



Geotechnical Report and Stability

Analysis Requirements

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Geotechnical Reporting Requirements

A geotechnical engineering report is required for all Clearing and Grading Permit applications submitted to the City of Bellevue. The geotechnical report must have been completed less than 5 years before the date of application and must pertain to the site and project described in the application. A geotechnical report older than 5 years or one for a different project on the same site may be accepted if the Geotechnical Engineer provides an addendum updating the report, or a letter stating the report is applicable to the site and the project currently proposed. Geotechnical reporting requirements may be waived for single-family permits if the applicant can demonstrate, to the satisfaction of the City of Bellevue, that soil or groundwater conditions at or near the site pose little or no risk for the project and that no on-site stormwater management practices are required for the project.

It is the responsibility of the Geotechnical Engineer to determine the actual scope of investigation, analysis, and reporting necessary to meet the Standard of Practice with respect to the project and its geotechnical requirements. The report must be signed and sealed by the Geotechnical Engineer.

The attached report outline describes the basic elements the City of Bellevue requires in each geotechnical report. The thoroughness of each element will greatly depend on the nature and complexity of the project and site conditions. For example, a report for a single family residence on a glacial till site without groundwater issues warrants a short, simple report, while a high-rise structure with a deep excavation on an alluvial site warrants a longer, much more detailed report. All elements should be included in detail unless they are clearly not applicable. For example, slope stability could be excluded if there are no slopes on the site or surrounding area, or shoring and retaining walls could be excluded if there are no requirements for temporary or permanent soil or rock retention.

Geotechnical Report Outline Summary

The summary presents the major conclusions and their basis. This section should be included in all lengthy or complex reports.

1.1 Introduction

- The Introduction sets the stage for the entire report and should be contained in the following sections.

1.2 Overview

- Introduce the formal project name and state the location.
- Briefly describe current or previous work used to form the basis for the conclusions and recommendations contained in the report.

1.3 Background

- Provide a description of the project's history if it is important to understanding why the study was performed.
- List other reports completed for the site or adjacent sites and note whether any environmental site assessments or other environmental work has been completed for the site.
- Provide a general description and give dimensions of the project including the general nature of the proposed development, e.g. grading, retaining walls, structures, construction materials, and utilities. Also, include proposed finish floor elevations, maximum depth of cut or fill, foundation and floor loads, etc.
- Describe all other details of the project which were assumed or relied upon in developing the conclusions and recommendations contained in the report.

1.4 Purpose and Scope of Services

- State succinctly the primary purpose for the geotechnical engineering services.
- Summarize the scope of geotechnical engineering services which form the basis for the conclusions and recommendations contained in the report.
- Indicate any limitations to the scope of geotechnical engineering services provided, particularly if the scope represents a departure from services typically provided on similar projects.

1.5 Investigation Summary

- Describe the dates, general nature, and extent of the geotechnical investigation. This section should include data research, borings, test pits, geophysics, physical laboratory testing, chemical testing, field instrumentation or testing, infiltration testing, etc.
- If the investigation was complex, present a complete and detailed explanation and results in the form of an appendix.

1.6 Report Overview

- Introduce and describe other sections of the report, directing the reader to critical sections, if appropriate.
- Identify and describe all attachments and appendices.

2.1 Site Conditions

The Site Conditions shall describe all site features relevant to the study and the geotechnical engineering conclusions and recommendations. Terminology should be clear and consistent and continue to be consistent throughout the entire report.

2.2 Location and Surface Conditions

- Present the project's specific address, location and cross streets.
- Generally, describe the site and adjoining properties, and indicate their current use.
- Describe surface elevation, topography and drainage. Clearly reference all elevations to City of Bellevue NAVD88 datum.
- Identify all current structures, subsurface utilities, wells, manmade fills, and other surface features.
- Describe vegetation, topsoil, paving, and other surface coverings.
- Describe any indications of historic geological processes or hazards on or near the site (i.e., slope instability, landslides, liquefaction, flooding, etc.).
- Describe any indications of surface releases or other contamination, or potential contamination sources.
- Describe any planned changes to the surface conditions described above which will take place after the investigation.

