Prototype Turbidity Curtain for the Westway Highway

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In the late 1970s and early 1980s, the New York State Department of Transportation (NYSDOT) was involved in selecting geotextiles to be used in a turbidity curtain being designed by consulting engineers for the NYSDOT proposed replacement of the West Side Highway in New York City. The proposed designs involved dredging material from the Hudson River and constructing an embankment in the river over an approximate length of 4.5 km (2.8 mi), extending approximately 183 m (600 ft) into the river. The project's Water Quality Certificate required that turbidity curtains be placed along the U.S. Pierhead line, totally isolating the areas of dredging and filling operations. It was determined that a turbidity curtain of the depth required to comply with the Water Quality Certificate had never been constructed in a tidal estuary. It was therefore decided to develop a laboratory test program followed by the on-site installation of a 180-m (600-ft) long prototype turbidity curtain. Both programs were aimed at supplying data to be used in the design of the actual turbidity curtain. Details of the testing program, design considerations, and conclusions reached from the prototype installation are given. Because of environmental concerns, however, this project was not constructed.

In the 1970s the New York State Department of Transportation (NYSDOT) was involved in the design of a replacement for the deteriorating West Side Highway in New York City. The proposed design consisted of constructing a hydraulic embankment 4.5 km (2.8 mi) long extending 183 m (600 ft) into the Hudson River. Extensive dredging of organic material from the river bottom was going to be necessary to key the embankment into the foundation soils.

The Water Quality Certificate was granted in April 1979, with the following conditions on the permit:

> (1) The Applicant shall provide the Department of Environmental Conservation (DEC) with the opportunity to participate, as necessary, in the on-going review of draft plans and specifications for dredging or filling in the project area in cooperation with the review team established by the New York State Department of Transportation. No portion of the project involving dredging or filling will be advertised for bidding purposes until final plans and specifications have been approved by the DEC insofar as they relate to maintenance of water quality in the project area. DEC review will be completed within 30 days.
> (2) Dredging and placement inside the pierhead line of dredged soil shall be done by mechanical means. If methods become available in the future, which can be shown by the Applicant to result in reduced release of suspended and settleable solids, this condition may be modified by the DEC to accommodate such alternate methods.
> (3) Silt screens (turbidity curtains) shall be placed along the U.S. Pierhead line (with returns to the shoreline where necessary) in order to totally isolate areas in which dredge and/or fill operations are conducted. The silt screens (turbidity curtains) shall be Carthage Mills woven plastic filter cloth (geotextile), or equivalent, with a 12-foot impermeable top curtain, and securely anchored to the river bottom.
> (4) The Applicant shall, in cooperation with the DEC, develop a program for water quality testing and monitoring during the dredging or filling operation of project construction. The water quality testing and monitoring program shall be approved by the DEC prior to advertising for bids for dredging or filling.
> (5) The Applicant shall be responsible for reimbursing the DEC for all costs incurred in reviewing of plans and specifications, assisting in development of a water quality testing and monitoring program, and for its continuing operation during all dredging and filling activity.
> (6) If conditions are revealed during the dredging and filling operation which result in substantial water quality degradation, construction shall cease on that portion of the project causing the problem until corrective measures are determined and implemented.

The purpose of the turbidity curtain was to create a settling basin within the U.S. Pierhead line, isolating the area of dredging and filling operations from the main channel of the Hudson River. In the settling basin, sediment drops out of suspension with little influence from the outside environment. This was necessary to protect the channel from becoming overloaded with material from the dredge-and-fill operations, which would affect the aquatic life and result in river sedimentation.

The project was estimated to be constructed in five dredging contracts. The project had two objectives: to minimize the amount of material suspended because of the dredging and to minimize the amount of suspended material that could escape into the river channel. The reason for this concern was the toxic materials and heavy metals present in the bottom sediments of the river.

To meet certificate condition 3, "or equivalent," it was required that an extensive laboratory evaluation be performed of geotextiles on the market. Because little information existed on the performance of a turbidity curtain of this depth in a tidal estuary, the results of this evaluation were to be verified by constructing a prototype turbidity curtain.

