Geotextile tube dewatering—Part 2: Successful project implementation

Part 1 of this paper presented recent developments in the design of geotextile tube dewatering projects. It was noted that the design of a tube dewatering project is very different from the design of a coastal or structural tube project. Similarly, the execution of a fine-grained dredged material or sludge dewatering project will require a different approach. This paper will provide implementation tips for a successful dewatering project.

Geotextile tubes

A successful tube dewatering project will meet the needs and expectations of the client. Usually this translates to a combination of cost-effectiveness, rate of dewatering, and cleanliness of effluent. The rate of dewatering has direct cost implications for both the project owner and the contractor. If there is insufficient volumetric capacity of tubes available, and the tubes dewater too slowly, then project costs may rise. Sometimes this is a perception problem, but perception (or unreal expectations) can be damaging to the perceived success of a project. The reality of watching a tube dewater after the pump is shut down is like watching grass grow. The goal of the designer is to maximize the dewatering rate while not sacrificing the cleanliness of the water escaping the tube (effluent).

Often, effluent cleanliness or clarity is of little consequence. In the case of contaminants or sediment discharge to receiving waters, however, it can be very important to the success of a project. In these cases a balance must be struck between the porosity of the fabric, the thickness of the filter cake (see Photo 1) and the flow rate of effluent. Chemical conditioning (polymer addition) has been economically used with tubes to help achieve this balance (International Dredging Review 2001). The combination of tensile strength and permeability that high-strength, woven polypropylene geotextiles provide results in an economical tube fabric suitable for a wide range of fine-grained waste materials.

Volumetric capacity

The cross-sectional area of a tube at various fill heights can be determined using commercially available software as described in Part 1 of this paper. That cross-section can then be translated into cubic yards per linear foot of tube, or gallons per linear foot. If you know the length and circumference of the tube, you can calculate the total volumetric capacity of the tube in either gallons or cubic yards.

Three standard tube circumferences are 15, 30 and 45 ft. (4.5, 9 and 13.7 m). At their efficient, safe fill heights, these tubes will contain roughly 0.6, 2.1 and 4.4 yd.³ (0.5, 1.6, and 3.4 m³) of material per linear foot, respectively. Therefore, a 100-ft. (30.5-m)-long, 30-ft. (9-m)-circumference tube will have a volumetric capacity of 210 yd.³ (160.6 m³ or 42,420 gal.). As described in Part 1, the throughput required to reach a filled volume of 42,420 gal. is far more than that, and is related to the exposed surface area and flow rate of the fabric and filter cake.

The cost-effectiveness of a dewatering project can also drop if the tubes are mismatched with the dredging equipment. Either the dredge operator is sitting idle while a tube is dewatering or the pump is inadequate to maximize the volume of the tube. Figure 1 is a chart of approximate flow rates and satisfactory tube volumes based on experience. Dredge production (output) is a function of several factors including pipe size, discharge length and the material being pumped. Dredge manufacturers typically provide production curves for sands and gravels, and a maximum flow rate for their dredge when pumping water. The flow rate for a fine-grained slurry will be considerably less than the maximum, and will also be dependent on the density (percent solids). Figure 1 is a rough guide based on dredges and pumps found in the industry.

If dredging conditions are expected to deliver 700 GPM of slurry to a 100-yd.³ (76.5-m³) tube (refer to Figure 1), experience has shown that the dredge is overpowered and the process will be inefficient. Some solutions include using a smaller dredge, using larger tubes, or splitting the discharge flow into two tubes simultaneously.

