EXPECTATIONS

Retaining Walls must be designed and constructed in such a way that they continue to meet design and performance criteria under static and dynamic loading conditions over their design life.

Examples of design and performance criteria include the following:

- Total and differential settlement, rotation, and sliding over the design life is compatible with the function, performance requirements, and wall materials
- Non-collapse during the design seismic event
- Drainage system remains functional
- Durability of Wall Facing

3.3.2 FACTOR OF SAFETY

The minimum factor of safety for Retaining Wall design must be established based on the specific site requirements.

Table 4: Retaining Wall Design Criteria – Typical Factors of Safety lists generally accepted design criteria for Retaining Walls; however, Engineering Professionals should always check with the local Authority Having Jurisdiction or other jurisdictional body to determine what requirements are in place.

If there are no factor of safety requirements, the ones provided in Table 4 should be used. Where these factors of safety cannot be met, the appropriate jurisdictional body should be notified.

Table 4: Retaining Wall Design Criteria – Typical Factors of Safety

DESIGN CONDITION	MINIMUM FACTOR OF SAFETY		
	STATIC LOADING	1-IN-475-YEAR SEISMIC EVENT	1-IN-2,475-YEAR SEISMIC EVENT
GLOBAL STABILITY			
Long-term	1.5	1.2	1.1[a]
End of construction/transient loading	1.3	N/A	N/A
EXTERNAL STABILITY			
Sliding	1.5[b]	1.2	1.1[a]
Overturning	2.0	1.5	1.1[a]
Bearing	2.0 to 3.0[c]	1.5	1.1[a]
PERFORMANCE			
Long-term	Varies depending on end use	Repairable damage[d] No collapse	Extreme damage[e] No collapse

NOTES

Abbreviations: N/A = not applicable

[a] Where factor of safety is close to or less than 1.0 using the peak horizontal acceleration, performance should be assessed based on the deformation criteria.

[b] Static loading for sliding is 2.0 if passive resistance in front of the wall is included in the calculation.

[c] The selection of this factor of safety is contingent on the method of analysis employed.

[d] Repairable damage: The owner may elect to have the Retaining Wall designed to experience repairable damage during the design earthquake. This means that the Retaining Wall can be repaired following an earthquake without complete reconstruction.

[e] Extreme damage: This normally applies to a severe loading event in which the Retaining Wall may suffer damage requiring complete reconstruction, but collapse does not occur.

3.4 RETAINING WALL PROJECT APPROACH

The typical approach that an Engineer of Record for a Retaining Wall project should undertake is outlined in the following stages. At the discretion of the Engineer of Record, it may be appropriate to combine some of these stages, depending on the complexity of the project. In addition, the level of detail and documentation included at the various stages should be backed up by a rationale that is supported by technical analysis.

1. Initial Assessment
2. Geotechnical Investigation
3. Conceptual Design
4. Detailed Design
5. Field Reviews and Design Changes
6. Assurance Statements

Each stage is discussed in detail below.

As noted earlier, the bylaws of Authorities Having Jurisdiction or other jurisdictional bodies may impose specific requirements on Retaining Wall design. These requirements should be reviewed at the start of the project to ensure they are incorporated into initial layouts, investigations, design, and specifications.

Formally defined terms are capitalized throughout the document (see the list of Defined Terms). Additional terms that should be noted are in Section 1.3 Introduction of Terms under

Table 1: Types of Retaining Walls and

Table 2: Characteristics of Typical Retaining Walls.

3.4.1 INITIAL ASSESSMENT

An initial assessment for the project should be undertaken. This includes the following:

- Confirm the owner's design requirements and design criteria regarding wall height and type, design life, minimum factors of safety, and serviceability requirements.
- Confirm there is an encroachment agreement, if elements of the Retaining Wall or work required to construct it will extend across a property line.
- Determine any specific requirements from the Authority Having Jurisdiction or other jurisdictional body.
- Investigate the physical setting and existing conditions for the location of the Retaining Wall, such as topography, property lines, easements, existing and/or proposed utilities, location of drainage discharge, and access issues, if any, and determine if a site survey is required. A reliable topographic survey showing proposed site grading and a conceptual drainage layout will assist with the development of a conceptual Retaining Wall design.

3.4.2 GEOTECHNICAL INVESTIGATION

The geotechnical investigation must be tailored to the specific application. The investigation is normally performed after the initial assessment.

Considerations that should be taken into account and reported on include the following:

- Published geological reports
- Site history with respect to stability or other geotechnical behavior, including previous earthworks, landslides, and/or mining activities
- Subsurface conditions, including depth of groundwater and likely variations
- Unit weight and soil strength parameters for natural soils, including consolidation parameters, if appropriate
- Peak ground acceleration (PGA) and spectral responses acceleration (Sa(T)) corresponding to the Retaining Wall location, typically obtained from Earthquakes Canada (Natural Resources Canada 2019), for the 1-in-475-year and 1-in-2,475-year seismic events
- Other site-specific conditions that may influence the design and construction (for example, riparian areas, sensitive vegetation, protected species, flooding potential)

Regardless of wall height and type (see Section 1.3.2 Retaining Walls), the soil and groundwater parameters used for design must be justified. The level of investigation and testing required will depend on the wall height, and on the potential of impact to the structural integrity of adjacent facilities or structures upslope and downslope (see Table 3: Retaining Wall Design Guide). However, in general, the investigation scope should meet CFEM requirements and collect quantitative data to below a depth where global stability may conservatively be assessed to govern (Canadian Geotechnical Society 2006).

