Chapter 20 - Geotechnical Reporting and Documentation

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20.1 General

ODOT geotechnical engineers, engineering geologists and consultants working on ODOT projects produce geotechnical reports, engineering geology reports and other various design memorandums, documents and products in support of project definition, project design, and final PS&E development. Also produced are project specific Special Provisions, plan details, boring logs, Geotechnical Data Sheets and the final project geotechnical documentation. Information developed to support these geotechnical documents are retained in the Geotechnical project folder in Project Wise. The information includes project site data, regional and site specific geologic data, exploration logs, field and laboratory test results, instrumentation and monitoring data, interpretive drawings, design calculations, and construction support documents. This chapter provides standards for the development, content, and review of these documents and records, with the exception of borings logs, which are covered in Chapter 5 and Materials Source Reports, which are covered in Chapter 4.

20.2 General Reporting Requirements

In general, all geotechnical design recommendations are documented with either a stamped hard copy to the project file or a stamped electronic copy. Verbal recommendations that influence contract plans or specifications or result in design changes are followed up with a formal document. Some geotechnical recommendations may involve very minor design or construction issues and therefore minimal review or documentation is required. The level of review and documentation depends on the type and complexity of the design or construction issue and the experience and qualifications of the engineer performing the work.

A geotechnical document (either a design memorandum or standard report) is required for most highway projects involving any significant geotechnical design elements such as earthwork, landslides or rock slopes, or structure foundations. When geotechnical design is required for a project, this work should be documented in the form of either technical memoranda or reports that summarize the work performed and the resulting design recommendations and products. For reports that cover minor individual project elements, a geotechnical design memorandum may suffice as the final geotechnical document. Geotechnical Memos are also prepared for larger, more complex projects, including all new bridges and bridge replacements in order to provide preliminary recommendation for the Bridge and Roadway designers in preparation of the TS&L Report and to be included in the DAP submittal. A final geotechnical document is issued for all geotechnical project design elements.

E-mail may be used for communicating preliminary geotechnical information or recommendations during the design process. E-mails may also be used to transmit review of construction submittals. In either case, a print-out of the e-mail are included in the project file. For time critical geotechnical designs sent by e-mail that are not preliminary, the e-mail is immediately followed up with a stamped document. A copy of the e-mail is maintained in the project file.

20.3 Quality Control

Quality control of geotechnical design work is an ongoing process occurring regularly throughout the entire design process. The ODOT quality control process is described in detail in Chapter 2.

20.4 Geotechnical Reporting Document Requirements

The geotechnical information and types of recommendations that are provided in the Geology Summary, Geotechnical Memo, and Geotechnical Report are provided in the sections that follow.

20.4.1 Geology Documentation

The Geology Summary would typically consist of the first sections of the Geotechnical Design Report. For projects where the design team deems it prudent, the Geology Report may be produced as a fully executed memo or report. The report is considered “final” by the POR and Reviewer and ready to present to the report users for their review and comment at 50 percent of DAP.

The Geology Summary is prepared by, or under the direct supervision of, the Engineering Geologist POR assigned to the project. The Engineering Geologist POR should maintain close communication with the Geotechnical Engineer POR to ensure that the required information is obtained and provided.

Regardless of the format of the Geology Summary, the intent is to suitably document the geologic conditions of a project site. The timely creation of this document avoids the loss of valuable geologic information, which provides a future real return on current investments by the agency in engineering geologic investigations. Further, since the geotechnical analysis and design rely upon the information transmitted in the Geology Summary, it must be completed in sufficient time to allow for the preparation of the Geotechnical Memo.

The following reporting guidelines are provided for use in developing the Geology Summary. Note that the majority of this information will also be included, section by section, in the front section of the Geotechnical Report. The list below is intended to be a general list and is by no means intended to be inclusive but all items that apply to the project are included in the summary.

Description

A general description of the project scope, project elements, and project background.

Surface Conditions

Description of Project site surface conditions and current land use.

Regional and Site Geology

This section describes the site stress history and depositional/erosional history, bedrock and soil geologic units, etc. from available geologic literature and/or from previous geologic reconnaissance reports.

Regional and Site Seismicity

This section identifies the active seismic sources meeting the criteria in (AASHTO Seismic Design Guide) affecting the site including nearby active faults. This section is generally only included in reports addressing structural elements (e.g., bridges, walls, etc.) and major earthwork projects. Refer to Chapter 7 for additional seismic design criteria that may be required.

Summary of Office Studies

A summary of the office studies collected on the site, including final construction records for previous construction activity at the site, as-built bridge drawings or other structure layouts, pile records, boring or test pit logs or other subsurface information, geologic maps or previous or current geologic reconnaissance results.

Summary of Field Exploration

A summary of the field exploration conducted, if applicable. Provide a description of the methods and standards used, as well as a summary of the number and types of explorations and field testing that were conducted. Include a plan map (or data sheet) in the appendix showing the locations of all explorations. Also include a description of any field instrumentation installed and its purpose, data and results. Provide final exploration logs in the report appendices along with any other field test data such as cone penetrometer, pressure meter, vane shear tests, or shear wave velocity profiles.

Summary of Laboratory Testing

A summary of the laboratory testing conducted. Provide a description of the methods and standards used as well as a summary of the number and types of tests that were conducted. Provide the detailed laboratory test results in the report appendices.

Soil and Rock Materials and Subsurface Conditions

This section includes descriptions of the soil/rock units encountered, but also how the units are related at the site, and their geologic origin. The soil and rock units are discussed in terms of the relevance and influence the materials and conditions may have on the proposed construction. Groundwater conditions should be described in this section of the report, including the identification and discussion of any confined aquifers, artesian pressures, perched water tables, potential seasonal variations, if known, any influences on the groundwater levels observed, and direction and gradient of groundwater, if known. The groundwater elevation is a very important item and should be provided in the report. The measured depth of groundwater levels, and dates measured, should be noted on the exploration logs and discussed in the report. It is important to distinguish between the groundwater level and the level of any drilling fluid. In addition, groundwater levels encountered during exploration may differ from design groundwater levels. Any artesian or unusual groundwater conditions are be noted as this often has important effects on foundation design and construction. If rock slopes are present, discuss rock structure, including the results of any field structure mapping (use photographs as needed), joint condition, rock strength, potential for seepage, etc.

Bedrock

- Rock identification and description according to the ODOT Soil and Rock Classification system (Chapter 5).
- Geologic age of the formation.
- Distribution, origin, structure, geometry, and geomorphology of each bedrock unit.
- Structural features/Structural Geology
- Weathering profile of each rock unit in the project area. Distribution and extent of weathered and/or altered zones. Differences in properties between fresh and weathered/altered rock.
- Relevant physical properties such as stratigraphic (bedding, inclusions, foliation, etc.) features and overall rock mass strength as well as other characteristics such as cementation, discontinuities, and overall variability throughout the rock mass.
- Rock Mass Rating (RMR) and Geologic Strength Index (GSI).
- Special characteristics or concerns such as excessive slaking after exposure or high variability in rock strength over short distances, etc.
- Any features that may affect project construction or design.

Surficial or unconsolidated deposits

- Soil identification and description according to the ODOT Soil and Rock Classification system (Chapter 5).
- Distribution, geometry, variability, and surficial expression and exposure of units.
- Relative age (if known), origin, depositional history, and mobility of units.
- Physical characteristics such as permeability, structure, and geologic composition of materials.
- Special features such as peats, expansive clays, indications of substantial volume changes, instability, or sensitivity.

Subsurface Profiles

Descriptions of soil and rock conditions are illustrated with subsurface profiles (i.e., parallel to roadway centerline) and cross-sections (i.e., perpendicular to roadway centerline) of the key project features.

A subsurface profile or cross-section is defined as a graphical illustration that assists the reader of the geotechnical report to visualize the spatial distribution of the soil and rock units encountered in the borings for a given project feature (e.g., structure, cut, fill, landslide, etc.).

Cross sections and profiles along certain features, such as landslides, may be needed to fully convey the site conditions and subsurface model. These profiles and cross sections help to define a geologic model of the subsurface materials and conditions. As such, the profile or cross-section will contain the existing and proposed ground line, the proposed structure profile or cross-section if one is present, the boring logs (including SPT values, soil/rock units, etc.), and the location of any water table(s). Interpretive information is provided in these illustrations, as appropriate, to adequately and clearly describe and depict the subsurface geologic model. The potential for variability in any of the stratification shown is discussed in the report.

Geotechnical Data Sheets

An unstamped figure of the final Geotechnical Data Sheets isprovided in the Geology Summary and/or the Geotechnical Report.

Surface hydrology and subsurface hydrogeologic conditions

All surface water features such seeps and springs, wetlands, and bodies of water are clearly located on maps. Groundwater surfaces, water-bearing zones, and aquifers (if existent) are clearly depicted on all subsurface drawings. Soil and rock units that affect groundwater is described and characterized. Variability in precipitation, temperature, water impoundment, etc. and its potential effect on the project site is described in detail. Provide the following additional information::

- Distribution, occurrence, and variation of hydrologic and hydrogeologic features
- Piezometric surface depth, seasonal variation, direction and gradient, and discharge and recharge areas.
- Relationships between surface, and groundwater and geologic and topographic features.
- Evidence for previous water occurrence at the site.
- The possible effects on groundwater that the project will have.
- Permeability of surficial materials that affect infiltration at the site.

Summary of Geologic Hazards

Provide a summary of geological hazards identified and their impact on the project design (e.g., landslides, rock fall, debris flows, liquefaction, soft ground or otherwise unstable soils, seismic hazards, etc.), if any. Describe the location and extent of the geologic hazard.

Engineering Geologic Recommendations

- Prediction of materials and geologic structures/features that will be encountered in proposed excavations and their impacts on performance and constructability.
- Areas to be avoided with respect to stability or constructability issues with locations clearly depicted on the drawings.
- Excavation considerations such as variable rock projections, groundwater seepage, obstructions, etc.
- Embankment construction considerations such as subdrainage, adhesion, and stability.
- Recommendations for erosion control, environmental mitigation, and stability.
- Suitability of on-site materials for use as engineered fill.
- Potential mitigation strategies for identified geologic hazards.
- Identification of potential material sources and disposal sites.

Additional Recommendations

- Additional explorations required to adequately characterize difficult site conditions encountered during design-phase investigations.
- Groundwater testing for construction dewatering or infiltration basin design.
- Rockfall protection measures.
- Subsurface drainage including trench drains, vertical drain wells, pumping, and horizontal drainage.

Appendices

Typical appendices include all final exploration logs of borings (showing Unit Description), test pits and any other subsurface explorations (including older exploration logs), Geotechnical Data Sheets (if available), layouts showing boring locations relative to the project features and stationing, subsurface profiles and typical cross-sections that illustrate subsurface stratigraphy at key locations (if available), laboratory test results, and instrumentation measurement results.

The detail contained in each of these sections will depend on the size and complexity of the project or project elements and the subsurface conditions. In some cases, design memoranda that do not contain all of the elements described above may be developed prior to developing a final geotechnical report for the project.

20.4.2 Geotechnical Memo

Geotechnical Memos are prepared for larger, more complex projects, including all new bridges and bridge replacements. Regardless of the level of detail, the primary purpose of Geotechnical Memos is to support the Bridge and Roadway designers in preparation of the Bridge TS&L Report and to be included in the DAP submittal. Since the preliminary documentation is typically presented in memo form, this manual uses the term Geotechnical Memo, in spite of the fact that this document could be a fully executed geotechnical report.

A Geotechnical Memo is typically finalized some 75 percent of the way through the DAP timeline. At this stage, the geologic reconnaissance of the project site has been conducted and the subsurface exploration program is substantially complete. Draft gINT drill logs and preliminary geotechnical analysis has been performed to characterize key elements of the design, assess potential hazards, evaluate potential design alternatives and estimate preliminary costs.

