5-20 FOUNDATION REPORT/GEOTECHNICAL DESIGN REPORT CHECKLIST FOR EARTH RETAINING SYSTEMS

Introduction

This checklist was developed to assist the geotechnical project professionals in preparing the Foundation Report (FR) or the Geotechnical Design Report (GDR) for the various types of earth retaining systems included in Topic 210 of the Highway Design Manual (HDM). The earth retaining system designers, specification developers, construction engineers and other project professionals can review this checklist in the early stages of a project to know what geotechnical design information can be expected in the above-referenced reports.

This checklist is a guide and does not include all items that may need to be included in the geotechnical or foundation reports. In particular, specialized earth retaining system applications, such as landslide mitigation or the use of lightweight materials as wall backfills, are likely to need additional investigation and report items. Similarly, not all items listed herein will need to be included in each report. The geotechnical project professional will need to evaluate each proposed earth retaining system on a site-specific basis, and only the relevant items from this checklist and, if necessary, additional items should be included in the foundation report.

Section A: Items Applicable to All Earth Retaining Systems

- Project site location with a vicinity or site map
- Project site description (topography, existing developments, etc.)
- Reason(s) and/or need for constructing the proposed earth retaining system
- Description of the wall type, geometry and layout (including the General Plan in the report is encouraged)
- Description of external loadings
- Description of site constraints (environmental, right-of-way, utilities, aesthetic, traffic, construction, etc.)
- Description of site geology

- Field exploration
  - Review of existing information
  - Site reconnaissance/feasibility
  - Exploration program
  - Field exploration, testing and sampling
- Laboratory test results
  - Classification/index tests
  - Gradation analysis
  - Compaction tests
  - Shear strength tests (direct, unconfined/uniaxial, triaxial, etc.)
  - Consolidation/collapse/swell or expansion index tests
  - Soil/ground water electrochemical/corrosion tests
- Subsurface conditions
  - Soil/rock profile/stratigraphy along the wall lay-out-line (LOL) and typical cross sections (for non-standard plan walls)
  - Groundwater conditions
  - Foundation soil/rock density/consistency and strength parameters (effective and/or total stress, as appropriate), and their applications and limitations
  - Soil compressibility (compression/recompression indices)
  - Collapse/swell/expansion potential
- Seismic hazard
  - Fault surface rupture hazard
  - Ground motion (include both median PBA and PGA)
  - Secondary seismic hazards (e.g., liquefaction, seismically-induced settlement, lateral spreading etc.)
  - Recommendations to mitigate seismic hazards
- Landslide hazard
  - Investigate and discuss potential landslide hazard. Attach or refer to the landslide investigation report if available

- Earthwork and wall backfill requirements/recommendations
  - Discussion on the suitability of the in-situ soils as foundation and/or backfill materials
  - Discussion on the need and recommended foundation soil improvements (compaction, over-excavation, removals, preloading, settlement period, etc.)
  - Removal of existing structures/facilities (e.g. slope paving)
  - Discussion on rock rippability
  - Discussion on temporary cut/support conditions
  - Dewatering requirements
  - Minimum toe cover (embedment depth)
  - Recommended minimum berm width
  - Backfill and retained materials requirements or recommendations (lightweight materials, density, gradation, strength, compressibility, corrosion etc.)
  - Backfill compaction requirements (e.g., percent compaction and water content etc.)
- Drainage and filtration recommendations behind wall/backfill
- Lateral earth pressure (for non-standard plan walls) or refer to the source diagram in Section 5 of the Bridge Design Specifications (BDS)
- Recommended coefficient of lateral earth pressure “K” values for different stages of construction
- Effects of wall construction on adjacent grounds and/or existing structures, utilities and other facilities, both above and below ground. Include allowable limits and estimates of both total and differential settlements of ground surface behind the wall, and wall settlement, lateral deflection and/or rotation
- Need and methods for pre-construction survey, documentation, observation and monitoring of adjacent ground and/or facilities
- Special provisions issues
- Global stability analysis (both static and seismic)
- Discuss scour and corrosion issues
- Wall and foundation constructability issues
- Log of Test Boring (LOTB) sheets

- Limitations and need for further review/consultation
  - Limitations and applicability of the investigation and report
  - Recommend draft PS&E to be sent to Geotechnical Services for review and concurrence
  - Recommend consultation during construction

Section B: Additional Items Applicable to Specific Earth Retaining Systems

B.1 State Designed Earth Retaining Systems with Standard Plans (Concrete Cantilever Types 1, 2, 3, 4, 5 and 6, and Crib Walls)

