

THE HARLEM RIVER BANK RESTORATION-DESIGNING THE EDGE

By:

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ABSTRACT

The Harlem River is a tidal estuary connecting the waters of the Hudson and East Rivers. It was developed as a shipping channel in the 19th century through a process of realignment, landfilling, bulkheading and dredging. In the portion of the Harlem River between 139th and 145th Streets, the river was narrowed with landfill on the Manhattan side and is protected with a steel sheet pile seawall. Over the years the sheet pile seawall suffered extensive corrosion and developed corrosion holes ranging from 1 mm to 6 mm. At high tide water enters through these holes and exits at low tide. This pumping action removed soils behind the seawall creating sink holes large enough to engulf newly planted trees and pavings. The City of New York Parks & Recreation (Parks Department) is responsible for developing the Harlem River Park and bike path and rebuilding the collapsed bank.

Parks Department selected Dewberry to collaborate on engineering design for the Harlem River Park waterfront incorporating solutions that support estuarine life, reduce wave energy, provide greenery, bioremediation and safe access. Dewberry considered various alternatives including greenwalls, gabions, marine cells, and steel sheet pile and selected gabions based on cost, durability, potential to increase estuarine habitat, potential to reduce wave energy, appearance, local availability and feasibility to install at this location. At two sections, the top of the wall is lower, to allow high tide water to enter into the tide pools behind the wall. Large, naturally rounded stones surround the tide pools so people can sit on the stones and get their feet washed by the tide water.

The construction of the gabion wall for the restoration of the Harlem River bank has been completed and a recent site visit revealed the uniqueness of this design compared to traditional seawalls used for the bank protection.

BACKGROUND AND EXISTING CONDITIONS

The financial capital of the world, the island of Manhattan, is surrounded by the Harlem River on the north and east, the East River on the east and south and the Hudson River on the west. The Harlem River is a tidal estuary connecting the waters of the Hudson and East Rivers. It was developed as a shipping channel in the 19th century through a process of realignment, landfilling, bulkheading and dredging. In the portion of the Harlem River between 139th and 145th Streets, the river was narrowed with landfill on the Manhattan side and is protected with a steel sheet pile seawall. But unfortunately, there was no cathodic protection for the steel sheet pile and as a result extensive corrosion took place at the splash zone. Underwater inspection showed



Existing Conditions

that approximately 55 percent of the sheet pile sections developed corrosion holes ranging from 1 mm to 6 mm. At high tide water enters through these holes and exits at low tide. This pumping action removed soils behind the seawall creating sink holes large enough to engulf newly planted trees and pavings. The site is approximately 600 m long, with useable park space varying from a width of 3 m to 30 m. The City of New York Parks & Recreation (Parks Department) is responsible for developing the Harlem River Park and bike path and rebuilding the collapsing bank.

In 2004, NYC Parks entered into an innovative research and brainstorming partnership called “Designing the Edge.” With funding from NYS Department of State, Parks Department landscape architect Marcha Johnson, PhD, ASLA, coordinated with Metropolitan Waterfront Alliance, Harlem River Park Taskforce, NYC Economic Development Corporation, and consulting artists, marine biologist, architect, and Stevens Institute to develop the new ideas for “Designing the Edges”. The aim was to build a waterfront prototype having high recreational, flood storage and habitat value by contrast with traditional esplanades with rigid, non-porous seawalls. Harlem River Park was selected as the initial site for this new approach. The finished landscape was designed by Ricardo Hinkle of Parks Department and Dewberry designed the replacement of the corroded steel sheeting using methods developed and tested in wave tanks via the Designing the Edge partnership.

UNDERWATER INSPECTION

In order to evaluate the extent of corrosion, a thorough underwater inspection was conducted. Underwater inspection showed that extensive corrosion took place in the

splash zone between the low and high tides. These areas are especially vulnerable to corrosion because they get wet and dry alternately.

Underwater inspection showed that approximately 55 percent of the sheet pile sections developed corrosion holes ranging from 1 mm to 6 mm.

