Case History

Deep Mixing for the New Orleans East Back Levee (USA)

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Introduction

Reach LPV-111 is a part of a levee system designed to protect the city of New Orleans and the surrounding areas from the storm surge resulting from a 100 year hurricane event (URL:http://www.mvn.usace.army.mil/hps2/). This reach specifically protects the Bayou Savage National Wildlife Refuge, which is the largest urban wildlife refuge in the United States and home to several threatened or endangered species of birds as well as many reptiles, amphibians and small mammals.

Due to the sensitivity of the protected marshlands, deep soil mixing technologies were utilized to limit the footprint of the raised levees. The increase in the load bearing capacity of the treated soil allows for a significant decrease in the footprint necessary to attain the required height increase.

The Hurricane Protection Office of the US Army Corps of Engineers attributed failure of the New Orleans East levees system to overtopping, erosion, and subsequent breaching of LPV 111 along the Gulf Intracoastal Waterway (GIWW), as well as other sections of flood protection during hurricane Katrina in 2005 (Figures 1 and 2).

Figure 1. Damaged Section of Levee after Hurricane Katrina (LPV-111)

Case History (continued)

Deep Mixing for the New Orleans East Back Levee (USA)

Figure 2 Damaged Section of Levee after Hurricane Katrina

Scope of work

The scope of work consisted of improving the soil beneath the existing levee in order to increase the height of the levee within a limited footprint. The levee to be improved was 8,527 meters (5.3 miles) in length (Figure 3). Deep Mixing was performed to a maximum depth of 20.5 meters (67' - Figure 4) and it was designed to increase the bearing capacity of the existing soils, limit future settlement, and to resist lateral loads imposed by storm surges on the levee (Figure 3). The general contractor was Archer Western/ Alberici JV (AWA) in alliance with TREVIICOS.

Figure 3 Overall view of the LPV-111 site

Case History (continued)

Deep Mixing for the New Orleans East Back Levee (USA)

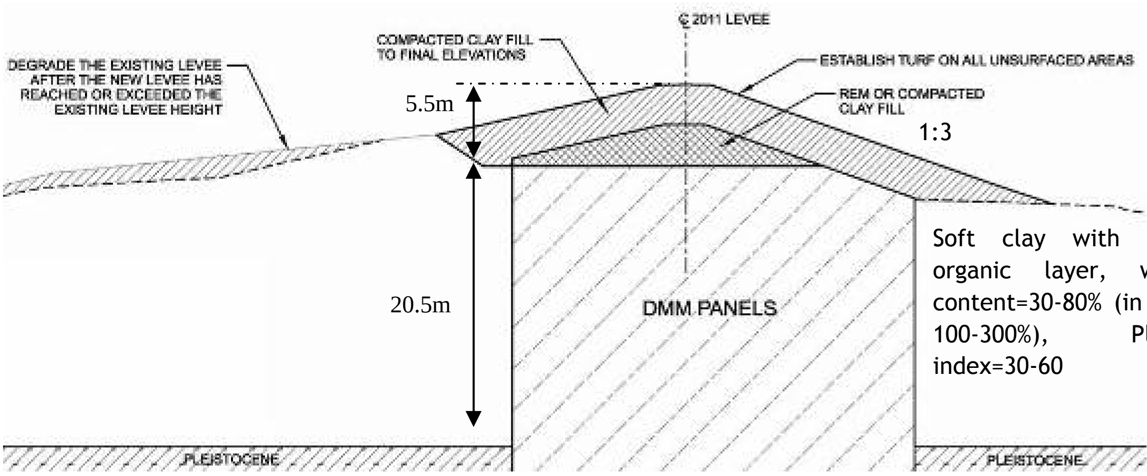

Figure 4. Typical Cross Section (REM: Recycled Embankment Material which is the cement/soil spoil from the Deep Mixing)

The 1.6 meter diameter (5.25 feet) DMM elements were overlapped to form a double auger element which then were arranged in buttresses perpendicular to the levee alignment. Buttresses were then installed at a maximum on center spacing of 4.7 meters (15.5 feet). One additional double auger DMM element was placed midway between consecutive buttresses at the centerline of the levee to further help prevent settlement (Figure 5).

