Reviewing MSE Retaining Wall Shop Drawings for Design-Build Projects

The purpose of the shop drawing review is to insure compliance with the minimum standards as described in the project specifications and the line and grade drawings in accordance with good engineering practice.

The MSE (Mechanically Stabilized Earth) retaining wall industry can be very competitive. Often seemingly minor price or quantity differences determine which system the contractor selects. Wall system contractors and vendors are then under significant pressure to economize the design and the components going into the wall system in order to improve their competitive position. In an effort to design to the minimum limits of what the plans and specifications will permit, the potential exists to misinterpret the specification or the plans and not be in compliance with the intended minimum standards. Reviewers must insure that the Engineer's intent, as reflected in the project plans and specifications, is achieved. Below is a suggested checklist for MSE wall reviewers that also discusses the most common omissions or errors.

MSE Retaining Wall Shop Drawing Review Checklist

1. All Drawings

- ❑ Are drawings in the correct format (size, etc.) and properly labeled?
- ❑ Are all pages numbered, in the correct order, and included in the drawing set?
- ❑ Did the wall design engineer properly seal all pages?

2. Title Sheet

- ❑ Is the correct project name, location and project number shown?
- ❑ Do the design parameters listed match those provided in the bid plans and specifications? Do they match those used in the calculations?
- ❑ Do the plans list limitations or qualifications that are inconsistent with the specifications?

3. Plan Sheet(s)

- ❑ Are the source of plans and dates referenced?
- ❑ Are all walls labeled including begin and end points and front face?

4. Elevation Sheet(s)

- ❑ Are wall elevations properly labeled "front face" and "back face"?
- ❑ Are utilities within or directly under the wall noted?
- ❑ Is the finished ground line shown on the elevations?
- ❑ Does the bottom of wall (top of leveling pad) elevation provide the minimum specified embedment below finished grade elevations throughout the length of the wall?
- ❑ Does the wall envelope shown on the shop drawing plans cover the envelope shown on the bid plans?
- ❑ Are high and low point elevations shown?

- ❑ Are corners and bends noted?
- ❑ Are roadway stations and offsets shown for highway projects?
- ❑ Are reinforcement lengths, type and vertical position clearly shown?
- ❑ Does the reinforcement vertical spacing meet the specification requirements?
- ❑ Are any notes regarding wall batter, maximum applied bearing pressure, etc. correct?

5. Wall Section(s)

- ❑ Is there a typical section for every design case situation shown?
- ❑ Does the cross section match the corresponding elevation view?
- ❑ Are sections drawn to scale or properly dimensioned?
- ❑ Is finished ground line shown indicating minimum embedment compliance?
- ❑ Is reinforced zone shown to begin at top of leveling pad?
- ❑ Are all reinforcement lengths the same for a given cross section for AASHTO projects?
- ❑ Are top of wall appurtenances shown and properly dimensioned?
- ❑ Do drainage details meet the requirements of the plans and specifications?
- ❑ Is the proper wall batter, if any, shown and does it meet the horizontal control requirements of the project plans?

6. Standard Details

- ❑ Are standard, but not applicable details marked out or eliminated?
- ❑ Are any required special details included?
- ❑ Are the proper size and shape face panels or units shown?
- ❑ Are the correct connection and drainage components shown, i.e. are the components those required to meet AASHTO for DOT projects?

7. Plan Specifications

- ❑ Are backfill specifications provided and do they meet bid specification requirements?
- ❑ Are any non-standard items noted such as Modified Proctor density, special leveling pads or drainage requirements and do they meet project bid specifications?

8. Calculations

- ❑ Is there a calculation for each wall section and does it match the wall plans?
- ❑ Do the calculations address all required factors of safety stipulated in the plans?
- ❑ Is global stability analysis provided for tiered walls if not already required?
- ❑ Are the factors of safety or reduction factors used to develop allowable strength for the reinforcement and the type or models of reinforcement consistent with those that served as the basis of acceptance for that wall system?
- ❑ Do the facing connection strength calculations meet the requirements of the design methodology prescribed in the bid documents?

Commentary - Discussion of common omissions and errors

1. **Wall Face Area** – The most common problem is the wall face area shown on the shop drawings does not fully cover the face area requirements of the bid plans. This typically occurs along the base or top of the wall where the wall designer/vendor does not embed the wall sufficiently to meet plan or code requirements.