ALTERNATE SOLUTIONS-DESIGNING THE EDGES

1. Sheet-Pile Walls

The traditional sheet-pile wall is the standard design for most waterfront structures. In this restoration project, Dewberry evaluated various ways to reuse the existing sheet-pile wall including patching the corroded areas.

The installation of a new sheet-pile wall in front of the existing wall with annular space filled with tremie concrete was also considered. The tremie concrete fill will provide the passivity against corrosion and properly designed sacrificial anode bed will protect the front portion of the sheet-pile wall, which is exposed to water. This would have provided a reasonable solution to the existing problem. However, the existing sheet-pile wall is located at the Army Corps of Engineers (ACE) Bulkhead Line; any protrusion into the river beyond this line will require extensive analysis and permitting efforts for the ACE.



Sheet-Pile Walls

Besides, the Parks Department committed to use Harlem River Park as a prototype to infuse fresh, new ideas into the design of New York's waterfront edges. From these ideas, a number of alternative solutions were developed and four of them were tested in a wave tank to evaluate the wave breaking forces and their absorption characteristics as well as the effects on velocity distribution, turbulence and sediment deposition.

2. Evergreen Walls

Evergreen Walls consist of precast concrete elements stacked at an angle which are filled with soil to create a gravity retaining wall. Plants grow in the soil pockets and conceal most of the concrete panels. Below permanent water level the panels are filled with stones instead of soils.



Evergreen Walls

Evergreen wall was tested in the wave tank

at Stevens Institute, New Jersey and showed that the flow velocity was reduced at the leading edge of the wall but the wall caused downward drag. The downward movement of water along the face of the evergreen walls is a concern from both safety and stability standpoints.

3. Gabion Walls

Gabions are wire mesh baskets filled with suitable stones that are tied together to serve as retaining walls. Gabions can be built vertically without any tilt, as in the case of evergreen walls, eliminating the possibility of any down drag.

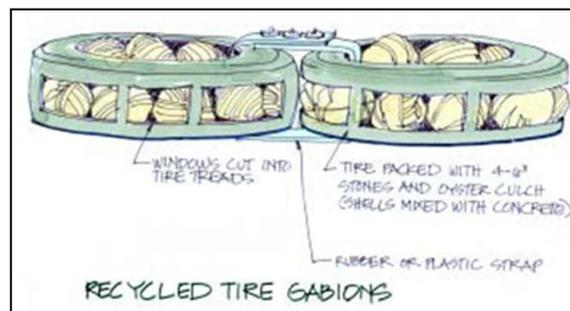


Gabion Walls

Gabions are very flexible and porous. Wave tank testing showed that the flow velocity along the edges was substantially reduced and there was no reflection of waves from the gabion walls. Most of the energy from the wave breaking forces was absorbed by the flexible gabion walls.

4. Tire Gabions

Tire gabions are variation of gabions where recycled tires are used instead of wire-mesh baskets. To provide adequate porosity the tire walls are slotted to create windows. Tire gabions are linked with rubber belt strips and stacked together to form a vertical, gravity retaining wall.



Tire Gabions

Although the tire gabions are considered vandal resistant and durable in marine environment, the wave tank study showed that the tire gabion would generate significant eddies where the waterline intercepts the vertical portion of the wall.

5. Marine Cells

Marine cells are also a variation of gabions and similar to cellular coffer dams made of cylindrical wire baskets filled with large stones. The semi-circular shape is beneficial in creating a shoreline with a variety of naturalistic conditions.

Marine cells, like tire gabions, created significant eddies during the wave tank testing.