For Retaining Walls that could potentially impact the structural integrity of adjacent facilities or structures, and/or if soft or potentially liquefiable soil conditions are present, site-specific seismic ground response analyses should be undertaken.

3.4.3 CONCEPTUAL DESIGN

Using the information from the initial assessment and the geotechnical investigation, a conceptual Retaining Wall design can be developed for the proposed grade separation. This conceptual design would take into account actual site conditions, availability of materials, geotechnical conditions, aesthetics, access, traffic and other surcharges, and surrounding developments, as well as the owner's design requirements and design criteria.

During this stage, the advantages and disadvantages of various wall types should be considered (see

Table 1: Types of Retaining Walls).

After performing a conceptual design evaluation, the preferred design should be discussed with the owner, then selected and advanced to the detailed design stage.

3.4.4 DETAILED DESIGN

3.4.4.1 Design Method

Depending on the type of Retaining Wall, an appropriate design methodology should be developed and followed.

The following steps are recommended:

1. Determine the external loading conditions, including the potential for scour or flooding.
2. Determine backfill materials, including unit weight, soil strength, and hydraulic conductivity parameters.
3. Determine lateral earth pressures, which will vary with the type of Retaining Wall used, for example, yielding or non-yielding (see Lateral Earth Pressures below).
4. Determine seismic lateral earth pressures, which will vary for the type of Retaining Wall used (see Lateral Earth Pressures below).
5. Evaluate internal stability, external stability, and global stability (see Global Stability below), including sensitivity analyses.
6. Assess drainage requirements (see Drainage below).
7. Estimate deformation (settlement and potential for rotation and lateral deformation) and mitigation, if required.
8. Determine bearing pressure and foundation treatment.
9. Consider liquefaction potential and mitigation, if required.
10. Develop documentation, including drawings, specifications, and reports, as appropriate (see Section 3.4.4.2 Documentation and Reporting below).

Specific Design Criteria for Different Wall Types

Following are some specific design criteria related to certain wall types:

- In accordance with the MoTI requirement that the maximum height of a Stacked Rock Wall may not exceed 3.7 m for Gravity Walls and 4.6 m when used as the Wall Facing of an MSE Wall, the Engineer of Record should carefully consider the difficulties of construction before considering higher Stacked Rock Walls than those prescribed here.
- For generally accepted Stacked Rock Wall guidance and specifications, refer to BC MoTI (2010), FHWA (2006), and City of Seattle (2004). For Stacked Rock Wall Retaining Walls adjacent to self-supporting slopes (for example, hard glacial till slopes), prescriptive wall dimensions (for example, City of Seattle 2004) may be used.
- For MSE Walls, the CFEM notes that typical reinforcement lengths are 50% to 70% of the wall height (Canadian Geotechnical Society 2006). Guidelines and references such as FHWA (2006) (which the CFEM references) and the *Supplement to CHBDC S6-14* (MoTI 2016) commonly recommend a minimum reinforcement length of 70% of the wall height. MSE Walls should generally be designed with a minimum soil reinforcement length of 70% of the wall height unless a rationale exists for adopting a shorter length.
- Unless constructed on rock foundations, the embedment depth at the front face of an MSE Wall must not be less than:
  - the frost depth, if sensitive to settlement; or
  - 600 mm on sloping ground (4H:1V or steeper) or where the soil in front of the Retaining Wall toe could be removed due to erosion or future excavation.

Regulatory Requirements

Throughout the design process, the Engineer of Record must consider the following regulatory requirements:

- Any regulatory requirement of the local Authority Having Jurisdiction or other jurisdictional body
- For geotechnical aspects, the requirements of the CFEM (Canadian Geotechnical Society 2006), the *CHBDC* (CSA 2014), and any other applicable document referenced in Section 3.2 Regulatory Requirements
  - For structural materials or Wall Facing, requirements of applicable standards published by the Canadian Standards Association (CSA), including those listed in the *BCBC* or VBBL under Section 4.3. Design Requirements for Structural Materials

Lateral Earth Pressures

Retaining Walls should be designed to support the appropriate full lateral earth, surcharge, and water pressures, as well as earthquake loadings.

Lateral earth pressures under both static and seismic loading should be determined using the methods in the CFEM (Canadian Geotechnical Society 2006), the *CHBDC* (CSA 2014), or other recognized guidelines and codes discussed in Section 3.2.5 Engineers and Geoscientists BC Guidelines and Section 3.2.6 Other Codes and Guidelines.

The process for determining lateral earth pressure for any type of Retaining Wall should comprise the following:

- If necessary, include compaction pressures imposed by compaction equipment used in wall construction. See the CFEM, the *CHBDC*, and the *Supplement to CHBDC S6-14* for guidance on typical values (Canadian Geotechnical Society 2006; CSA 2014; and BC MoTI 2016, respectively).
- While silt and clay should be avoided as backfill, where they cannot be avoided, use an earth-pressure coefficient of 1.0.
- Consider the impact and loading effects of a slope located above the Retaining Wall.