The Geotechnical Memo is prepared by the Geotechnical Engineer POR assigned to the project. The POR should maintain close communication with the Bridge, Hydraulic and Roadway designers, as well as the Geotechnical Engineer Reviewer and Engineering Geologist POR, to ensure that the required information is provided.

Purpose

Provide a brief statement as to the purpose and intent of the Geotechnical Memorandum. This section should note that the recommendations included in this memorandum are preliminary and based on our office studies and initial phase of subsurface exploration. Recommendations may change and this should be considered an important part of the iterative design process.

Introduction

Given the early and somewhat preliminary nature of the Geotechnical Memorandum, this section is crucial and should not be overlooked. The Introduction needs to clearly describe the project as currently understood by the Geotechnical Engineer POR. Presenting current project details addresses the reticence Geotechnical Engineers may have with respect to providing usable recommendations for a project that will inevitably change. By fully describing the project scope, expected elements including structures, preliminary foundation loads, and other parameters provided by others and assumed by the Geotechnical Engineer, the limitations associated with the recommendations can be well understood by the users of the report.

Seismic Design Criteria

The presentation of complete and accurate seismic design criteria is important with respect to allowing the project designers to proceed with the preliminary design of structural elements, including bridges. The initial portion of this section should include an evaluation of active faults within 6 miles of the project site and an opinion as to the potential for fault rupture at the site (based on the proximity of known faults).

With respect to seismic design of structures, the important topics to be covered by this section include site class and site amplification factors developed in accordance with AASHTO guidelines. Further, the memo should include recommended design response spectra for Life Safety and Operational performance levels developed using the ODOT Design Response Spectrum Program and Cascadia Subduction Zone ARS.

Geologic Hazards

Describe the geologic hazards that may impact the proposed project including landslides, debris flow, rock fall, potential sink holes or lava tubes, liquefaction, soft ground or otherwise unstable soils, seismic hazards, and severe erosion conditions. Describe the location and extent of the geologic hazard as well as potential mitigation strategies.

Liquefaction

For projects where liquefaction will have an impact on the design of the project, the Geotechnical Memorandum should confirm information already provided to the design team. A preliminary evaluation of liquefaction should be completed as soon as possible in the project and if significant, communicated to the design team.

The liquefaction section should include a discussion of liquefaction potential and likely impacts on the project, including estimates of settlement, lateral spread, and downdrag on piles. Recommendations for liquefaction mitigation, if appropriate, should also be discussed.

Earthwork Recommendations

The memo should contain a discussion of significant earthwork related issued identified. These may include recommendations for the inclination of embankment and cut slopes, a discussion of the suitability of onsite material for use as compacted embankments, and the feasibility of wet weather construction.

Structure Recommendations

The recommendations for bridge structures should include a discussion of the foundation loads (Service, Strength, Extreme, etc.), types considered and a rationale for the selected foundation system. In order to inform the bridge type size and location effort, the memo should include selected foundation type(s) as well as a description of anticipated foundation size(s), number, and location(s). All load combinations, lateral and axial loads, including liquefaction-induced loads, are included. The memo includes recommendations for the preliminary design of abutment walls and wingwalls including coefficients of lateral earth pressure (K_a, K_o, K_p).

For deep foundations, LPile Parameters are provided for each interpreted soil layer, the thickness, model soil type, ϒ′, cohesion intercept, friction angle, P-Y modulus, and E50. This information is typically provided in tabular format where parameters begin at the top of the deep foundation.

For retaining walls, the memo discusses the retaining wall types considered and rationale for selected type as well as the the retaining wall size,location, and the earth pressure diagrams and recommended coefficients of lateral earth pressure (K_a, K_o, K_p).

Liquefaction Mitigation

If liquefaction is identified, a description of potential mitigation strategies that could be used to achieve the project design objectives.

20.4.3 Geotechnical Reports

In general, final geotechnical reports are developed based on an office review of existing geotechnical data for the site, a detailed geologic review and geologic model of subsurface conditions of the site, and a complete subsurface investigation program, meeting AASHTO and FHWA standards. Design analysis are then conducted based on the results of the field investigation work, combined with any institution or laboratory test data, and the resulting design recommendations are included in the geotechnical report along with construction recommendations and project special provisions as appropriate.

Geotechnical reports for bridge foundation design projects are used to communicate and document the site and subsurface conditions along with the foundation and construction recommendations to the structural designer, specifications writer, construction personnel, and other appropriate parties. The importance of preparing a thorough and complete geotechnical report cannot be overemphasized. The information contained in the report is referred to during the design phase, the pre-bid phase, during construction, and occasionally in post-construction to assist in the resolution of contractor claims.

The following reporting guidelines are provided for use in developing the final Geotechnical Report. Include all items below that apply to the project.

Description

A general description of the project scope, project elements, and project background.

Surface Conditions

Description of Project site surface conditions and current land use.

Regional and Site Geology

This section describes the site stress history and depositional/erosional history, bedrock and soil geologic units, etc. from available geologic literature or from previous geologic reconnaissance reports.

Regional and Site Seismicity

This section identifies the major seismic sources affecting the site including nearby active faults. This section is generally only included in reports addressing structural elements (e.g., bridges, walls, etc.) and major earthwork projects. Refer to Chapter 7 for additional seismic design criteria that may be required.

Summary of Office Studies

A summary of the office studies collected on the site, including final construction records for previous construction activity at the site, as-built bridge drawings or other structure layouts, pile records, boring or test pit logs or other subsurface information, geologic maps or previous or current geologic reconnaissance results.

Summary of Field Exploration

A summary of the field exploration conducted, if applicable. Provide a description of the methods and standards used, as well as a summary of the number and types of explorations and field testing that were conducted. Include a plan map (or data sheet) in the appendix showing the locations of all explorations. Also include a description of any field instrumentation installed and its purpose, data and results. Provide exploration logs in the report appendices along with any other field test data such as cone penetrometer, pressure meter, vane shear tests, or shear wave velocity profiles.

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Subsurface Profiles

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Geotechnical Data Sheets

An unstamped figure of the final Geotechnical Data Sheets is provided in the Geotechnical Data Report and/or the Geotechnical Report.

Summary of Geologic Hazards

Provide a summary of geological hazards identified and their impact on the project design (e.g., landslides, rock fall, debris flows, potential sink holes or lava tubes, liquefaction, soft ground or otherwise unstable soils, seismic hazards, and severe erosion conditions etc.), if any. Describe the location and extent of the geologic hazard.

Analysis of Unstable Slopes

For analysis of unstable slopes (including existing settlement areas), cuts, and fills, provide the following:

- Analysis approach,
- Assessment of failure mechanisms,
- Determination of design parameters (including residual shear strength as applicable),
- Factors of safety used, and
- Any agreements within ODOT or with other customers regarding the definition of acceptable level of risk.

Included in this section, would be a description of any back-analyses conducted, the results of those analyses, comparison of those results to any laboratory test data obtained, and the conclusions made regarding the parameters that are used for final design.

Recommendations for Stabilization of Unstable Slopes

Provide geotechnical recommendations for stabilization of unstable slopes (e.g., landslides, rock fall areas, debris flows, etc.). This section provides the following information and recommendations as appropriate:

- A discussion of the mitigation options available,

- Detailed recommendations regarding the most feasible options for mitigating the unstable slope,
- A discussion of the advantages, disadvantages, and risks associated with each feasible option,
- Cost estimates for each option are included, as appropriate.

Earthwork Recommendations

Provide a summary of geotechnical recommendations for earthwork (embankment design, cut slope design, drainage design, and use of on-site materials as fill). This section provides the following recommendations as applicable to the project:

- Embankment design recommendations, such as the maximum embankment slope angles, allowed for stability and any measures that need to be taken to provide a stable embankment (e.g., geosynthetic reinforcement, wick drains, staged embankment construction, surcharge, lightweight materials, use of rip rap etc.),
- Estimated embankment settlement and settlement rate, along with any recommendations for mitigating excess post construction settlement. Include any recommendations for foundation improvement (sub-excavation) such as the need for removal of any unsuitable materials beneath the proposed fills and the extent of these areas,
- Cut slope design recommendations, including the maximum cut slopes allowed to maintain the required stability. Recommendations for control of seepage or piping, erosion control measures and any other mitigation measures required to provide a stable slope is included,
- On-site, “select,” soil units are identified as to their feasibility for use as embankment material, discussing the type of material for which the select soils are feasible, the need for aeration, the effect of weather conditions on their usability, and identification of select materials that are not be used in embankment construction. The potential of non-durable rock materials are identified and discussed, as appropriate.

Rock Slope and Rock Excavation Recommendations

Provide geotechnical recommendations for rock slopes and rock excavation. Such recommendations include, but are not limited to the following:

- Recommended rock slope design and fallout area,
- Rock scaling,
- Rock bolting/dowelling, and other stabilization requirements (if appropriate), including recommendations to prevent erosion/undermining of intact blocks of rock,
- Internal and external slope drainage requirements,
- Feasible methods of rock removal such as controlled blasting or ripping,

- Detailed plans and cross sections as needed to clearly depict the areas requiring rock slope stabilization and the methods and designs recommended.

Bridge and Other Structure Recommendations

Provide geotechnical recommendations for bridges, tunnels, hydraulic structures, and other structures. See Section 20.7 for additional information required for bridge foundation designs. This section provides the following minimum information:

- Discussion of foundation options considered,
- Recommended foundation options, and the reason(s) for the selection of the recommended option(s),
- Foundation design recommendations:
  - For strength limit state – nominal and factored bearing resistance, lateral and uplift resistances,
  - For service limit state – settlement limited bearing, and any special design requirements,
  - For extreme event limit state – nominal bearing, uplift, and lateral resistance, and soil spring values,
  - Design recommendations for scour, when applicable.

Seismic Design Parameters and Recommendations

Provide the following for seismic design parameters and recommendations:

- Site location latitude and longitude decimal format to at least four digits,
- Three point design spectra using the General Procedure in AASHTO for the 2014 USGS seismic hazard maps for the 1000-year events,
- Eighteen point design spectra based on the CSZ Earthquake event (for bridges on and west of US97)
- Site Class and Soil Coefficients (F_{pga}, F_a, F_v),
- Design Response Spectrum (from AASHTO General Procedure and/or Ground Response Analysis).

Summary of Liquefaction Analysis

Provide a summary of liquefaction analysis. If liquefaction is predicted, provide:

- Estimates of embankment deformations including predicted settlement and lateral displacements,
- An assessment of potential bridge damage and approach fill performance for both the 500 and 1000 year events,
- Estimates of seismic-induced downdrag loads (if applicable),
- Soil properties for both the liquefied and non-liquefied soil conditions, for use in the lateral load analysis of deep foundations,

- Reduced foundation resistances,
- Liquefaction mitigation design recommendations (if necessary),
- Results of ground response analysis and site-specific response spectra (if applicable),
- Earth pressures on abutments and walls in buried structures.

Retaining Wall and Reinforced Slope Recommendations

Provide geotechnical recommendations for retaining walls and reinforced slopes. This section provides a discussion of:

- Wall/reinforced slope options and the reason(s) for the selection of the recommended option(s),
- Foundation type and design requirements:
  - For strength limit state - bearing resistance, lateral and uplift resistance if deep foundations selected,
  - For service limit state - settlement limited bearing, and any special design requirements,
  - Seismic design parameters and recommendations (e.g., design acceleration coefficient, extreme event limit state bearing, uplift and lateral resistance if deep foundations selected) for all walls except for ODOT Standard Retaining Walls,
  - Design considerations for scour when applicable,
  - Lateral earth pressure parameters (provide full earth pressure diagram for non-gravity cantilever walls and anchored walls).