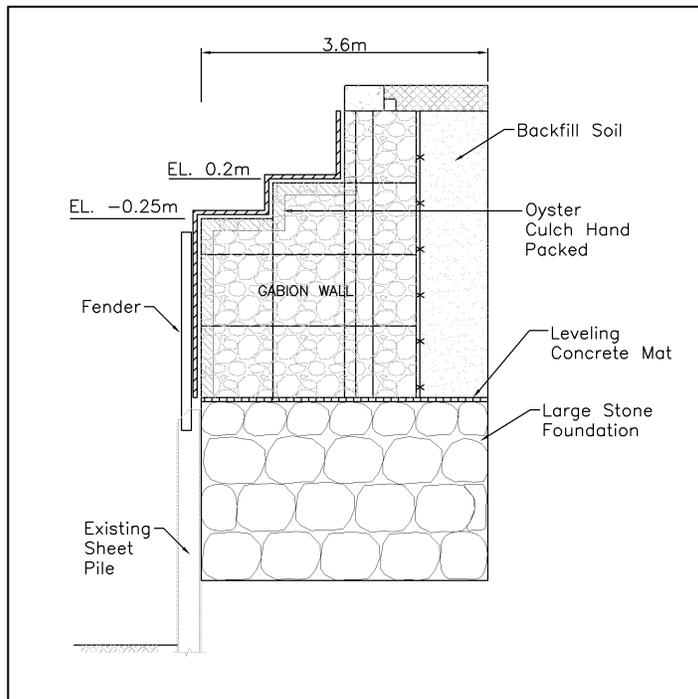
Marine Cells

RECOMMENDED DESIGN

Considering above five alternatives and based on the results of wave tank testings it was concluded that the best solution for the restoration of the Harlem River bank would be the gabion walls.

Design of Gabion Walls

The standard gabion baskets are PVC coated welded or twisted wire. However, in the splash zone the PVC coated wire mesh will be exposed to alternate drying and wetting due to variation of tides. This may cause cracking of the PVC coating exposing the steel wire to saline water and excessive corrosion. In addition, the exposed PVC coating is vulnerable to ultra violet rays from the sun which causes brittleness and subsequent failure of the PVC coating. Tensor type plastic gabion basket is suitable for saline water and ultra violet rays but very weak against tear, particularly if a boat rams against the wall. In order to address above issues, Dewberry specified 316L stainless steel wires, fused together as opposed to welded to form the baskets. The stainless 316L steel is the best suited material for saline environment and strong enough to sustain impacts from runaway boat. In addition, an extra layer of stainless steel wire mesh was added at the front end of the wall to provide additional rigidity and strength to absorb any impacts from boats.

