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Upgrading earthen levees with press-in piling and the GRB System

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ABSTRACT: Sheet piles have been utilized to achieve existing earthen levee upgrades on many projects because of their strength, durability, waterproofness, flexibility in choice of length and rigidity, and relative ease of construction. However, installation of sheet piles into existing levees faces a challenge if the project is very close to homes or in tight working space. This paper will discuss a couple of levee repair and upgrade projects in the U.S. that utilized press-in piling combined with the GRB system to overcome this type of logistical difficulty.

1 PRESS-IN PILING AND GRB SYSTEM

1.1 *Press-in piling on earthen levee upgrade*

Pressed-in sheet and pipe piles have been increasingly utilized for the upgrades of existing earthen levees for coastal as well as riverine use. The authors have been personally involved in some of the levee and seawall damage recovery projects built after the 2011 Great East Japan Earthquake/Tsunami and existing levees' upgrade projects in California, Florida, and Louisiana in the U.S. The primary reasons for the selection of the press-in piling over other methods are summarized as follows:

- Noise and/or vibration associated with piling need to be mitigated due to the proximity to nearby homes and sensitive structures.
- Project sites are physically confined.
- Piles have to be installed into hard soil, debris, or through existing concrete structures. This can be accomplished with press-in piling assisted with an auger attachment for sheet piles or the rotary press-in piling (Gyropress) method in the case of pipe pile installation.

1.2 *GRB system and its advantages*

The GRB (the initialism for Giken Reaction Base) System is a combination of proprietary piling equipment which transports, pitches, and presses in piles: all on the top of already installed piles. Because it eliminates the need for a construction access passage on the ground or above water, depending on the project's conditions, it enables pile installation where the access to the piling location is limited. See Figure 1 for its components and their functions.

In the case of levee upgrades, the access to the pile lines is often limited on a narrow strip of land with a body of water on one side and residential units, businesses, schools, or busy roadways on the other side. Two case studies on levee repair and upgrade that used the GRB System in the U.S. will be discussed hereinafter.

2 EAST GARDEN GROVE - WINTERSBURG CHANNEL NORTH LEVEE EMERGENCY PROJECT (HUNTINGTON BEACH, CALIFORNIA)

The East Garden Grove - Wintersburg Channel is a drainage waterway located in Huntington Beach, California maintained by the Orange County Public Works Department. It was originally constructed back in the Orange County, California, which is operated and 1960's with its levees built primarily of native soil. It has a trapezoidal shape section with a 4.9-to-5.5-meter-wide unlined bottom and 3.0-to-3.5-meter-high embankments on both sides. The side slope is 1.5 to 1.0 (horizontal to vertical). In response to the damage caused by the 2005 storms, the Orange County Board of Supervisors declared

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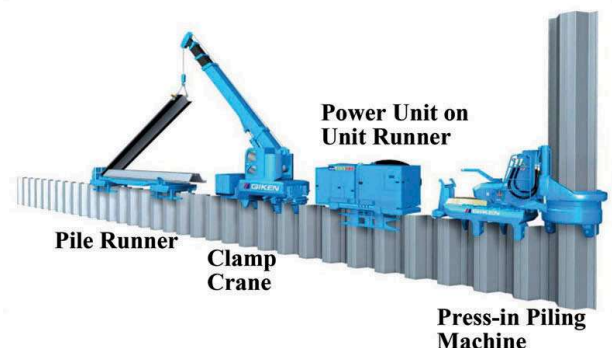

Figure 1. Concept of the GRB system.

a local emergency and its public works department decided to fix the levees with sheet piles to be installed with the press-in piling method. See Figure 2 for the conditions of the levee prior to the emergency repair.

The area behind the levee repair was designated as wetlands to be protected from human activities including construction related trucking or equipment placement thereon. Due to this logistical constraint, the GRB System or an equivalent was so specified for the sheet pile installation for the levee repair work. See Figure 3 for the project's specifications on the use of the GRB System or Engineer's approved equal.

Figure 2. Channel 05 levee prior to the emergency repair.

