Fabric forms conform to any shape

Synthetic textile forms are used in or out of water, above and below grade, and left in place

Shore protection made of blocks cast in place by pumping concrete into large fabric bags.

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If we free our minds from the constraints of stiff, rigid, inflexible formwork for concrete, many previously difficult jobs are practical and many heretofore impossible jobs can be done. The use of a flexible and permeable form—a fabric—opens interesting possibilities.

A highly permeable fabric in the shape of a bag or similar enclosure can act as a form for concrete or grout equally as well above ground, where air is displaced from within the form, or in water, where water is displaced from within the form. The solidified mass can easily be made in many different configurations. Equally important is that the empty form can be placed in difficult-to-reach locations and then filled by pumping after it is properly positioned.

The major variables to be considered in this type of application of the use of construction fabrics are the following:

- Type of fabric to be used. This depends on the desired permeability of the fabric, the viscosity of the concrete fill material, the ease of making joints and closures, the desired stiffness of the form before filling, the final shape of the solidified mass of concrete or grout, the cost, and the danger of patent infringement.
- Placement of the fabric form insofar as construction method, type of labor and inspection before filling are concerned.
- Design of the concrete filling the fabric form.
- Accessibility, time and cost of placing concrete to fill the form.
- Manner of curing the concrete after placement.
- Inspection of completed installation to check on the adequacy of the work and to see if further modifications are required.
- The setting up of a possible long-term monitoring system if desirable.

The fabrics used are made from nylon, polyester, polypropylene, polyamide, polyethylene and other fibers or combinations. The finished fabrics are usually from 0.003 to 0.15 inch thick and weigh from 0.2 to 15 ounces per square yard.2 The many fiber types coupled with different manufacturing processes have led to a large and ever increasing number of commercially available fabrics.

These fabrics lend themselves to a wide variety of innovative uses and contractors are finding new and efficient applications not previously conceived. Many of the fabrics are patented, however, and a number of specific uses are also patented. Consequently, before undertaking any application the contractor should make certain that he is not infringing on any patent. This can be done by discussion with a manufacturer (see box) or a consultant in the field. Following are descriptions of some unique applications:

Underpinning bridge piers

In the fall of 1968 the Pennsylvania Department of Transportation discovered a void beneath a pier of a 28-span through-girder bridge that crosses the Susquehanna River. They elected to repair immediately. For various reasons they decided to try to place concrete under water by using a permeable fabric form. A woven nylon tube was designed to fit into the void between the bottom of the pier foundation and the supporting rock below. This tube was pressure-filled with fine-aggregate concrete (grout) and extended into the void as much as possible and partly outside of the pier. Prior to inflation, pipes were placed into the void beneath the pier and, after the tube of nylon was inflated with the pumped concrete, the same concrete mixture was then injected into the void behind the tube (Figure 1). Sufficient pipes were placed so that water could be vented out from the void, thus ensuring that complete filling beneath the pier was accomplished.

In June 1972 a hurricane rampaged through the area. A number of bridges were destroyed and many other bridges experienced scour problems beneath their foundations. When this bridge was reinvestigated it was found that the tube of concrete was in place and no further scour had been experienced at this pier although eight other piers of this structure had experienced damage from the velocity and volume of the water that had poured down the valley. These piers and other piers and abutments were subsequently repaired by fabric form techniques. After another hurricane hit the same area in 1975, causing flows that exceeded the one-in-a-hundred-year prediction, additional diving inspections showed that structures previously repaired by fabric form techniques had experienced no further major scour problems.

Caution is required in the use of this technique because underlying foundation material must be firm and relatively unyielding; the deformation ability of the underpinning is governed by the relatively inflexible characteristics of the unreinforced concrete.

Fabric tubes for offshore facility

An LNG facility located in Chesapeake Bay required the use of a sunken tunnel to transmit the liquefied natural gas from a shaft 1 mile offshore to the onshore storage facility.

