CHAPTER 2 — EVALUATION OF SMSE WALL SUITABILITY

Evaluating the applicability of an SMSE wall system for a project application is a multi-step process, ideally completed prior to conducting the design phase. A flow chart of the evaluation process is presented in figure 2. The process includes three major steps:

1. Conducting pre-decision evaluation studies.

2. Deciding to use an SMSE wall system.

3. Designing the SMSE wall system.

Details of the pre-decision evaluation studies and decision to use an SMSE wall system (steps 1 and 2) are presented in this chapter. Design details are addressed in the following chapters. Chapters 3 through 6 provide the results of modeling and testing that support the design considerations presented in this guideline, and the user will find an example of the design process (step 3 above) described in chapter 7.

2.1 PRE-DECISION EVALUATION STUDIES

A geotechnical site evaluation and preliminary roadway or project design must be completed in sufficient detail to support the pre-decision evaluation studies. The pre-decision evaluation studies consist of three tasks addressing feasibility and suitability of an SMSE wall system for a given project. They are:

1. Feasibility assessment of MSE wall construction.

2. Evaluation of shoring requirements (i.e., geometry, type of shoring system).

3. Feasibility design of the SMSE wall system.

2.1.1 MSE Feasibility Assessment

The first task is to evaluate the feasibility of MSE wall construction for the proposed project. Selection of the most appropriate wall type for a given location on a project can have significant effects on the project cost, schedule and constructability. The same methods applied to any project where an MSE wall would be given consideration as a potential construction method should be used. Factors to consider in order for an MSE wall to be a viable design option include:

- Economical sources of suitable fill material available for MSE wall construction.

- Space constraints at the project location are such that construction of an MSE wall provides an economic advantage over a reinforced or unreinforced slope.

- Geotechnical foundation conditions are suitable to support the MSE structure, or special measures for foundation improvement can be reasonably and economically applied.