The prototype curtain was built between Piers 59 and 60. The panels of the curtain consisted of two sections: a permeable geotextile and an impermeable barrier attached to the top of the geotextile. Installation of the prototype turbidity curtain was completed in October 1981, with testing and observations continuing through March 1982.

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TECHNICAL CONSIDERATIONS

Soil Profile

The soil profile for the site consisted of three strata. The upper stratum consisted of 11.3 m (37 ft) of very soft to soft black organic silty clay. The middle layer consisted of 11.9 m (39 ft) of stiff gray organic silty clay. Finally, the lower layer consisted of 36.6 m (120 ft) of medium to stiff clay with fine sand seams.

Turbidity Curtain Site Design

On the basis of site conditions, the following criteria were used in the design of the prototype turbidity curtain:

1. Approximate 1-m (3-ft) wave height,
2. Current of 0.5 knot perpendicular to the curtain,
3. Ice load of 2 kN/m,
4. Ballast weight sufficient to keep the curtain on the bottom during the dredging and filling operations,
5. Flotation a minimum of 4 times the submerged weight of the ballast,
6. Curtain height to be 1.5 times the mean high-water depth to allow vertical billow to reduce stress of the curtain geotextiles,
7. Horizontal billow 6.1 m (20 ft) from support center lines,
8. Differential head across the curtain of 63.5 mm (2.5 in.),
9. A 3.7-m (12-ft) high impermeable barrier at the top of the curtain to meet the Water Quality Certificate requirements,
10. Seams within the geotextile materials sewn with a minimum overlap of 75 mm (3 in.) and four lines of stitching. [The seams in the impermeable panels were thermally welded with a minimum overlap of 37.5 mm (1.5 in.).]

GEOTEXTILE SELECTION

Geotextile Properties

The properties selected for the geotextiles were to be a minimum wide width strength of 175 kN/m in the weakest principal direction and a minimum permittivity of 0.4 sec^{-1}, as determined by the NYSDOT Soil Mechanics Bureau (SMB). The strength criterion was based on the loadings described in the design criteria, applying a factor of safety of 2. The permittivity criterion of 0.4 sec^{-1} was selected on the basis of the anticipated volumetric flow rate anticipated from tidal action.

Early in the design, a soil retention criterion based on a NYSDOT–SMB Soil Retention Test was included. The criterion was 75 percent soil retention on a soil-and-water slurry with 7.6 g of soil per 1000 cc of Hudson River water (the anticipated field value).

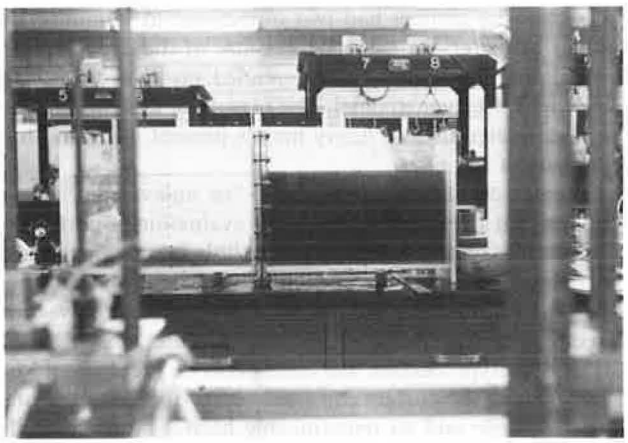

FIGURE 1 Soil retention test.

Laboratory Test Program

The laboratory test program in conjunction with the design of the prototype turbidity curtain consisted of performing the following tests on the various geotextiles available: (a) soil retention, (b) long-term water flow, (c) geotextile permittivity, (d) geotextile wide-width strength, and (e) geotextile seam strength.

Soil Retention Test

The soil retention test was performed using an acrylic tank as shown in Figure 1, the dimensions of which were approximately 1 m (37.5 in.) long, 152 mm (6 in.) wide, and 355 mm (14 in.) high. A slide panel held the test specimen in the middle of the tank, thus forming an upstream and a downstream chamber.