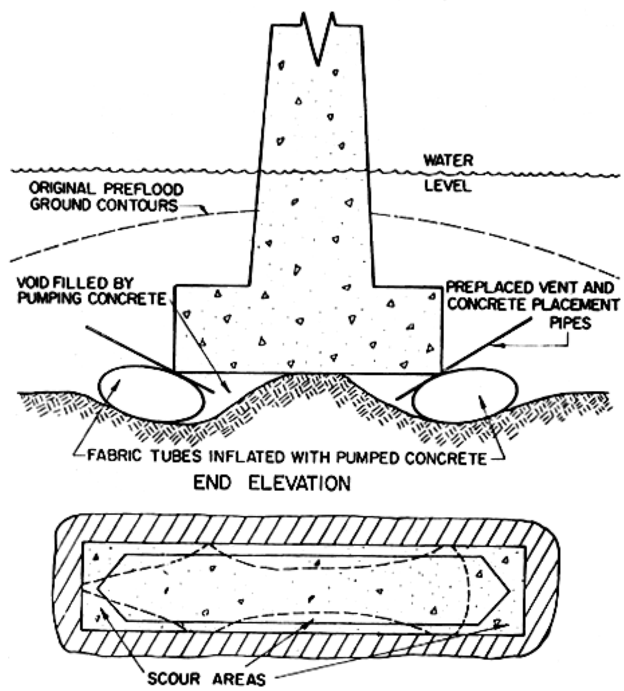


Figure 1. Scour repair of bridge piers.

The last tunnel section installed connects to the offshore shaft underneath the operating platform. The original design called for the placement of large armor stones as the final protective cover for the tunnel. However, the operating platform was already in place and these large stones would have to be literally thrown underneath, with danger of damaging the 54-inch precast cylinder piles that support the operating platform.

Instead, two layers of large-diameter nylon fabric tubes inflated with concrete were designed and installed. Past experience has shown that fabric forms, when pumped with concrete, form a shape where the height is roughly one-half the width. Therefore, a design was developed where tubes of concrete up to 70 feet long with a height of 3 feet and a width of 6 feet were alternated with and adjacent to tubes 2 feet high and 4 feet wide. A second row was alternated with this design to interlock the structure and form a relatively smooth surface (Figures 2 and 3).

The concrete mix was a grout consisting of 750 pounds~_ of cement, 2200 pounds of concrete sand and approximately 500 pounds' of water; 6 percent entrained air was used. Divers took the fabric tubes 30 feet to the bottom of the bay and positioned them with cables. The tubes had self-closing injection points, and the concrete was pumped through 2-inch hoses into the tubes. The tubes were built up on alternate sides of the tunnel to allow the concrete to set prior to placement of adjacent tubes. Over 975 cubic yards of concrete were injected into 50 tubes.

Tubes can also be used to support, anchor and protect pipelines above ground. A typical installation is shown in Figure 4. Where pipelines cross rivers they can be held in place and protected as shown in Figure 5.

Concrete-filled fabric tubes have also been used for revetments. These are installed and inflated to various lengths, heights and thicknesses by pumping the concrete from an accessible area (Figure 6). Another application of tubes has been to repair the eroded downstream slope of a dam (Figure 7).