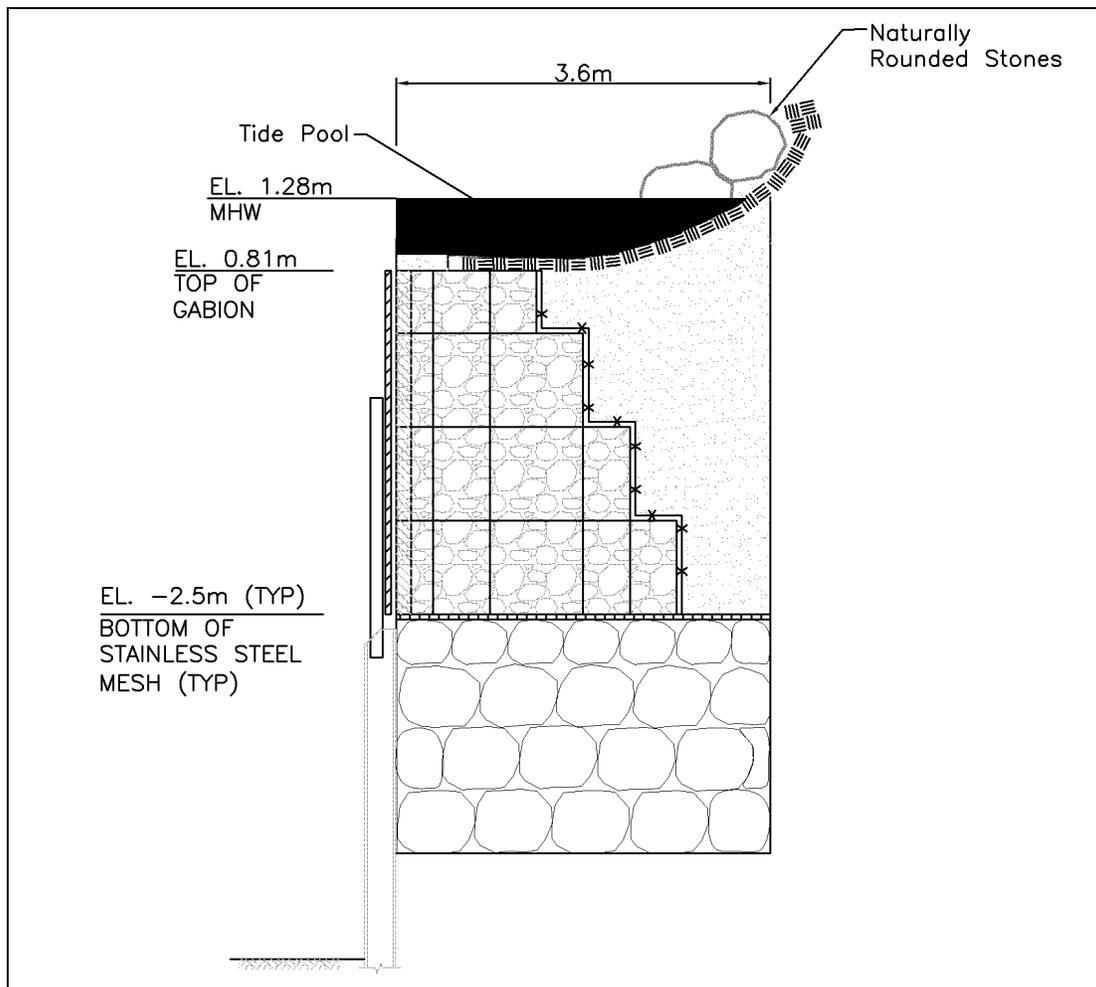


Design of Gabion Walls

The design of foundation to support the gabion walls offered a great challenge. The mud-line of the Harlem River is extremely soft to support any structure. Dewberry, therefore, recommended removing the mud as much as possible, then place the large stones encapsulated with filter fabric. Large stones were preferred to mass tremie concrete mat to provide more flexible foundation to accommodate differential settlements. Once the stones were placed, a lean concrete leveling mat was poured in dry to provide level surface for constructing the gabion walls. The existing steel sheet-pile wall was cut at the top of the stone fill.

Tide Pool Design

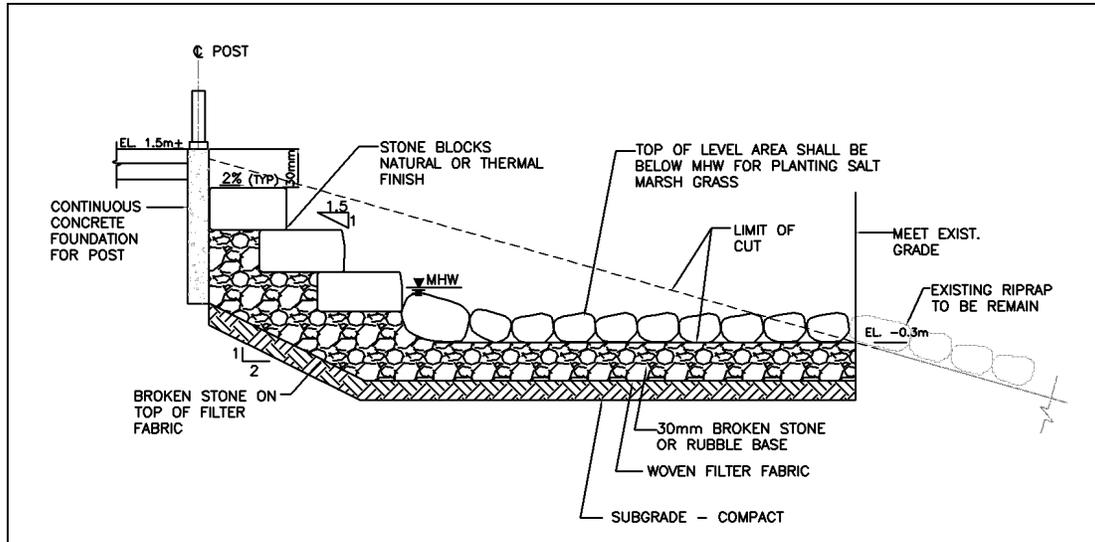
Wave tests indicated that cove structures retard the velocity and enhance the trapping of the sediments. It is, therefore, desirable to construct a number of tide pools (coves) at different elevations relative to mean low water along the wall. At two sections, the top of the gabion wall is lower, to allow high tide water to enter into tide pools behind the wall. Large, naturally rounded stones surround the tide pools so people can sit on the stones and get their feet washed by the tide water.