Non-Proprietary Walls and Reinforced Slopes

For non-proprietary walls/reinforced slopes requiring internal stability design (e.g., geosynthetic walls, soil nail walls, and all reinforced slopes), provide the following:

- Minimum width for external and overall stability,
- Embedment depth,
- Bearing resistance,
- Settlement estimates,
- Soil/rock adhesion values,
- Soil reinforcement spacing, strength, and length requirements in addition to dimensions to meet external stability requirements,
- Or anchored walls, provide achievable anchor capacity, no load zone dimensions, and design earth pressure distribution.

Proprietary Walls

For proprietary walls, provide the following:

- Minimum width for external and overall stability,

- Embedment depth,
- Bearing resistance,
- Settlement estimates,
- Design parameters for determining earth pressures.

Traffic Structure, Soundwall and Building Recommendations

Provide geotechnical recommendations for traffic structures, soundwalls and buildings. This section provides the following minimum information:

Provide the following foundation information:

- Discussion of foundation options considered,
- Recommended foundation options, and the reason(s) for the selection of the recommended option(s),
- Foundation design recommendations.

For mast arm and strain pole foundation lateral resistance, provide soils information required lateral, axial, and in some instances torsional resistance. This includes soil type (cohesive or cohesionless), unit weight, soil friction angle or un-drained shear strength and groundwater level. Provide the highest groundwater level anticipated at any time during the life of the structure. If site conditions do not allow the use of the Broms method, provide soils information required for the LPile or strain-wedge analysis methods as appropriate.

For structures that have standard foundation design drawings, provide the site-specific soil designation (i.e. “Good,” “Average” or Type “A” or “B,” etc.) for use with the standard drawing. Also provide recommendations on whether or not the foundation soils and site conditions meet all requirements shown on the standard drawing, such as slope limits and settlement criteria. If soil or site conditions are variable along the length or under the foundation, clearly delineate these areas on a plan map and provide recommendations for each delineated area.

If the foundation materials or site conditions do not meet the requirements for using the standard drawings, such as conditions of hard rock or very soft, “Poor” soils, provide soil unit descriptions, soil properties, groundwater information and other design recommendations as required for design of the foundation to support the proposed structure. This includes the following information as a minimum:

- Description of the soil units using the ODOT Soil & Rock Classification System,
- Ground elevation and elevations of soil/rock unit boundaries,
- Depth to the water table,
- Soil design parameters, including effective unit weight(s), cohesion, φ, K_a, K_p, and/or P-y curve or strain-wedge data as appropriate,
- The allowable bearing capacity for spread footings and estimated wall or footing settlement (and differential settlement) as appropriate,

- Overall stability factor of safety,
- Any foundation constructability issues resulting from the soil/rock or groundwater conditions.

Recommendations for Infiltration/Detention Facilities

Provide geotechnical recommendations regarding infiltration rate, impact of infiltration on adjacent facilities, effect of infiltration on slope stability, if the facility is located on or near a slope, stability of slopes within the pond, and foundation bearing resistance and lateral earth pressures (vaults only). See the *"ODOT Hydraulics Manual"* for additional details on what is required for these types of facilities.

Recommendations for Non-Standard Foundation Designs

Provide construction recommendations and any special provisions that may be required for non-standard foundation designs. This may include things such as non-standard sub-excavation, backfill and compaction requirements, blasting specifications or the use of temporary casing for drilled shafts.

For buildings provide the following as appropriate:

- Nominal resistance or bearing capacities and associated resistance factors or factors of safety as appropriate,
- Settlement calculations and the amount of total allowable and differential settlement described for the structure.

Provide recommendations regarding temporary slopes, stabilization of unstable ground, ground improvement and retaining wall recommendations including:

- Any foundation constructability issues resulting from the soil/rock or groundwater conditions,
- Earthwork recommendations, including recommendations for fill or cut slopes, material requirements, compaction, ground stabilization or improvements and provisions for drainage as applicable.

Long-Term Construction Monitoring Needs

In this section, provide recommendations on the types of instrumentation needed to evaluate long-term performance or to control construction, the required schedule for reading instruments, length of monitoring period, how the data is used to control construction or to evaluate long-term performance, and the zone of influence for each instrument. Include recommendations for the proper installation and protection of all instrumentation during construction.

In relation to construction considerations, address issues of construction staging, shoring needs and potential installation difficulties, temporary slopes, potential foundation installation problems, earthwork constructability issues, dewatering, etc.

Construction Issues and Recommendations

In this section provide information on adverse subsurface conditions, site constraints, and other issues that could have a significant impact on the contractor's selection of means and methods of construction and on the overall project costs. Adverse subsurface conditions may include the presence of cobbles and boulders, existing foundations or other buried structures, high groundwater or artesian conditions, soil voids, very soft unstable (caving) soils, expansive soils, contaminated soils and other conditions that need to be recognized and understood by the contractor and Agency personnel.

Site constraints such as low overhead clearance, areas of difficult access or restricted construction, buried utilities, nearby structures that may be sensitive to construction vibrations and other site restrictions that could adversely affect construction is provided.

References made to environmental permits, noise regulations, and other documents relating to the construction of the geotechnical elements of the project are accurate, factual and pertain specifically to geotechnical construction are documented.

Appendices

Typical appendices include all exploration logs of borings (showing Unit Description), test pits and any other subsurface explorations (including existing exploration logs), Geotechnical Data Sheets, design charts for foundation bearing and uplift, P-y curve input data, design detail figures, layouts showing boring locations relative to the project features and stationing, subsurface profiles and typical cross-sections that illustrate subsurface stratigraphy at key locations, laboratory test results, instrumentation measurement results, and input and output of all analyses performed.

The detail contained in each of these sections will depend on the size and complexity of the project or project elements and the subsurface conditions. In some cases, design memoranda that do not contain all of the elements described above may be developed prior to developing a final geotechnical report for the project.

20.5 Geotechnical Data Sheets

This is not an inclusive list of specific features that require Geotechnical Data Sheets. A judgment-based decision on when to include Geotechnical Datasheets is expected to have better outcomes than prescriptively listing when to include them in the Project Plans. **A Geotechnical Data Sheet is produced for projects where a subsurface investigation has been conducted.**

If subsurface information is needed for project design, it is included for project construction. Geotechnical Data Sheets are expected for projects with geotechnical elements unless there is a clear case for not providing them.

20.5.1 Location of Geotechnical Data Sheets in Project Plans

The recent development of CADD standards and ODOT plan sheet title blocks facilitates the inclusion of Geotechnical Data Sheets with the structure(s) or feature(s) within the contract plan set. This was not previously possible due to the differing standards between sections within the Agency. Geotechnical Data Sheets are to be located with the structure or feature that it was developed for in the plan set. Placing the Geotechnical Data Sheets sequentially with the structure or feature provides contractors and others involved with construction the information developed during the design and eases retrieval for future reference.

Geotechnical Data Sheets are to be placed after the plan sheet and before the profile sheet for the related structure or feature. When a structure or feature has the plan and profile depicted on one single sheet then the Geotechnical Data Sheet immediately follow that sheet. Data Sheets developed for Cuts, Fills, and Embankments, will be associated with the appropriate Plan View sheet and follow the Profile Sheet for that section. When more than one Geotechnical Data Sheet is produced for a project, a Geotechnical Data Sheet Index depicting the locations is to be provided. Duplication and overlap of information on Geotechnical Data Sheets is avoided.

See the Bridge CAD Manual for direction on plan sheet numbering and title block information for Geotechnical Data Sheets. For structures requiring a structure number for the Bridge Data System (BDS), a Drafter with appropriate BDS access will provide drawing numbers for Geotechnical Data Sheets.

20.5.2 Sheet Layout and Content

The content of a Geotechnical Data Sheet is based on the Final Logs produced by the Project Engineering Geologist. Location and placement of explorations, legend development, and unit descriptions, among other attributes, are the responsibility of the Project Engineering Geologist.

20.5.3 Layout

Geotechnical Data Sheets can be arranged in multiple ways to depict subsurface conditions. The minimal content to display on a Geotechnical Data Sheet is a plan and profile showing the subsurface conditions that underlie the subject structure/feature with the profile along the roadway centerline. This is the principle layout that is to be provided for every structure/feature but it does not restrict additional plans on separate sheets that aid in depicting the underlying geologic conditions. In some instances, a Section or Cross-section may be used in lieu of a Profile.

Additional profiles offset from centerline or along structure alignments such as wall centerlines or the sides of bridges may also be produced. Cross-sections may be used in place of, or to supplement the profile for wide features or where complex geology exists. Sections may also be drawn at skewed angles to the centerline where needed to best display subsurface conditions or to show a specific element such as the principal axis of a landslide.

Geotechnical Data Sheets in the contract plans must be stamped by appropriate Professional of Record (POR) in accordance with the Agency's Stamping Policy.

20.5.4 Plan

The plan view shows existing structure(s) (if applicable) or feature(s) in addition to the proposed structure(s) or feature(s). For bridges, existing and proposed bent and abutment locations are located and labeled. The footprint or general layout of other structures and features are shown. These features are drawn on the Geotechnical Data Sheet at a scale suitable for easy viewing of applicable features.

Provide the alignment to be used for construction of the structure/feature. Stationing sufficient to orient the drawing and to provide reference to the structure/feature elements being constructed. Stationing follows the CPM requirements for stationing from left to right on the sheet. Provide the project alignment on all sheets whether or not structure-specific alignments are used for construction. The location of explorations such as borings, test pits, cone penetrometer tests, seismic lines or other subsurface explorations must be shown. Each location is identified with correct symbology assigned by the CPM. Provide the survey location directly adjacent to the exploration number. This survey information includes the exploration number, the name of the alignment, station, and offset with Right or Left offset indicated. For projects without alignments, the coordinates of the exploration would be shown instead. These coordinates are the same as the project coordinate system. If cone penetrometer, pressure meter, vane shear, packer or other in-situ testing is performed, a note stating that the results of these tests are available in the Geotechnical Report.

Provide water body boundaries and flow direction, if applicable, that lie within the plan view of the structure or feature. Label the water body with the name of that body of water or use unnamed if there is not a name. Intermittent waterways are labeled or depicted as such with the applicable symbology.

Provide existing contour lines as gray-shaded. Contours must be displayed with numeric labels indicating their elevation at an appropriate interval without unit labels. Provide the contour interval on the plan sheet. Features or lines that do not serve a clear purpose with respect to conveying information about the site conditions to be omitted.

20.5.5 Profile

The profile view shows the engineering geology interpretation of the subsurface conditions at the structure or feature location. This interpretation is depicted by geologic graphic columns or "stick logs" that represent each exploration at the station and elevation at which they occur along the alignment. Geologic graphic columns consist of separate sections that represent the subsurface materials by patterned symbology. An Engineering Geologic Unit Description is used to describe the materials represented by the patterns in a legend format. The legend-style Engineering Geologic Unit Descriptions are separate and distinct from the standard legend showing the standard graphic symbols.

Each Engineering Geologic graphic column is labeled at the top with the exploration number offset (optional), elevation, and the date the boring was completed.

Additional information with depth is shown alongside the Engineering Geologic graphic column. Samples and in-situ test results are shown with their designated symbols at the depth they were taken or performed along the right side of the graphic column. SPT (Standard Penetration Test) intervals are to be labeled by their N-Value. Sample intervals are denoted by the vertical length of the symbol. Continuous sampling methods such as rock coring are shown by dimensions labeled with the sample name. Groundwater is shown on the left side of the graphic column. The standard groundwater symbols are placed at the depth of the highest and lowest groundwater levels measured. These symbols are labeled with the dates that the readings were taken. Provide a statement if no groundwater was encountered.