The project repaired approximately 1,140 meters of erosion on the north levee with 989 pairs of 13.7-meter-long PZ35 type sheet piles (575mm wide and 378mm deep each). See Figure 4 for the typical soil conditions and the corresponding location of the sheet pile. It was designed to have the pile top elevation to be at 4.5 meters above the channel's invert after planned improvement. The embedment depth was approximately13.2m. Figure 5 is the aerial view of the Channel 05 project and the surrounding area with the emergency repair alignment shown in a yellow line on the north side of the channel, which was worked on from January to February of 2008. Phase 2 (in blue lines) was later upgrade work completed in 2014 with partly single but mostly double sheet pile walls and deep soil mix columns between the double walls (Fayad et al. 2015). Phase 3 (in light green) are currently (2020 to 2021) being worked on.

The GRB System that was deployed on the emergency repair project comprised of a press-in piling machine for Z-shaped sheet piles (Silent Piler SCZ675WM model), a Unit Runner for the power pack for the piling machine, a Clamp Crane (CB3-3 model), and a Pile Runner. See Figure 6 for the profile of the 10-ton-capacity Clamp Crane which was used on the project. It has the maximum lifting height of 32.1 meters above the ground and the maximum operating radius of 30.2 meters.

The sheet pile installation was conducted on a 24-7 basis to complete the repair before the next rainy season. This was achievable only because of the low noise and low vibration nature of press-in piling (White et al. 2002). Actually, there were no noise or vibration related complaints made by the local residents: some of whom were as close to the piling operation as 50 meters. Residents who lived on the

Install Sheet Piles shall be accomplished using the GRBs (Giken Reaction Base System) or ENGINEER'S approved equal. The GRBs shall have all equipment for the piling operation supplied and operated from the top of the pile without the need for external staging beyond the initial Start and End of Project. The:

1. Silent Press-In Piler
2. Engine Unit
3. Clamp Crane
4. and Pile runner

or approved equal and shall all work atop of the sheet pile.

Figure 3. Project's specifications (excerpt) on the use of the GRB System or Engineer's approved equal (Pages F-14 and 15, Orange County, California, 2007).

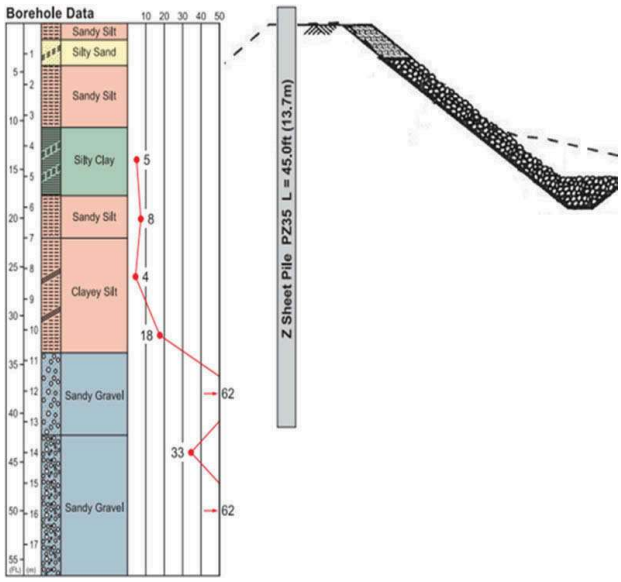

Figure 4. Typical soil conditions and sheet pile location.

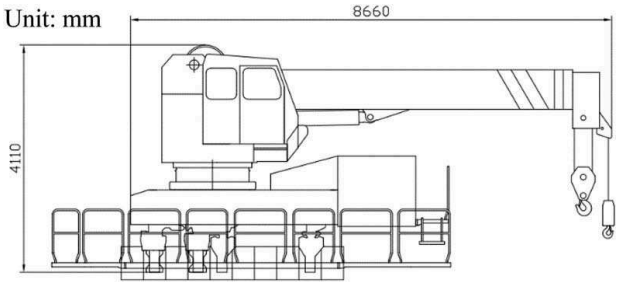

Figure 6. Profile of CB3-3 clamp crane.

Figure 7. Installed line of sheet piles with press-in piling and the GRB system.

opposite side of the channel even voiced their desire to have their side of the levee to be reinforced immediately in a similar manner. See Figure 7 for the installed line of sheet piles with the piling operations in the distance and the wetlands on the left of the levee.

It had been anticipated that the sandy gravel layer at the depth of 11 to 13 meters with N-value higher than 50 would require the use of an auger attachment for press-in piling so the piling subcontractor (Giken America Corp.) brought the attachment to the jobsite to be ready. However, the piling work was able to be completed without using it. The average production rate was as high as 25 pairs per 12-hour shift and the maximum was 45 pairs in a 12-hour period. Press-in piling impressed the state regulatory agencies (California Fish & Wildlife and California Coastal

Figure 5. Aerial photograph of the levee repair and the surrounding area, base map via Google Map).