- Evaluation of the suitability of the standard plan wall at the site (e.g., if site soil parameters meet the requirements of the design soil parameters listed under the standard plan design, then the standard base width and toe cover are adequate)
- Allowable soil bearing capacity at the wall base elevation for spread footings
- Pile data table (pile type, diameter, and wall thickness for pipe piles; design load, nominal resistance, cut-off elevation, design and specified tip elevation etc.) for pile footings

B.2 State Designed Earth Retaining Systems Which Require Special Designs

B.2.1 Standard Plan Walls with Modified Wall Geometry, Foundations and Loading Conditions

- Reasons/conditions why special design is required
- Impacts of modified wall geometry, foundations and loading conditions, etc.
- Allowable bearing capacity at wall base elevation

B.2.2 Non-Gravity Cantilever and Anchored Walls

B.2.2.1 Sheet Pile Wall

- Recommendation for minimum pile embedment depth (or pile tip elevations) based on geotechnical requirements (e.g., socketing into competent material and/or global stability requirements, etc.)
- Describe special provision issues (e.g., groundwater, difficult driving conditions, etc)
- Basal stability

B.2.2.2 Soldier Pile Walls with Lagging

- Method of pile installation (e.g., driven or cast-in-drilled hole)
- Recommendation for minimum pile embedment depth (or pile tip elevations) based on geotechnical requirements (e.g., socketing into competent material and/or global stability requirements, etc.)
- Recommendation for lagging embedment below finish grade
- Describe special provision issues (e.g., groundwater, caving, difficult drilling/driving, potential effects of driving induced vibration/noise on adjacent facilities and/or occupants etc.)

B.2.2.3 Tangent/Secant Soldier Pile Wall

- Recommendation for minimum pile embedment depth (or pile tip elevations) based on geotechnical requirements (e.g., socketing into competent material and/or global stability requirements, etc.)
- Describe special provision issues (e.g., groundwater, caving, difficult drilling due to hardness or extreme variations from very soft to very hard and oversized material etc.)

B.2.2.4 Slurry Diaphragm Wall

- Type of slurry wall (e.g., conventional reinforced concrete, soldier pile, tremie concrete etc.)
- Recommendation for minimum wall embedment depth based on geotechnical requirements (e.g., socketing into competent soils and/or global stability requirements, etc.)
- Describe special provision issues (e.g., groundwater, difficult trenching and trench stability etc.)
- Soil gradation and hydraulic conductivity

B.2.2.5 Soil-Cement Mix Wall

- Complete design and specifications for soil mix wall, including:
  - Required soil-cement mix element percent coverage
  - Required soil-cement mix depths; presentation of the decision process for required depth during design; and establish possible refusal criteria (depth), which is equipment dependent, during construction.
  - Layout of soil-cement mix area
  - Soil-cement mix element compressive strength (need to use statistical criteria, e.g., average of "x" kPa and no more than "y" % tests with less than "z" kPa)
  - Soil particle gradation for each soil layer (contractor needs this information for cement mix design)
  - Special details and design notes, e.g., minimum horse power of augering/mixing equipment, required water/cement ratio, etc
  - Special provisions for material and construction (e.g., requirement for the contractor's submittal of equipment and cement mix design for review and approval)
  - Difficult drilling/mixing conditions
  - Performance specifications requirements, e.g., coring equipment, minimum % recovery, minimum Rock Quality Designation (RQD), number and distribution of core specimens for compressive strength test; possible in-situ testing procedure, etc.

B.2.2.6 Anchored Walls (Structural or Ground Anchors)

- Method of soldier/anchor pile installation (e.g., driving or cast-in-drilled hole). Driven piles are not usually used as soldier piles with tieback applications.
- Recommendation for minimum pile embedment depth based on geotechnical considerations (e.g., based on global stability requirements or embedment into competent material etc.)
- Provide theoretical or, if known, actual failure plane based on Slope Indicator (SI) reading

B.2.2.6 Anchored Walls (Structural or Ground Anchors) *(cont.)*

- Recommendation for lagging embedment below finish grade (usually 600 mm/2ft.)
- Characterization of the soil conditions immediately behind the walers, and the corresponding bearing capacity (based on allowable passive or lateral soil bearing capacity, as applicable)
- Unbonded zone length based on theoretical or actual failure plane
- Special provision issues (e.g., groundwater, caving, difficult drilling, cement sacks for grouting when recommended, need for instrumentation or monitoring etc.)