Provide Rock Core Tables to show specific rock core data for each boring. Provide a table for each Engineering Geologic graphic column with rock coring with the core run, percent recovery, hardness, Rock Quality Designation (RQD), and date obtained. Place these tables below the profile where the corresponding Engineering Geologic graphic column occurs. Sheet space limitations may require a different distribution of the rock core tables.

Profiles are shown along the alignment(s) used for construction as described in the preceding LAYOUT section. Provide each Engineering Geologic graphic column aligned with the corresponding exploration symbol on the plan view immediately above the profile. Profiles are displayed on station and elevation grids. Label stations on the bottom of the grid. Include labeled elevations on the left side of the grid. Grid lines may be subdued to avoid conflict with Engineering Geologic graphic columns showing geologic interpretations or the various Engineering Geologic graphic column labels. Profiles are labeled as “PROFILE AT ‘LINE NAME’”.

Avoid depicting numerous explorations on a single profile, which obscure data or lead to a cluttered appearance. Several options can be used to alleviate this situation:

- Expand the horizontal scale of the drawing
- Use supplemental sections, profiles, or cross-sections. Provide supplemental sections, profiles, and cross-sections in the Geotechnical Data Sheet format.

20.5.6 Sections and Cross-Sections

Sheets displaying sections or cross-sections are typically used to improve understanding for large structures/features or complex subsurface conditions. However, they are required for all landslides and for cuts, and embankments that are large enough to necessitate subsurface exploration. Cross-sections should be considered for wide or skewed structures, structures founded on spread footings, and where variable-lengths of deep foundations result from high local relief or geologic structure.

Plan views may be shown on section and cross-section sheets where needed. Illustrate the section line on the Plan View of the primary geotechnical data sheet and label with the section arrow and designation when section sheets are utilized.

Illustrate the existing ground line along the section and the Engineering Geologic graphic columns as described above under Profile. Sections drawn on a grid with the elevations labeled on the left and right side of the grid table and the horizontal offset from centerline labeled on the bottom of the grid or on the bottom and top of the grid. Grid lines may be subdued to avoid conflict with Engineering Geologic graphic columns showing interpretations or the various Engineering Geologic graphic column labels.

Cross-sections developed perpendicular to the centerline alignment may be labeled as “SECTION ‘Station’ “. Sections developed at angles other than perpendicular are labeled as “SECTION ‘alphabetic letter – alphabetic letter’ “.

20.5.7 Unit Descriptions

Provide unit descriptions and their corresponding symbols in a legend-style format on each Geotechnical Data Sheet. The Unit Descriptions contain descriptions for the engineering geologic units on that specific sheet. The unit descriptions on a Geotechnical Data Sheet are a compilation of the physical and engineering properties from the final logs. These unit descriptions are compiled from the descriptions on the logs of explorations represented on the individual sheet. Engineering geologic unit descriptions and properties are often singularly consolidated in the Engineering Geology or Geotechnical Engineering reports. Do not use broad-ranging descriptions on a Geotechnical Data Sheet unless every exploration for the project is represented on that data sheet. The Project Geologist must compile the description for the legend based on the explorations shown on that sheet. Project-specific information may be conveyed on a Data Sheet from other referenced project data sources. An example of this would be a specific note on a boulder-bearing Engineering Geologic unit that did not encounter boulders in the sheet’s specific borings, but were found elsewhere in the same unit or presented in the published literature.

20.6 Additional Reporting Requirements for Structure Foundations

The geotechnical designer provides the following additional information to the structural designer for use in the design of structure foundations:

20.6.1 Spread Footings

If spread footings are recommended, provide the following information in the geotechnical report:

- Elevations of the proposed footings, a clear description of the foundation materials the footings are to be constructed on and minimum cover requirements,
- Specify whether or not the footings are to be keyed into rock. Check with the bridge designer to see if a "fixity" condition is required in rock. On sloping rock surfaces, work with the structural designer to determine the best "bottom-of-footing" elevations,
- Nominal bearing resistance available for the strength and extreme event limit states,
- Settlement limited nominal bearing resistance for the specified settlement (typically 1 inch) for various effective footing widths likely to be used for the service limit state,
- Resistance factors for each limit state, and
- Minimum footing setback on slopes and embedment depths.

The allowable footing/wall settlement is a function of the structure type and performance criteria and the structural designer should be consulted to establish allowable structure settlement criteria.

To evaluate sliding stability and eccentricity, the geotechnical designer provides resistance factors for both the strength and extreme event limit states for calculating the shear and passive resistance in sliding. Also the soil parameters φ, K_p, γ, K_a, and K_{ae} are provided for calculating the passive and active resistances in front of and behind the footing.

To evaluate soil response and development of forces in foundations for the extreme event limit state, the geotechnical designer provides the foundation soil/rock shear modulus values and Poisson's ratio (G and μ).

The geotechnical designer evaluates overall stability and provides the maximum (un-factored) footing load which can be applied to the design slope and still maintain an acceptable safety factor (1.5 for the strength and 1.1 for the extreme event limit states, which is the inverse of the resistance factor). A uniform bearing stress, as calculated by the Meyerhof method, is used for this analysis. Example presentations of the LRFD footing design recommendations to be provided by the geotechnical designer are shown in Table 20-1, 20-2, 20-3 and Figure 20-1.

Table 20-1 Example Presentation of Soil Design Parameters for Spread Footing Design

Parameter	Abutment Piers	Interior Piers
Soil Unit Weight, γ (soil above footing base level)	x	x
Soil Friction Angle, Φ (soil above footing base level)	x	x
Active Earth Pressure Coefficient, K_a	x	x

Parameter	Abutment Piers	Interior Piers
Passive Earth Pressure Coefficient, K_p	x	x
Seismic Earth Pressure Coefficient, K_{ae}	x	
Soil Unit Weight, γ (soil above footing base level)	x	x

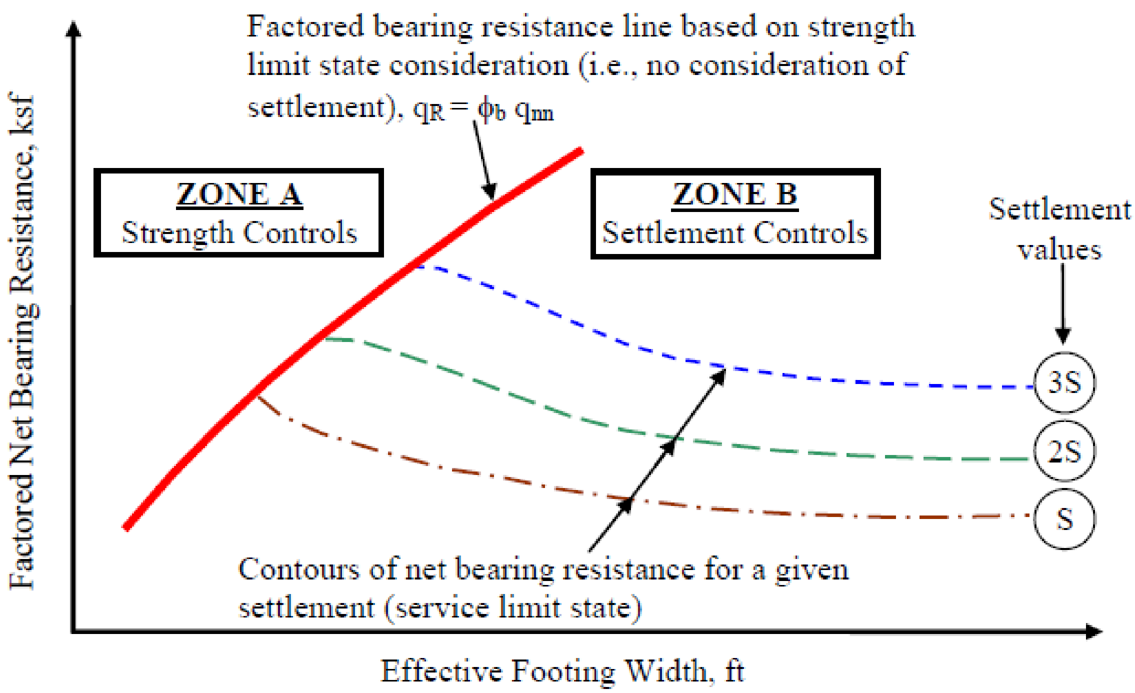
Table 20-2 Example Table for Summarizing Resistance Factors used for Spread Footing Design

Resistance Factor, φ			
Limit State	**Bearing**	**Shear Resistance to Sliding**	**Passive Pressure Resistance to Sliding**
Strength	x	x	x
Service	x	x	x
Extreme Event	x	x	x

Table 20-3 Example Table for Spread Footing Bearing Resistance Recommendations

Bent	Footing Size	Footing Elev.	R_n	ϕ	ϕR_n

Figure 20-1 Example of Spread Footing Bearing Resistance Recommendations. (from FHWA-RC/TD-10-001 (2010)



20.6.2 Pile Foundations

20.6.2.1 Bearing Resistance

Pile bearing resistance recommendations may be provided using either of the following two approaches.

1. A plot of the nominal bearing resistance (R_n) is provided as a function of depth for various pile types and sizes (for strength and extreme event limit states). This design data is used to determine feasible nominal pile resistances and the corresponding estimated pile depths required. See Figure 20-2 for an example of this pile data presentation.
2. If the required nominal bearing resistance (R_n) is known, the estimated depth at which it could be obtained may be provided in tabular format for one or more selected pile types and sizes.

Resistance factors for bearing resistance for all limit states is provided (see Table 20-4 for an example).

Figure 20-2 Example Plots of Pile Bearing and Uplift Resistance.

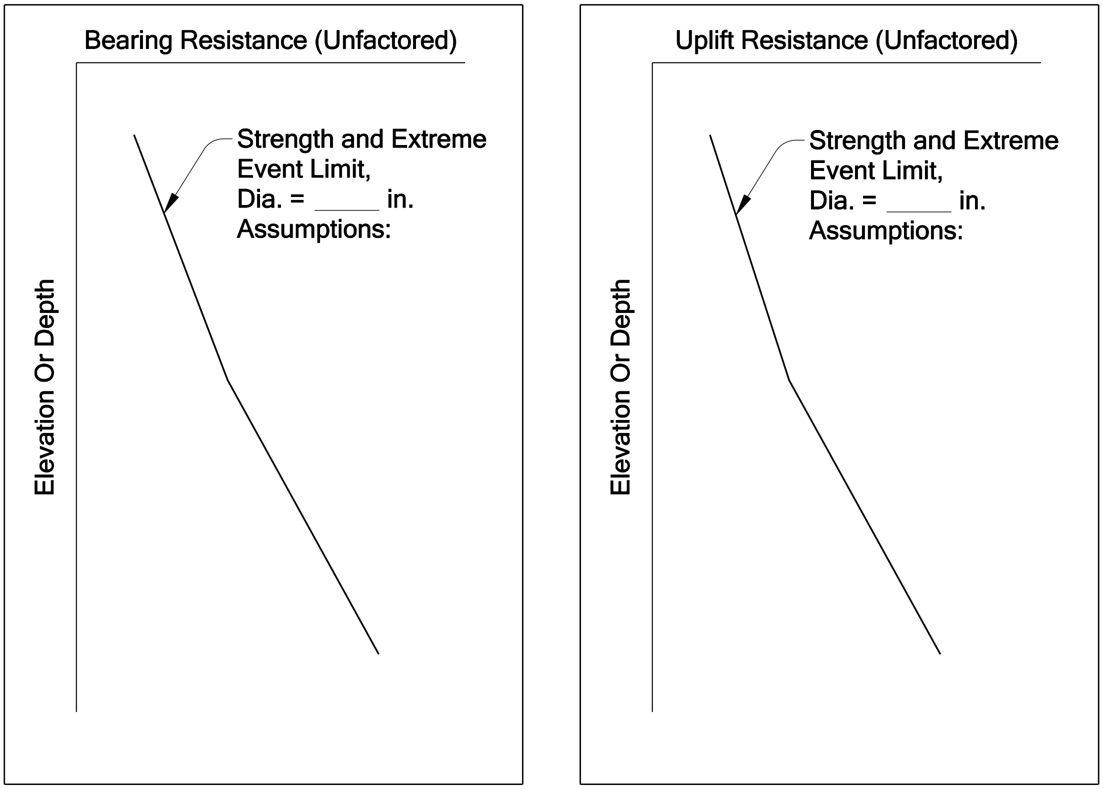


Table 20-4 Example Table of Resistance Factors for Pile Design.