- Disregard passive resistance in the top 300 mm of material in front of the Retaining Wall, or more if it might be removed. If passive resistance is utilized in the wall design, the required wall movement to develop passive resistance with respect to wall performance and displacement limits must be considered.
- Consider the allowable Retaining Wall deformations.
- Consider equipment loading and other types of surcharges that could be imposed during or after construction.

Deformations for slopes and Retaining Walls under static loads should be determined using the methods given in the CFEM (Canadian Geotechnical Society 2006).

Seismic deformations of slopes and Retaining Walls may be estimated using the approaches developed by Bray, as outlined in *Guidelines for Legislated Landslide Assessments for Proposed Residential Developments in BC* (Engineers and Geoscientists BC 2010) and Bray et al. (2010), using the 1 in 2,475-year earthquake mandated in the *BC Building Code* 2018.

Consideration should be given to having adequate setback from a slope that exists below the Retaining Wall.

Global Stability

Where a Retaining Wall is located on a slope, its impact on the stability of the slope needs to be analyzed. This may include assessment of seismic slope stability if the seismic loading is sufficiently high. Suggested methods for assessing seismic slope stability as outlined in *Guidelines for Legislated Landslide Assessments for Proposed Residential Developments in BC* (Engineers and Geoscientists BC 2008) could be used; however, the governing jurisdictional body may have specific requirements.

For the case of a Retaining Wall with a backslope or toe slope steeper than 2H:1V, or where soil conditions merit, the global stability needs to be addressed and the slope needs to be considered in the wall design.

Drainage

The following should be considered when assessing drainage requirements for Retaining Walls:

- Adequate drainage is needed behind each Retaining Wall, unless the wall has been designed for full hydrostatic pressure or the backfill is free-draining. Where possible, a drainage system should be designed to be maintenance-free. Adequate drainage may require a blanket drain or chimney drain consisting of material with a hydraulic conductivity that is well in excess of that of the backfill material. The drainage layer must not clog over time, and the backfill must be sufficiently free-draining to prevent the build-up of seepage pressures within the active zone behind the Retaining Wall.
- Water from the drainage system should be discharged by using drain pipes or weep holes through the wall that remain accessible. The drainage system must divert water away from the structure or properly within the structure and not impact downstream elements or properties.
- Cleanouts should be considered for Retaining Wall drains to facilitate maintenance.
- The impact of external sources of water, including stormwater, should be minimized by directing runoff away from the Retaining Wall.

As a guide, free-draining backfill consists of material with no more than 5% by mass passing the 0.075 mm sieve on the fraction smaller than 2 mm.

3.4.4.2 Documentation and Reporting

The following aspects should be documented in the detailed design stage:

- Owner's requirements regarding Retaining Wall type, design life, and serviceability requirements
- Site plan/legal survey, including the location of the proposed Retaining Wall(s) and adjacent structures and utilities
- Wall height
- Soil stratigraphy

- Groundwater condition
- External loading
- Slope Protection and/or Wall Facing type
- Fill materials
- Soil reinforcement type and length, if required
- Drainage provisions
- Global stability analysis
- Internal stability analysis
- External stability analysis
- Results of independent review, if applicable (see Section 4.1.7 Documented Independent Review of Structural Designs)

Drawings and Specifications

Detailed design includes preparation of "Issued For Construction" drawings and specifications that capture the intent of the design. These drawings should include, at a minimum:

- a profile along the length of the wall showing variations in wall height, fill height behind the wall, and invert elevations of wall foundation drains; and
- cross-sections showing typical wall details, including wall batter, foundation preparation, leveling pad details, drainage provisions, erosion protection of exposed slopes above the wall, and guardrail details (if required).

Sufficient information and guidance must be provided by the Engineer of Record to ensure the Retaining Wall construction meets the intent of the design. In addition to drawings, the following items may be required:

- Material specifications
- Placement and compaction specifications
- Drainage system requirements
- Construction sequence, if it affects geotechnical conditions and safety
- Surface water or groundwater management requirements
- Construction constraints (for example, temporary excavations)
- Quality control requirements for construction materials and their placement
- Erosion control requirements during construction
- Descriptions of the effort to be expended during field review by the Engineer of Record

Documented Checks and Independent Review of Design

Documented checks of engineering work must be completed and retained (see Section 4.1.5 Documented Checks of Engineering Work). The checking process must confirm the adequacy and appropriateness of the design, including that the prepared work meets the input requirements and the appropriate standard of practice.

For Retaining Walls over 3.0 m high or those deemed to be high risk, documented independent review of designs must also be undertaken (see Section 4.1.7 Documented Independent Review of Structural Designs).

Reporting

Reporting should be prepared that documents the investigation and design process. As a minimum, the reporting should include relevant information from published geological reports; the results of the site and geotechnical investigations; design criteria (soil properties, wall loads, method of design); drainage requirements and design; wall type; detailed geotechnical design recommendations including with respect to global stability, lateral earth pressures, and estimated displacements; limitations; construction recommendations; and, if applicable, recommendations for monitoring and maintenance.

Some jurisdictions may require a comprehensive report; in particular, for higher Retaining Walls with potential to impact the structural integrity of adjacent structures or facilities. Alternatively, reporting may be in the form of a memorandum and/or as part of design calculations or drawings.

