PREAMBLE TO AND SHORT HISTORY OF CONSTRUCTION AND GEOTECHNICAL ENGINEERING USING SYNTHETIC FABRICS

Joseph P. Welsh, P.E.
Consultant, Public Landing, MD, USA

ABSTRACT

Robert Koerner and I became acquaintances and friends in the early 1960's mainly through our activities with the Philadelphia Sectors of ASCE. We quickly got over our differences (Villanova vs. Drexel, Construction vs. Academia) and formed a good working relationship. He would come up with a research idea and I would try to find a practical site to try it.

BACKGROUND

In the 60's I was Vice President of the East Coast operation for Intrusion Prepakt, a now defunct international specialty contractor. They had developed and patented Fabriform, the use of fabric forms to pave slopes both above and below water. Spin off of this technology included fabric tubes of concrete for pile jacketings, under water scour prevention and rectification, etc.

This use of fabrics in construction whet my appetite to learn more and I soon found out that the fabric manufacturer knew little about the use of fabrics in construction. Their main reason for venturing into this high volume market was to keep their manufacturing equipment turning despite the downturn in the rug and furniture market.

Recognizing the need to educate, I approached a friend and editor for Wiley's Construction Guide, Dan Morris, as to how to get a contract to write a book on the subject. I further recognized that as a contractor I had little skills, time, etc. for writing a book and approached Bob Koerner.

Together we received a contract from Wiley to produce a book and began our education.

Bob produced 90% of the manuscript and due to his hard work diligence the first book on Synthetic Fabrics was published in 1980. The dust covers of some of the books was TYPAR, (a first as far as I know). Back calculating, as to royalties received vs. hours spent, the rate was less than $0.25/hour. Using the book as a teaching guide we gave a series of 6 all-day short courses for ASCE in 1980 – 82, and I realized what a tough act Bob was to follow.

Case Histories

Of the many case histories of utilizing fabrics as a concrete or grout form, I have selected three for this paper. The first two were included in the book, but are recounted because of their significance in verifying the validity of the techniques.

Case History I – Pennsylvania Electric's Seward Station 215 KW Fossil Plant is situated on the west bank of the Conemaugh River approximately 11 miles (18.7km) northwest of Johnstown, Pennsylvania.

The Johnstown area first obtained flood notoriety when the South Fork Dam broke on May 31, 1889, killing over 3,000 people. This Dam located on the South Fork Run, 14 miles (22.5 km) east of Johnstown, feeds into the Little Conemaugh River, which joins Stoney Creek in Johnstown to form the Conemaugh River. The next major flood to hit the Johnstown area was caused by the severe 1936 winter. Much snow fell in January and February and very low temperatures prevented it from melting. Then in late February, an extremely warm period caused rapid melting of the snow and ice in the rivers and Johnstown and the Conemaugh River were once again flooded. Although property damage was high, due to previous warnings, loss of life was very light. This flood of 1936 was determined by the hydrologists to be in excess of a one-in-two-hundred-year storm! The peak maximum discharge of the Conemaugh River at Seward Station was estimated to be 2,650 cm (90,000 cubic feet) per second. When Pennsylvania Electric Company's engineers were designing a new dike to surround Flyash Pond No. 2, they wanted to make sure that the dikes were not only strong enough to take the force of any future flood waters, but also higher than the two past major storms. The siting of Flyash Pond No. 2 was along the bank of the Conemaugh River about a mile (1.6 km) southwest of the Seward Station immediately downstream from the little town of Robindale. The purpose of the dikes was mainly environmental in line with Pennsylvania Electric's continuing interest in producing power for its clients as economically as possible, but taking every step to protect the environment.

Pennsylvania Electric was concerned that if another major flood occurred, and if the Flyash Disposal area was not protected, that the light flyash would be carried downstream and pollute the environment. The height of the compacted earth dike surrounding the disposal site was designed to have a top elevation of 1,086.5. Existing ground at the river side of the toe of the slope varied between 1,060 and 1,067.

The river side of the dike was designed to have a 2-in-1 slope and the face of the dike was designed to be protected by 20.3 cm (8-inch) filter point Fabriform revetment mats, with the top of the revetment mat toed in to the dike at elevation 1,081.5, the height of the 1936 flood at this location. Also, in order to prevent undercutting of the dike, the Fabriform was designed to have a 0.61 m (2 foot) toe into original ground at the bottom of the dike. The Fabriform revetment mat was approximately 304 m (1,000 feet) long.

The Fabriform mattress was installed in October-November 1976. The patented Fabriform system consists of two sheets of high strength nylon which were connected together on a 20.3 cm (8-inch) grid pattern. The connection points serve a dual purpose of acting as filter points to prevent buildup of hydrostatic pressure behind the mattress. When laid on a slope, the mattress was blown up with a specially-designed concrete mixture. One of the patented features of the Fabriform mattress is that nylon is designed to allow water in the concrete mix to bleed through the fabric without allowing the cement to escape. This lowering of the water cement ratio produces up to 20% higher strength in the concrete in the mattress.

After the mattress was installed, the upper 1.5 m (5 feet) of the dike were placed from elevation 1,086.5 to 1,091.5.

On July 20, 1977, heavy rains inundated the Johnstown area of Pennsylvania causing floods of a greater magnitude than the 1889 and 1936 flood. At the Seward Station site waters were 1.5 m (5 feet) higher than the 1936 storm and the peak discharge was over 97,000 cfs (27,000 cms). The town of Robindale, situated between Flyash Disposal Pond No. 2 and the Seward Station, was completely wiped out; fortunately, no loss of life was suffered here. However, other residents of the area were not as fortunate with over 75 known dead throughout the Johnstown area.

