DISTRICT ENGINEER MEMO

Subject: Bulkheads Construction utilizing Deadman Anchor Piles Embedded into the Waterside Levee Slope

The purpose of this memo is to explain how piles interact with the supporting soil when subject to horizontal loads. The technical name for this engineering subject is referred to as the "mechanics of laterally loaded piles."

Bulkheads are walls constructed in water to retain (support) earthen fill. A fancy name for a retaining wall built in water. Bulkheads commonly rely on "piles" embedded into the soil for support. The load transfer details for the design of pile supported bulkheads vary. Some use wood lagging as the facing system supported by timber whalers, others use steel sheet pile as the facing with steel whalers. But the mechanics of how the piles function in the soil is the same regardless of the pile material or the details of the facing system used to transfer retained earth loads to the piles.

In the attached graphic, figure 1 depicts a cross-section of what is referred to as a "normal wall" with no deadman anchor pile. The word normal is not used here to mean that walls that use deadman anchor piles are not common. Bulkheads using deadman anchor piles are common. The phrase "normal wall" is used here for the author's convenience.

The wall shown in figure 1 depicts the "soil rupture zone" supported by the bulkhead. This soil wedge zone is the horizontal load on the wall. The soil resistance distribution on the pile is also shown.

Figure 2 contains a schematic of a "failed bulkhead" by pile rotation. One common way to repair failed bulkhead's is to push the front pile back into place which creates a temporary void area of loose soil that cannot be relied on for support in the near term. This area of loose soil if not corrected during construction would take a significant amount of time for natural correction to occur. And even then, from an engineering perspective, it would be difficult to be confident that adequate soil capacity would ever be provided for the pile.

In these situations it is common to then drive a deadman anchor pile and use it to support the failed front pile with an anchor rod of some sort. Figure 2 shows the distribution of soil resistance around the deadman pile. In order for deadman piles to be effective, they must be placed with proper spacing from the failed front pile to prevent overlapping zones of soil resistance.

The schematic shown in figure 3, shows that a bulkhead can fail by breakage of the pile which differs only slightly from a pile failure by rotation as shown in figure 2 above. Again a common repair is to install deadman pile and anchor rods as discussed in figure 2 above. It is important to understand that as the front pile rotates (deflects horizontally) due to the horizontal load imposed by the soil wedge zone, the deadman anchor pile must also rotate and deflect horizontally in order to develop sufficient soil resistance to resist the pull imposed by the anchor rod connecting the two piles.

Piles **"must"** deflect horizontally to develop soil resistance. The more they deflect horizontally, the more soil resistance is developed. Figure 3 depicts the void created behind the pile head in the waterside levee slope. This size of this "void" depends on the horizontal load imposed on the pile and the stiffness of the supporting soil. For clean well drained sands that define the "best case scenario" under static loads (meaning no earthquake loads), the pile can be expected to displace 1 to 2 inches at ground level. For liquefiable sands considered to be of very poor quality, the pile can be expected to displace 8 to 10 inches at ground level. If earthquake loads are considered, the pile can be expected to displace 18 to 36 inches at ground level or even totally collapse the bulkhead wall. Any deadman pile horizontal displacement places an extremely undesirable state of stress on the waterside levee slope resulting in preferential seepage pathways of high risk to the stability of the levee.

Figure 4 indicates that the bulkhead can be repaired without the use of deadman anchor piles by installing new piles at the bulkhead face beyond the waterside levee toe.

If you have any questions, please feel free to contact myself or Blake Johnson.

Sincerely,

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