2012 ACEC Engineering and Surveying Excellence Awards

1. Role of the Entrant's Firm in the Project

The Mannik & Smith Group, Inc. (MSG) has been the engineer for the Frenchtown Charter Township Resort District Authority (RDA) for over a decade. MSG was requested by the RDA to provide comprehensive engineering services for the rehabilitation and reconstruction of approximately 7 miles of Lake Erie flood protection seawall.

It has been nearly 40 years since the Army Corps of Engineers (USACE) constructed the rock filled, gabion type flood control structures along the shores of Lake Erie to protect the thousands of residents and their homes in Frenchtown Township from severe and repeated flooding. The majority of the dike system has since fallen into disrepair and become structurally inadequate with significant areas where high lake levels will breach the deteriorated structures.

The original efforts by MSG date back to 2001 when the RDA requested that MSG perform a complete structural engineering and elevation analysis of the existing flood control dike system along the Lake Erie shoreline in Frenchtown Township. The process has taken nearly a decade from the initial study and cataloging of the entire township shoreline dike system to the development of a comprehensive solution and development of engineering plans.

MSG in conjunction with the RDA developed a Master Plan for rehabilitation or replacement of the 7 miles of existing Lake Erie Seawall. The project has been divided into zones based on location along the shoreline. The zones are subdivided into projects and have been prioritized based on condition of the existing wall to be rehabilitated. Currently there are 5 Zones and 14 Sub-Zones identified as part of the Master Plan.

MSG services included topographic survey, geotechnical investigations, design and analysis of wall concepts, cost estimating, development of seawall replacement and rehabilitation plans, bid document preparation, bidding assistance, construction survey staking, construction engineering and observation services and material testing including coordination with over forty separate parcel and landowners (Phase 1), the United States Army Corp of Engineers (USACE), the Michigan Department of Environmental Quality (MDEQ), local municipalities, and various subdivision beach association boards. Project plans provided details of the existing wall, the proposed design for the replacement and/or rehabilitation of the seawalls, utilities, cofferdam construction, SESC measures, temporary dewatering requirements and temporary construction access provisions.

A USACE/MDEQ Joint Permit Application was developed and submitted for review and approval. Through extensive coordination, review and revisions and a cooperative effort with regulatory agencies an approved Joint Permit was obtained for Zone 1 proposed work. Additional permits will be required for each future contract. During preliminary stages of the permitting process MSG was required to minimize all impacts to

the Lake Erie Shoreline. Preliminary meetings conducted by MSG included agencies such as the MDEQ, USACE, MDNR, Fisheries, and Congressman Dingell's Office.

The first contract for this project (Phase 1) was let for construction in May of 2010 and involved the Master Plan area identified as Zone 1, which included approximately 1 mile of seawall rehabilitation. Zone 1 is located from Grand Beach to Baycrest subdivision and included several beach association subdivisions and private parks. Rehabilitation for this zone included removal of existing gabion baskets and other make-shift walls from stacked concrete barrier to welded beams, restoration of a portion of the existing concrete walls and complete replacement of the majority of existing walls with soldier pile cast-in-place concrete or precast concrete panel walls including installation of wave deflectors. Major construction activities were completed by May of 2011 with minor restoration and miscellaneous project close-out items in the fall of 2011.

Design Considerations

The fundamental purpose of the seawall along the Lake Erie shoreline includes flood protection, shoreline protection and soil retention. All three of these characteristics were considered as the study, analysis and design unfolded for this project, as follows:

- Flood Protection: The height of the wall was a key consideration in developing our design. The FEMA flood elevation currently published for this area along the Lake Erie Shoreline is 578.15 referenced to the International Great Lake Datum of 1985 (IGLD 85). In order to accommodate a flood and surge that would produce water elevations of this height the proposed minimum wall height was set to 579.00 IGLD 85. In some cases, due to the height of the surrounding finished grade, the top of wall elevation was set at a higher elevation.

- Shoreline Protection: In addition to controlling the height of the water the seawall had to be constructed with materials that would withstand the brutal forces of nature including both cold winter ice conditions and strong summer storms. Several engineering materials were considered including concrete, steel, polyethylene, and large riprap. It was determined that in order to minimize disruption to the shoreline following completion of construction and to maximize protection of the shoreline a concrete wall system would be utilized. Wave action created from storm surge and wave runup was also considered. MSG investigated and utilized wave energy dissipaters constructed at the crest of the wall. The energy dissipaters or flares were designed with a radius and an approximate angle of 54 degrees to the vertical face of the wall that would redirect crashing waves onto the waves approaching the shoreline. The flares were a key element in the design of the panels to reduce the amount of energy that causes erosion along an unprotected shoreline.

- Soil Retaining: In addition to the seawall providing protection from flooding and erosion it also serves a major function as a soil retaining wall. This characteristic was used to develop the basic size of the wall. Cohesive soil characteristics and pressures were used for the design based on information obtained from the geotechnical investigations that were performed by MSG. Net water pressures were included assuming saturated soil conditions for a portion of the soil strata and low water conditions. This combination generated maximum wall pressures and forces used for sizing the structural wall elements.