Gaffney et al. (1999) showed that as the circumference doubles, tube capacity quadruples. Since most projects are viewed in terms of cubic yards or tons, the economics of larger tubes are almost always better. There are problems, however, with larger tubes. Two mechanisms of tube dewatering are enhanced drainage path and increased...
surface area per cubic yard. Larger tubes have a longer drainage path and less surface area per cubic yard, therefore the dewatering rate usually suffers. Tubes as large as 60-ft. (18.3-m) circumference have been used by the author and others (Taylor et al., 2001) but with some loss in efficiency. The full theoretical volume of a 60-ft. (18.3-m) circumference tube cannot safely be achieved due to the excessive hydrostatic pressure acting on the seams and fabric. After the failure of a 60-ft. (18.3-m) circumference tube, Taylor et al. limited tube heights below 8.5 ft. (2.6 m), reducing the cost savings associated with the larger tubes.

The cost of failed tubes, including cleanup, slow, inefficient dewatering, reprocessing solids, and the difficulty involved in handling tubes greater than 45-ft. (13.7-m) circumference make their use with biological sludges dubious. With contaminated materials, the higher factor of safety associated with smaller tubes or high-strength polyester tubes is often desired.

**Tube layout**

Tubes are often deployed when there is inadequate space to dry dredge material, or when the available space would require a long pumping distance. Since tubes dewater faster than an open-air disposal pit, the tubes can be laid out on a parking lot or grassy field with only minor, short-term inconvenience to the owner.

When using a temporary dewatering area, it is extremely important to be aware of slopes. Tubes can roll, particularly while being filled or if they are large. Tubes are quite stable after the material has settled and consolidated. Tubes should be deployed on nearly flat surfaces with slopes less than or equal to a 1% grade. Anchoring tubes is a good idea whenever filling them, but it is required when tubes are placed on slopes between 1 and 2% grade. Anchoring can be accomplished by attaching line to the loops sewn into the sides of the tube, then anchoring the line to heavy stakes driven into the ground. Sometimes a tube will roll even when anchored, especially on grades greater than 2%. In those cases, it is advisable to have concrete barriers or water-filled barriers in place to prevent movement of the tube during filling.

Slope also relates to drainage. A large volume of water will be released from the tube during filling and it needs to go somewhere. In some cases it is useful to create a sump at the low end of the dewatering area to collect the effluent. The effluent can then be returned to the water treatment system, thus creating a closed-loop dewatering system. For clean dredging operations, the effluent can simply be returned to the receiving waters after passing over a grassy swale or through a silt fence, depending on the situation. With larger dredges, the amount of water that is released from a tube can be so great that it can cause erosion of the dewatering area. It is therefore advisable to cover a freshly graded dewatering area with a layer of plastic prior to deploying the tubes (see Photo 2).

**Figure 1: A generalized chart comparing dredge discharge capacity at various tube volumes (a similar chart could be created for sandy fill materials).**

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**Photo 2: Tube deployed over a plastic layer to prevent erosion of dewatering area.**
Polymers

Polymers have been used in dewatering sludge for many years. The use of polymers with tubes, and particularly dredged material, is quite new. A thorough review of chemical conditioning is not possible in this paper, particularly since the combination of polymers and tubes is in its infancy. We have learned however, that a small amount of polymer can increase the dewatering rate and improve the cleanliness of effluent draining from the tube. Certain polymers can increase the final percent solids (dryness) and can precipitate metals from solution. This is very helpful when dewatering contaminated waste. When polymers have been used, the amount is typically 1/3 or less the amount used by traditional dewatering methods such as presses.

In general, polymers will either coagulate fine particles (which are often charged) into larger, stable particles or will flocculate particles into large masses. In both cases the larger particles can settle faster. Sometimes a combination of coagulation and flocculation is desired. The proper use of polymer will control the filter cake permeability which will achieve the successful balance of effluent cleanliness and dewatering rate.

The decision to use polymers will largely be economic and driven by project goals. If a project will be judged by successfully meeting a stringent effluent water quality criteria, polymers may be warranted. If some fines, or colloidal (color) is acceptable in the filtrate, then polymers may not be required. If the material is known to dewater slowly, hindering the dewatering progress, polymers may allow faster filling and the use of fewer tubes. Often, material will dewater quickly and cleanly without the use of chemical conditioning, and, in fact, have been used successfully for years without polymers.