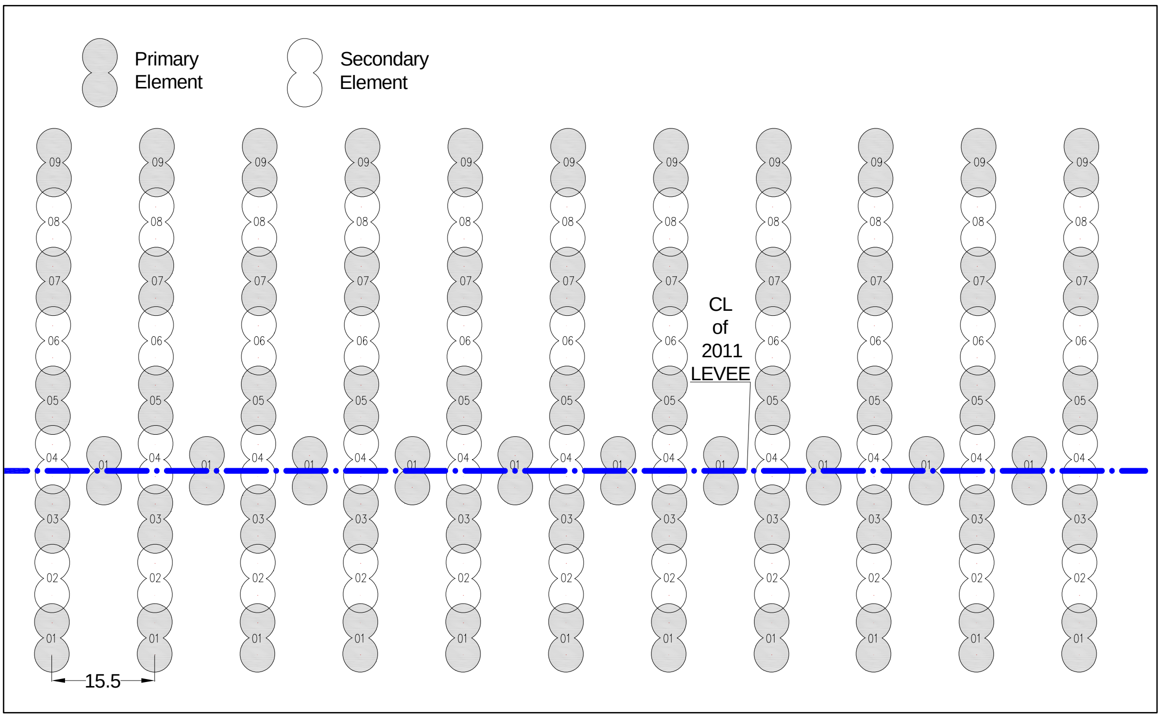

Figure 5. Typical DMM Buttress Layout

Case History (continued)

Deep Mixing for the New Orleans East Back Levee (USA)

Over 17,000 elements were installed to compete the project. Most elements were formed by using double auger rigs. Each auger was 1.6 meter (63 in) in diameter and had an overlap of 0.30 meters (12 in). Some areas of the site had limited access and single auger TTM rigs were utilized in these areas. The wet method of DMM was utilized.