Tide Pool Design

Cove Design

There is an existing large cove at the beginning of the gabion wall on the south end. The three sides of the cove were protected with riprap, large chunk of concrete and junks. There was no access for the people to the cove and the cove itself became an eye shore. To address the above issues, Dewberry completely redesigned the cove by removing all junks and concrete blocks; flattening the slope to place properly designed riprap under water and placing large, flat, natural stones above the high water level for people to sit on the hand-placed stones and fish.



Cove Design

CONSTRUCTION ISSUES

Access

The access to the site was extremely difficult. The land access was limited to a ramp from the Harlem River Drive. Even the use of the ramp was restricted to a certain time of the day. The best access to the construction site was from the Harlem River. Phoenix Marine, the contractor for the project, primarily used the Harlem River for the transportation of all materials and construction of the river front gabion walls from the barges.

Dewatering behind the existing sheet-pile wall

The contract document suggested patching up the corrosion holes in the existing sheet pile prior to excavating behind the wall. Once excavation was completed, dewatering was recommended to lower the water level so the large stones, leveling mat and gabion walls could be constructed in dry. But it became apparent when the differential water head reached about 1.0m, the water level could not be lowered any

further by pumping because a large volume of water was entering through the patched holes and sheet-pile joints. The design thereby was modified to place large stones under water and place tremie concrete to fill the voids. Once the stones settled, the water level was lowered to the top of the stones and the leveling mat was placed in dry. Then the gabion walls were constructed in dry.



Dewatering behind the existing sheet-pile wall

Surface Ponding

After the construction of the gabion walls and backfilling, surface ponding occurred at two locations behind the walls. Concerns were expressed whether the sink holes were developing like before. A thorough evaluation, however, revealed that the local ponding at two locations were caused by missing filter fabric. Due to the absence of over-lapping filter fabrics at two interfaces, the rain water removed the underlying soil and caused pondings. Once the filter fabrics were added the problem of local depressions and pondings were resolved.

COMPLETED PROJECT

In August 2009 the entire project was completed and in the near future Mayor of New York City will inaugurate the park for public use. The gabion seawall was completed at cost of about \$4.0 million and it took about 2 years. A recent visit showed the unique design for the gabion walls in absorbing waves, the effectiveness of the tide pools and pleasant aesthetics of the large cove.

CONCLUSIONS

The standard design for river front structure usually consists of steel sheet-pile or concrete walls, but the final design for the reconstruction of the Harlem River seawall between 139th and 142nd Street utilized the concepts of Designing the Edges, which incorporated the following features:

- The gabion wall with cove and tide pools provides a unique shoreline instead of a straight wall.
- Tide pools allow safe access to shallow water entertainment.
- Gabions with rocks in the basket encourage the attachment of shellfish and growth of salt marsh grasses to enhance habitat.
- The flexible gabion walls have unique characteristics to absorb wave energy (no reflection), making the near environment quieter and safer.