Some materials such as pulp and paper sludge, anaerobic animal waste, and wastewater treatment sludge may not dewater to an acceptable percent of solids in an acceptable amount of time without chemical conditioning. With these biological sludges, the correct polymer can be the difference between success and failure.

Example
dewatering project

Suppose a marina needs to be dredged. After conducting a bathymetric survey, it is determined that 4,000 yd. (3,058 m.) of sediment must be removed. Samples of the sediment indicate that the material is a sandy silt at 20% solids in situ. The receiving waters are upstream of a state wildlife sanctuary. The only dewatering area is an “L” shaped parking lot, having dimensions as shown in Figure 2. How many tubes of what size will be required?

The first step is to try various configurations of tubes to see if all 4,000 yd. can be accommodated in one phase.

Configuration 1
Two 100-lineal-ft., 45-ft. circumference (30.5-lineal-m, 13.7-meter-circumference) tubes can fit (snugly) in the 40-ft.-x-100-ft. (12.2-m-x-30.5-m) direction. This yields approximately 800 yd. (612 m.) of capacity.

Configuration 2
Two 100-lineal-ft., 45-ft. (30.5-lineal-m, 13.7-m-circumference)-circumference tubes can fit (snugly) in the 40-ft.-x-100-ft. (12.2-m-x-30.5-m) direction. This yields approximately 800 yd. (612 m.) of capacity.

Two 200-lineal-ft., 45-ft.-circumference (61-lineal-m, 9.1-meter-circumference) tubes and one 200-lineal-ft., 30-ft.-circumference (61-lineal-m, 9.1-meter-circumference) tube can fit in the remaining 52-ft.-x-200-ft. (15.9-m-x-61-m) direction. This yields approximately 2,000 yd. (1,529 m.) of capacity.

Total capacity equals 2,800 yd. (2,141 m.).

Since the material is sandy silt, a large consolidation factor can be expected. A sample of the material could be tested to better determine that number, or a conservative guess could be made. If a 40% volume reduction (consolidation) occurs during the filling and dewatering process, then Configuration 2 would yield 3,920 yd. (2,997 m.) of capacity.

At this point there are several options to consider. Since the project is upstream of a sensitive area, effluent cleanliness is important. The small incremental cost of polymer addition may be economically viable since the effluent will be cleaner, the tubes will release water faster, and consolidation will occur sooner. With polymer addition, it is highly likely that all 4,000 yd. (3,058 m.) of material will be accommodated. Without, the client faces two possibilities. He may have to excavate two 100-lineal-ft. (30.5-lineal-m) tubes while filling the 200-ft. (61-m) tubes, and purchase one more tube, or have the contractor struggle at the end of the job, trying to cram the remaining 100 yds. (76.5 m.) into the existing tubes on site.

There are economic considerations to each of these options.

Summary

From Part 1, Apparent Opening Size (AOS) and grain size are not reliable indicators of retention within a geotextile tube. The combination of tensile strength (400 x 550 lbs./lin. (70 x 95 kN/m)) and permeability (20 gpm/ft. (810 L/min/m))
that high-strength woven polypropylene geotextiles provide, results in an economical tube fabric suitable for a wide range of fine-grained waste materials.

When choosing the appropriate geotextile-tube fabric, there is usually a trade-off between the dewatering rate and effluent cleanliness. The use of polymers can improve both the flow rate and cleanliness. The decision to use polymers will largely be economic and driven by project goals.

The cost-effectiveness of a project can suffer if the tubes are mismatched with the dewatering equipment. Planning and forethought are required to insure proper effluent drainage from the site, to minimize the risk of rolling, and to provide an efficient filling process for the dredge operator.

For small- to medium-sized dredging operations, tubes usually offer the least cost, least energy usage, and most environmentally friendly dewatering option available.

References


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