A slurry of water and soil was introduced on the upstream side and allowed to flow through the geotextile into the downstream chamber and out into a large circular tank. The percentage of soil retained by the test specimen was determined by taking a grab sample of the slurry after it had passed through the geotextile and performing a hydrometer analysis on it. The percentage retained was calculated on the basis of the initial slurry dilution of 7.6 g of soil/1000 cc of water. As previously indicated, the testing was performed using Hudson River water so as to duplicate actual conditions as closely as possible.

Rather than 7.6 g/1000 cc of water dilution, it was determined that only 2.3 g/1000 cc of Hudson River water would actually be in suspension at the turbidity curtain location. The sedimentation time for particle fall is highly dependent on the percentage of soil in suspension. The lower dilutions settle out faster, and therefore less soil is available to pass through the turbidity curtain. Initial laboratory testing of the 7.6-g/1000-cc dilution produced results well within the 75 percent retention criterion. Because the lower dilution would result in faster settlement, the retention percentage could only be better, so the test requirement was eliminated.

Long-Term Water Flow Test

Concern arose over what effect the existing conditions of the Hudson River water would have on the performance of the curtain. To answer this concern, long-term flow tests were

performed using the tank from the soil retention test with the various geotextiles inserted.

Hudson River water was allowed to flow through the geotextile for 6 hr. For all the geotextiles tested, it was determined that by the end of the 6-hr period the river water had plugged the geotextiles to the point where little or no flow of water through the geotextile was taking place. This was another reason for eliminating the 75 percent retention criterion (i.e., because the geotextile clogged in a relatively short period of time, very little or no soil could pass through the geotextile regardless of the percent dilution).

Permittivity Test

The permittivity of a geotextile is defined as the volumetric flow rate of water in the normal direction through the geotextile per unit of head per unit of area. The testing was done using the constant head method (now ASTM Method D4491 for the water permeability of geotextiles). Figure 2 shows the device used. No testing was done on the impermeable barrier.

Wide-Width and Seam Strength Testing

The wide-width strength of the geotextiles being considered for use was determined using what is now ASTM Test Method D4595, Tensile Properties of Geotextile by the Wide Width Strip Method. The same technique was used in testing the seam strength.

Specimens 200 mm (8 in.) wide with 100 mm (4 in.) gage length were tested in both the geotextile and the seam test. The strain rate of the test was 10 percent/min.

No strength testing was done to investigate ultraviolet degradation of the impermeable barrier.

Materials Selected

On the basis of the criteria decribed above, the panels for the prototype turbidity curtain were fabricated from Amoco Propex 1325 and 4557, Bradely Materials Filterweave 70-C, and Hoechst Trevira 1160. The impermeable panels were made of Shelter-Rite 8028, a PVC-coated polyester material.

The prototype turbidity curtain consisted of four panels 34 m (110 ft) long by 11 m (35 ft) high, including the 3.7-m (12-ft) high impermeable barrier; one panel 34 m (111 ft) long by 5 m (16 ft) high; and two closure panels 5 m (15 ft) long by 11 m (35 ft) high. The closure panels provided a means of access in and out of the area within the curtain. Figure 3 shows the fabricated curtain, and Figure 4 shows the curtain in place.

PERFORMANCE AND RESULTS

The prototype turbidity curtain was evaluated for 5 months. The water quality was investigated by Lawler, Matusky & Shelly, and the entire system was evaluated by Mueser, Rutledge, Johnston and Desimone.

Monitoring the performance of the entire system resulted in the following findings:

1. Tension in the cables, monitored with load cells, showed a maximum load in the natural environment of approximately 45 kN. Ice conditions did not produce loads exceeding this.
2. Structural tests involved running a tugboat at various speeds and distances parallel to the curtain to generate wave action. The loading in the cables due to wave action and prop wash was measured. A maximum load of 42.4 kN was produced by the prop wash.