The following documentation should be provided to the owner:

- Technical specifications
- Any applicable instructions or guidance
- "Issued For Construction" drawings
- Assurance statement (see Appendix A: Engineer of Record – Retaining Wall Assurance Statement in these guidelines).

3.4.5 FIELD REVIEWS AND DESIGN CHANGES

During construction of the Retaining Wall, the Engineer of Record must have field reviews carried out and documented. Refer to Section 4.1.6 Documented Field Reviews During Implementation or Construction for more information on field reviews.

If design changes during construction result in departures from the technical specifications and "Issued For Construction" drawings, these changes should be documented and provided to the owner. Good engineering practice is to revise the "Issued For Construction" drawings with a set of sealed "Final Design Drawings" that reflect all of the design changes made during construction, as outlined in *Quality Management Guidelines – Use of Seal* (Engineers and Geoscientists BC 2017).

Some jurisdictions may ask for "As-Built" drawings or "As-Constructed" drawings. The Engineer of Record is discouraged from using the terms "As-Built" drawings or "As-Constructed" drawings. Instead, if asked for such drawings, the Engineer of Record must follow the protocol for "Record Drawings" laid out in *Quality Management Guidelines – Use of Seal* (Engineers and Geoscientists BC 2017).

3.4.6 ASSURANCE STATEMENTS

When the construction of the Retaining Wall is completed, the Engineer of Record should complete the assurance statement found in Appendix A: Engineer of Record – Retaining Wall Assurance Statement, and any other legal instrument the Authority Having Jurisdiction or other jurisdictional body requests.

The assurance statement, along with the appropriate design documentation, are to be provided to the owner. The intent of the assurance statement is to confirm that the Retaining Wall design meets the specified performance criteria, that permanent wall lateral deformations will meet the requirements for service-level performance and damage-level performance, and that field reviews have been completed for the project.

3.4.7 ADDITIONAL SERVICES

3.4.7.1 Monitoring and Maintenance Planning

An additional service that an Engineer of Record may provide is developing a monitoring program and/or a maintenance program for the Retaining Wall.

Monitoring confirms that the ongoing performance of the Retaining Wall continues to meet expectations. Regular maintenance minimizes the risk of conditions arising that could adversely affect Retaining Wall behavior.

4.0 QUALITY MANAGEMENT IN PROFESSIONAL PRACTICE

4.1 QUALITY MANAGEMENT REQUIREMENTS

Engineering Professionals must adhere to the applicable quality management requirements during all phases of the work, in accordance with the Association's Bylaws. It is also important to be aware of whether additional quality management requirements exist from Authorities Having Jurisdiction or through service contracts.

To meet the intent of the quality management requirements, Engineering Professionals must establish and maintain documented quality management processes for the following activities:

- The application of relevant professional practice guidelines
- Authentication of professional documents by the application of the professional seal
- Direct supervision of delegated professional engineering activities
- Retention of complete project documentation
- Regular, documented checks using a written quality control process
- Documented field reviews of engineering designs/recommendations during implementation or construction
- Where applicable, documented independent review of structural designs prior to construction

4.1.1 PROFESSIONAL PRACTICE GUIDELINES

In accordance with the *Act*, s.4(1) and Bylaw 11(e)(4)(h), Engineering Professionals are required to comply with the intent of any applicable professional practice guidelines related to the engineering work they undertake. One of the three objectives of the Association, as stated in the *Act* is "to establish, maintain, and enforce standards for the qualifications and practice of its members and licensees". Practice guidelines are one means by which the Association fulfills this obligation.

These professional practice guidelines establish the standard of practice for Retaining Wall design. Engineering Professionals who carry out these activities are required to meet the intent of these guidelines.

4.1.2 USE OF SEAL

In accordance with the *Act*, s.20(9), Engineering Professionals are required to seal all professional engineering documents they prepare or deliver in their professional capacity to others who will rely on the information contained in the documents. This applies to documents that Engineering Professionals have personally prepared and those that others have prepared under their direct supervision.

Failure to seal these engineering documents is a breach of the *Act*.

As outlined in Section 3.4.4.2 Documentation and Reporting, various forms of documentation are produced during Retaining Wall design. Documents that require sealing are any that include engineering work and may include, but are not limited to, reports,

specifications, drawings, memos, and field instructions. The Engineering Professional must also seal the assurance statement located in Appendix A: Engineer of Record – Retaining Wall Assurance Statement.

For more information, refer to *Quality Management Guidelines – Use of Seal* (Engineers and Geoscientists BC 2017).

4.1.3 DIRECT SUPERVISION

In accordance with the *Act*, s.1(1) and 20(9), Engineering Professionals are required to directly supervise any engineering work they delegate. When working under the direct supervision of an Engineering Professional, unlicensed persons or non-members may assist in performing engineering work, but they may not assume responsibility for it. Engineering Professionals who are limited licensees may only directly supervise work within the scope of their license.

With regard to direct supervision, the Engineering Professional having overall responsibility should consider:

- the complexity of the project and the nature of the risks;
- which aspects of the work should be delegated;
- the training and experience of individuals to whom work is delegated; and
- the amount of instruction, supervision, and review required.