Although some scour of the upper unprotected dike above the mattress took place, the mattress itself looks like the day it was installed, except for some minor damage caused mainly by heavy debris in the flood waters scraping the mattress.

Case History 2 - In the fall of 1968, District 3-0, Pennsylvania Department of Transportation, while performing a bridge inspection, encountered a void beneath Pier 16 of L.R. 25, Northumberland County. This 28 span thru girder bridge crosses the Susquehanna River between Sunbury and Shamokin Dam, PA. A recreational dam was planned immediately downstream from this bridge which would raise the water level to a greater depth and would change the flow characteristics of the river. Because of these facts and the seriousness of the underscour, it was elected to repair this scour problem immediately.

The Susquehanna River at this point is approximately 875 m (2,500 feet) across, which would make the cost of an access road and cofferdam extremely expensive. The pier rests on a rock bottom which would complicate the installation of a sheet pile cofferdam. Therefore, PennDOT elected to try a new technique of placing concrete underwater by the utilization of a fabric form. In effect, a nylon tube was designed to fit into the void caused by scour between the top of the rock and the bottom of the pier foundation. This tube was pressure filled with pumped fine grain concrete; and extended partially into the void and partly outside 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 space behind the tube. Sufficient pipes were placed so that water could be vented out from the void, thus, assuring that complete filling of the void was accomplished.

In June of 1972, Hurricane Agnes rampaged through the mid-Atlantic States. One of the hardest hit areas was the Susquehanna Valley of Central Pennsylvania. A considerable number of bridges were destroyed and subsequent investigations by PennDOT indicated that may other bridges had experienced scour problems beneath their foundations. In the course of the bridge-damage inspection, the above-referenced bridge was re-investigated and found that the tube of concrete was in place and no further scour was experienced at this pier. However, eight other piers of this structure had experienced damage from the velocity and volume of the water that had poured down this valley and these piers and other piers and abutments were repaired by the fabric form techniques. In 1975, Hurricane Eloise hit the same area of Pennsylvania and, once again, flows exceeded the one-in-a-hundred-year prediction. Additional diving inspections showed that structures previously repaired by the fabric form technique had experienced no further major scour problems.

Thus, two major storms had verified that not only was the fabric form technique an economical method of repairing scour damage, but that it would protect the structures from further major scour problems.

Case History 3 – The $300 million LNG Facility located at Cove Point, Maryland on the Chesapeake Bay, featured many unique construction concepts. Environmental consideration dictated that use of a sunken tube to transmit the liquid nitrogen gas from the 1-mile offshore shaft to the offshore storage facility.

The last tunnel section installed connects to the offshore shaft underneath the operating platform. The original design called for placement of large armor stone as the final protective cover for the tunnel. However, with the operating platform in place and with limited clearance beneath the operating platform, this would mean that floating equipment would have to place these large stones from outside the perimeter of the operating platform and the Joint Venture of Raymond-Kiewit-Tidewater was concerned of damaging the 137 cm (54-inch) precast cylinder piles which support the operating platform by the placement of these large stones, which would literally have to be thrown underneath the structure.

The Joint Venture, therefore, asked RayTech, the Marine Design organization, for a safe alternate to the armor stone placement operation. RayTech suggested utilization of two layers of large diameter tubes inflated with concrete. Past experience has shown that fabric forms when pumped with concrete, form roughly a shape where the height is one-half the width. Therefore, a design was developed where tubes of concrete up to 21.4 m (70 feet) long with a height of 1 m (3 feet) and a width of 2 m (6 feet) were alternated with tubes 0.6 m (2 feet) high and 1.2 m (4 feet) wide and a second row was alternated with this design to interlock the structure and form a relatively smooth surface.

In the summer of 1976, the SOILTECH Department of Raymond International mobilized for placement of these tubes and set up on the small boat dock immediately adjacent to the operations platform, an 8 cubic yard (6.1 cm) concrete agitator. As the on-site batch plant was previously dismantled, the concrete supplier loaded the dry portions at his plant 50 miles (80.5 km) away and added water at the job site. The ready-mix trucks discharged this concrete into two four-yard (3.6 m) concrete buckets mounted on a barge, and a tug transmitted this barge one mile (1.6 m) to the offshore facility where the concrete was pumped into the agitator. Divers took the predesigned nylon fabric tubes 9.2 m (30 feet) to the bottom of the Bay and positioned them with cables at both ends. The nylon tubes had self-closing injection points and the concrete was then pumped through 5 cm (2-inch) hoses into the tubes. The tubes were built up on alternate sides over the fill of the tunnel to allow the concrete to set prior to placement of adjacent tubes. Over 975 cubic yards (743 m^3) were injected into the fifty tubes by this method. Due to economics and political reasons, the plant sat idle until recently.

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Although this seminar focuses on the technical aspects of Professor Robert M. Koerner's career, it also is in recognition of his retirement from Drexel University as an educator. Over my career I have had the pleasure of interacting with many of Bob's former students. Two who have been co-workers, co-authors, helpful in my career and appreciative of the Drexel Civil Engineering education, and particularly the role of Professor Koerner. Robert Rubright(Class of 1974), Chief Operations Officer, Keller International; and George Burke (Class of 1977 & 1986), Executive Vice President and Chief Engineer, Hayward Baker Inc.

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