Schedule

The schedule for the project was quite simple, but very aggressive; as the project had to be substantially completed by June 1, 2011. The original start date for the DMM was to have been November 9, 2009, and the DMM was to be completed by March 30, 2011. The validation portion of the project started November 24, 2009. Due to the length of the project, the Validation Phase was divided into 5 areas specified along the levee to ensure proper parameters were in accordance with actual geology. The Validation Phase included the installation of test elements in 5 different areas spaced along the levee (Figure 6) to insure that the parameters selected for the DMM would produce acceptable results. It was originally intended that all 5 areas of the Validation Phase were to be completed before actual production started. However, in order to insure completion of the project on time, production TEST was initiated when only two Validation areas were complete. Conservative DMM parameters were utilized until the remainder of the Validation areas could be completed. Once all validation AND PRODUCTION TEST locations were complete, production began in full force. DMM work was scheduled accordingly while occurring simultaneously with earthwork. One additional DMM rig and two additional grout plants were mobilized to make sure the completion date was met.

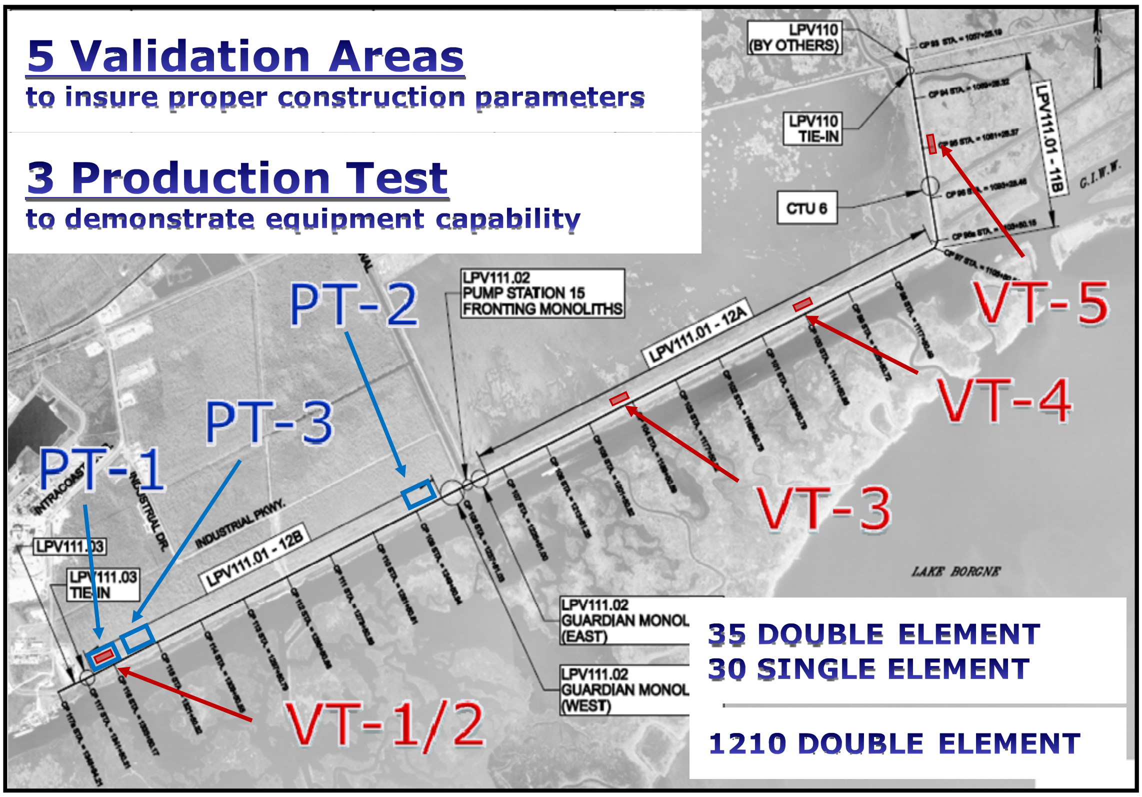

Figure 6. Validation and Production test Layout

Case History (continued)

Deep Mixing for the New Orleans East Back Levee (USA)

Materials

The material used for the project consisted of binder and water. The binder consisted of type I/II Portland Cement and slag cement. The proper proportions of cement/slag were determined during the Bench-Scale Testing program. For the entire project, over 417,000 tons (460,000 short tons) of binder was used.