Careful consideration must be given to delegating field reviews. Due to the complex nature of field reviews, Engineering Professionals with overall responsibility should exercise judgment when relying on delegated field observations, and should conduct a sufficient level of review to have confidence in the quality and accuracy of the field observations. (See Section 4.1.6 Documented Field Reviews During Implementation or Construction.)

For more information, refer to *Quality Management Guidelines – Direct Supervision* (Engineers and Geoscientists BC 2018a).

4.1.4 RETENTION OF PROJECT DOCUMENTATION

In accordance with Bylaw 14(b)(1), Engineering Professionals are required to establish and maintain documented quality management processes that include retaining complete project documentation for a minimum of ten (10) years after the completion of a project or ten (10) years after engineering documentation is no longer in use.

These obligations apply to Engineering Professionals in all sectors. Project documentation in this context includes documentation related to any ongoing engineering work, which may not have a discrete start and end, and may occur in any sector.

Many Engineering Professionals are employed by organizations, which ultimately own the project documentation. Engineering Professionals are considered compliant with this quality management requirement when a complete set of project documentation is retained by the organizations that employ them using means and methods that are consistent with the Association's Bylaws and guidelines.

For more information, refer to *Quality Management Guidelines – Retention of Project Documentation* (Engineers and Geoscientists BC 2018b).

4.1.5 DOCUMENTED CHECKS OF ENGINEERING WORK

In accordance with Bylaw 14(b)(2), Engineering Professionals are required to perform a documented quality checking process of engineering work, appropriate to the risk associated with that work.

Regardless of sector, Engineering Professionals must meet this quality management requirement.

In this context, 'checking' means all professional deliverables must undergo a documented quality checking process before being finalized and delivered. This process would normally involve an internal check by another Engineering Professional within the same organization. Where an appropriate internal checker is not available, an external checker (i.e., one outside the

organization) must be engaged. Where an internal or external check has been carried out, this must be documented.

Engineering Professionals are responsible for ensuring that the checks being performed are appropriate to the level of risk. Considerations for the level of checking should include the type of document and the complexity of the subject matter and underlying conditions; quality and reliability of background information, field data, and elements at risk; and the Engineering Professional's training and experience.

It is important to note that checking is a requirement for all Retaining Wall projects, not just projects that have a structural engineering aspect to them.

For more information, refer to *Quality Management Guidelines – Documented Checks of Engineering and Geoscience Work* (Engineers and Geoscientists BC 2018c).

4.1.6 DOCUMENTED FIELD REVIEWS DURING IMPLEMENTATION OR CONSTRUCTION

In accordance with Bylaw 14(b)(3), field reviews are reviews conducted at the site of the construction or implementation of the engineering work. They are carried out by an Engineering Professional or a subordinate acting under the Engineering Professional's direct supervision (see Section 4.1.3 Direct Supervision).

Field reviews enable the Engineering Professional to ascertain whether the construction or implementation of the work substantially complies in all material respects with the engineering concepts or intent reflected in the engineering documents prepared for the work, and that actual site conditions encountered during construction are consistent with those upon which the design was based.

For Retaining Walls, some of the geotechnical engineering aspects of field reviews may include the following:

- Reviewing temporary excavation stability and foundation-bearing services prior to Retaining Wall installation.
- Confirming drainage measures are adequate to prevent hydrostatic pressures during the wall design life.
- If applicable, confirming installation direction for primary strand of geogrid in an MSE Wall is understood by the contractor.
- Conducting field reviews that the Engineer of Record, at his or her professional discretion, considers necessary to ascertain whether the work substantially complies in all material respects with the plans and supporting documents prepared by the Engineer of Record. In instances where the backfilling could affect the structural integrity of adjacent structures, the Engineer of Record must ensure that the frequency and level of intensity of field reviews are appropriate for the site conditions.
- Confirming that all other materials meet the specification.

For Stacked Rock walls, detailed field review during construction is particularly important because performance depends on the individual rock quality and the quality of construction in order to achieve optimal placement of individual rocks that produce an integral structure. The Engineer of Record must perform field reviews to confirm that:

- rocks are intact and massive with no open fractures, foliation, or other planes of weakness;
- continuous or horizontal joints within the Retaining Wall are avoided;
- good contact between adjacent rocks, especially on the front face of the Retaining Wall, is provided; and
- voids left between rocks with smaller pieces are filled to minimize the risk of migration of the backfill.

Field reviews should be carried out at intervals appropriate to the stage of construction to observe the quality and the progress of the construction. The timing and number of field reviews are at the discretion of the Engineer of Record.

For more information, refer to *Quality Management Guidelines – Documented Field Reviews during Implementation or Construction* (Engineers and Geoscientists BC 2018d). In the event that the Engineer of Record is not engaged to complete field reviews, refer to Section 3.7 of those guidelines for protocols the Engineer of Record should follow.

4.1.7 DOCUMENTED INDEPENDENT REVIEW OF STRUCTURAL DESIGNS

Bylaw 14(b)(4) refers to an independent review in the context of structural engineering. An independent review is a documented evaluation of the structural design concept, details, and documentation based on a qualitative examination of the substantially complete structural design documents, which occurs before those documents are issued for construction. It is carried out by an experienced Engineering Professional qualified to practice structural engineering, who has not been involved in preparing the design.

