FORENSIC ANALYSIS: HABIRSHAW PARK, YONKERS, NY

PROJECT BACKGROUND

Habirshaw Park is one of six locations included in a study called What Made Shorelines Resilient: A Forensic Analysis of Shoreline Structures on the Hudson River Following Three Historic Storms. The sites had either traditional or non-traditional nature-based shoreline stabilization techniques and were impacted by Tropical Storms Irene and Lee in 2011 and Post-Tropical Storm Sandy in 2012. Separate case studies describing each site and the impact of the three storms have been prepared. Two additional reports describe the methodology used and the common project performance factors. All eight documents can be found at http://www.hrnerr.org/shorelinesforensicanalysis. Each Forensic Analysis included the review of historic photographs and design drawings, interviews with project managers and designers, field data collection, and modeling of the hydrodynamic conditions during each of the three storms. Collectively, this information was used to create a holistic picture of each site, from which the critical project performance factors could be determined. Impacts from debris, undersized stones, improper slopes, as well as monitoring and maintenance protocols, adaptive management, and maturity of vegetation were all considered. Overall, the study revealed that the Habirshaw Park site fared well during the three major storms due to effective monitoring, maintenance, and adaptive management.

SITE BACKGROUND

Habirshaw Park, in Yonkers, NY, is the location of the Beczak Environmental Education Center. Habirshaw Park lies along the eastern bank of the Hudson River in a heavily industrialized section of Yonkers. The site on which the park is located was historically an industrial manufacturing site for Habirshaw Cable & Wire and was later used by the Naval Militia Reserve and Habirshaw Social Club as a recreational site. Due to its industrial past, the soils at the site were contaminated with industrial debris, heavy metals, and petroleum. In 1999, Westchester County purchased the site with support from Scenic Hudson, and Scenic Hudson was subsequently granted a conservation easement by the County. The intent of the easement was to limit...
future development at the site to a list of acceptable uses, which included development of the site as a public park for recreational and educational purposes. The site redevelopment included removal of impervious cover, remediation of contamination, stabilization and restoration of the shoreline, as well as the creation of an interactive education center. Shoreline restoration was completed in 2004, and the site now contains a functioning brackish tidal marsh with native vegetation that is protected by a sill and dune. Due to the ecological enhancements of the shoreline stabilization, Habirshaw Park is highlighted as a Demonstration Project in the Hudson River Sustainable Shorelines Project (https://www.hrerrer.org/hudson-river-sustainable-shorelines/).

SHORELINE STABILIZATION HISTORY

To create a history of the shoreline evolution at Habirshaw Park, we used Google Earth for aerial photographs and www.historicaerials.com for both aerial photographs and topographic maps. A time-lapse video of the changes was created and is archived at https://www.hrerrer.org/hudson-river-sustainable-shorelines/shorelines-engineering/. Habirshaw Park sits between two adjacent properties that have bulkheads. An analysis of the historic aerial photographs gives some indication that at one time during its industrial past, the park’s shoreline may also have had a bulkhead. A short pier can be seen in one of the older photographs, most likely related to its prior use as an industrial site. More recently, concrete and asphalt rubble were dumped along the shoreline to address the erosion problem. Such a response, although generally illegal, is unfortunately quite common along urbanized sections of the lower Hudson River. The photographs in Figure 2 show, from left to right, the site post-restoration in 2007, the site immediately after Sandy, and the site several days after Sandy. The last photograph in particular demonstrates that the project survived Sandy and overall performed as expected in the storm.