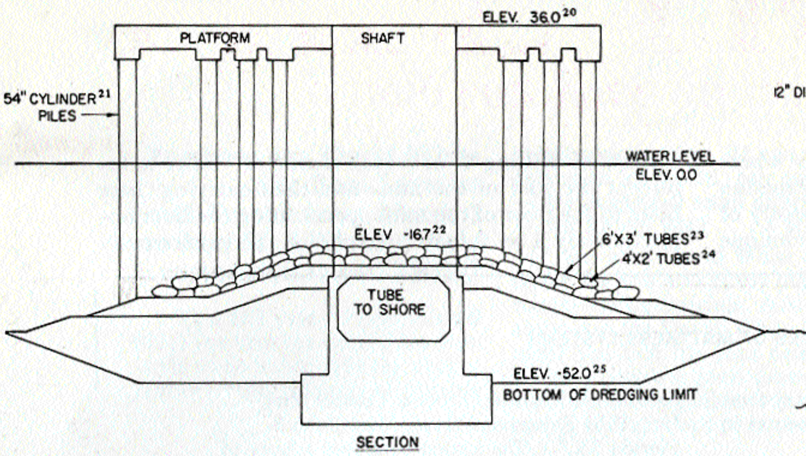


Figure 2. *Fabric tubes at offshore shaft of LNG facility.*

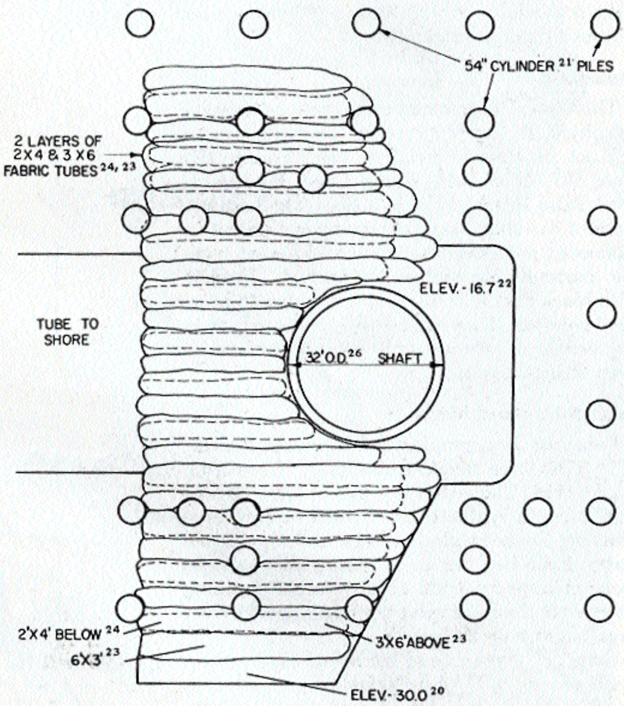


Figure 3. *Plan view of fabric tubes at offshore shaft of LNG facility.*

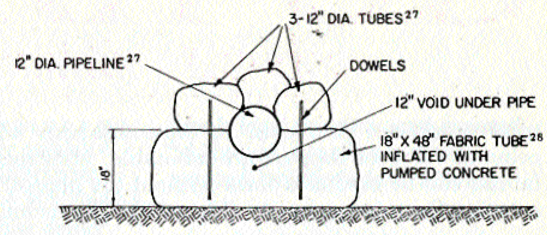


Figure 4. *Typical section through pipeline on land.*

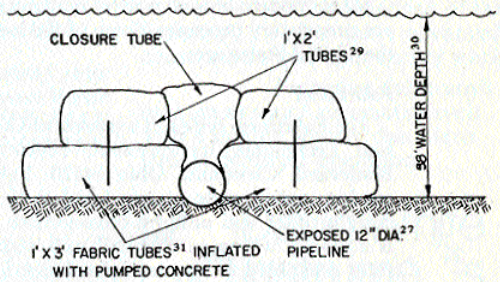


Figure 5. *Typical section through pipeline exposed in river.*

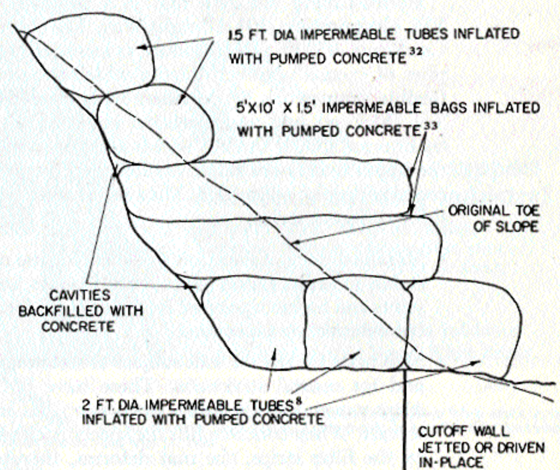


Figure 6. *Typical lakefront toe of slope rehabilitation and erosion control.*

Pile jacketing

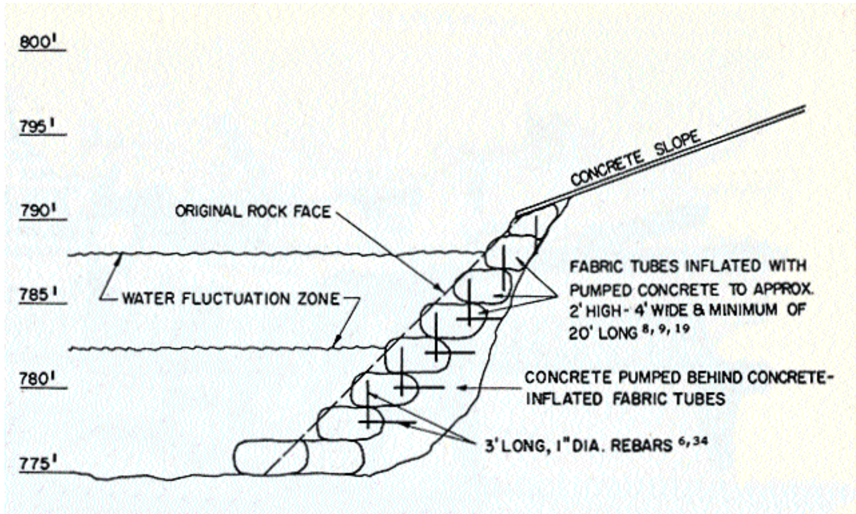
Deteriorated wood, steel or concrete piles can be repaired by using a jacket of woven nylon fabric that closes with a heavy industrial zipper that runs from top to bottom as described in an accompanying article.