As outlined in the *Quality Management Guidelines – Documented Independent Review of Structural Designs* (Engineers and Geoscientists BC 2018e), independently supported structures designed in BC such as Retaining Walls may require having an independent review performed. The Association recommends that as best practice, any Retaining Wall over 3.0 m high or those deemed to be high risk, be included in this requirement to have documented independent reviews conducted by a qualified professional, whether that is a structural and/or geotechnical Engineering Professional, as best suits the type of wall.

For Retaining Walls that have complex site conditions, complex designs, or have a wall height that is greater than 9.0 m, the Engineer of Record should consider having the independent review commence earlier in the process to include review of the conceptual design.

For more information, refer to *Quality Management Guidelines – Documented Independent Review of Structural Designs* (Engineers and Geoscientists BC 2018e).

5.0 PROFESSIONAL REGISTRATION & EDUCATION, TRAINING, AND EXPERIENCE

5.1 PROFESSIONAL REGISTRATION

It is the responsibility of Engineering Professionals to determine whether they are qualified by training and/or experience to undertake and accept responsibility for carrying out design and field review tasks related to Retaining Walls (Code of Ethics Principle 2).

5.2 EDUCATION, TRAINING, AND EXPERIENCE

Retaining Wall design and field review, as described in these guidelines, requires minimum levels of education, training, and experience in many overlapping areas of engineering. The Engineering Professional taking responsibility must adhere to the Association's Code of Ethics (to undertake and accept responsibility for professional assignments only when qualified by training or experience) and, therefore, must evaluate his or her qualifications and must possess the appropriate education, training, and experience to provide the services.

The level of education, training, and experience required of the Engineering Professional should be adequate for the complexity of the project.

Typical qualifications for the Engineer of Record and supporting team of professionals may include education and experience in the following areas :

- Civil engineering
- Structural engineering
- Soil mechanics and geotechnical engineering

The academic training for the above skill sets can be acquired by taking formal university or college courses or through continuing professional development. There may be some overlap in courses and specific courses may not correlate to specific skill sets. An Engineering Professional should also remain current with evolving topics, through continuing professional development. Continuing professional development can include taking formal courses; attending conferences, workshops, seminars, and technical talks; reading technical publications; doing web research; and participating in field trips.

6.0 REFERENCES AND RELATED DOCUMENTS

Documents cited these guidelines appear in Section 6.1 References.

Related documents that may be of interest to users of these guidelines but are not formally cited elsewhere in this document appear in Section 6.2 Related Documents.

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6.2 RELATED DOCUMENTS

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7.0 APPENDICES

APPENDIX A: ENGINEER OF RECORD – RETAINING WALL ASSURANCE STATEMENT

Note: This Assurance Statement must be completed, signed, and sealed by an individual who:

(i) is a professional engineer or licensee registered or licensed by the Association of Professional Engineers and Geoscientists of the Province of British Columbia (the "Association");

(ii) has read the Association's *Professional Practice Guidelines – Retaining Wall Design* (the "Guidelines"), and has considered the guidance provided in the Guidelines;

(iii) is qualified by education, training, and experience to serve as "Engineer of Record", as that term is defined in the Guidelines; and

(iv) has undertaken responsibility for the project described below in the capacity of Engineer of Record.

[Print clearly and legibly]

TO: **OWNER** DATE: _____

_____
Name

_____
Address

_____

FOR: **PROJECT**

_____

_____

_____

_____

In preparing the Retaining Wall design, I confirm that the following tasks have been completed:

RETAINING WALL CHECKLIST

General (all Retaining Walls):

Check that the following items have been addressed:

- ☐ 1. Reviewed requirements of the governing jurisdiction, and documented all other codes, specifications, and guidelines used.
- ☐ 2. Established design criteria based on applicable codes and confirmed criteria with owner.
- ☐ 3. Completed a site assessment to determine site factors to be incorporated into the Retaining Wall design and construction.
- ☐ 4. Conducted geotechnical investigation to determine site conditions and appropriate geotechnical parameters for analysis and design.
- ☐ 5. Determined external loading conditions (for example, traffic and construction surcharge loads, potential scour, or flooding).
- ☐ 6. Provided lateral earth pressures recommendations for static and seismic loading (these will vary based on the type of wall used).
- ☐ 7. Analyzed static global stability of slope – minimum factor of safety >1.5 for N! cases where N is the number of terraces
- ☐ 8. Analyzed seismic global stability of slope, if applicable – minimum factor of safety 1.1 or acceptable wall displacement
- ☐ 9. Assessed liquefaction potential (provided mitigation measures, if applicable).
- ☐ 10. Provided recommendations for general site and wall drainage.
- ☐ 11. Provided recommendations for erosion protection, Slope Protection/Wall Facing.
- ☐ 12. Assessed the potential impact of wall construction on the slopes above and below the wall.
- ☐ 13. Assessed the potential impact of the wall on adjacent structures.

Gravity Walls:

Check that the following items have been addressed:

- ☐ 1. Analyzed for overturning, sliding, and bearing capacity under static conditions.
- ☐ 2. Analyzed for overturning, sliding, and bearing capacity under seismic conditions, if applicable.
- ☐ 3. Completed internal design of the wall (structural design).
- ☐ 4. Detailed an adequate drainage system.
- ☐ 5. Provided appropriate information and guidance for wall construction, including placement specifications, temporary slopes, drainage works, quality control requirements.