The water used in the grout mix was supplied by a potable (city) water line installed along the entire length of the project.

Drill Rigs

A total of eight DMM drill rigs were utilized. Three double, and two single axis using TREVI Turbo Mix (TTM) and three double axis rigs were supplied by FUDO Construction using CI-CMC.
The 5 Soilmec TTM rigs; 3 SR-90s, 1 SR-80 and 1 SR-70 were all equipped with the Drilling Mate System (DMS) software to insure the quality of the elements. The TTM rigs are equipped with pass through rotaries. The grout was mixed at localized grout plants and sent to the rig where it was injected at pressures between 100 and 200 bar through strategically place nozzles to provide homogeneous soil mixing (Figures 7 and 8).

The 3 FUDO rigs were supplied with top drive rotaries and a parameter recording system. These rigs utilized air pressure supplied at 15 bar simultaneously with low pressure grout (Figure 9).

Figure 7. TREVIICOS Rig (Soilmec SR-90 - double shaft)

Figure 8. TREVIICOS Rig (Soilmec SR-70 – single shaft)

Case History (continued)

Deep Mixing for the New Orleans East Back Levee (USA)

Mixing Equipment

Twelve locations for the grout plants (Figure 10) were equally spaced along the project to facilitate the supply of grout to the DMM rigs. Eight complete grout plants were supplied and were relocated as areas of the project were completed. The equipment required for each grout plant included; 1 high shear grout mixer, one agitator, 2 SOILMEC high pressure pumps, 2 vertical cement silos, 1 cement pig, and one 75,000 liter water tank. Each of these plants was capable of mixing more than 225 tons (250 short tons) of binder per shift.

Coring Equipment

The specification required that 3% of the elements be cored to verify the quality of the DMM. To accomplish this, 3 Soilmec coring rigs were utilized with a PQ3 or Geobore coring system (Figure 11). The cored samples were typically retrieved once the columns had set for at least 26 days. Subsequently, on the 28th day after element installation, these samples were trimmed and Unconfined Compressive Strength testing was performed. (Designed UCS is 100psi=700kPa)

Figure 9. FUDO DMM Rig – (double shaft)

Figure 10. Grout Batching Plant

Case History (continued)

Deep Mixing for the New Orleans East Back Levee (USA)

Figure 11. Coring Rig

Case History (continued)

Deep Mixing for the New Orleans East Back Levee (USA)

Production methods

In order to meet the demanding schedule, production work occurred 24 hours per day, 5.5 days per week. At the peak of production, TREVIICOS had over 170 personnel working. By the completion of the project, over 500,000 man-hours were worked.

The delivery of cement was a key factor in maintaining production rates that would keep the project on schedule. On an average day, over 100 cement tankers, carrying about 23 tons each, were needed to supply the 7 grout plants in operation. The peak production rate for one month was approximately 140,000 cubic meters (180,000 cubic yards) of DMM treatment.

Logistics

In order to meet the demanding schedule on LPV-111, batch plant placement, rig sequencing, and site support was critical to the successful completion of the project.

The 7 active batch plants were spaced at approximately 500 meter (1,500 feet) intervals along the protected side of the Levee. Each batch plant could supply grout to one double axis DMM rig or two single axis DMM rigs. The concern of the placement of the plants was that, with increased pumping distance, there was a risk of comprising grout quality, especially considering the extreme high temperatures during the summer months in New Orleans. Each batch plant could store approximately 225 tons (250 short tons) of binder. The cement tankers used to feed the silos had to share the site haul road with the trucks hauling clay (Figure 12) and other site traffic, so extra binder capacity was needed to insure an adequate supply of binder.

Figure 12. Haul Road Traffic

The DMM rigs were positioned on a platform prepared by AWA, and the DMM rigs were always on timber mats to guarantee the stability of the rigs. The sequencing of the elements was in a primary/secondary pattern (Figure 2).