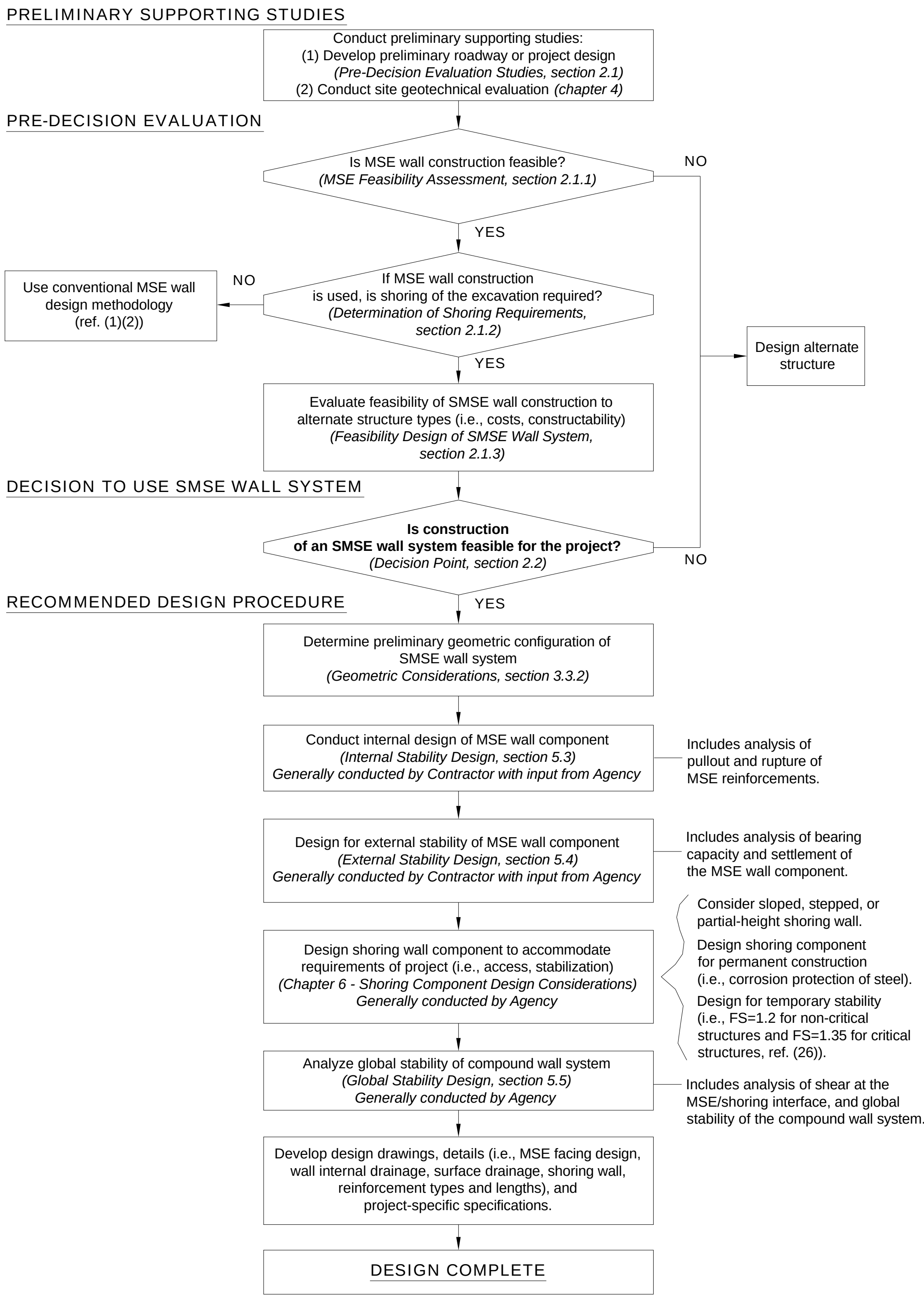

Figure 2. Flow chart. Design methodology for SMSE wall systems.

After examining the above factors, a conceptual design for the MSE structure should be completed, sufficient in detail to support evaluation of shoring requirements and feasibility design of the SMSE wall system. This portion of the study includes developing the performance criteria for the structure, such as surcharge loads, design heights, settlement tolerances, foundation bearing capacity, required toe embedment depth, and others as outlined in Elias et al.[2]

2.1.2 Determination of Shoring Requirements

Where a conventional MSE wall (i.e., minimum reinforcement length of 0.7*H*) can be constructed without shoring the excavation, the wall can be designed and constructed using conventional design methodology and practices. FLH has adopted Elias et al. as their current standard practice for design of conventional MSE walls.[2] These guidelines closely follow AASHTO.[1]

If space constraints dictate that construction of the MSE wall will impact traffic, several options should be considered before implementing shoring requirements. These options include temporary road closures, detours, or temporary lowering of the road grade to facilitate MSE wall construction.

If MSE wall construction is deemed viable, but space constraints at the project location are such that the MSE wall excavation cannot be made at an appropriate slope angle, a preliminary estimate of the shoring requirements should be made.

2.1.3 Feasibility Design of SMSE Wall System

Where shoring is required for MSE wall construction to be feasible, investigate the feasibility of combining the two wall components into an SMSE wall system. Keep in mind that the total cost for design and construction of an SMSE wall system should always be compared to the total cost for design and construction of other wall types and construction methods.

Examples of instances where selection of an SMSE wall system may prove viable are:

- <u>Fill wall constructed in steep terrain</u> where required bench excavation for traditional MSE wall construction is not feasible.

- <u>Space unavailable to excavate for MSE reinforcement lengths</u> due to need to maintain traffic during wall construction.

- <u>Stabilization of existing slope required prior to construction of fill wall</u> to remediate a landslide or excessive erosion (i.e., achieve global stability).

An SMSE wall system is often feasible when global stability controls the design, or when only a small additional roadway width is required. Construction of an SMSE wall system addresses global stability concerns using the shoring wall where, in addition to providing temporary excavation support, shoring provides stability of the earth mass behind the MSE wall component.

In the case where a narrow width of additional roadway is required, existing traffic lanes may remain open while a shoring wall is constructed to facilitate construction of an MSE wall with relatively short reinforcement lengths (i.e., SMSE wall system).

Once it is determined that construction of a fill-side retaining wall requires construction of a shoring wall, the design of the shoring structure should consider the following questions:

- What type of shoring wall is most cost effective for the conditions at the site?
- Is shoring required for the full height of the proposed wall, or is it possible to excavate an unsupported soil or rock slope for a portion of the height?
- Can the shoring wall be constructed at a batter or be a stepped structure?

Because shoring is typically required for MSE wall construction in cases where insufficient construction right-of-way prevents construction of a temporary slope, top-down construction methods such as soil nailing are often used. If soils are not conducive to soil nailing, other options for shoring include driven piles, drilled piers, tie-backs, sheet piles, micropiles, etc.

2.2 DECISION POINT

The results of the pre-decision evaluation studies are used to answer the question:

Is construction of an SMSE wall system the best alternative for the proposed project?

The decision will be based on the relative costs and speed of construction, but may incorporate other considerations such as aesthetics and compatibility with other project construction or structures. The decision to use an SMSE wall system should involve a collaborative effort among the design team members.

