Influence of the Construction of Uncased Drilled Shafts at Close Proximity to MSE Wall Facing

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ABSTRACT Deep foundation supported abutments are typically supported independently from the MSE structure by installing deep foundations that extend through the MSE structure and compressible foundation materials to competent bearing strata. The traditional method used for bridge pile installation in combination of MSE walls, consists of extending temporary casings upward through the MSE structure as the walls are built thus allowing horizontal earth reinforcing elements to be positioned around the casings. Once the wall is complete, deep foundation elements are installed through the casings. A new bridge piling installation method has been established using high density polyethylene geogrid that allows for piling installation to proceed without the need for casings. This paper describes the development of the method and construction observations used to determine the influence of the drilling technique on the stability of the geogrid reinforcement and the need for temporary casing on the stability of the MSE wall facing.

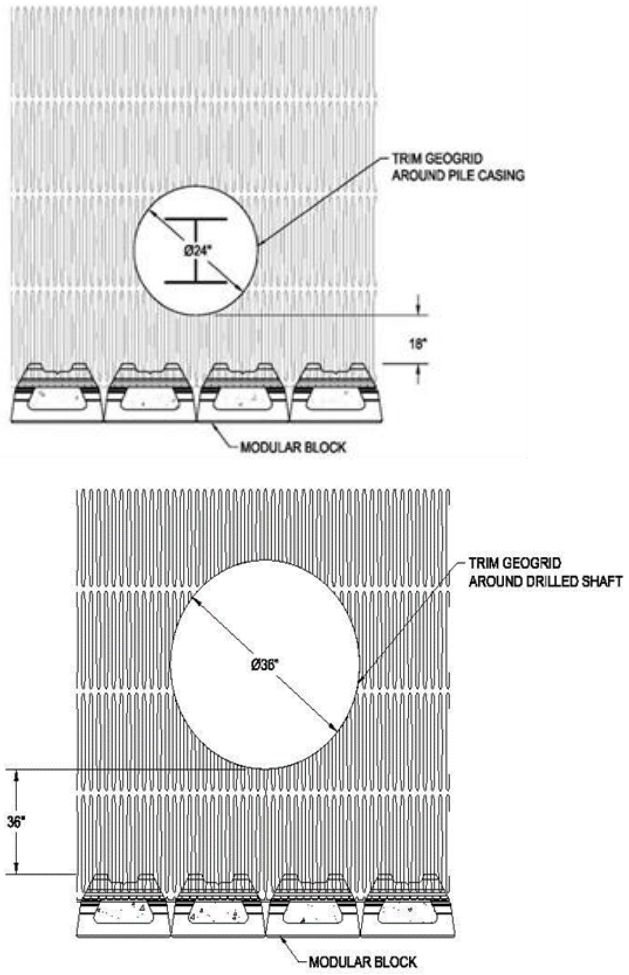
Introduction

The Mechanically Stabilized Earth (MSE) walls with geogrid reinforcement have grown in popularity since their first introduction in North Americas in the early 1980's due to its cost-effectiveness, performance and the long-term chemical durability of the reinforcement material. Geogrid reinforced MSE walls are now a common solution for supporting critical structures such as bridge abutments both in spread footing supported abutment and deep foundation supported abutment applications.

FHWA provides design guidelines for condition in which deep foundation elements such as driven piles or drilled shafts are used when spread footing supported abutments are not a viable option. FHWA recommends using casing where significant post construction settlement or negative friction is anticipated (Berg et al., 2009). FHWA also recommends a minimum clear distance of 460mm (18 inches) and 910mm (3 feet) respectively (Figure 1) from the back face of MSE wall facing to the front of the driven piles' casing and drilled shafts respectively where the casings are installed prior to the MSE wall construction. The minimum of 910mm (3 feet) for drilled shaft is required to allow proper fill placement and compaction in the area. The MSE reinforcements are typically splayed no more than 15-degree or in the case of geogrid reinforcements cut around the deep foundation elements.

The constructability of driving steel H piles without casing through HDPE geogrid reinforcement has been evaluated. The H piles were driven into the reinforced MSE wall facing 610mm (2 feet) from the back of wall facing and no significant movement and loads

Fig. 1. Traditional Minimum Clear Distance of Deep Foundation behind MSE Wall



were observed during and after the pile driving (Berg et al. 2007). In addition, studies have shown that drilled shaft with casing can be constructed at a minimum of 910mm (3 feet) from the back face of wall with the geogrid trimmed around the drilled shafts prior to MSE wall construction (Han et al. 2010). However, the feasibility of drilled shaft installation through MSE reinforced mass at close proximity to the wall facing without casing and without geogrid trimming around shafts have not been studied.

To understand the influence of a drilled shaft on a MSE wall, we constructed a test wall to determine the influence of the drilling technique on the stability of the geogrid reinforcement and the need for temporary casing on the stability of the MSE wall facing. The drilled shafts extended through the reinforced MSE wall backfill and were installed in a one-step process after the completion of the wall.

Test Wall

A near vertical (0.45-degree batter) eight feet tall MSE wall was constructed in Dixon, California using dry-cast modular block facing mechanically connected to high density polyethylene (HDPE) geogrids to simulate a MSE abutment wall with drilled shaft deep foundation as shown in Figure 2. The modular block facing was founded on unreinforced concrete leveling pad, the 8ft long HDPE geogrids were connected to the facing with mechanical connectors at every two block (400mm) spacing and the backfill was well-graded Sand (SW) per USCS classification meeting California Department of Transportation (Caltrans) Class 2 base.