   Sometimes, it is as simple as embedding the wall an average of 2 feet not a minimum of 2 feet as shown in the drawings and as typically required on DOT projects. Equally common is providing the minimum embedment from the bottom of the leveling pad instead of the correct top of leveling pad or bottom of wall facing system. The leveling pad is not a structural member of the system and should not be included as part of the embedment unless specifically directed. A 6" leveling pad thickness included in the wall area reduces the facing quantity by 500 SF of wall per 1000 LF of wall. A quick review check is to measure the embedment at each step of the leveling pad and check elevations along the top of wall steps. A more thorough check is to plot the coordinates for the minimum embedment and top of wall line and then make sure each step is at or below the minimum embedment line and above the minimum profile grade line.

   A similar problem can occur along the top of wall when the wall designer/vendor does not keep the top of wall at or above the profile grade elevations and only stays approximately at the elevations provided. Extra large (tall) CIP copings can also be detailed which can also artificially decrease the wall area provided and reinforcement required.

   Since the minimum reinforcement length is a function of the wall height as measured from the top of the leveling pad to the top of the wall, these practices can reduce the required reinforcement lengths and the amount of select backfill required as well.

2. **Substitution or Omission of Key Components** – Another common error is to substitute untested or un-reviewed materials or simply leave out key components. For most systems either a history of prior use of the components or, for transportation projects, a DOT or HITEC review is the basis for acceptance of the system. It is expected by the specifier that the Owner would get these same components and methods of design. This is not always the case as the submitted shop drawings may not reflect the anticipated materials. Some common changes are:

   - Use of a different facing unit or panel, such as using different shaped or thickness panels or units
   - Connection components being left out or a non-standard connection scheme being shown, such as using 2 out of 3 components of a facing connection system
   - Different reinforcement is proposed, such as using un-reviewed reinforcements from unfamiliar vendors
   - Using lower reduction factors (RF factors) for geosynthetic reinforcement than indicated in the HITEC review or previously submitted systems

   It is usually a good idea to obtain a copy the HITEC report of the system under review for comparison purposes with the submitted designs.

3. **Reinforcement Vertical Spacing** – For 12” deep SRW (segmental retaining wall) units, the recommended maximum vertical spacing is 24”. For DOT projects, AASHTO (section 5.8.8.2) limits the maximum vertical spacing of reinforcement layers of SRW systems to the lower of 2 times the unit depth (ie: 2 x 12” = 24”) or 31 inches. Rarely is the 31” criteria exceeded, but it is not uncommon to see the spacing exceed 2 times the unit depth.

4. **Non-Uniform Reinforcement Lengths** – AASHTO 5.8.1 states that all reinforcement shall be of the same length in a given cross section with only rare exceptions provided for. In cases where the Factor of Safety in sliding governs the reinforcement length (typically occurring when walls have steep backslopes), some designer/vendors will use the shortest length to meet FS ≥ 1.5 on each reinforcement layer in a given cross section, using shorter and shorter reinforcement lengths as they move up in the wall until they reach the 0.7H minimum. This practice is inconsistent with AASHTO guidelines and past practice.

5. **Overall Reinforcement Length and Strength** – For projects where a base bid retaining wall is provided, the reinforcement lengths on any alternate plans being reviewed should be the same or longer than the base bid and the reinforcement at each level should be equal or greater in connection and long term tensile strength than the specified reinforcement.

6. **Facing Connection Strength** – For private projects using NCMA (National Concrete Masonry Association) design guidelines, connection strength testing is required for each SRW unit and each type (brand and strength) of reinforcement. For DOT projects, AASHTO 5.8.4.2 states that the design load at the connection shall equal to the maximum load in the respective reinforcement layer. Further, in Section 5.8.7.2, the allowable connection strength for extensible/geosynthetic systems may require accounting for creep tension behavior at the connection and shall use an overall FS = 1.5. Some designer/vendors ignore these requirements.

7. **Material Requirements** – For private projects, the soil parameters should be those provided in the bid documents or that can be reasonably estimated for the onsite soils. For DOT projects, the backfill is generally the same for all MSE systems (AASHTO 7.3.6.3) except:

    - For extensible/geosynthetic reinforcement, the maximum particle size is 3/4” and the minimum reduction factor for durability, RF_d , is 1.1.
    - For inextensible/steel reinforcement, the soil resistivity > 3000 ohm-cm

    For private projects, the facing unit concrete requirements for segmental walls are typically 3000-psi minimum and 8% absorption maximum. Under AASHTO criteria, the minimum compressive strength is 4000-psi and the maximum absorption reduced to 5%.

8. **Wall Batter** – It is important to verify that any wall batter shown on the wall plans or necessary for some wall systems will fit into the space shown on the bid plans. Wall batter requires increasing the wall height to preserve drainage swales for walls with backslopes or encroaching into buffers at the toe or top for walls with level backfill. Also, the batter used in the calculations and the batter shown on the plans must be consistent.