Fig. 8-39. Typical wick drain installation equipment

Source: Photo courtesy of TerraSystems, Inc.

of sand that are installed by driving a pipe pile fitted with a trapdoor bottom plate into the ground. The pipe is subsequently filled with sand that stays in the ground as the pipe is extracted. Wick drains are corrugated plastic strips covered with filter fabric that are pushed into the ground with a specially designed mandrel. Wick drains have been used extensively to decrease the time required for drainage of pore water from deep deposits of cohesive materials (Hansbo 1979). The vertical drains are used to accelerate consolidation of fine-grained materials and avoid a buildup of excess pore water pressure that can lead to slope stability problems. Closely spaced wick drains provide a short horizontal drainage path for pore water to travel to where it is conveyed to the surface and carried away.

In the few years that wick drains have been available, they have received wide acceptance and have almost totally replaced the use of sand drains. They are cleaner, easier, and faster to install and are more reliable, efficient, and cost-effective than sand drains (Morrison 1981). It should be noted, however, that in certain situations the filter fabric can become smeared with fine-grained soils that reduce the effectiveness of the method.

Lightweight Fill

Lightweight aggregate, commonly used in the production of lightweight concrete, currently is being used as a geotechnical backfill material. Its high strength-to-weight ratio can be used to solve stability, settlement, and high lateral earth pressure problems associated with many waterfront structures.

Rotary-kiln-produced expanded shale aggregate has a number of important properties that make its use as a lightweight backfill material viable. The angle of internal friction is in the range of 40° to 45°, and compacted dry unit weights below 65 lb/ft^3 are possible (Childs et al. 1983). Individual particles have fairly high abrasion resistance and do not exhibit appreciable breakdown in the field. The material also can be supplied in a number of standard gradations.

Though lightweight fill is more expensive than granular backfill material, it can lead to an economical solution by allowing the use of lighter structural members for new construction. Lightweight backfill also may be used to relieve lateral earth pressures on existing distressed structures. Not only has lightweight aggregate been used successfully for numerous small rehabilitation projects, but also its use on large-scale projects has proved economical (Carchedi and Porter 1983).

Low-density cellular concrete recently has been used to reduce loads on existing waterfront structures (Palermo 1985). The material is aerated before being pumped in a slurry consistency, and resultant unit weights are on the order of 36 lb/ft^3. Buoyancy of the material can be an issue if closed-cell concrete is used. Recently, an open-cell, low-density concrete has been developed that saturates when flooded rather than floats.

Mechanically Stabilized Earth

Mechanically stabilized earth (MSE) is another relatively new concept in foundation engineering. Originally developed for a vertical retaining wall system (Koerner 1997), it has proved useful in many other foundation applications. MSE retaining walls are built with individual interlocking members attached to a series of rows of reinforcing strips or geosynthetic grids. The strips or grids reinforce the soil by acting as a series of tension members, reducing lateral earth pressure to such an extent that only lightweight face panels or blocks are required to prevent the loss of fill.

The use of reinforced earth in the marine environment has been reasonably successful (Ingold 1982, Munfakh 1985) (Fig. 8-40). Construction can be somewhat difficult, however, because of the nature of the environment, especially where deep water or large tidal fluctuations exist. The use of filter fabrics or face unit sealants usually is required to prevent migration of fines from the backfill. Concerns about the corrosion of metal reinforcing strips have been addressed with coatings and the recent use of geosynthetic grids.

The concept of soil reinforcement also can be applied to the design of embankments and fills over soft ground. The reinforcing material allows the use of steeper slopes and reduces the possibility of stability failure. Site fills layered with inclusions of geotextiles or geogrids can sustain higher surface loads from cranes and other marine facility equipment.