2.3 Geologic Setting

- Provide an overview of regional geology, local stratigraphy, groundwater occurrence, etc.

2.4 Subsurface Soil Conditions

- Describe each soil or geologic unit encountered by their classification and group units with respect to the properties that are most relevant to the conclusions and recommendations. Give each unit group a unique, clear, common title and consistently refer to this unit by its given title throughout the report.
- Provide the results of field soil infiltration tests for on-site stormwater management.
- Provide important results of the laboratory physical property testing and its indications of soil behavior.
- Avoid detailed descriptions of the sequence of units found in individual borings; rather, focus on variations in the units across the site, if appropriate. Refer the reader to the exploration logs for details.
- Describe any expected changes in subsurface conditions that may occur with time after the investigation.

2.5 Groundwater Conditions

- Describe the nature and occurrence of groundwater.

- Provide an opinion on likely seasonal variations in groundwater levels or flows, and the possibility for changes from those encountered at the time of exploration.
- Show groundwater levels on soil logs.

2.6 Subsurface Contamination

- Describe the nature and extent of soil and/or groundwater contamination as revealed by the explorations. Reference any applicable Environmental Assessments if performed.
- Provide important results of the analytical laboratory testing and indications about contamination distribution and concentration.
- Indicate limitations of knowledge on the nature and extent of contamination.
- Discuss possible changes that may occur in these conditions over time.

3.1 Discussion and Conclusions

The Discussion and Conclusions should set out major geotechnical issues and alternatives for the project, along with the Geotechnical Engineer's conclusions, in a succinct and clear manner. This section shall clearly describe the logic and reasoning supporting the recommended approach, or alternative approaches. Specific recommendations shall be very limited in this section; they should be presented in a separate Recommendations section.

Discussions and conclusions should:

- Build on information described in the previous sections.
- Use consistent terminology to describe project features, soils, and construction materials.
- Explain any apparent inconsistencies in the data or investigation.
- Clearly describe any limitations or restrictions to the conclusions and recommendations.

3.2 Slope Stability

- Summarize data and analysis used to evaluate slope stability.
- Provide an opinion regarding the risk of instability on the site or adjacent properties currently, during construction, and after the project is completed.
- Describe how design and construction recommendations will reduce or eliminate the risk of instability.
- Discuss any construction or post-construction measures necessary to verify slope stability.

3.3 Seismic Considerations

- Provide an opinion on the expected level of ground motion during a major earthquake. For seismic analyses, acceleration factors should be estimated based on a peak ground acceleration with a 10 percent of probability of exceedance in 50 years (i.e. a 475-year return period). Alternatively, a site-specific seismic study can be conducted to determine an appropriate peak ground acceleration.
- Describe any seismic risks associated with an earthquake such as liquefaction, lateral spreading, landslides, or flooding.
- Describe how design and construction recommendations will reduce or eliminate the impact of seismic risks.

3.4 Site Work

- Describe what is anticipated for site grading and earthwork and provide an opinion on the proper sequence and approach to accomplish the site work.
- Describe key issues which will impact proper earthwork, including short term slope stability, on-site and import fill materials, groundwater and drainage, rainfall and moisture sensitive soils, and erosion.
- Describe how these issues should be addressed during construction, including dewatering, temporary retaining structures, and erosion control.
- Include specific recommendations for on-site erosion control based on erosivity of site soil and presence of groundwater, surface water, and slopes.
- Include statements regarding the importance of construction monitoring by a geotechnical engineering firm.

3.5 Infiltration

- Describe which of 4 methods allowed in the Utility Engineering Standards (Storm chapter D2-06.5) was used to determine infiltration rates.
- Summarize data and analysis used to evaluate site suitability for infiltration facilities.
- Show location(s) of any infiltration tests on the site plan, and call out areas with infiltration rates suitable for infiltration facilities on the site plan.
- Estimate infiltration rates in inches per hour at depth sufficient to include those elevations up to the required depth (up to five feet) below proposed infiltration facilities and in areas deemed unsuitable for infiltration.
- Provide an opinion on the risk of onsite and downslope flooding or erosion that may result from infiltration facilities in any soils suitable for infiltration.

- Describe how design and construction recommendations will reduce or eliminate the risk of facility failure, erosion and flooding.