Commission) so they recommended the use of the method for future projects by the county (Fayad et al. 2015). The county has been utilizing pressed-in sheet piles for their subsequent levee upgrade projects including the aforementioned Phases 2 and 3 work on the same levee. Additionally, J.F. Shea Construction, Inc. based in Southern California, who had undertaken the emergency levee repair as a general contractor, later purchased a new unit of Silent Piler and the associated auger attachment for their future self-performing work after having seen the advantages of press-in piling on this project. And, they are currently working on the Phase 3 as the general contractor.

3 SANDALWOOD CANAL IMPROVEMENTS (JACKSONVILLE, FLORIDA)

The City of Jacksonville, Florida is in the northeast corner of the Florida peninsula and at the mouth of Florida's longest river, the St. Johns River. The city is integrated with Duval County and has the largest area as a city in the contiguous United States (Wikipedia on Jacksonville, Florida). Its eastern suburb toward the beach is very flat and low-lying where the Sandalwood Canal is located and discharges to Hogpen Creek. The canal is approximately 10 kilometers long, running through densely built single-family residential neighborhoods. See Figure 8 for the project location and the surrounding environment.

The subject project, "Sandalwood Canal In-channel Improvements Project (Hodges Bl. from Beach Bl. to Atlantic Bl., Project No. P-80-01)", was let by the city to repair the damaged earthen levees from an earlier flooding as well as to increase the drainage and retention capacity of the existing canal by widening and deepening with 9-meter-long steel sheet piles to be embedded in a fine sand layer.

Because all of the piling work would have to be done just behind many homes, the project specified the use of press-in piling in order to minimize the piling related noise and vibration impact. See Figure 9 for the corresponding part of the specifications. The Z-shaped PZC18 sheet piles (635mm wide and 387mm deep each) were used. The levee's right of way was 12.2 meters wide with access easement on both shores which would have a minimum of 3.1-meter wide flat shoulders. These shoulders were wide enough for small flatbed trucks to haul in sheet piles but not wide enough for a truck-mounted crane to operate for lifting and pitching sheet piles from a flatbed truck to the piling machines. See Figure 10 for a typical cross section and soil conditions with the vertical locations of the sheet piles.

The piling subcontractor, Giken America Corp., utilized two units of press-in piling machines (Silent Piler SCZ675WM model) with one 2.9-ton-capacity Clamp Crane (CB2-8 model) which had the maximum lifting height of 25.0 meters above ground and the maximum operating radius of 22.6 meters. See Figure 11 for its profile.