Stacked Rock Walls:

Check that the following items have been addressed:

- ☐ 1. Analyzed for overturning, sliding, and bearing capacity under static conditions.
- ☐ 2. Analyzed internal stability, including sliding between rocks at different heights within the wall.
- ☐ 3. Analyzed for overturning, sliding, and bearing capacity under seismic conditions, if applicable.
- ☐ 4. Detailed an adequate drainage system.
- ☐ 5. Demonstrated by previous performance or laboratory testing that the rock proposed for use in the wall will be durable.
- ☐ 6. Provided appropriate information and guidance for wall construction, including placement specifications, rock sizes/weights and stacking requirements, temporary slopes, drainage works, quality control requirements.

Mechanically Stabilized Earth Walls:

Check that the following items have been addressed:

- ☐ 1. Analyzed for overturning, sliding, and bearing capacity and internal stability under static conditions.
- ☐ 2. Analyzed for overturning, sliding, and bearing capacity and internal stability under seismic conditions, if applicable.
- ☐ 3. Analyzed the adequacy of the wall facing to withstand applicable loads, including the loads from connections to soil reinforcement.
- ☐ 4. Provided specifications for soil reinforcement.
- ☐ 5. Confirmed that minimum soil reinforcement length is 70% of the wall height, or provided justification for alternate length.
- ☐ 6. Detailed an adequate drainage system.
- ☐ 7. Provided appropriate information and guidance for wall construction, including placement specifications, temporary slopes, drainage works, quality control requirements.

Reinforced Concrete Cantilever Retaining Walls:

Check that the following items have been addressed:

- ☐ 1. Analyzed for overturning, sliding, and bearing capacity under static conditions.
- ☐ 2. Analyzed for overturning, sliding, and bearing capacity under seismic conditions, if applicable.
- ☐ 3. Completed internal design of the wall (structural design).
- ☐ 4. Detailed an adequate drainage system.
- ☐ 5. Provided appropriate information and guidance for wall construction, including placement specifications, temporary slopes, drainage works, quality control requirements.

Submittals:

Check that the following items have been addressed:

- ☐ 1. Site plan showing wall location; wall footprint; existing and proposed ground slopes behind and in front of wall; locations of roads, structures, utilities, and all other facilities in the vicinity of the wall; and locations of the wall foundation drainage and other appurtenant drains, including associated discharge locations.
- ☐ 2. Profile along the length of the wall showing variations in wall height, fill height behind the wall, invert elevations of wall foundation drains, and all other features that are included in the design or in close proximity to the wall.
- ☐ 3. Cross-section showing typical wall details, including wall batter, foundation preparation, leveling pad details, drainage provisions, erosion protection of exposed slopes above the wall, guardrail details (if required), and other features that are included in the wall design.
- ☐ 4. Specifications for backfill and retained soil gradation and all other materials to be incorporated into the Retaining Wall (i.e., geosynthetics, concrete, anchors, drainage media), placement and compaction requirements, field review and compaction testing to meet stability and performance design requirements, drains, erosion control during construction, and concrete, reinforcement, and other structural components.
- ☐ 5. Monitoring and maintenance plan, if applicable.

Field Reviews:

Check that the following item has been addressed:

- ☐ 1. The obligation for field reviews as per Bylaw 14(b)(3) has been fulfilled to ascertain whether the implementation or construction of the work substantially complies in all material respects with the design.

ENGINEER OF RECORD – RETAINING WALL ASSURANCE STATEMENT

I certify that I am a professional engineer or licensee registered or licensed by the Association, that I am qualified to serve as Engineer of Record as defined in the Guidelines, and that I have undertaken responsibility for this project in the capacity of Engineer of Record.

Name (print)

Signature

Date

Address

Phone

Email

(Affix Professional seal here)

If the Engineer of Record is a member of a firm, complete the following:

I am a member of the firm _____
and I sign this letter on behalf of the firm. *(Print name of firm)*