![Figure 2 – From left to right: constructed site (April 2007), post-Sandy (Nov. 1, 2012), and post-Sandy (Nov. 3, 2012).](image)

DESIGN AND ECOLOGICAL ALTERATIONS

Prior to the restoration effort, the entire Habirshaw Park site was covered by impervious material. The existing shore zone had consisted of a poorly functioning concrete- and asphalt-covered slope with minimal vegetation. Up to 4000 square feet of this failing revetment was regularly inundated by the tides. Some portions of the failing concrete were removed, and some concrete rubble was reused as a partial sill (labeled breakwater in Figure 3). The sill serves to protect the constructed tidal marsh from the intense wave and wake energy experienced at the site. The site design included the sill, a brackish tidal marsh, a beach and dune (Figure 3). Site preparation began
in 2003 and consisted of removing contaminated soils and invasive vegetation, grading the shoreline, removing hardened shoreline, and constructing a marsh sill. Creation of the tidal marsh began in 2004 by expanding the tidal area to over twice its original size, including a fresh and brackish water marsh, tidal channel and tidal pool. Vegetation was planted both in the low marsh and along the higher dune. Diverse native plant species were included to attract both aquatic and terrestrial organisms. Figure 4 shows the site immediately after planting (left) and sometime later after the vegetation become established (right).

![Figure 3 - Habirshaw Park site plan (Creative Habitat Corp.).](image)

![Figure 4 - Vegetation planting in May 2004 (left) and established plantings (right).](image)
COLLECTION OF ENGINEERING DATA

Multiple sources of data were collected and analyzed to understand the behavior of the shoreline at Habirshaw Park. The conclusions of the Forensic Analysis at Habirshaw Park were based on the following sources/types of information:

- Historic Aerial Photographs
- Topographic Maps
- Photographs (construction, pre- and post-storm photographs of the site)
- Initial Site Visit
- Discussions with Property Owner/Design Engineer
- Engineering Plans
- Final Site Visit (including topographic/bathymetric survey)
- Hindcast of Storm Conditions (Wave and Water Level Climatology)

CHARACTERIZATION OF SITE CONDITIONS

The Habirshaw shoreline is located in a VE Zone with an advisory base flood elevation (ABFE) of 12 ft NAVD88, while the majority of the upland portion of the site lies within an AE zone with an ABFE of 10 ft NAVD88 (FEMA Flood Hazard Resources Map last modified on March 24, 2014). The V-zone designation signifies that the expectation is that the shoreline area surrounding Habirshaw will be impacted by waves greater than 3 ft during the 1% annual chance of occurrence storm, while the ABFE represents the water elevation expected during the same storm. The ABFE and V-zone designation represent useful baselines with which to compare both the typical and storm conditions at the site. The Sustainable Shorelines physical forces climatology (http://www.hrerr.org/hudson-river-sustainable-shorelines/shorelines-engineering/physical-forces-statistics/) dataset was used to characterize the conditions during a typical year. The climatology was based on a one-year numerical simulation of conditions within the Hudson, generated using an ultra-high resolution version of the NYHOPS numerical model. The climatology was developed based on the conditions in 2010, which was a typical year and included one significant Nor’easter. The maximum hindcast water level (WL\text{max}) in 2010 was 5.45 ft above NAVD88, while the maximum (H_{\text{max}}) and median (H_{\text{med}}) wave heights were 1.55 ft and 0.22 ft, respectively. An analysis of the fetches at the site confirms that the site is moderate energy with respect to wind-waves. The relevant fetches are shown in Figure 5, where the average and maximum fetches were found to be 5,770 ft (1.1 mi) and 7,320 ft (1.4 mi), respectively.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Climatology</th>
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<tbody>
<tr>
<td>WL_{\text{max}} (ft NAVD88)</td>
<td>5.45</td>
</tr>
<tr>
<td>H_{\text{max}} (ft)</td>
<td>1.55</td>
</tr>
<tr>
<td>H_{\text{med}} (ft)</td>
<td>0.22</td>
</tr>
<tr>
<td>Ice t_{\text{med}} (in)</td>
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<tr>
<td>Ice t_{90%} (in)</td>
<td>4.3</td>
</tr>
<tr>
<td>H_{\text{wake}} (in)</td>
<td>16+</td>
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</tbody>
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Figure 5 – Habirshaw Park fetch analysis.
Ice information collected by the U.S. Coast Guard and compiled as a part of the climatology (https://www.hrnerr.org/hudson-river-sustainable-shorelines/shorelines-engineering/ice-conditions/) indicates that the site is subjected to minimal icing. The median ice thickness (Ice $t_{\text{med}}$) observed during the ice season (December-March) was 1.6” with thicknesses up to 4.3” occurring 10% of the time (Ice $t_{90\%}$). Wake observations recorded over a 2-day period during the summer of 2012 and 2013 by summer students contained maximum recorded wakes ($H_{\text{wake}}$) of over 16”. Topographic and bathymetric surveys of the site were conducted to obtain detailed information about upland elevations, nearshore slopes, and offshore depths. The survey data (Figure 6) indicate that offshore of the project site the contours are extremely uniform, sloping rapidly between depths of -5 ft (NAVD 88) and -20 ft, then more gently from -25 ft out to a depth of -40 ft. The area immediately offshore of the sill is fairly flat, creating an ideal platform for its construction. The upland portion of the site slopes fairly uniformly from the shoreline up to an elevation of approximately 10 ft adjacent to the building.