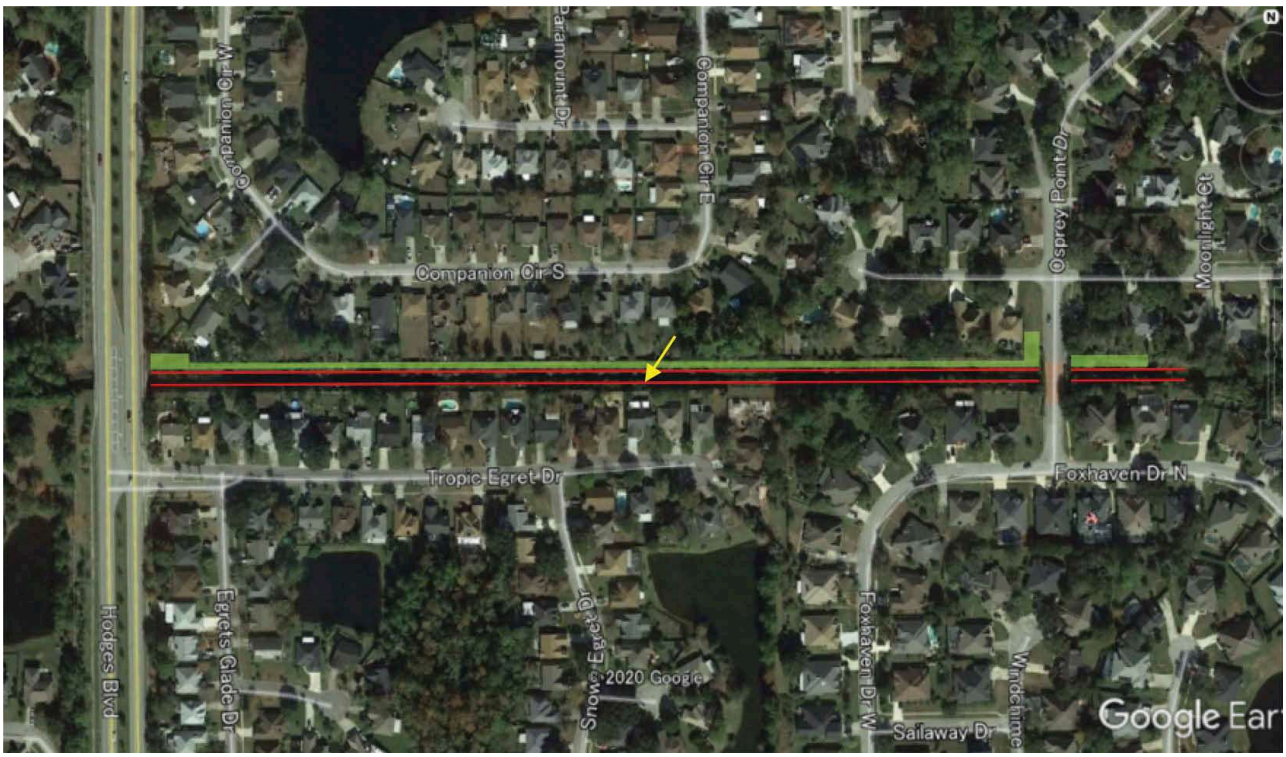

Figure 8. Aerial photograph of the project and the surrounding area (sheet pile lines in red and a truck access road in light green with staging areas as light green rectangles on both ends, base map via Google Earth).

31.40.13 **SHEET PILE INSTALLATION**

31.30.13.1 HYDRAULIC PRESS-IN EQUIPMENT

Steel sheet piling shall be installed and extracted using the hydraulic press-in method. Steel sheet piling shall be hydraulically pressed-in extracted using the following approved equipment utilizing an identical non-vibratory, non-percussive hydraulic press-in method.

The hydraulic press-in equipment shall not produce more than 70dB of noise, at a distance of 25 feet from the equipment, while in operation. It shall not produce any measureable vibration at the ground surface, at a distance of 25 feet form the equipment, while in operation

Figure 9. Project specifications (excerpt) on the use of press-inpiling.