3.6 Retaining Structures

- If temporary retaining systems are necessary, provide an opinion as to the most appropriate type of temporary retaining system or systems.
- Summarize the data and analysis used to evaluate permanent retaining systems.
- If permanent retaining systems are necessary, provide an opinion on the most appropriate permanent retaining system or systems and describe their expected performance with respect to stability and deflection.
- If reinforced soil slopes or reinforced soil backfill are to be used, clearly define all limitations on backfill materials, reinforcement, and drainage.
- If rockeries, modular block walls, or other non-structural slope protection systems are expected, describe the limitations on such systems.
- Emphasize any aspects of site work, particularly with respect to native soil materials, backfill, and drainage, which could impact performance of the retaining structures.
- Include statements regarding the importance of construction monitoring by a geotechnical engineering firm.

3.7 Rockeries and Modular Block Walls

- Emphasize that rockeries and modular small block walls are not retaining walls or structures.
- Indicate that the primary function of a rockery or block wall is to protect the slope face by preventing soil erosion and sloughing. Rockeries and block walls should be considered maintenance items that will require periodic inspection and repair. Thus, rockeries and block walls should be located so that they can be reached by a contractor if repairs become necessary.
- Discuss what type of inspection and testing may be required during rockery or block wall construction.

3.8 Foundation Support

- Summarize the data and analysis used to evaluate foundation systems.
- Provide an opinion on the most appropriate foundation system and alternatives, along with the expected level of performance with respect to load capacity and settlement.
- Emphasize any aspects of site work which could impact the performance of foundations.

- Include statements regarding the importance of construction monitoring by a geotechnical engineering firm.

4.1 Recommendations

The Recommendations should present all detailed geotechnical engineering recommendations for design and construction in a clear and logical sequence. For each item covered in the recommendations sections, present the following:

- Specific design recommendations along with their limitations, factors of safety, minimum dimensions, and effect of expected variations in actual conditions.
- Specific construction recommendations including definitions, materials, execution, monitoring, testing, or other quality control measures, and any other construction requirements to support the design recommendations.
- Responsibility for seeing that each recommendation is met, such as owner, geotechnical engineer, other design consultants, or contractor. The ultimate responsibility is held by the owner of the project; however, all design parties have shared responsibility. Construction responsibilities are directly related to the contractor.

4.2 Site Grading and Earthwork

- Provide specific design recommendations for 1) depth of stripping, 2) soil excavation limits and slopes, 3) depth and lateral limits of over excavation to remove unsuitable materials, 4) preload fills, 5) location and thickness of particular fill material or compaction requirements, 6) maximum temporary and permanent slopes, 7) permanent surface and subsurface drainage systems, and 8) permanent erosion controls.
- Provide specific construction recommendations for 1) clearing, 2) on-site and/or import fill materials,
- 3) excavation and compaction equipment, 4) fill material moisture conditioning, placement, and compaction, 5) proof-rolling, in-place density testing, and other quality control measures, 6) temporary seepage and drainage control measures, 7) permanent surface or subsurface drainage system installation (as appropriate), 8) temporary slope protection and erosion control measures, and 9) protection of infiltration facilities (including bioretention and pervious pavement) from compaction and from sediment contamination during construction.
- All design and construction methodologies should be specific and identifiable; no generalized or vague statements are acceptable.

4.3 Temporary Shoring and Retaining Walls

- Provide specific design recommendations for 1) active and passive earth pressures, 2) surcharge pressures, 3) bearing capacity, 4) minimum or maximum dimensions and depth of penetration, 5) lateral support, 6) wall or backfill drainage systems, and 7) any other appropriate structural details.
- If appropriate, provide specific design recommendations for tie-back anchors including 1) anchor inclination, 2) no load zones, 3) minimum anchor length, 4) anchor bond zone, 5) anchor adhesions, and 6) corrosion protection.
- Provide specific construction recommendations for 1) installation, 2) on-site and/or import backfill materials, 4) backfill material moisture conditioning, placement, and compaction, 5) in-place density testing or other quality control measures, and 6) seepage and drainage control.
- If appropriate, provide construction recommendations for tie-back anchors including 1) anchor installation methods, 2) anchor testing, and 3) monitoring.