**HINDCAST STORM CONDITIONS**

Conditions during the three historic storms were hindcast using the NYHOPS numerical model. Hindcast water levels (Figure 8) during both Irene and Sandy significantly exceeded the 95th percentile based on the 2010 climatology. The hindcast predicts water level in excess of 10 ft during Sandy, which is reasonably consistent with a high-water mark of 9.00 ft NAVD88 collected by the USGS one block south of the site. FEMA’s most recent Sandy storm surge extent map (Figure 7) matches the modeling, observations, and survey data well and confirms that the majority of the site was submerged during the storm. Hindcast wave heights (Figure 9) during both Irene and Sandy significantly exceeded both the 95th percentile and maximum wave heights from the 2010 climatology. Wave heights during Irene were slightly larger (0.25 ft) than those during Sandy. While these results reflect the significance of the storm with respect to the typical conditions, in an absolute sense, wave heights of less than 1.5 ft are generally not considered high-energy events. Previous studies have shown that many sill/breakwater sites are able to survive major storms because during the storm they are submerged, allowing the waves to pass over the top of the structures without causing significant damage to the structure or shoreline erosion.
DOCUMENTED PERFORMANCE

After the initial planting in 2004, the upland vegetation took hold and was able to survive, but the sill proved insufficient for protecting the marsh. In 2007 a project was undertaken to increase the elevation of the sill and enhance its resistance to wave, debris, and ice impacts. The simple solution was to encase the existing rock within a mesh bag to form a low-tech gabion. Maintenance at the site since construction has consisted of removing stranded woody debris and common reed (an invasive species capable of overtaking the marsh), as well as mending damaged fencing and replacing dislodged stones (Figure 10). In 2007, a significant amount of vegetation had to be replaced because of overgrazing by Canada Geese. Over time, routine monitoring and inspection revealed that wave energy and ice caused several stones from the sill to dislodge, requiring additional maintenance and adaptive management. Wildlife recorded at Habirshaw have included fiddler crabs, great blue heron, monarch butterflies, killifish, blue crabs, and shrimp.
FINDINGS

The Habirshaw site survived all three historic storm events as well as several severe winters with minimal damage. The long-term durability of the site is likely related to several factors. The design of the site was based on both traditional engineering analyses (wave heights, tides, cut/fill estimates) and local ecological considerations (salinity, planting medium, and plant selection). One of the key factors in the long-term sustainability of the site has been effective monitoring and maintenance. Consistent debris removal has helped to allow the majority of the vegetation to flourish. The vegetation is also evaluated on a routine basis to determine if additional plantings are required. When it was determined that the original sill was ineffective, steps were taken to correct the problem, and a low-cost gabion-type structure was added. During two of the three storms considered, the majority of the site was submerged, contributing to its survival. This suggests that other factors such as wakes (for which the available data are extremely limited), ice, or debris may have a more significant impact on the project than the wind-driven waves associated with large storm events. Similar to several of the other sites studied, damage was caused by the significant amount of ice during the winter of 2013-2014. We observed during monitoring that sections of the mesh bags encapsulating the raised portion of the sill were beginning to rupture. Repairs were made in response to this observation by the Bezcak staff in the fall of 2014.