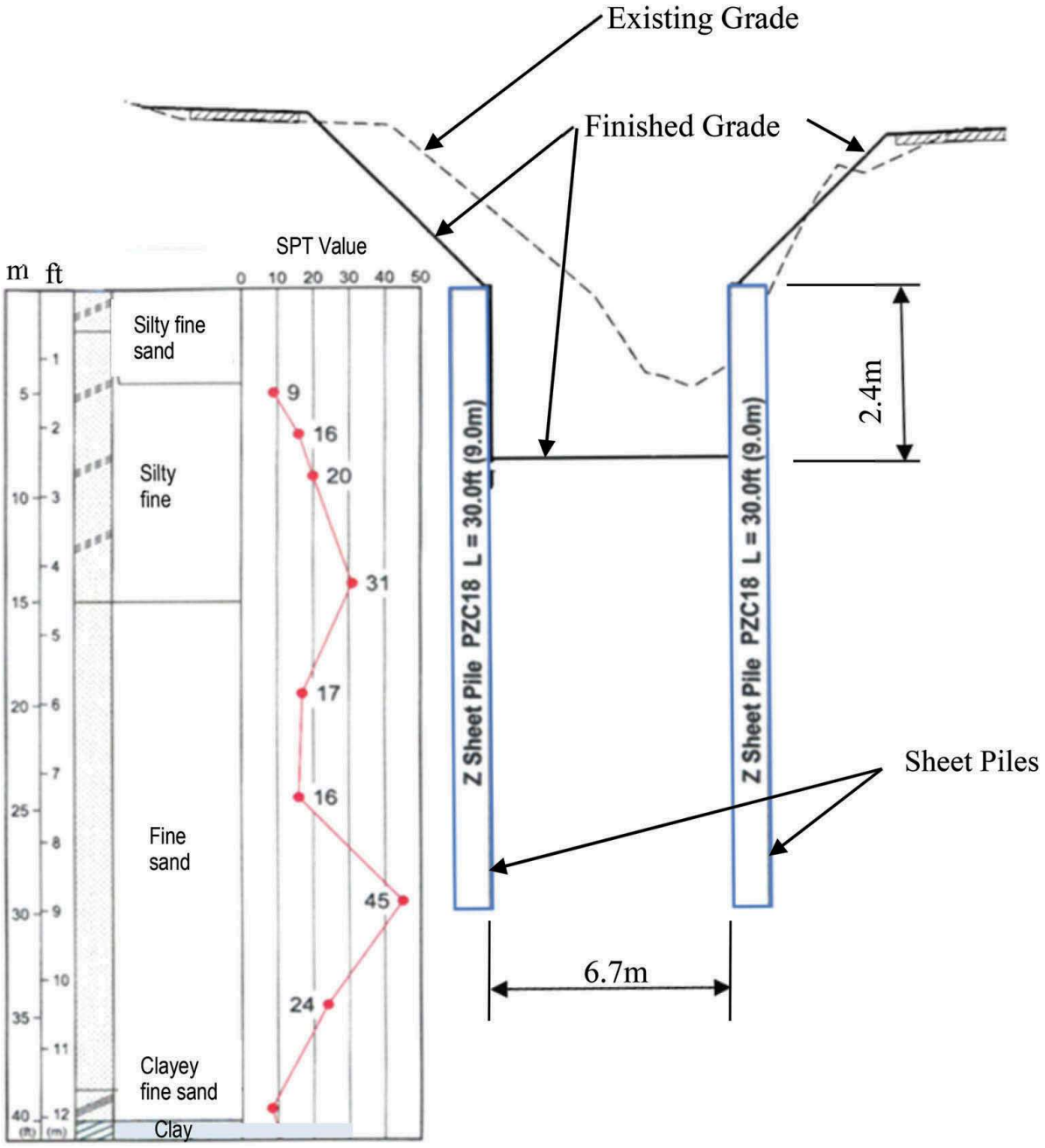

Figure 10. Typical cross section and soil conditions.

In order to reduce in-stream exposure of equipment to flood water during construction, the sheet piles were installed during the dry winter season between November 2007 and February 2008.

After clearing vegetation and initial grading including excavation of the levee shoulders for piling work, the press-in piling work was conducted on both levees simultaneously side by side as shown in Figure 12 so the Clamp Crane (painted in yellow) was able to pitch the sheets to both piling machines. Although it was not the full GRB System, the combination of two press-in piling machines and the Clamp Crane successfully accomplished the sheet pile installation in a very narrow but long strip of construction zone. Approximately 950 pairs of sheet piles were installed without causing damage to the nearby homes. The average production rate was 25 pairs per 10-hour shift with the maximum of 35 pairs in a 10-hour period. Figure 13 shows the section with installed sheet piles in both levees while backfilling and shaping of the levees were in progress following pile installation.

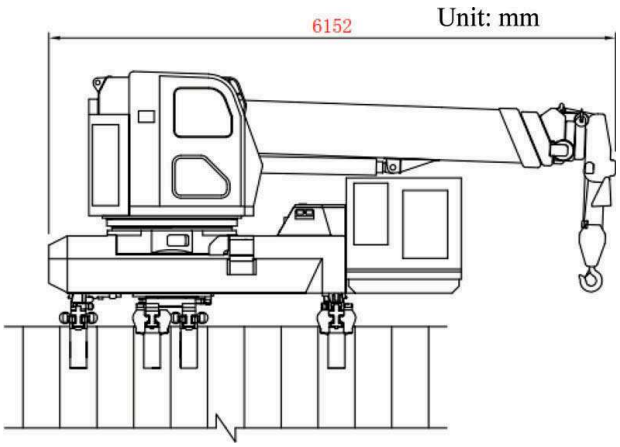

Figure 11. Clamp crane CB2-8.

Figure 12. Clamp crane pitching sheet piles to press-in piling machines.

Figure 13. Competed sheet pile installation with backfilling and shaping of the levees in progress.

4 CONCLUSION

- Pressed-in sheet piles are widely used for the repair and retrofit/upgrades of existing earthen levees in the U.S.
- Press-in piling has low-noise and low-vibration advantages over other methods. It enables pile installation in densely populated residential areas without disturbing residents.
- Press-in piling with the GRB System achieves pile installation in a very narrow and long work zone as exemplified with the case study projects.
- Some local government agencies in the U.S. have been specifying press-in piling as well as that in combination with the GRB System for their levee projects.

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