4.4 Rockeries

- Provide recommendations as outlined in the Associated Rockery Contractors (ARC) Standard Rock Wall Construction Guidelines (December 1992).
- The geotechnical engineer should provide direct input to the design of the rockeries and provide construction monitoring and testing as appropriate. Specific design parameters may include: Rock quality, density, frequency of testing, slopes, keyways, surcharges, drainage, rock sizes, face inclination, and surface drainage.

4.5 Reinforced Soil Structures

- Geogrid or geotextile fabric may be used to reinforce a fill. Reinforcement results in a more stable slope and helps reduce the risk of significant long term maintenance. If reinforced slopes are used, the geotechnical engineer should specify, at a minimum, the fill soil materials, vertical spacing of the reinforcement, the specific type of reinforcement and the distance to which it must extend into the fill, the amount of overlap at reinforcement joints, and the construction sequence. Additional design parameters will be required for each specific site.

4.6 Structure and Foundations

- Provide seismic design recommendations for 1. Building Code soil type and Site Coefficient, and 2. any specific recommendations to reduce the risk of damage due to earthquakes
- Spread footing foundations - provide design recommendations for 1. Bearing soils, 2. bearing capacity, 3. minimum footing depths and widths for both interior

and exterior footings, 4. lateral load resistance, and 5. foundation drainage system

- Mat foundations - provide design recommendations for 1. bearing soils, 2. bearing capacity, 3. modulus of subgrade reaction, 4. minimum dimensions, and 5. lateral load resistance.
- Pile foundations - provide design recommendations for 1. type of pile, 2. means of support (end or friction), 3. minimum dimensions and depths, 4. allowable vertical and uplift capacity, 5. allowable lateral loads and deflections, and 6. group effects and minimum spacing.
- Spread footing or mat foundations - provide construction recommendations for 1. foundation subgrade preparation and protection, 2. verification of bearing capacity, and 3. installation of foundation drainage system.
- Pile foundations - provide construction recommendations for 1. pile driving equipment, 2. pile installation, 3. pile load tests or verification piles, and 4. monitoring and testing during pile installation.

4.7 Floors

- Slab-on-Grade Floors - provide design recommendations for 1. slab base rock thickness, 2. capillary break, 3. vapor barrier, and 4. floor system drainage.
- Supported Wood Floors - provide design recommendations for 1. vapor barrier, and 2. crawl space drainage.
- Slab-on-Grade Floors - provide construction recommendations for 1. subgrade preparation, 2. slab base rock placement and compaction, 3. capillary break and vapor barrier installation, and 4. floor drainage system installation (if appropriate).

4.8 Pavements

- Provide design recommendations for 1. pavement design section, and 2. pavement drainage (see the requirements of the [Bellevue Transportation Department Design Manual](#)).
- Provide construction recommendations for 1. pavement subgrade preparation and verification, and 2. pavement base and subbase materials, placement, and compaction.

4.9 Utilities

- Provide construction recommendations for 1. utility excavation, 2. bedding material placement, and 3. backfill material, placement, and compaction.

- Provide construction recommendations for subgrade preparation, monitoring and inspection during infiltration facility (including bioretention and pervious pavement) installation, where applicable.
- Provide information as required in Section D2-06.5 of the [City of Bellevue Utilities Storm and Surface Water Engineering Standards](#).

4.10 Drainage

- Recommend provisions for subsurface drainage at walls, floors, and footings (see section CG7-12 of the Bellevue Clearing & Grading Development Standards for wall drain requirements).
- Evaluate permanent and temporary surface and subsurface drainage for both walls and floors if applicable. Provide approximate flow rates in gallons per minute and pipe sizes if required by design.
- Recommend locations suitable for infiltration facilities, if any.

4.11 Hazards

- Present additional information if natural or man-made hazards exist on the property. King County Map Folio of Sensitive Areas delineate hazards in the categories of wetlands, streams and flood hazard, erosion, landslide, seismic, and coal mine hazards. Recommendations should be general and further studies may be required.