These fabric forms have economic advantages over other concrete forming systems because they are light in weight, relatively low in cost and easy to install at any location above the mudline.

Columns for mine and cavern stability

In many parts of the world abandoned underground mines and limestone cavities have caused major structural subsidence problems. In those instances where columns for roof support are advisable, construction fabrics can be used as a form without the necessity of entering the mine or cavity (Figure 8). The technique consists of drilling 4- or 5-inch-diameter' holes to intercept the roof of the mine and then carrying these holes to the floor of the mine, penetrating the floor approximately 1 to 2 feet.' A tube of fabric, normally woven nylon, of a predetermined diameter is wrapped around a grout pipe and snaked down the drill hole into the key at the floor of the opening. Then fine-aggregate concrete is injected under controlled pressure as the grout pipe is withdrawn. The tube of fabric has to be supported at the sur-

Figure 7. Erosion repair of downstream slope of dam.



face or through rings at the top of the fabric with a cable system to the ground. Each application requires determining how much pressure the fabric can withstand, and it may be necessary to pump the tube in multiple lifts. Reinforcing steel can be placed either in the cavity area only or for the full length of the column. The critical point in this application is to get maximum support of the column of concrete at the roof of the mine.

This technique has the advantage over other methods of forming columns in that a positive form can be economically installed. This is because the system avoids having a considerable quantity of concrete expanded into a large and wasteful base to build up the angle of repose of the concrete to the roof of the mine.

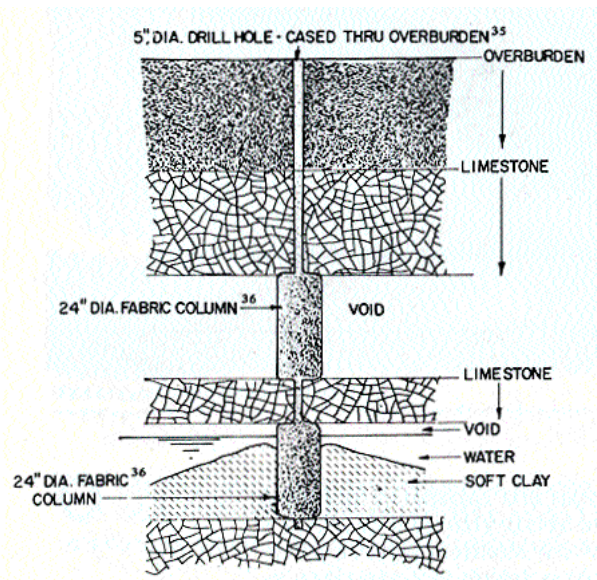


Figure 8. Concrete-inflated fabric tubes for mine and limestone cavity support.

Using this same technique, a bulkhead can be created in an underground mine by drilling a line of holes, pumping into alternate fabric columns, then placing fabric in the intermediate locations and blowing them up with concrete to interlock between the originally placed columns.

Erosion control

Erosion prevention and control is big business. With soaring real estate prices, accelerating building in coastal areas, and the ever attractive magnetism of water for recreational purposes this business will present ever increasing challenges. Fabric forms have played an important role in meeting this challenge.

Revetment mats can be used on slopes as a method of erosion control. The mattresses generally consist of double layers of woven fabric forms placed on the slope to be protected and filled with concrete (see accompanying article).

Typical mix proportions of concrete fill for erosion control mats are:

	Pounds per cubic yard	Kilograms per cubic meter
Cement	900-1000	535-595
Concrete or masonry sand	2200-2000	1305-1185
Water	570-610	200-360
Lost water	218	130

By the loss of water through the fabric the water-cement ratio drops from the 0.63-to-0.61 range down to 0.39

Many modern erosion control mattress systems are patented processes. In addition to the systems listed in the box there are a large number of systems manufactured elsewhere in the world (see book from which this article is excerpted). 13C

Editor's note

This article is excerpted from two chapters of the recently published book, Construction and Geotechnical Engineering Using Synthetic Fabrics, by Robert M. Koerner and Joseph P. Welsh, copyrights 1980 by John Wiley & Sons Inc. This hard-cover book of approximately 288 pages is available for $24.95 from the publisher, John Wiley & Sons Inc., Box 092, Somerset, New Jersey 08873.

PUBLICATION #C800401