Resistance Factor, φ		
Limit State	**Bearing Resistance**	**Uplift**
Strength	x	x
Service	x	x
Extreme Event	x	x

Once R_n is known (or the total driving resistance, R_{ndr}, if applicable) and the cutoff elevation of the pile is obtained from the bridge designer, then the “Engineers Estimated Length” can be determined for steel piles. The Engineer’s Estimated Lengths are required in the project special provisions for each bridge bent. Table 20-5 below is as example of how this information is presented. The table is modified as necessary to account for reduced capacities due to scour, liquefaction, downdrag or other conditions.

Table 20-5 Pile Resistances & Estimated Lengths (Br. 12345)

Pile Type: PP16x0.50"

Bent	Rn (kips)	φRn (kips)	C.O. Elev. (ft.)	Est. Tip Elev. (ft.)	Engr's Est. Length, (ft.)	Req'd. Tip Elev. (ft.)
1	450	180	210	130	80	150
	350	140	210	145	65	150
2	450	180	170	120	50	135
	350	140	170	130	40	135
3	450	180	200	125	75	140
	350	140	200	135	65	140

Legend & Table Notes:

R_n = Nominal pile bearing resistance

φR_n = Factored pile bearing resistance, (φ based on field method used to determine the required nominal pile bearing resistance)

C.O. = Pile cutoff elevation

20.6.2.2 Downdrag

If downdrag loads are anticipated, the following is provided:

- Estimated downdrag load, DD,
- Depth of the downdrag zone, or thickness of the downdrag layer,
- Downdrag load factor,
- Cause of the downdrag (settlement due to vertical stress increase, liquefaction, etc.),
- Also the total driving resistance, R_{ndr}, (the required nominal pile driving resistance), taking into account the downdrag loads, is provided.

20.6.2.3 Scour

If scour is predicted, the depth of scour and the skin friction lost due to scour, R_{scour}, is provided. The total driving resistance, R_{ndr}, (the required nominal resistance), taking the loss of friction due to scour into account, is provided.

20.6.2.4 Uplift Resistance

For evaluating uplift, the geotechnical designer provides the following:

- Nominal (un-factored) and factored uplift resistance, R_n, either plotted as a function of depth or as a single value for a given minimum tip elevation, depending on the project needs.,
- Skin friction lost, due to scour or liquefaction that is to be applied to the uplift resistance curves, (provided either separately, in tabular form, or include on plots of uplift resistance with depth),
- Resistance factors for either single piles or pile groups (as appropriate).

20.6.2.5 Lateral Resistance

The geotechnical designer provides the soil parameters necessary to develop p-y curves and perform the lateral load analysis. The p-y curve soil input data provided for each soil or rock unit as defined by the top and bottom elevations of each unit. Resistance factors for lateral load analysis do not need to be provided, as the lateral load resistance factors will typically be 1.0.

The parameters required are typically those required for the LPile, GROUP or DFSAP proprietary computer programs and the p-y soil/rock parameters provided is in a format for easy insertion into either of these computer programs. Coordinate with the structural design as necessary to determine which program input values are required. It is important that the geotechnical designer maintain good communication with the structural designer to determine the kind of soil parameters necessary for the lateral load analysis of the structure. If liquefaction of foundation soils is predicted, soil parameters are provided for both the liquefied and non-liquefied soil conditions. Table 20-6 is an example format for presenting the required data for a non-liquefied soil condition.

Table 20-6 Soil Parameters for Lateral Load Analysis (non-liquefied soil condition).

Bridge 12345; Bents 1 & 3

ELEVATION (ft.)		p-y Curve Model*	K (lbs./in^3)	SOIL PARAMETERS				SOIL DESCRIPTION
From	To			γ,(pci)	c,(psi)	e_{50}	φ	
63.5	55.0	Soft Clay	500	0.06	3.5	.007	--	Sandy Clayey Silt to Silty Clay (fill)
55.0	30.0	Stiff clay without free water	1000	0.07	13	.005	--	Silt w/ trace sand & clay to Clayey Silt, low plasticity
30.0	10.0	Stiff clay without free water	2000	0.072	20	.004	--	Clay to Silty Clay, med.-high plasticity, very stiff

* For the LPile program provide the appropriate soil type from the default types listed in LPile or provide custom P-y curves if necessary.

If lateral loads imposed by special soil loading conditions such as landslide forces are present, the lateral soil force or stress distribution and the load factors to be applied to that force or stress, are provided.

20.6.2.6 Required Pile Tip Elevation for Minimum Penetration

Provide a required pile tip elevation for piles at each bent. The required tip elevation represents the highest acceptable tip elevation that will still provide the required resistances and performance under all loading conditions. The required tip elevation (sometimes referred to as "Minimum Tip Elevation") is typically based on one or more of the following conditions:

- Pile tip reaching the required bearing layer or depth,
- Providing required uplift resistance,
- Providing required embedment for lateral support,
- Satisfying settlement and/or downdrag criteria,
- Providing sufficient embedment below scour depths or liquefiable layers.

The required pile tip elevations provided in the Geotechnical Report may need to be adjusted depending on the results of the lateral load or uplift load evaluation performed by the structural designer. If adjustments in the required tip elevations are necessary, or if changes in the pile diameter are necessary, the geotechnical designer is informed so that pile drivability and resistance recommendations can be re-evaluated. The required tip elevation may require driving into, or through, very dense soil layers resulting in potentially high driving stresses. Under these conditions a wave equation drivability analysis is necessary to make sure the piles can be driven to the required embedment depth (tip elevation) without damage.

20.6.2.7 Pile Tip Reinforcement

Specify steel pile tip reinforcement if piles are to be driven through very dense granular soils containing cobbles and boulders or for penetration into weak rock. Pile points (H-piles) or shoes (pipe piles) are typically specified. In pipe pile driving conditions where difficult driving through dense sand and gravel is anticipated before reaching the required tip elevation, inside-fit pipe pile shoes are sometimes used to help retard the formation of a soil plug at the pile tip. Section 02520 of the Boilerplate Special Provisions must be included in the project specifications for specifying the proper steel grade for pile tip reinforcement and other requirements. Also note that outside-fit pile tip reinforcement (points or shoes) can reduce the friction resistance and this effect is taken into account in design before specifying outside fit tips or shoes.

20.6.2.8 Pile Splices

The contractor is responsible for providing the Engineer's Estimated pile length. ODOT pays for splices when piles are driven over the Engineer's Estimated Length. Provide the number of anticipated pile splices that might be needed due to variability of the subsurface conditions. This number of splices is included as a bid item in the contract documents.

20.6.2.9 Pile Driving Criteria and Acceptance

The method of construction control and pile acceptance must be specified in the report for each project. All piles are accepted based on field measured pile driving resistances, established by the FHWA Gates equation, wave equation analysis, PDA/signal matching methods or load test criteria.

The pile driving analyzer (PDA) with signal matching (CAPWAP) is also sometimes used on projects where it is economically justified. Full scale static load tests are rarely performed but are recommended for large projects where there is potential for substantial savings in foundation costs.

Typical ODOT practices regarding the use of dynamic driven pile acceptance methods are described as follows:

FHWA Gates Equation: For routine pile design projects with nominal pile bearing resistances less than or equal to 600 kips, the default dynamic formula used to establish pile driving criteria is the FHWA Gates Equation. When using this equation a resistance factor of 0.40 is applied to the nominal bearing resistance to determine the factored resistance.

Wave Equation Analysis Program (WEAP): Wave Equation driving criteria is generally used for the following situations:

- Nominal pile resistances greater than of 600 kips,
- Where driving stresses are a concern (e.g., short end-bearing piles or required penetration through very dense strata),
- Very long friction piles in granular soils.

A resistance factor of 0.50 is applied to the nominal bearing resistance to determine the factored resistance. When the wave equation method is specified, the contractor is required to perform a wave equation analysis of the proposed hammer and driving system and submit the analysis as part of the hammer approval process. The soils input criteria necessary for the contractor to perform the WEAP analysis needs to be supplied in a table in Section 00520 of the contract special provisions. An example of a completed table that would be provided in the geotechnical report (and special provisions) is shown below.

Table 20-7 Example of Wave Equation Input Table.

Bridge No. 12345; Bents 1 & 2

Pile Type	Pile Length (ft.)	Quake (in.)		Damping (in./sec.)		Friction Distribution (ITYS)	IPRCS (Note 2)	R_n (kips)
		Skin	Toe	Skin	Toe			
PP16 x 0.50	85.0	0.10	0.15	0.20	0.20	Note 1	95	620

Note 1: Use a rectangular distribution of skin resistance over the portion of the pile underground.

Note 2: IPRCS is the percent skin friction (percent of R_n that is skin friction in the WEAP analysis).

Refer to the Section 00520 of the Standard and Special Provisions for additional specification requirements. Provide WEAP input data for the highest (worst-case) driving stress condition, which may not always be for the pile at the estimated tip elevation.

Pile Driving Analyzer (PDA) with Signal Matching: Large pile driving projects may warrant the use of dynamic pile testing using a pile driving analyzer for additional construction quality control and to save on pile lengths. Generally the most beneficial use of PDA testing is on projects with large numbers of very long, friction piles driven to high resistance. However, there may be other reasons for PDA testing such as high pile driving stress conditions, testing new pile hammers, questionable hammer performance or to better determine the pile skin friction available for uplift resistance. A resistance factor of 0.65 can be applied to the nominal bearing resistance determined by PDA and signal matching analysis if an adequate number of production piles are tested. *AASHTO Article* ***10.5.5.2.3*** should be referenced for the procedures to use for PDA/Signal Matching pile acceptance. A signal matching (CAPWAP) analysis of the dynamic test data is always performed to determine the axial nominal resistance and to calibrate the PDA resistance prediction methods. The piles are tested after a waiting period if pile setup or relaxation is anticipated.

20.6.3 Drilled Shafts

To evaluate bearing resistance, the geotechnical designer provides, as a function of depth and for various shaft diameters, the nominal bearing resistance for end bearing, R_p, and side friction, R_s, used to calculate R_n, for strength and extreme event limit state calculations (see example figures below). For the service limit state, the bearing resistance at a specified settlement, typically 0.5 or 1.0 inch (mobilized end bearing and mobilized side friction)are provided as a function of depth and shaft diameter. See Figure 19.3 for an example of lateral earth pressures for gravity wall design for an example of the shaft bearing resistance information that is provided. Resistance factors for bearing resistance for all limit states are reported.

Downdrag

If downdrag loads are anticipated, the following are provided:

- The depth of the downdrag zone, or thickness of the downdrag layer,
- The downdrag load, DD, as a function of shaft diameter,
- The downdrag load factor,
- The loss of skin friction due to downdrag,

- The cause of the downdrag (settlement due to vertical stress increase, liquefaction, etc.).

20.6.3.1 Scour

If scour is predicted, the depth of scour and the skin friction lost due to scour, R_{scour}, is provided by the Hydraulic Engineer and documented in the report.