Case History (continued)

Deep Mixing for the New Orleans East Back Levee (USA)

Batch Plant Quality Control

Quality control of the batch plants was a crucial component in the process to verify that the grout supplied to the DMM rigs met the specifications. The mixing equipment was calibrated using test weights periodically to insure proper proportioning. Tests performed on the fresh grout included apparent viscosity, using a Marsh Funnel, and density, using a calibrated mud balance. Cylinders of the fresh grout were taken daily from each plant and checked for unconfined compressive strength.

DMM Rig Quality Control

All of the DMM rigs were equipped with a GPS system to facilitate the accurate layout of the elements. The rig GPS was validated at least once per shift by a hand-held GPS to verify element location.

The SOILMEC drill rigs were equipped with the Drill Mate System (DMS) installed to control, record, and transmit installation parameters and rig performance data (Figure 13). The DMS was also capable of controlling the drill rig to preset parameters for up to 4 different soil types. The DMS transmitted all the data by e-mail when each element was completed so it could be reviewed for accuracy in near real time.

In the same context, ISSMGE Website will be improved; that means that it will be easy to use, including complete contents and activity and will be properly described. It will also include RSS news subscription, members' blogs and forums. Thus, ISSMGE members will be able to access to geotechnical knowledge resources of successful universities to improve the level of the global geotechnical knowledge, and declare their demands directly to the society as well as the society can.

Furthermore, it is hoped in the next future that all young members around the world find same facilities to send their message (especial investigation results, geotechnical pictures, educational videos) to the other members simply and inquire their geotechnical questions easily via geotechnical forum.

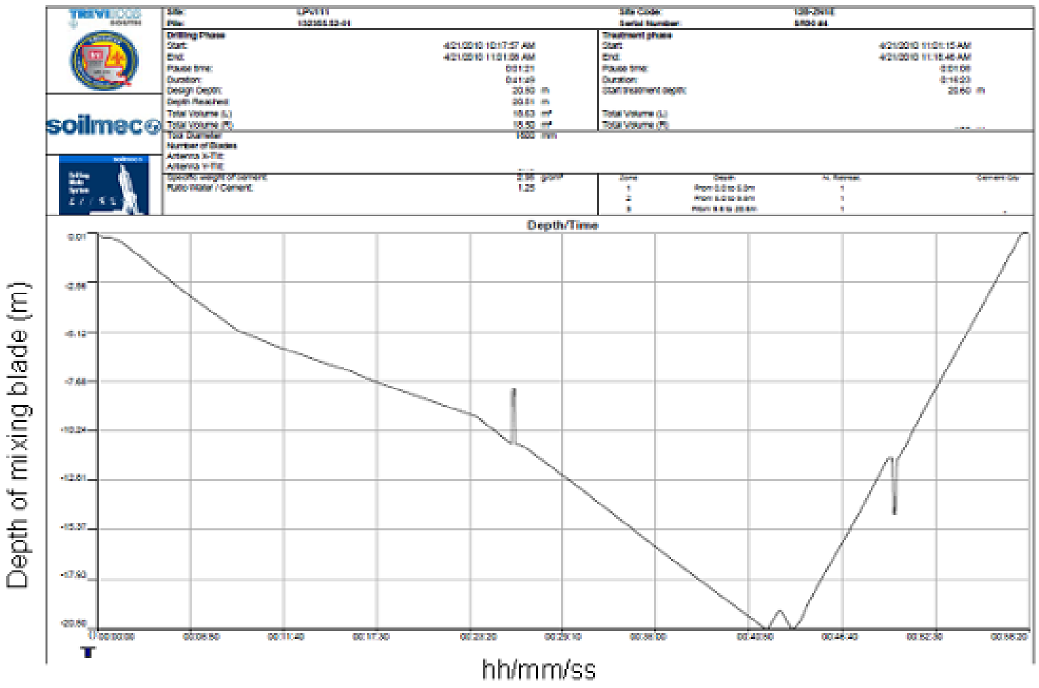

Figure 13. DMS Report

Case History (continued)

Deep Mixing for the New Orleans East Back Levee (USA)

The DMM rigs supplied by FUDO were equipped with a system capable of monitoring and recording the installation parameter (Figure 14).