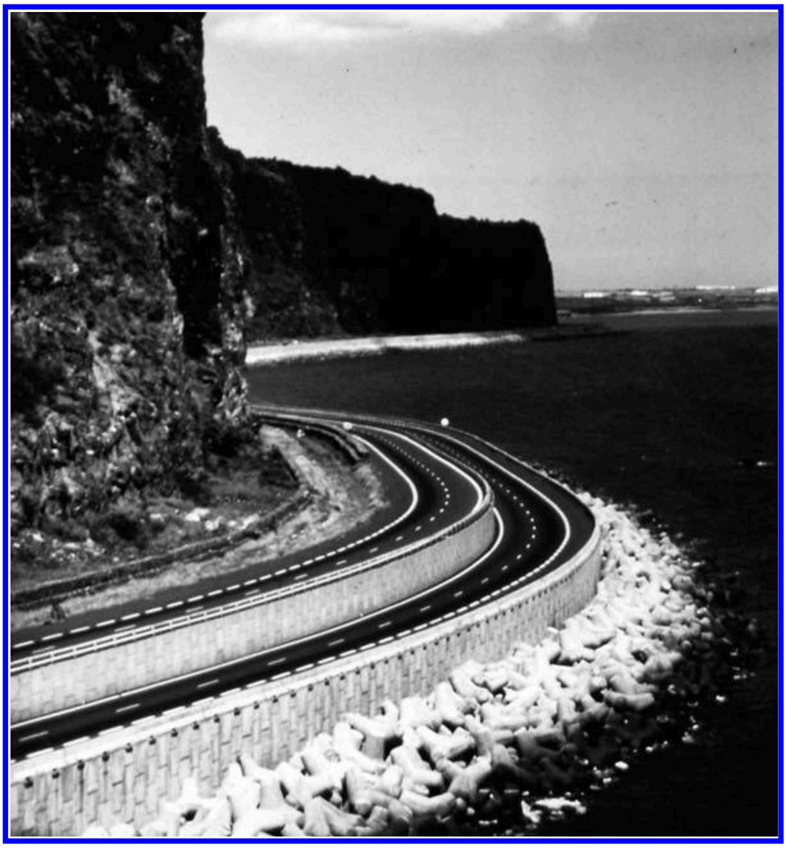

Fig. 8-40. Use of reinforced earth wall in the marine environment

Source: Photo courtesy of Reinforced Earth Company

Fabrics and Filter Materials

The use of fabrics in geotechnical engineering has boomed in recent years. Numerous types of fabrics are being used for filters, impermeable barriers, reinforced earth, wick drains, drainage mats, and erosion control.

In waterfront engineering, the use of fabrics has been mainly for filters and erosion control. Normally, filters for granular soils used in coastal structures are made up of graded layers of gravel and stone (PIANC 1992). Materials in the proper gradation are often of limited availability or costly, and proper placement is often time-consuming and difficult to control. Woven fabrics have been used successfully in a number of coastal structures to alleviate filter problems and preclude the possibility of structural failures caused by leaching and erosion of construction materials (Dunham and Barrett 1974).

Fabrics have been widely used to distribute loads from equipment, fills, and stockpiled materials. When placed over soft or organic soils, they also can help to control mud waves from subsequent filling or capping operations.

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CHAPTER 9

Floating Port Structures

Floating structures are prominent features in many ports, serving as floating docks for small-craft berthing and sometimes as piers or wharves for larger oceangoing vessels. There are also floating dry docks, breakwaters, mooring and navigation buoys, camels and separators, containment booms, and plants and equipment of a wide variety. This chapter is primarily concerned with basic design principles that apply in general to all floating-structure types, with particular regard to floating-pier applications. Basic principles of buoyancy, stability, motion response, and certain aspects of structural design are reviewed. Mooring and anchoring systems are of major importance in floating-pier design, so their basic design principles are presented. Means of access to floating piers; ancillary systems such as ballast control, pumping, and flooding; and miscellaneous design features are reviewed. The final section of this chapter is devoted to floating docks for marinas and small-craft facilities.

9.1 Structure Types and Applications

This section provides an overview of basic configurations and applications of floating structures commonly used in the berthing and mooring of vessels. Floating dry docks and floating caisson gates that form the closure of basin-type dry docks, which also are common port floating structures, are discussed in Chapter 10.

Floating Piers and Platforms

Floating piers are usually made in one of three basic hull configurations, as illustrated in Fig. 9-1: the *single pontoon* (rectangular prism) or barge-type hull; the catamaran or multipontoon configuration with the deck spanning transversely between pontoon units; and the *semisubmersible* type, frequently used in mobile offshore drilling units, with a deck superstructure supported on any number of vertical, usually cylindrical, buoyancy columns, which are themselves often connected below the waterline to continuous submerged pontoonlike buoyancy units.