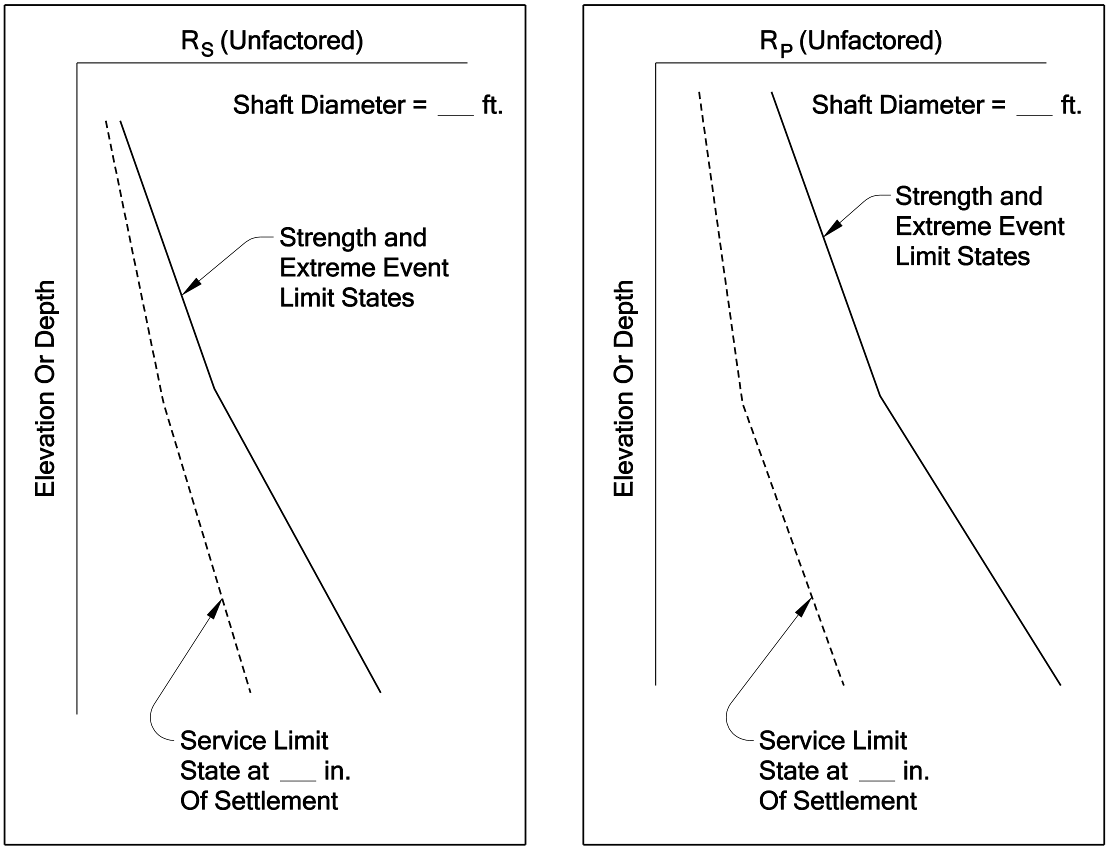
20.6.3.2 Uplift Resistance

For evaluating uplift, the geotechnical designer provides, as a function of depth, the nominal and factored uplift resistance. The skin friction lost due to scour or liquefaction that is to be applied to the uplift resistance curves are documented (either separately, in tabular form, or included on the plots of uplift resistance with depth). Resistance factors for either single shafts or shaft groups are reported.

20.6.3.3 Lateral Resistance

Provide soil input values for the LPile, GROUP or DFSAP program as described in Section 19.7.2.5. Coordinate with the structural design as necessary to determine which program input values are required. Resistance factors for lateral load analysis generally do not need to be provided, as the lateral load resistance factors will typically be 1.0.

Figure 20-3 Typical shaft bearing resistance plots (all limit states).



20.6.3.4 Crosshole Sonic Log Testing

Access tubes for crosshole sonic log (CSL) testing are typically provided in all drilled shafts unless otherwise recommended by the geotechnical designer. Typically, one tube is provided per foot of shaft diameter with a minimum of 3 tubes provided per shaft. All CSL tubes are 1-1/2" inside diameter Schedule 40 steel pipe conforming to ASTM A53, Grade A or B, Type E, F, or S.

The amount of CSL testing needs to be determined for each project is recommended in the Geotechnical report and shown on the plans. Specify the minimum number of CSL tests to be conducted and the location of these tests. The actual number of tests can be increased, if necessary, during construction depending on the contractor's work performance. The amount of testing that is performed depends on the subsurface conditions, the redundancy of the foundation system and the contractor's work performance. The first shaft constructed is always tested to confirm the contractor's construction procedures and workmanship. Subsequent tests are based on the following guidelines and engineering judgment:

- Test every single-shaft bent,
- Minimum of 1 CSL test per bent (or shaft group) or 1/10 shafts.
- Redundancy in the substructure/foundation,

- Soil conditions (potential construction difficulties like caving soils, ground swelling, and boulders),
- Groundwater conditions (wet holes, artesian conditions).

See Chapter 18 for additional guidelines for CSL testing procedures during construction

20.6.3.5 Shaft Reinforcement Lengths in Rock Socket Applications

For rock socket shaft designs where the top of rock is uncertain (as described in Chapter 17), provide the following in the Geotechnical Report and in the project special provisions:

- The additional length(s) of shaft reinforcement needed to account for the uncertainty in the top of the bearing layer for rock socket applications,
- The requirement that the contractor's drilled shaft equipment must be capable of drilling the full extra shaft length. This requirement must be included in the project Special Provisions.

20.6.4 Geotechnical Report Checklist for Bridge Foundations

The Geotechnical Report Review Checklist in Appendix 19-A Geotechnical Report Review Checklist is used to check the content and completeness of geotechnical reports prepared for bridge foundation projects. The checklist is completed by the Professional-of-Record for the project. The checklist questions are completed by referring to the contents of the geotechnical report. For each question, a yes, no, or not applicable (N/A) is provided. A response of "I don't know" to any applicable section on the checklist is not to be shown with a check in the "Not Applicable" (N/A) column. All checklist questions answered with “NO” are fully documented on subsequent pages of the checklist.

A copy of the completed checklist, and all comments and explanations, are included with the geotechnical report when submitted for review to ODOT.

20.6.5 Geotechnical Report Distribution

Geotechnical reports are posted on eBIDS and distributed to the following personnel:

- Structure Designer
- Roadway Designer
- Specification Writer
- Project Leader
- Project Manager (more copies if requested for contractors)
- Hydraulic Engineer (if appropriate)

- Project Geologist

20.6.6 Retaining Walls

To evaluate bearing resistance for gravity walls, the geotechnical designer provides q_n, the nominal bearing resistance available, and q_{serv}, the settlement limited bearing resistance for the specified settlement for various effective footing widths (i.e., reinforcement length plus facing width for MSE walls) likely to be used (see Figure 20-4). Resistance factors for each limit state are also provided. The amount of settlement on which q_{serv} is based shall be stated. The calculations assume that q_n and q_{serv} will resist uniform loads applied over effective footing dimension B' (i.e., effective footing width (B - 2e)) as determined using the Meyerhof method for soil). For footings on rock, the calculations assume that q_n and q_{serv} will resist peak loads and that the stress distribution is triangular or trapezoidal rather than uniform. The geotechnical designer also provides wall base embedment depth requirements or footing elevations to obtain the recommended bearing resistance.

To evaluate sliding stability, bearing, and eccentricity of gravity walls, the geotechnical designer provides:

- Resistance factors for both the strength and extreme event limit states for calculating the shear and passive resistance in sliding,
- Soil parameters φ, K_p, γ and depth of soil in front of footing to ignore when calculating passive resistance,
- Soil parameters φ, K_a, and γ used to calculate active force behind the wall,
- Coefficient of sliding, tanφ,
- Seismic design parameters:
    - Peak ground acceleration coefficient (PGA)
    - Short period spectral acceleration coefficient (S_S)
    - Long period spectral acceleration coefficient (S_1)
    - Site class
    - Peak ground acceleration coefficient modified by the zero period site factor (A_s)
    - Horizontal seismic acceleration coefficient (k_h)
    - Seismic active pressure coefficient (K_{AE}) – where Mononobe-Okabe method is suitable
    - Dynamic active horizontal thrust, including static earth pressure (P_{AE}) – where Mononobe-Okabe method is <u>not</u> suitable
- Separate earth pressure diagrams for strength and extreme event (seismic) limit state calculations that include all applicable earth pressures, with the exception of traffic barrier impact loads (traffic barrier impact loads are developed by the structural designer).

The geotechnical designer evaluates the overall stability. If overall stability controls the required wall width, the designer provides the minimum footing or reinforcement length required to maintain an acceptable safety factor (1.5 for the strength and 1.1 for the extreme event limit states, which is the inverse of the resistance factor, i.e., 0.65 and 0.9, respectively).

Figure 20-4 Example of bearing resistance recommendations for gravity walls

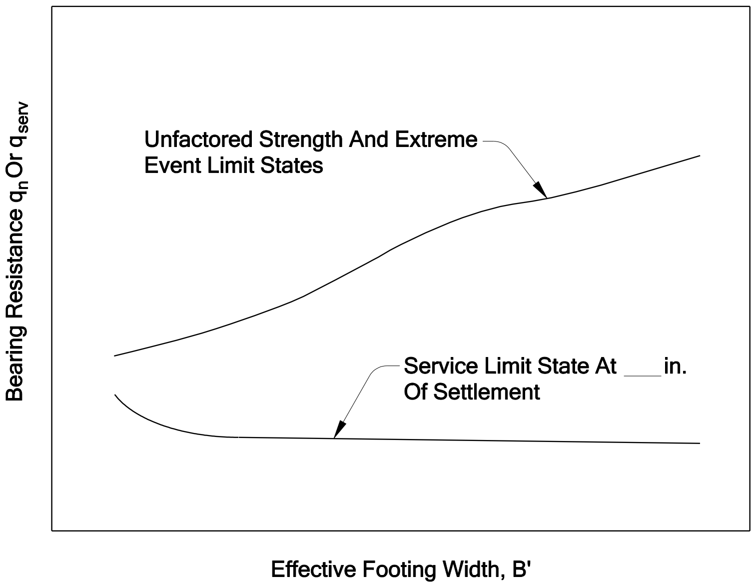
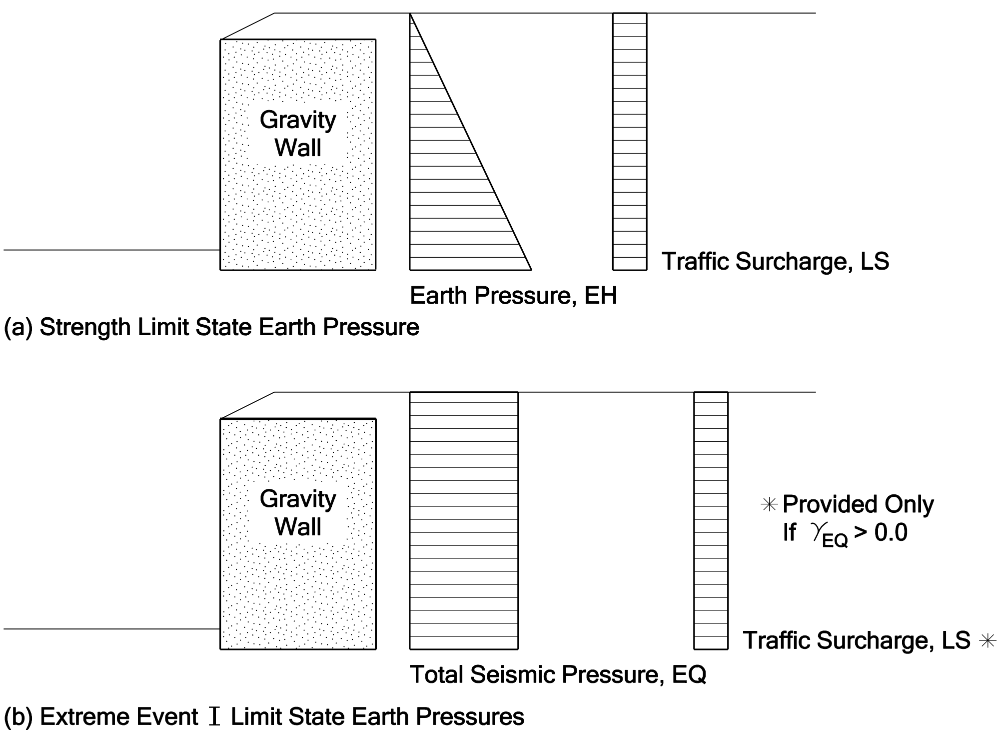


Figure 20-5 Example of lateral earth pressures for gravity wall design



For non-proprietary MSE walls, the spacing, strength, and length of soil reinforcement is provided, as well as the applicable resistance factors. MSE reinforcement properties are specified in the special provisions for *Section 02320*. Spacing and length requirements may also be best illustrated using typical cross sections.

