LIVING SHORELINE DESIGN USING NUMERICAL AND PHYSICAL MODELS TO CREATE A PUBLIC PARK IN EUCLID, OHIO

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INTRODUCTION

The shoreline of Euclid, Ohio consists of silty-clay cliffs that are naturally eroding into Lake Erie, supplying sediments to the littoral system. Updrift stabilization and entrapment of sands along the shoreline have led to accelerated deterioration of Euclid's cliffs along a thousand meter stretch of lakefront. Due to the cliffs' unstable nature and privately held ownership, long stretches of shoreline are inaccessible and only a few property-owning residents have visual access to the lake. Through state funding and creative negotiations, the City of Euclid and SmithGroupJJR were given permission to create a recreational waterfront park using both hard and soft engineering techniques designed to dynamically adapt to the forces of Lake Erie and not impede natural littoral transport. A series of numerical and physical modeling studies were undertaken to optimize a natural design that will remain stable throughout extreme events. This design married revetments, headland habitat beaches, offshore breakwaters, vertical structures, submerged structures, tee-groin breakwaters, recreational sand beaches, and natural plant stabilization techniques to achieve a stable, resilient waterfront park that can be enjoyed by the public.

PROJECT REQUIREMENTS

The project criteria require the shoreline to not impede the current littoral transport system during and following construction. Furthermore, all park infrastructure is to remain stable and sustain only minor damage during the 100-yr. return period wave event coupled with recorded high-water levels.

In order to meet these conditions, the engineers used creative design solutions to reduce, speed up, and even reverse shoreline currents through placement of emergent and submerged structures. Many layouts were tested using numerical models before constructing a scaled physical model of the full project site.

NUMERICAL MODELING

A series of numerical models were used to determine the site conditions and conceptually lay out the shoreline improvements. These models included SWAN for wave transformation, a Boussinesq-type model for nearshore processes due to the unique bathymetry, and MOHID for wave-generated currents. By nesting these programs together, the engineers were able to better understand how manipulations to the shape or materiality of a coastal structure would affect the function of the design as a whole.

PHYSICAL MODELING

A three-dimensional physical model of the foreshore and shoreline along the project site was designed and constructed at a geometric scale of 1:27.5 in the National Research Council's Ocean, Coastal and River Engineering's Large Area Wave Basin facility, located in Ottawa, Canada. Modeling trials consisted of stability testing to ensure structures remained intact and within damage thresholds during low probability events, and littoral transport testing to sculpt the shoreline in order to lessen the retention time of bypassing sediments. The beach sediment was modeled using both coarse and fine sand that deformed naturally in response to wave forcing. The model was fitted with two portable wave machines to generate user-specified irregular wave climates and equipped with a series of instrumentation to measure wave conditions, wave-induced nearshore currents, and changes in the shape of the model beach. Over 90 simulations with various permutations of coastal structures and beach layouts were tested to inform and support the detailed design of the shoreline protection features. The resulting design will stabilize this eroding shoreline and return lakeshore use and access to the public.

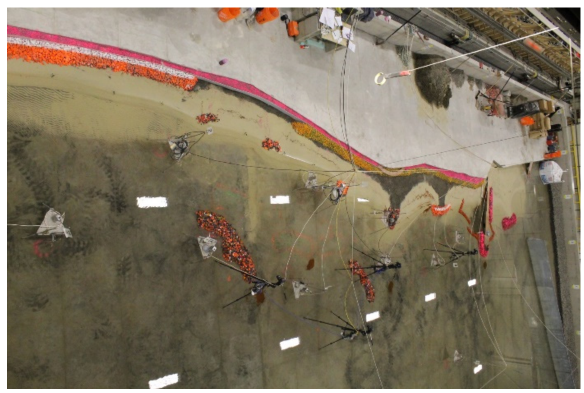

Figure 1 – Physical Modeling of Littoral Transport

Figure 2 – Oblique of Natural Shoreline Improvements