APPENDIX B: ILLUSTRATIONS OF TERMINOLOGY FOR RETAINING WALLS

Figure B - 1: Retaining Wall Terminology

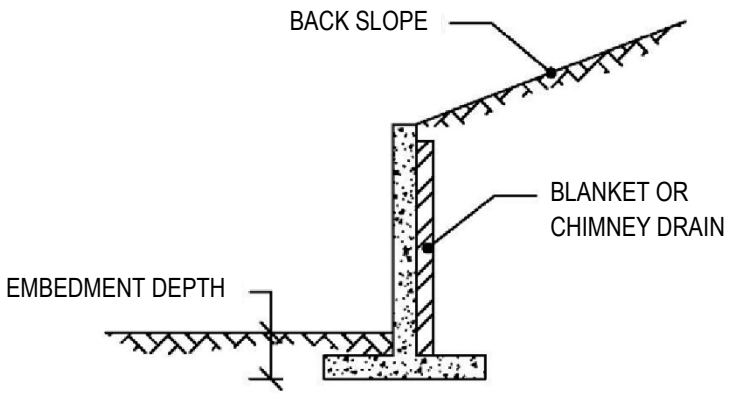

FIGURE B-1a

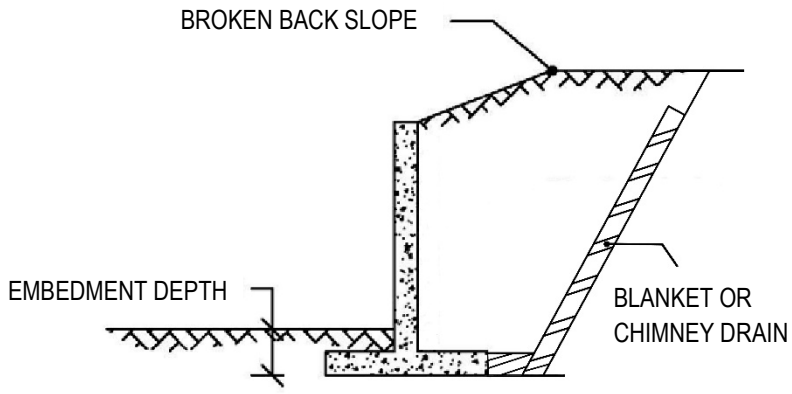

FIGURE B-1b

Note: Figures adapted from City of Nanaimo (2014).

Figure B - 2: Retaining Wall Height Determination

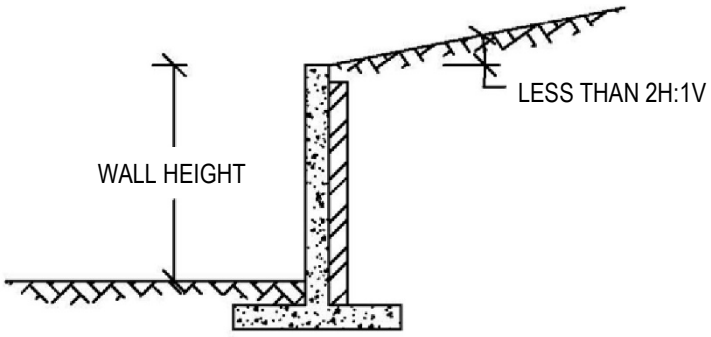

FIGURE B-2a

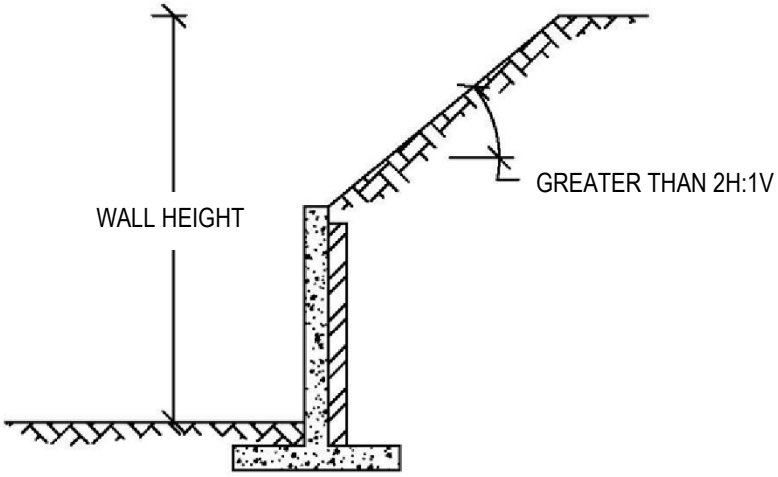

FIGURE B-2b

Note: Figures adapted from City of Nanaimo (2014).

Figure B - 3: Retaining Wall Movement Type

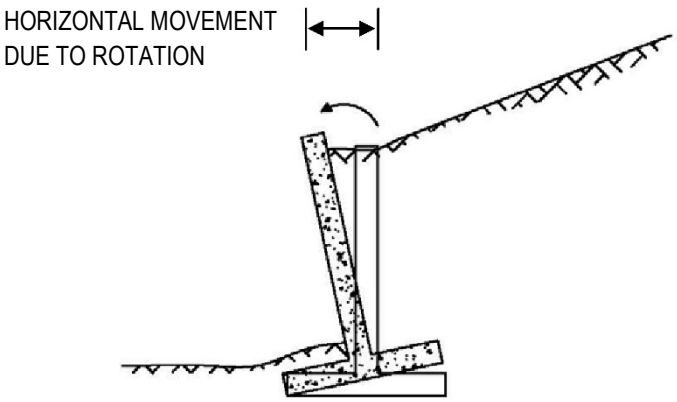

FIGURE B-3a

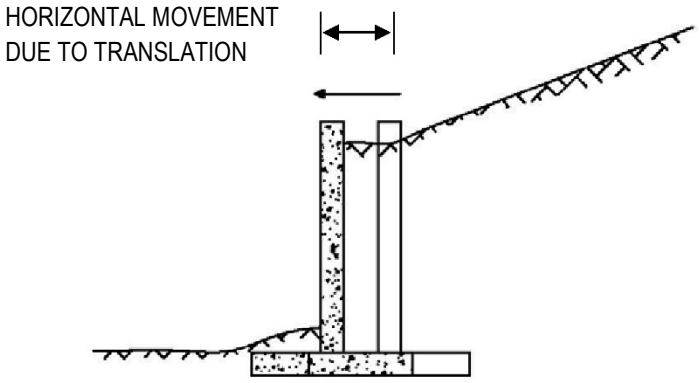

FIGURE B-3b

Note: Figures adapted from City of Nanaimo (2014).

NOTES:

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