For non-gravity cantilever walls and anchored walls, the following are provided:

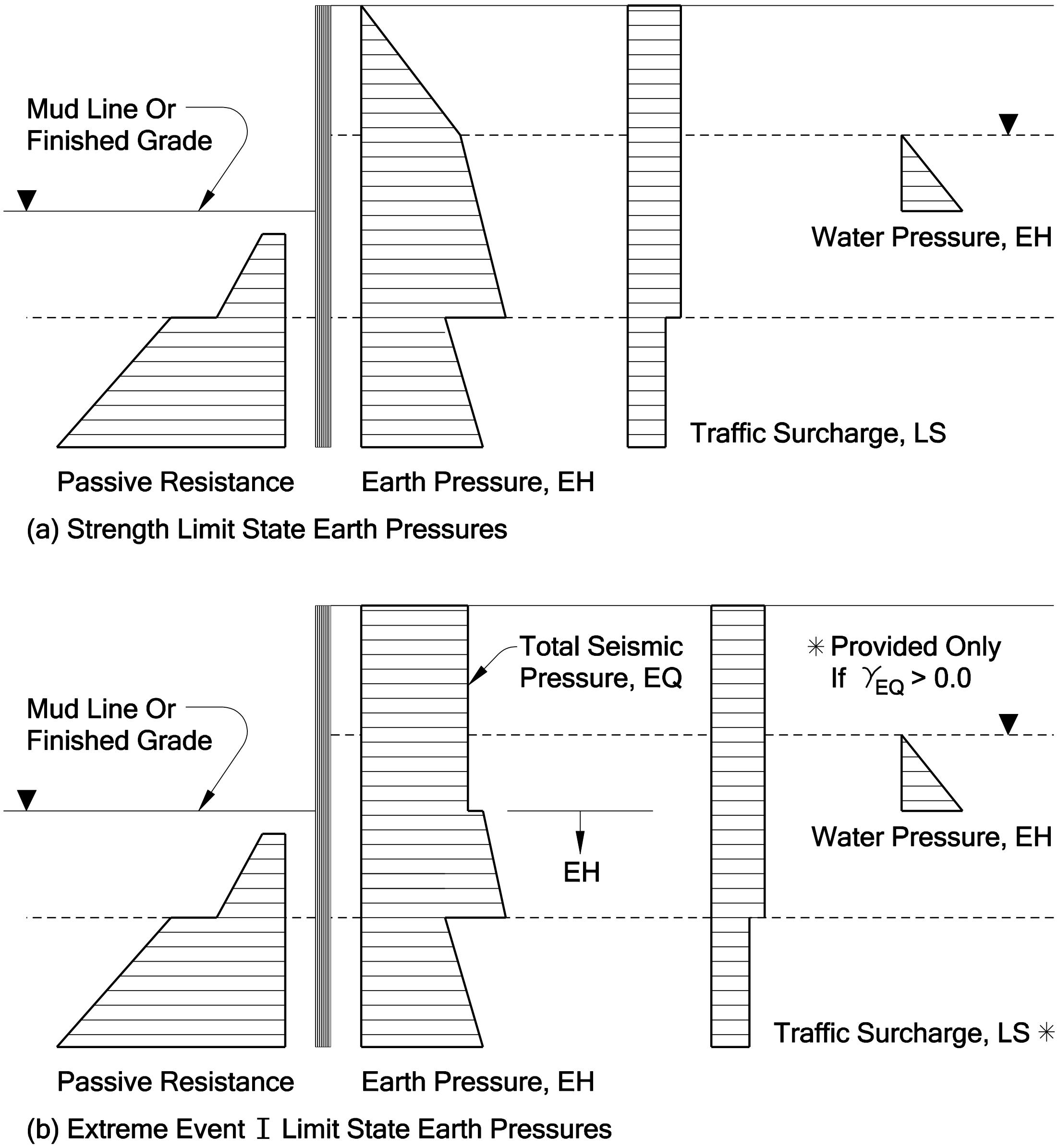
- Bearing resistance of the soldier piles or drilled shafts as a function of depth (see Figure 20-3),
- Lateral earth pressure distribution (active and passive),
- Minimum embedment depth required for overall stability,
- No load zone dimensions,
- Anchor resistance for anchored walls, and the associated resistance factors.

Table 20-8 and Figure 20-6 provides an example presentation of soil design parameters and earth pressure diagrams for non-gravity cantilever and anchored walls to be provided by the geotechnical designer.

Table 20-8 Example presentation of soil design parameters for design of non-gravity cantilever walls and anchored walls.

Parameter	Value
Soil Unit Weight, γ (all applicable strata)	x
Soil Friction Angle, Φ (all applicable strata)	x
Active Earth Pressure Coefficient, K_a	x
Passive Earth Pressure Coefficient, K_p	x
Seismic Earth Pressure Coefficient, K_{ae}	x
Averaged γ used to determine K_{ae}	x
Averaged Φ used to determine K_{ae}	x

Figure 20-6 Example presentation of lateral earth pressures for non-gravity cantilever and anchored wall design.



20.7 Geotechnical Design File Information

Documentation that provides details of the basis of recommendations made in the geotechnical report or memorandum is critical not only for review by senior staff, but also for addressing future questions that may come up regarding the basis of the design, to address changes that may occur after the design is completed, to address questions regarding the design during construction, to address problems or claims, and for important information for developing future projects in the same location, such as bridge or fill widening. Since the engineer who does the original design may not necessarily be the one who deals with any of these future activities, the documentation must be clear and concise, and easy and logical to follow. Anyone who must look at the calculations and related documentation should not have to go to the original designer to understand the calculations being performed.

The project documentation must be consistent with FHWA guidelines and as set forth in this chapter. Details regarding what this project documentation should contain are provided in the following sections.

20.7.1 Documentation for Preliminary Geotechnical Design

Document sources of information (including the date) used for the preliminary evaluation. Typical sources include as-built bridge or other structure drawings, as-constructed roadway drawings, existing test hole logs, geologic maps, previous or current geologic reconnaissance results or previous site investigation work and instrumentation data. Also document the following:

- The details of the geologic reconnaissance site visit, including any photos.
- Provide a description of the foundation support used for the existing structure, including design bearing capacity, if known, and any foundation capacity records such as pile driving logs, load test results, etc.
- From the contract or maintenance records, summarize any known construction or maintenance problems encountered during construction or throughout the life of the structure. Examples from the construction records include over-excavation depth and extent, and why it was needed, seepage observed in cuts and excavations, dewatering problems, difficult digging, including obstructions encountered during excavation, obstructions encountered during foundation installation (e.g., for piles or shafts), slope instability during construction, changed conditions or change orders involving the geotechnical features of the project, and anything else that would affect the geotechnical aspects of the project.
- For any geotechnical recommendations made, summarize the logic and justification for those recommendations. If the recommendations are based on geotechnical engineering experience and judgment, describe what specific information led to the recommendation(s) made.

20.7.2 Documentation for Final Geotechnical Design

In addition to the information described above in Section 20.7.1, the following information is documented and maintained in the project geotechnical file:

1. List or describe all given information and assumptions used, as well as the source of that information. For all calculations, an idealized design cross-section that shows the design

element (e.g., wall, footing, pile foundation, buttress, rock slope, etc.) located in context to the existing and proposed ground lines, and the foundation soil/rock is provided. This idealized cross-section shows the soil/rock properties used for design, the soil/rock layer descriptions and thicknesses, the water table location, the existing and proposed ground line, and any other pertinent information. For slope stability, the soil/rock properties used for the design is shown on the computer generated output cross-section.

2. Additional information and/or a narrative is provided which describes the basis for the design soil/rock properties used. If the properties are from laboratory tests, state where the test results, and the analysis of those test results, can be found in the final geotechnical design documentation and how those test results apply to the specific site conditions and strata encountered including consideration of site geological history. If using correlations to SPT, cone data or other measurements, state which correlations were used, the range of applicability of the correlation to the available measurements, the potential uncertainty in the estimated property value due to the use of that correlation and any corrections to the data made,
3. The design method(s) used must also be clearly identified for each set of calculations, including any assumptions used to simplify the calculations, if that was done, or to determine input values for variables in the design equation. Write down equation(s) used and the meaning of the terms used in equation(s), or reference where equation(s) used and/or meaning of terms were obtained. Attach a copy of all curves or tables used in making the calculations and their source, or appropriately reference those tables or figures. Write down or summarize all steps needed to solve the equations and to obtain the desired solution.
4. If using computer spreadsheets, provide detailed calculations for one example to demonstrate the basis of the spreadsheet and that the spreadsheet is providing accurate results. Hand calculations are not required for well proven, well documented programs such as XSTABL, SLOPE/W, SHAKE2000 or GRLWEAP. Detailed example calculations that illustrate the basis of the spreadsheet are important for engineering review purposes and for future reference if someone needs to get into the calculations at some time in the future. A computer spreadsheet in itself is not a substitute for that information.
5. Highlight the solutions that form the basis of the engineering recommendations to be found in the project geotechnical report so that they are easy to find. Be sure to write down which locations or piers where the calculations and their results are applicable.
6. Provide a results summary, including a sketch of the final design, if appropriate.

Each set of calculations (for each structure) is sealed and dated by the professional-of-record. If the designer is not registered, the reviewer initials and dates the calculations. Consecutive page numbers should be provided for each set of calculations and each page should be initialed by the reviewer.

A copy of the appropriate portion of the FHWA checklist for geotechnical reports (i.e., appropriate to the project) is included with the calculations and filled out as appropriate. This checklist will aid the reviewer regarding what was considered in the design and to help demonstrate consistency with the FHWA guidelines.

20.7.3 Geotechnical File Contents

The geotechnical project file(s) contains the information necessary for future users of the file to understand the historical geotechnical data available and all the geotechnical work that was performed as part of this project. This would include the scope of the project, the dimensions and locations of the project features, the geotechnical investigation plan, field and laboratory testing and results, the geotechnical design work performed and design recommendations.

Two types of project files should be maintained: 1) the geotechnical design file(s), and 2) the construction support file(s).

