Stabilization of Dredge Spoils to Meet Environmental and Geotechnical Performance Criteria

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KEYWORDS: Soil Stabilization, Soil Modification, Sediment Remediation, Remediation, Dredge Stabilization, Dredge Solidification, and Beneficial Reuse of Dredge Materials.

ABSTRACT

The use of dredge spoil as construction materials, or the commercial development of dredge spoil piles is often restricted by the geotechnical properties of the material, or environmental characteristics. This paper presents a treatment technology that has been used successfully to treat over 4,000,000 cubic yards of dredge spoils. The treated spoil piles have been developed into Liquid Natural Gas Terminals, Refineries, roads, and commercial sites. Treated spoil materials have been used to construct levees, dikes, and pads for tanks and buildings. The process requires the analysis of the chemical composition of the dredge materials, moisture content, and particle size distributions to develop an admixture that will create a final product that meets the desired performance criteria. Generally the performance criteria includes a final strength in excess of 20 psi (UCS), Plasticity Index (PI) ranging from 10 to 35 percent, permeability of < $1x10^{-6}$ cm per second, and leachability of contaminants below EPA Standards.

The patented technology utilizes various waste by-products from the power, cement, and lime manufacturing industries combined in calculated ratios to cause the growth of a mineral that consumes water; bonds soil particles together; and increase the internal friction of adjacent soil particles. The effect is similar to the reaction created by the hydration of cement, but utilizes waste products. The water consumption is several times that of cement. The process is market under the trade name of Low Solids Stabilization (LSS) Technology

DREDGE SPOIL PILE VALUE

Dredge piles are often strategically located adjacent to ports and other major navigable waterways, and as a result are idea for locating facilities which rely on ships and barges for import and export of product. In addition to location, dredge piles offer an advantage for permitting. The environmental impact of beneficially reusing a dredge pile are minimal, and the case can be made that since these piles have historically been subjected to dredge placement no ecosystem has been established, and thus the environmental impact of construction of new facilities is minimal.

These benefits have recently been leveraged to accelerate permitting and construction of multiple facilities in Texas and Louisiana. These facilities were constructed on dredge piles ranging in depth from nine to 18 feet.

PROCESS

The patented LSS Technology utilizes waste products from coke and coal fired power plants, limekiln dust and cement kiln dust. When blended in the proper ratios in the presences of water, minerals such as Calcium Silicate Hydrate (CSH) form. This mineral is the main bonding mineral formed when cement hydrates. The mineral grows and attaches to other CSH minerals and to soil particles. However, if the moisture content of the dredge spoils is greater than 50 percent the CSH alone will not be cost effective. The LSS process couples this high strength mineral with a mineral that consumes significant quantities of water. In the LSS Technology the second mineral that forms consumes 26 moles of water for each mole of the mineral formed. The combination of both minerals forming during hydration results in a stabilized dredge having significant strength (25 – 55 psi Unconfined Compressive Strength), and high erosion resistance (ND-1).

CASE HISTORIES

To illustrate the viability of utilizing this technology to develop commercial or industrial sites two case histories are discussed. Both sites were abandoned US Army Corps of Engineers dredge piles.

The first site was in Louisiana, and represented over 50 years of dredge accumulation. The dredge pile was 16 feet in depth, and the base was only 2 feet above mean sea level (MSL). The owner’s strategy was to acquire a large track of land at a reasonable rate, and to develop the property into a terminal for receipt of imported product. The dredge pile offered an idea location adjacent to a major waterway, and had the added benefit of creating minimal environmental impact. The final design included a deep-water dock, construction dock, five tanks with earthen secondary containment, and a process area. For construction to be feasible over 2,000,000 cubic yards of dredge spoil were stabilized to strengths in excess of 50 psi. The stabilized dredge was used to: 1. Construct secondary containment levees surrounding the five above ground storage tanks; 2. Create a working surface to support high ground pressure cranes and pile driving equipment; and 3. To create the subgrade for numerous foundations, lay-down yards, and parking lots. This site sustained two direct hits by Hurricanes Rita and Ike. These events offered a real world test of the strength and erosion resistance of dredge spoil treated with LSS, and at the end of the project the 16 foot storm surge created so little erosion that no materials were required to final grade the levee slopes.

Figure 1: Dredge spoils with a strength of zero were stabilized to support a 2:1 slope, retain an ultimate strength in excess of 25 psi when measured using an unconfined compressive strength test.

Figure 2: Hurricane protection levees were constructed from stabilized dredge spoils and we placed on a 2:1 slope. No failures, significant erosion, or structural problems have been identified in the 3 years since construction.

The second case history illustrates the actual load bearing capacity that can be created on a COE dredge pile using this technology. For a refinery expansion in Southeast Texas a large percentage of the new refining equipment was being manufactured off-site and shipped to the site in modules.   The location of the expansion was within a mile of a major navigation channel, but was separated from the channel by a COE dredge pile. The spoil area was active and had received dredge as recently as two years earlier.

The plan included the construction of a road across the dredge pile that could support a 1200-ton module.   The dredge was 9 feet in depth, and was underlain by 45 feet of low strength silts and clays. The final design included the stabilization of the top 7 feet of dredge, installation of 1,000,000 linear feet of wick drains, and preloading the site to accelerate consolidation. The consolidation was monitored with inclinometers and vibrating wire piezometers.

Figure 3: The refinery road was constructed across a dredge pile by stabilizing the dredge spoils and consolidating the underlying soft clays and silts.