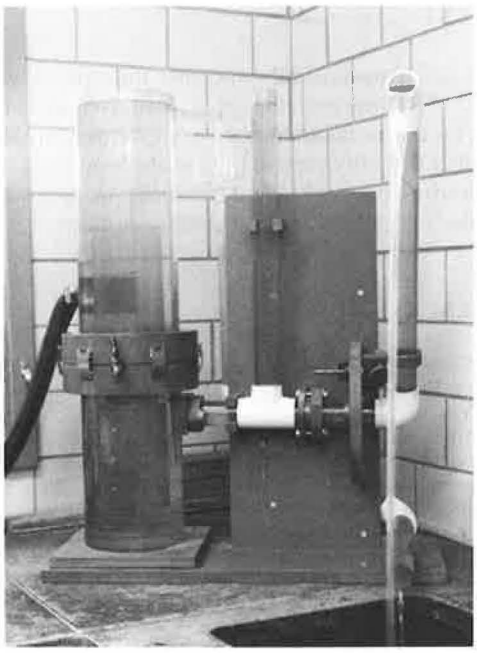

FIGURE 2 Permittivity test.

FIGURE 3 Fabricated curtain.

FIGURE 4 Curtain in place.

3. During stages of the structural testing, the curtain was visually inspected by a diver. Some of the grommets in the closure panels were seen to have pulled out.

4. After 4 weeks, two panels were removed for visual inspection, and laboratory permittivity testing was performed on one panel. Overall, the panels showed little or no damage from the structural tests. There was a brown, slimy coating over the curtain. Laboratory permittivity tests on one panel showed a reduction by a factor of 10 in this property.

5. One of the panels removed for inspection was reinstalled. This along with the others remained in place for 5 months through late fall and winter.

COST

NYSDOT had estimated the cost of the prototype turbidity curtain to be $454,380, including fabrication, structural support (three pile clusters driven in the river), installation, testing, and reports. The low bid received was $431,240.

CONCLUSIONS

Based on observations, the following conclusions were drawn concerning the prototype turbidity curtain system:

1. A curtain could be fabricated and installed to meet the Water Quality Certificate requirements.
2. Both the woven and nonwoven geotextiles performed satisfactorily.
3. Hudson River water in its natural environment quickly reduced the permittivity of the geotextile.
4. Because there was little accumulation of ice that year, it had relatively little effect on the curtain and its support system.
5. The criteria for selection of the geotextiles should be permittivity and wide-width strength properties.

RECOMMENDATIONS

Based on the results of this installation, several recommendations were made for the larger turbidity curtain proposed for use in the embankment construction on the project. Among these were the following:

1. Reduction in width of the thermally welded seams in the impermeable barrier,
2. Use of PVC-coated fabrics for the closure panels instead of urethane coating (urethane showed signs of deterioration and was significantly more expensive than PVC),
3. Reduction of the ballast weight in the closure panel,
4. Prohibition of the use of rolled microfilm for the flotation collar assemblies,
5. Reduction of the vertical billow in the curtain, and
6. Incorporation into the design of an opening in the curtain 150 m (500 ft) away from the turbidity source to compensate for clogging of the geotextile by Hudson River water. (This was to allow equalization of water elevation on both sides of the curtain from tidal activity. The distance was based on the relationship of the settlement velocity of suspended solids in the river environment and the water velocity due to the tidal fluctuations.)

COMMENT

Because of environmental concerns, the project was never constructed. However, the observations and conclusions reached for this installation were incorporated into the design of a smaller turbidity curtain in Upstate New York, and have also served as the basis for developing an approved list of geotextiles for general use in turbidity curtains.

REFERENCES

1. *West Side Highway Project Report on Prototype Turbidity Curtain.* Mueser, Rutledge, Johnstone & Desimone Consulting Engineers, New York City, May 1982.
2. *West Side Highway Project Evaluation of Test Results: Silt Curtain Fabrics.* Mueser, Rutledge, Johnstone & Desimone Consulting Engineers; Woodward-Clyde Consultants, Inc., New York City, Sept. 1983.
3. *Final Supplemental Environmental Impact Statement—Westside Highway Project.* U.S. Army Corps of Engineers; U.S. Department of Transportation, Nov. 1984.