The geotechnical design file specifically contains the following information:

- Historical project geotechnical;
- As-built data and historical geotechnical information related to, the project;
- Geotechnical investigation plan development documents;
- Geologic reconnaissance results;
- Cross-sections, structure layouts, etc., that demonstrate the scope of the project and project feature geometry as understood at the time of the final design, if such data is not contained in the geotechnical report;
- Information that illustrates design constraints, such as right-of-way location, location of critical utilities, wetlands and location and type of adjacent facilities that could be affected by the design;
- Boring log field notes;
- Boring logs;
- Field test results, (CPT, pressure meter, vane shear, shear wave measurements);
- Laboratory test results, including rock core photos and records;
- Field instrumentation measurements;
- Final calculations only, unless preliminary calculations are needed to show design development;
- Final wave equation runs for pile foundation constructability evaluation;
- Key photos (must be identified as to the subject and locations), including CD with photo files;
- Key correspondence (including e-mail) that tracks the development of the project and contains information regarding design changes or geotechnical recommendations. This does not include general correspondence that is focused on project coordination activities.

The geotechnical construction file contains the following information (as applicable):

- Pile hammer approval letter with driving criteria including wave equation analysis;
- Construction submittal reviews (retain temporarily only, until it is clear that there will be no construction claims);

- PDA/CAPWAP results;
- Embankment or other instrumentation monitoring data;
- Change order correspondence and calculations;
- Documentation of any changes to the original geotechnical design or specifications;
- Claims-related correspondence and data;
- Photos (must be identified as to the subject and locations), including electronic storage with photo files;
- CSL reports and any correspondence concerning shaft defects, repair work and the approval of drilled shafts.

20.7.3.1 Consultant Geotechnical Reports and Documents Produced For ODOT

Geotechnical reports and documents produced by geotechnical consultants (including geotechnical work performed for Design-Build projects) shall be subject to the same reporting and documentation requirements as those produced by ODOT staff, as described in this chapter. The detailed analyses and/or calculations produced by the consultant in support of the geotechnical report development shall be provided to ODOT.

20.8 References

Section intentionally blank.

Appendix 20-A Geotechnical Report Review Checklist

(Structure Foundations Supplement)

YES	NO	N/A	
			1 Title/Cover Page
			1.1 Heading “Geotechnical Report” in larger letters
			1.2 Bridge Name
			1.3 Bridge Number
			1.4 Section Name
			1.5 Highway & Milepoint
			1.6 County
			1.7 Key Number
			1.8 Date
			2 Table of Contents
			3 Detailed Vicinity Map
			4 Body of Report
			4.1 Introduction
			4.1.1. Is project scope and purpose summarized?
			4.1.2 Is a concise description given for the general geologic setting and topography of the area?
			4.2 Office Research
			4.2.1 Summary of all pertinent records and other information that relate to foundation design and construction.
			4.3 Subsurface Explorations and Conditions
			4.3.1 Is a summary of the field explorations, locations, and testing given?
			4.3.2 Is a description of general subsurface soil and rock conditions given?
			4.3.3 Is the groundwater condition given?
			4.4 Laboratory Data
			4.4.1 Are laboratory test results (e.g., natural moisture, Atterberg Limits, consolidation,
			shear strengths, etc.) discussed and summarized in the report?
			4.5 Summarize Hydraulics Information that affects foundation recommendations
			4.5.1 Bridge options providing required waterway
			4.5.2. 100 and 500-year scour depths and elevations
			4.5.3. Riprap protection; class, depth, and extent
			4.6 Seismic Analysis and Evaluation
			4.6.1 Bedrock acceleration coefficients (500 & 1000-yr) and AASHTO soil profile type
			4.6.2 Liquefaction analysis and bridge access & performance assessment (settlement, stability, lateral deformation)
			4.6.3 Liquefaction Mitigation recommended?
			4.6.3.1. Mitigation design, specifications and cost estimates supplied?
			4.7 Foundation Analyses and Design Recommendations
			4.7.1 Foundation Options and Discussion
			4.7.2 Pile Foundations
			4.7.2.1. Type (steel pipe, H-pile, concrete, displacement/friction or end-bearing)
			4.7.2.2. Material specification (e.g., ASTM & steel grade), size (e.g.,O.D. and thickness)
			4.7.2.3. Tip treatment; open or closed-ended, tip protection required
			4.7.2.4. Ultimate nominal resistance, estimated cutoff elevation, estimated tip elevation. “estimated” or “order” length and
			minimum required tip elevation.
			4.7.2.5. Axial factored resistance and resistance factor
			4.7.2.6. Nominal and factored uplift resistances
			4.7.2.7. Lateral resistance
			4.7.2.6.1. Soil parameters for LPILE or COM624P analysis (e.g., p-y data, liquefied & nonliquefied soil conditions)
			4.7.2.8. Pile group settlement addressed?
			4.7.2.9. Downdrag potential addressed?
			4.7.2.8.1. Provide downdrag loads, load factors and discussion of how downdrag loads are accounted for or mitigated?
			4.7.2.10. Reduced pile resistances (axial, uplift, lateral, etc) as a result of liquefaction, scour or downdrag
			4.7.2.11. Driving Criteria and Driveability Analysis
			4.7.2.10.1. Dynamic equation where driveability or driving stress problems are not expected
			4.7.2.10.2. Wave Equation for nominal resistances greater than 540 kips or expected driving stress problems.
			4.7.2.12. Static or dynamic load testing
			4.7.2.11.1 Are specifications provided describing how the tests are conducted and clearly defining all responsiblities?
			4.7.3. Drilled Shafts
			4.7.3.1. Shaft type (i.e., end-bearing, friction or combination)
			4.7.3.2. Nominal axial resistance provided for various diameters and lengths (depths or tip elevs.)
			4.7.3.3. Rock socket lengths specified (and/or shaft tip elevations)
			4.7.3.4. Estimates of shaft settlement with depth under unfactored (service) load conditions.
			4.7.3.5. Resistance factors and factored resistances.
			4.7.3.6. Shaft group effects addressed?
			4.7.3.7 Lateral capacity addressed?
			4.7.3.7.1. Soil parameters for COM624P or LPILE analysis provided (e.g., p-y data, liquefied & nonliquefied soil conditions)
			4.7.3.8 Static or dynamic load testing required?
			4.7.3.8.1 Are specifications provided describing how the tests are conducted and clearly defining all responsiblities?
			4.7.4. Spread Footings
			4.7.4.1. Description and properties of the anticipated foundation soil or rock
			4.7.4.2. Nominal bearing resistance as function of effective footing width
			4.7.4.3. Nominal bearing resistance for a given settlement (service limit state)
			4.7.4.4 Resistance factors and factored bearing resistance for strength and extreme limit states
			4.7.4.5. Recommended maximum elevation for base of footing
			4.7.4.6. Soil parameters for sliding and eccentricity provided?
			4.7.4.7. Overall stability checked?

YES	NO	N/A	
			4.7.5. Retaining Walls
			4.7.5.1. Description and properties of the anticipated foundation soil
			4.7.5.2. Nominal bearing resistance as function of effective footing width
			4.7.5.3 Nominal bearing resistance for a given settlement (service limit state)
			4.7.5.4. Resistance factors and factored bearing resistance for strength and extreme limit states
			4.7.5.5. Recommended maximum elevation for base of footing
			4.7.5.6. Overall stability, sliding, overturning.
			4.7.5.7 Earth pressure recommendations and diagrams
			4.7.5.8 Wall type options
			4.7.6. Engineered Fills
			4.7.6.1. Are materials, gradation, placement and compaction requirements provided for the engineered fill?
			4.7.6.2. Are the dimensions of the Engineered Fill clearly shown (in plan & cross section)
			4.7.7. Are foundation recommendations provided for Temporary and/or Detour Structures?
			4.8 Construction Issues and Recommendations
			4.8.1. Pile Foundations
			4.8.1.1. Have potential obstructions (e.g., boulders, riprap, existing foundations, utilities, etc.) been identified?
			4.8.1.2. Any limited head room or other clearance issues?
			4.8.1.3. Have the effects of pile driving vibrations on adjacent structures been evaluated?
			4.8.1.3.1 Is a preconstruction survey recommended to document existing conditions?
			4.8.2. Drilled Shafts
			4.8.2.1. Shaft stabilization issues discussed and evaluated (e.g., temporary or permanent casing, slurry)
			4.8.2.2. Adequate discription of any boulders, obstructions or other difficult conditions expected to be encountered provided?
			4.8.2.3. Discussion of expected groundwater conditons
			4.8.3. Spread Footings
			4.8.3.1. Anticipated foundation material adequately described
			4.8.3.2. Shoring required?
			4.8.4. Retaining Walls
			4.8.4.1. Anticipated foundation material adequately described
			4.8.4.2. Shoring required?
			4.8.4.3. Backfill and drainage requirements identified
			4.8.5. Temporary Excavations
			4.8.5.1. Discussion of any shoring and bracing
			4.8.5.2. Cofferdams
			4.8.5.3. Groundwater mitigation method
			4.9. Special Provisions
			4.9.1. Pile Foundations (Section 00520)
			4.9.1.1. Soil input parameters for Wave Equation Analysis
			4.9.1.2. Set period and redriving (freeze) addressed?
			4.9.1.3. Preboring required?
			4.9.1.4. Jetting permitted?
			4.9.1.5. Is tip protection required?
			4.9.1.6. Number of pile splices provided
			4.9.1.7. Specs for PDA, CAPWAP or other load testing provided?
			4.9.2. Drilled Shafts
			4.9.2.1. Crosshole Sonic Log Tests described? (number, locations, etc.); Section 00512.42.
			4.9.3. Spread Footings
			4.9.3.1. Any special excavation or foundation preparation specs required? (Section 00510)
			4.9.4. Retaining Walls
			4.9.4.1. Bearing resistance equation provided for MSE walls.
			4.9.4.2. Geotextile/geogrid material properties required? (Section 02320)
			4.9.5. Are unique special provisions provided (e.g. liquefaction mitigation)?
			4.9.6. Are special notes to the Contractor regarding subsurface materials or conditions required and if so, are they provided?
			4.10. Limitations
			4.11. General
			4.11.1. Has the report been independently reviewed by a qualified geotechnical engineer?
			4.11.2. Is the report stamped, dated, and signed by a registered PE licensed to practice in Oregon?
			5 Appendices
			5.1. Foundation Data Sheet (see example)
			5.1.1. Plan View
			5.1.1.1. Are the locations of the proposed, existing, detour structure (if applicable) and other important features shown?
			5.1.1.2. Are the locations of all explorations clearly shown (by station and offset)?
			5.1.2. Profile View
			5.1.2.1. Is the groundline profile(s) shown (centerline and/or 3 line profile)?
			5.1.2.2. Are the explorations plotted on the profile at the correct elevation and location?
			5.1.2.3. Is an identification number and the completion date shown for each exploration?
			5.1.2.4. Are the subsurface materials and conditions depicted with soil and rock descriptions in conformance
			with the ODOT Soil and Rock Classification Manual? Are the appropriate graphic symbols (see attached) used?
			5.1.2.5. Are the insitu tests and sample types (typically SPT or undisturbed samples) shown on the boring profile at the correct depth?
			5.1.2.6. Are the SPT results (uncorrected "N" values) shown on the profile?
			5.1.2.7. Are the highest measured groundwater levels, and the date measured, shown on the profile?
			5.1.2.8. Are percent rock core recovery, rock hardness, RQD and unconfined compressive strength (if available)
			values shown in a summary table?
			5.1.3. General
			5.1.3.1. Is the presentation of the subsurface information adequately shown on the Foundation Data Sheet (i.e. proper scaling and font size)?
			5.1.3.2. Has the Foundation Data Sheet been independently reviewed?
			5.1.3.3. Is the Foundation Data Sheet stamped, dated, and signed by a registered PE or CEG licensed to practice in Oregon?
			5.2. Exploration Logs
			5.3. Plan and Elevation of existing structure (if applicable)
			5.4. In situ test data and results
			5.5. Laboratory test data and results
			5.6. Photographs
			5.7. Other references as needed
			6 Foundation Analyses and Design Calculations Attached

May, 2006