Fig. 2. Near Vertical Modular Block Geogrid Reinforced MSE Wall

Seven, 910mm (3 feet) diameter drilled shaft were located 460mm (18 inches) from the back of the facing along the test wall with each of the boring locations having various reinforcing and face detailing as depicted in Table 1. The geogrids were precut to fit around the drilled shaft locations in all bore holes (Figure 3a) except for 6 and 7 where the geogrids were intact without removal (Figure 3b). The top geogrid layer for bore holes 6 and 7 was placed at 810mm (32 inches) from the top of wall. Various block facing details such as core fill, grouts, reinforcing bar, masonry glue or the combinations of the materials were used to evaluate the need for specific detailing required for such drilling operation. Figure 4 shows grout with horizontal and vertical rebar reinforcing while Figure 5 shows core fill with horizontal reinforcing only within the core of the blocks.

Fig. 3a. Precut Geogrid Around Bore Hole

Fig. 3b. No Precut Geogrid Installation

Tab. 1. Face Block Treatment and Geogrid Detailing at drilled Shaft Locations

Drilled Shaft Location or Bore Hole No.	Face Block Treatment	Geogrid Details
1	Core fill, #3 horizontal rebar in all block courses. Masonry glue on top 5 block courses	Geogrid Precut around drilled shaft
2	Grout, #3 horizontal and vertical rebar on all block courses	Geogrid Precut around drilled shaft
3	Core fill and #3 horizontal rebar in all block courses except grout and #3 horizontal rebar on top 5 courses.	Geogrid Precut around drilled shaft
4	Core fill and #3 horizontal rebar in all block courses except grout and #3 horizontal rebar on top 5 courses.	Geogrid Precut around drilled shaft
5	Core fill, #3 horizontal rebar in all block courses. Masonry glue on top 5 block courses	Geogrid Precut around drilled shaft
6	Core fill and #3 horizontal rebar in all block courses except grout and #3 horizontal rebar on top 5 courses.	No Geogrid Precut
7	Core fill, #3 horizontal rebar and masonry glue on top 5 block courses only	No Geogrid Precut

Fig. 4. Block Core with Grout, Horizontal and Vertical Rebar

Fig. 5. Block with Core Fill and Horizontal Rebar

After the MSE wall construction, drilling was performed at predetermined drilled shaft locations (1.8m center to center) with a CF2.5 compact hydraulic drill using a 910mm (3 feet) toothed rock auger as shown in Figure 6. The auger was advanced slowly into the reinforced MSE mass at a slow speed 305mm per minute. Displacement measurements were recorded at the facing blocks from fixed points along the MSE wall footing to capture any movement in the wall after drilling operations. Measurements were taken from three locations on the face of blocks at centerline of each drilled shaft locations prior to drilling. The measurements were taken again immediately after drilling at the same locations prior to drilling.

Results and Discussions

Drilled shaft installation through geogrid reinforced MSE mass, especially at close proximity from wall face often raised concerns as the geogrid reinforcements may be caught and pulled out from the backfill by the auger, and therefore cause misalignment to the wall face. The displacement at the facing blocks prior to and after drilling operations from the test wall are recorded as shown in Table 2. Based on the measurements, the drilling operations at close proximity from wall face did not result in measurable movement at the wall facing regardless of reinforcement and facing detailing.

Fig. 6. Drilling after MSE Wall Construction with Rock Auger

Drilling was not performed at holes 2 and 3 since all other drilled locations had the least combinations of geogrid detailing and block facing treatments than these two. In addition, given that the wall performed well without measureable movement in the hole 7 where the geogrid was not precut and horizontal rebar was used only on top 5 courses of the block, the additional testing was deemed unnecessary.

The geogrid layers at all bored hole locations were cleanly sheared and showed no evidence of being pulled by the auger as shown in Figure 7. The bored hole remains open with no sign of collapse even on sandy backfill.

The planar geogrid reinforcement layers and the effects of soil-geogrid interaction result in a composite system with higher confining stresses between the backfill particles over the integrated reinforcement layers were measured (Bussert et al, 2010).

Tab. 2. Offset measurement in millimetre (mm) at Fixed Point on MSE Levelling Pad

Drilled Shaft Location or Bore Hole No.	Block Course above Leveling Pad Pre-Drilling			Block Course above Leveling Pad Post Drilling		
	1	7	12	1	7	12
1	102	140	156	102	140	156
2	102	121	137	--	--	--
3	102	124	140	--	--	--
4	102	137	178	102	137	178
5	102	114	140	102	121	137
6	102	152	191	102	152	191
7	102	108	191	102	108	191

Fig. 7. Geogrid Sheared and Supporting the Drilled Hole

Conclusions

The feasibility of drilled shaft installation without casing at close proximity to the wall facing after geogrid reinforced MSE wall construction has been confirmed through the full-scale test wall. Drilling operations can be performed as close as 460mm (18 inches) from the MSE wall facing with minimal remedial block facing treatments at the core. This method of construction allows proper compaction of the backfill in the tight space between drilled shaft and wall facing, and reduces the impact of downdrag and therefore cost of the deep foundation structure.

We found that it is acceptable to drill through the HDPE geogrid at close proximity to the wall facing without precutting the geogrid around the drilling zone for the future shaft location. The compacted composite mass of the planar geogrid reinforced zone allowed the drilled hole to stay open and geogrid to be drilled through without measurable movement to the wall facing.

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