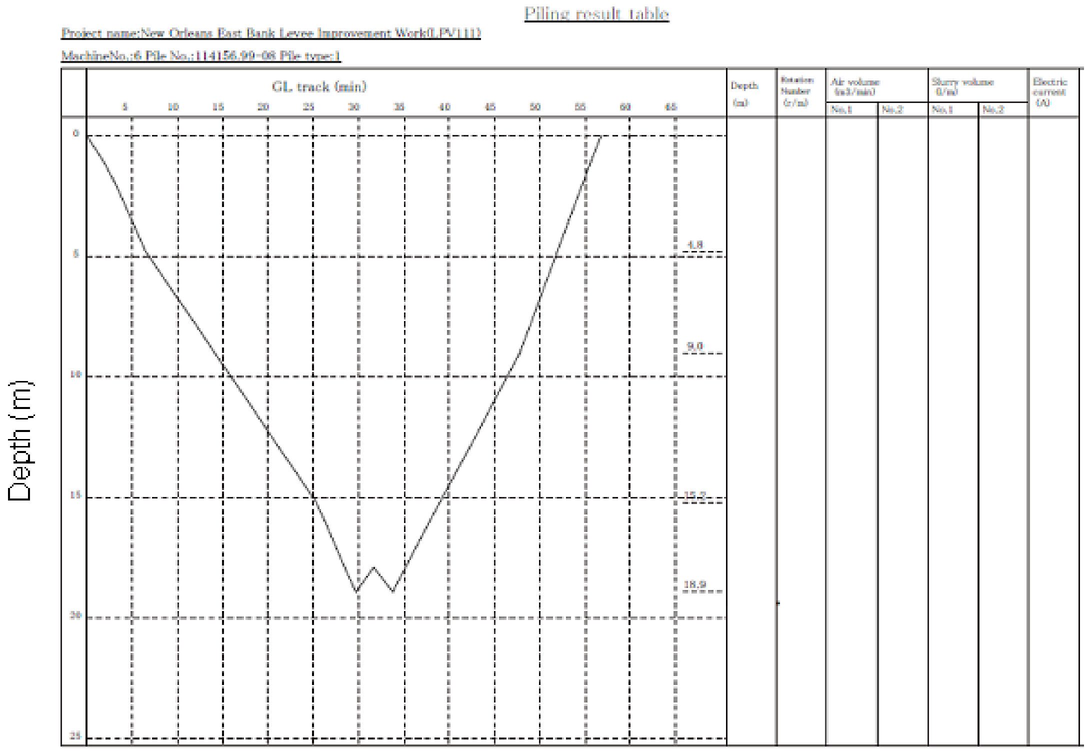

Figure 14. FUDO Rig Report

CONCLUSION

This gives a brief overview of the equipment used and the logistics of the largest DMM project performed to date in the United States, and one of the largest land projects ever performed anywhere. It also provides an overview of the challenging logistics required to move and place massive quantities of binder in a short period of time. Other facets of this world-class project such as quality control, laboratory mix test and advanced mixing technology, can be found in additional papers that will be presented at the **4th International Conference on Grouting and Deep Mixing in New Orleans in 2012 (ICOG2012, DFI)**.

The challenges presented on the LPV-111 project were daunting, but with the assistance of all the parties, the DMM portion of the project was completed ahead of schedule with exceptional quality.

AKNOWLEDGMENTS

Hundreds of individuals contributed to the success of the LPV 111 project. The authors wish to acknowledge the following individuals in particular: Pete Cali, David Druss, Tom Cooling, Donald Bruce, Pete Nicholson, George Filz, AWA and all involved with TREVIICOS and FUDO.