FLH has had experience with SMSE-type wall construction in recent years, as discussed in the next section. Section 2.2.2 describes the process used to assist in the selection of an SMSE wall system for a project application.

2.2.1 FHWA Experience with SMSE Walls

FLH has recent experience with compound wall systems, including El Portal Road in Yosemite National Park, California; Sentinel Slide remediation in Zion National Park, Utah; and Ice House Road in Eldorado National Forest, California. All of these projects involved repair of roadways in steep mountainous terrain by construction of fill-side retaining walls after fill failures or excessive erosion as a result of landslides and/or flooding.

El Portal Road re-construction in Yosemite National Park, California, involved outboard widening of 12.3 km of roadway damaged during El Ninõ flooding in 1997. Design drawings for the El Portal Road project included four compound wall construction options:

1. Traditional MSE wall constructed in front of a partial-height soil nail wall with no connection between the MSE and shoring components.

2. MSE wall with shortened reinforcements (0.4*H* minimum) constructed in front of a permanent full-height soil nail wall with mechanical connection between the MSE and shoring components.

3. Traditional MSE wall constructed in front of a temporary full-height soil nail wall with no connection between the MSE and shoring components.

4. MSE wall with shortened lower reinforcements and stabilizing rock bolts where bedrock materials are encountered.

Of the design alternatives provided for the El Portal Road project, option 3 was constructed. Figure 3 is a photo of the roadway reconstruction.

Figure 3. Photo. El Portal Road re-construction.

In 1995, Sentinel landslide reactivated and formed a temporary dam in the North Fork of the Virgin River in Zion National Park, Utah, which runs parallel to the park's main access road. The dam ultimately breached causing complete erosion of approximately 180 meters of the highway. In an effort to limit disturbance to the landslide slope while maintaining a two-lane access road adjacent to the river, a compound retaining wall, which included shoring via soil nailing to facilitate T-wall® installation, was constructed.[3] The T-wall, consisting of pre-cast concrete T-shaped units, resembles a crib-type wall with its design and function based partially on MSE principles. However, design of the T-wall did not incorporate the retaining benefits provided by the shoring wall. Figure 4 is a photo of T-wall construction in front of the soil nail wall at Zion National Park. Scour resistance was provided by constructing a secant pile wall adjacent to the river at the foundation level of the compound wall.

Figure 4. Photo. Compound wall construction at Zion National Park.

Ice House Road in Eldorado National Forest, California, required repair after a fill failure occurred in 1997. Repair of the roadway included retaining wall construction and reinforced slope repair. Due to project constraints and to limit the required amount of excavation, MSE walls were constructed in front of partial-height shoring walls. Though partial shoring was employed, the minimum aspect ratio for the full-height of the MSE walls was specified as 70 percent of the wall height, in accordance with traditional MSE wall design approaches.

Though potential SMSE wall applications have been evaluated for other FLH projects, few have been constructed, likely due to lack of guidance on such wall systems. Designing cost effective wall systems for these applications provided the impetus for this study.

2.2.2 SMSE Wall Selection Process

A flow chart developed to assist in evaluation of the proper wall type for a given project application is illustrated as figure 5, with emphasis on SMSE wall applications. Once a difference in grade has been identified as part of the design process, the decision must be made to construct a slope (reinforced or unreinforced) or a retaining wall. If adequate space exists, construction of a slope should first be considered. With regard to wall selection, the following general criteria require consideration: cut or fill situation, constructability, and aesthetics.

First consider whether the wall will be built in cut, fill, or a combination thereof. Though fill-type walls may be constructed in cut situations, the opposite is not true for all types of cut walls (i.e., soil nail walls). However, the construction of fill walls in cuts requires additional excavation behind the face of the wall, and possibly shoring, depending on the space available for excavation. When shoring is required for construction of an MSE wall in a cut situation, construction of an SMSE wall is likely more economical than a traditional MSE wall with temporary shoring; however, a more appropriate cut-type wall should first be considered.