Report Figures and Illustrations

1. Vicinity Map

Include a Vicinity or Location Map which presents adequate street and/or other physical references to allow clear identification of the project location. This map may be an individual figure or be included on the Site Plan.

2. Site Plan

Show the project boundaries, property lines, existing features and the proposed development and structures.

A north arrow and scale should be included along with all subsurface exploration locations. The accuracy of exploration locations should be indicated on the Site Plan or in the report.

3. Exploration Logs

Include logs of all explorations describing soil units encountered, soil classification, density or stiffness, moisture conditions, groundwater levels, stratigraphic sequence, common geologic unit name, and other descriptive information.

4. Laboratory Test Data

Include figures or tables of laboratory test results if presentation of all the data, in the text, would require more than a simple paragraph to supplement the data provided in the exploration logs.

5. Cross Sections

Include cross sections to visually present all but the simplest subsurface conditions.

6. Typical Details

Include figures, graphs, and other visual aids to clearly present detailed recommendations. Provide design details (stamped by a professional engineer) on drawings such as: rockeries, reinforced earth, interceptor trenches, wall and footing drains, utility backfill, and other details used for a particular design.

Standards for Slope Stability

Analyses Study Requirements

The geotechnical engineer should review and evaluate the stability of natural, temporary, and permanently constructed slopes on or adjacent to the property to be developed. Such review should, at a minimum, include:

- Review of published geologic data referencing or including the site.
- Review of previous studies of the site performed by geotechnical engineers.
- Reconnaissance of the site for signs of slope instability.

Where such review, in the opinion of the engineer or the City, indicates that the stability of the slopes are reduced by the proposed development, or that the natural slopes may have a factor of safety of less than 2.0 in the static case or 1.5 in a dynamic (seismic) case, then the geotechnical engineer shall perform additional, more detailed review and evaluation of the stability of the slope. Such additional review and evaluation should, at a minimum, include:

- Drilling and sampling of test borings to a depth necessary for the evaluation of slip surfaces with factors of safety lower than the above criteria, or to at least 15 feet or 10 percent of the slope height (whichever is less) beyond the most critical slip surface for the design.
- Laboratory shear testing of soil samples which are representative of all significant zones or layers of soil and/or rock through which the potential slip surfaces pass.

- Performing a limit equilibrium analyses or other approved analyses of all significant critical slip surfaces associated with the slope. Approved analyses may be conducted by a computer program if the methodology and assumptions are clearly delineated and the name, version number, and solution methodology of the program are clearly presented in the report. For pseudo-static seismic analyses, the acceleration factor must be based on a peak ground acceleration with a maximum of a 10 percent of probability of exceedance in 50 years (i.e. a 475-year return period). A higher peak ground acceleration should be used (e.g. one with a 2 percent probability of exceedance in 50 years), if the engineer and the applicant consider it appropriate for the project. Alternatively, a site specific seismic study can be conducted to determine an appropriate maximum horizontal acceleration. The geotechnical report must include cross sections of the slope(s) and critical slip surfaces produced as part of the slope stability analyses.
- Other analyses as required by the City.

Design Requirements

For a limit equilibrium analyses, design factors of safety for slopes shall be no less than the following:

	Temporary Slope	Permanent Slope	Permanent Slope
		Low Threat	High Threat
		Upon Failure ¹ (see below)	Upon Failure ² (see below)
Static	1.25	1.40	1.50
Dynamic	1.05	1.10	1.15

The analysis should consider the impact of groundwater in the modeling of soil strength and density parameters, and in other ways considered appropriate by the engineer. A conservative wet season analysis should be used for permanent slopes and those temporary slopes which will be constructed at any time between, and including, the months of October 1 and May 31.

Alternative analyses may be proposed by the geotechnical engineer and accepted by the City, if they are based upon accepted and published methodologies which evaluate static and dynamic loading cases, as well as the consequences of the type of slope failure under consideration. Other design requirements remain the same.

Table Notes:

1 Permanent slopes termed "Low Threat Upon Failure" are those slopes whose failure will not impact buildings or other structures inhabited by humans.

2 Permanent slopes termed "High Threat Upon Failure" are those slopes whose failure will impact or have a reasonable engineering probability of impacting building or other structures inhabited by humans.