B.2.3 Gravity Walls (Concrete Gravity Wall, Rock Gravity Wall, Gabion Basket Wall)

- Allowable foundation soil bearing capacity at wall base elevation
- Geometry of the gravity block(s)
- Special provisions issues
- Provide special details, as necessary

B.2.4 Soil Reinforcement System

B.2.4.1 Mechanically Stabilized Embankment (MSE)

- Allowable foundation soil bearing capacity at wall base elevation
- Minimum base width from global stability analysis
- Evaluation of the applicability of wall design using Standard Detail XS Sheets to the site. For example, if the site soil parameters meet the requirements of the design soil parameters listed in the XS Sheet General Notes, then standard base width and toe cover is adequate
- Investigation and discussion on the availability of source(s) of wall backfill materials including on-site excavated soils that will meet the Special Standard Provision (SSP) requirements

B.2.4.2 Salvaged Material Retaining Wall (Value Engineering)

- Identify and qualify source(s) of salvaged material
- List of desired salvaged materials at each source
- Complete design and specifications for salvaged material retaining wall (or use one of the existing design), including:
  - Wall type
  - Wall batter
  - Reinforcement type and layout
  - Wall face type and layout
  - Wall face to reinforcement connection details
  - Modification details to salvaged material
  - Special details and design notes
  - Special provisions for materials and construction
- Identify qualified source of backfill or provide specifications for imported backfill
- Plan of instrumentations and monitoring program

B.2.4.3 Soil Nail Walls

- Wall face batter
- Diameter of grouted hole
- Inclination angle of nails
- Soil/rock density and strength parameters
- Maximum and minimum horizontal and vertical soil nail spacing
- Vertical distance from top of wall to top most row of soil nail assembly
- Minimum and maximum horizontal distances from the beginning/ end of the wall and first/last soil nail
- Maximum vertical distances from the bottom of wall to bottom of soil nail assembly
- Soil nail profile lines
- ASTM designation of bars, grade and bar sizes
- Design ultimate bond strength, in kilopascal (kPa)/(psi)

B.2.4.3 Soil Nail Walls *(cont.)*

- Design nail head punching shear capacity, assumed or as provided by the Division of Engineering Services-Structure Design (DES-SD)
- Schedule of nail lengths
- Locations of the test soil nails for both proof and verification testing
- Special provision issues (e.g., ground water, caving, drilling difficulty and sloughing of excavated face)
- Describe construction considerations including monitoring recommendations
- SNAIL run outputs

B.2.4.4 Tire Anchored Timber Wall

- Complete design and specifications for salvaged material retaining wall using existing plans details and specifications
- Identify qualified source of backfill or provide specifications for imported backfill
- Plan of instrumentation and monitoring program

B.3 Proprietary Earth Retaining Systems

- These systems are not specifically addressed in a foundation report. Information provided in the foundation report for the mandatory State design system should be sufficient for any proposed proprietary alternative system

B.4 Experimental State Design Earth Retaining Systems

B.4.1 Geosynthetic Reinforced Walls

- Cross sections at different wall height showing the geosynthetic reinforcement design (e.g. MSEW runs)

B.4.1 Geosynthetic Reinforced Walls (cont.)

- Complete design and specifications for geosynthetic reinforcement including:
  - Wall face batter
  - List of reinforcement types, with different Long Term Design Strength (LTDS) used for design.
  - Establish elevation view for presentation of geosynthetic reinforcement layouts, reinforcement lengths and reinforcement types.
  - Wall face material recommendations
  - Wall face to reinforcement connection recommendation
  - Special details and design notes
  - Special provisions for geosynthetic material and construction. Include the need for the contractor's submittal of geosynthetic material test results used to establish the LTDS, which include (1) Ultimate Tensile Strength, T_{ult}, (2) Creep Reduction Factor, $RF_{creep,}$ (3) Durability Reduction Factor, $RF_{durability}$, and (4) Installation Damage Reduction Factor, $RF_{installation\ damage}$, which are backfill dependent, for review and approval.
  - Plan of instrumentation and monitoring program, if needed
- Identify qualified source of wall backfill or provide specifications for imported wall backfill

B.4.2 Mortarless Concrete Block Gravity Walls

- Describe surface and/or channel water flow (since this type of wall is susceptible to water infiltration and freeze/thaw cycle damage)
- Wall batter
- State if partial reinforcement coverage is allowed
- Minimum wall embedment depth – critical for contractor to submit alternative layout

B.4.2 Mortarless Concrete Block Gravity Walls (cont.)

- Maximum wall height.
- Contingency plan for surface treatment or replacement of damaged blocks – various amount of blocks cracks/splits through the middle, especially with poor workmanship
- Select proprietary concrete block systems (at least three are desired), preferably pre-qualified
- Complete design and specifications for each of the selected proprietary block systems, based on the manufacture's requirements/ recommendations
- Complete design and specifications for geosynthetic reinforcement similar to the geosynthetic reinforced wall, if needed.
- Sub-excavation and backfill requirements or other ground improvement techniques (if needed)
- Identify qualified source of backfill or provide specifications for imported backfill
- Plan of instrumentations and monitoring program, if needed

(original signed by Richard D. Land)

Richard D. Land
Deputy Chief, Division of Engineering Services,
Structure Design