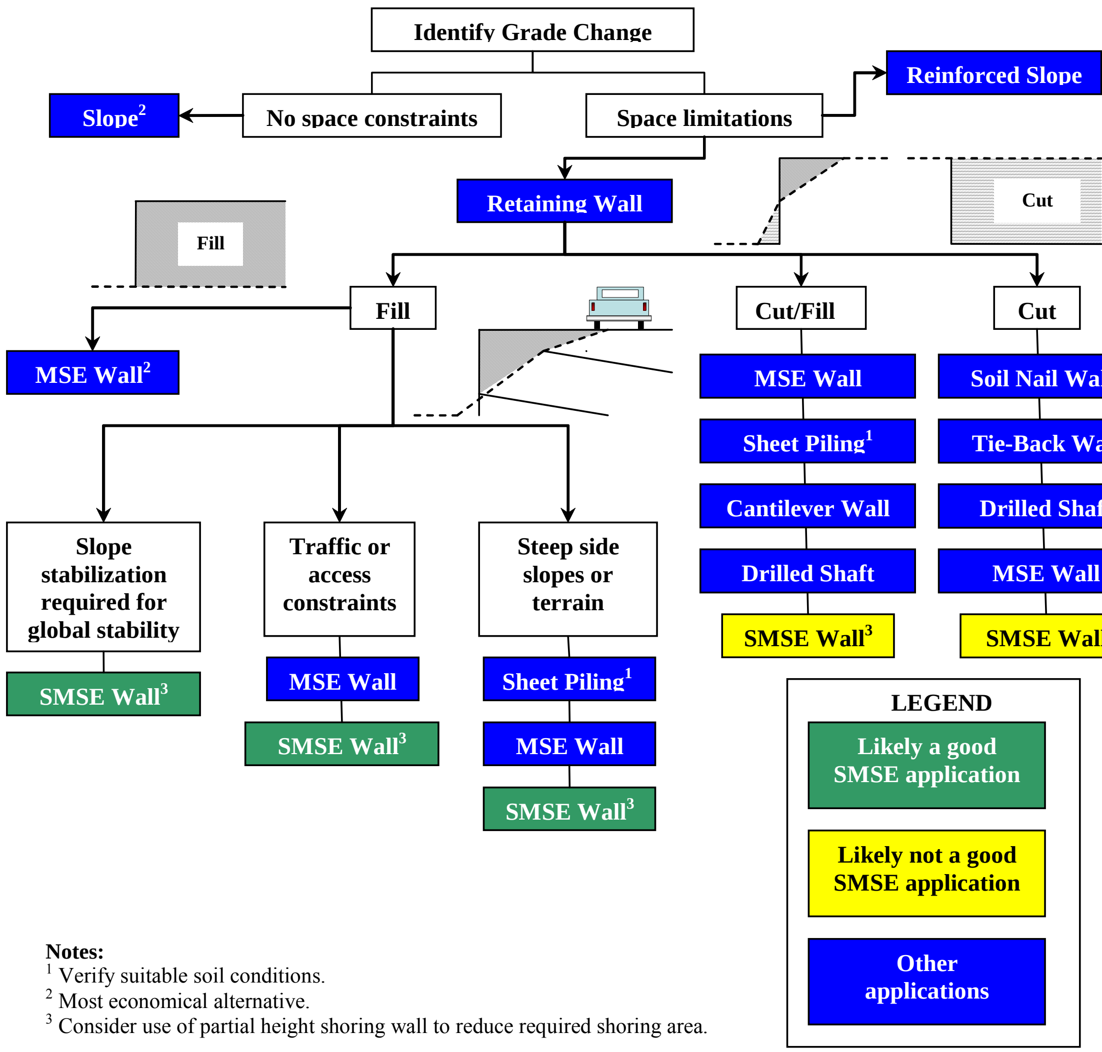

Figure 5. Flow chart. Flow chart for assistance in SMSE wall selection.

Fill wall construction is on either level or sloping ground. For level ground situations, construction of an MSE wall is generally most economical. MSE walls on slopes require an excavated bench for construction. Excavation of the bench is accomplished either through construction of a temporary slope or a shoring wall. Excavation procedures should follow those outlined by the Occupational Safety and Health Administration (OSHA).[4] SMSE wall systems require the use of permanent shoring, but allow shorter MSE reinforcements than a traditional MSE wall, and consequently, potentially reduced excavation quantity. Where temporary shoring is employed, MSE walls should be designed using conventional methods.[1,2]

Cut/fill conditions involve placing fill on the upper portion of a slope and cut in the lower portion of the slope. Construction of a traditional MSE wall requires that adequate space is available for excavation. When provided with space limitations, an SMSE wall may be constructed; again, other wall types may be more economical such as soldier pile, secant or tangent pile walls, tie-back walls, or sheet pile walls.

SMSE walls may be the most economical or practical solution for sites requiring fill wall construction with one or more of the special circumstances presented in section 2.1.3, especially where the terrain is steep, space constraints are present or global stability is a concern. Determination of SMSE applicability requires an analysis based on the pre-evaluation studies performed early in the design phase. A geotechnical site evaluation and preliminary roadway or project design provide the detailed information required to make the evaluation.