Structural Design Decisions and Methodology

Numerous structural wall systems were investigated to accommodate the design parameters listed above. Some of these systems included reinforced concrete cantilever walls, driven steel sheet pile, tied-back steel or concrete walls, riprap revetments, vinyl and composite sheet pile, break walls, and many more. It was determined that in order to minimize impact to the shoreline, reduce the footprint of the wall, protect existing environmental conditions and sensitive areas along the Lake Erie shoreline, provide the necessary flood and shoreline protection, provide the soil retaining strength and construct a cost effective wall with substantial longevity, a soldier pile wall system would be utilized. Due to the shallow bedrock conditions along the shoreline MSG engineers utilized a cantilever wall design embedding steel pile into rock. Rock coring machines cored holes into the rock to the required depths. The holes were then backfilled with concrete. Precast concrete panels were then installed between the piles. The wall was backfilled with low strength control density fill in order to eliminate voids or non-compacted soils between the existing structures (portions left in place) or the shoreline and the new concrete wall. The precast panels were designed as simple spans between the steel piles and reinforced accordingly. As indicated above, flares were cast integral at the top of the panels in controlled conditions off site and shipped to the site for installation.

The soldier pile and panel system develops strength from the depth of rock embedment. The rock depth to install the piles was determined by computing forces acting on the wall from soil, water, ice, and other loads that would be resisted by the rock. Cohesion was also considered as the soil strata predominately consisted of clay soils. Rock shear strengths were computed from rock core data and correlation with similar published rock types. Overall wall stability including overturning, sliding, and bearing were checked against appropriate factors of safety. Bending and shear stresses were computed for the steel piles to be within tolerable stress limits provided by AASHTO.

While a precast concrete wall was predominately used for seawall construction, there were several areas, due to site restrictions or deflections in the wall, which required use of reinforced concrete cast-in-place walls. This eliminated the need to fabricate expensive specialized panel sizes and configurations and allowed the contractor to make necessary adjustments on site.

Aesthetics was a major concern for this project. MSG worked diligently with the RDA, landowners, beach associations and other stakeholders to provide an aesthetically pleasing finished product. Form liners to provide graphics on the exposed face was considered, but determined to be costly and would also create possible “catch points” for debris. A smooth faced wall with a rubbed finish and treated with a penetrating sealer for protection against the elements was determined to be the most cost effective solution.

Environmental minimal impact – The soldier pile wall “footprint” required limited disruption to the existing shoreline and numerous residential obstacles that had to be worked around in order to complete the project. Since the wall is essentially vertical construction excessive excavations required by other wall systems were eliminated that reduced the overall impact to the natural habitat of shoreline and aquatic species.

2. Role of Other Consultants Participating in the Project:

Following the initial design and sizing of the soldier pile and panel wall, MSG consulted with well known engineers affiliated with the University of Toledo to provide quality assurance of the design methodology, including Dr. Gerald R. Frederick, Ph.D, P.E., and Dr. Andrew G. Heydinger, Ph.D, P.E. Both provided input for the design concepts, the detailed structural analysis and structural elements of the wall.

Construction Methods and Construction Design Elements

The contractor elected to install a continuous concrete MDOT type barrier wall lakeside of the temporary access roadway. This helped to confine the stone was eroding into the lake and protected the work area from wave action. A turbidity curtain was also installed in Lake Erie in close proximity to the shoreline in areas where earth excavation was required. Silt fence was installed landward of the construction limits. The temporary access roadway was constructed on concrete slabs and 4-6 inch crib rock from the old USACE gabions. Geotextile fabric was installed under the concrete and rock for protection of the shoreline. The temporary roadway was removed upon completion of work.

In certain areas, 18 inch wide concrete backwalls were constructed due to the configuration of the existing dike systems. The lower grade beam of the backwalls were poured against the earth trench will full resteel cages. The top section was formed and poured in place. No wave deflectors were required on the backwalls.

The precast concrete panels were fabricated off site at Stress-Con Precast Industries and shipped to the job site. The panels were lifted into place between the galvanized soldier pile, which were placed on 8 ft. centers. The piling was installed into augured excavation approximately 3-4 feet into bedrock and filled with concrete.

The new concrete walls had cast in place concrete steps at several locations as well as concrete cast in place closure pours. Openings for steps were protected by aluminum stop planks set into framed drop-in panels. Drainage behind the walls used specially designed yard drains with weep hole set in the walls with check valves.

3. Brief Description of Entrant's Contribution to the Project:

- Original or innovative application of new or existing technology – The project considered a multitude of existing and innovative application of technologies throughout the study of the existing walls and options for the construction of the new walls, as noted under "Structural Design Decisions and Methodology" above. The project involved unique and diverse engineering design and construction challenges, much of which had to be studied and developed by MSG, since there was surprisingly little available data for this type of construction.

- Future value to the engineering profession – There is significant value to the engineering profession, as the design work for this project was unique to this particular application and will provide guidance for future engineering application on the remainder of the phases for this project as well as other potential projects along the Great Lakes shoreline or other similar applications. In fact, the USACE had requested a copy of our design plans and information to review and consider as part of a similar project being designed by the USACE along the shores of Lake Erie in the Detroit Beach area (not a part of the RDA projects) as part of the reconstruction of the USACE Advanced Measures dike system.

- Social, economic and sustainable design considerations – There were significant considerations with all three of these design considerations, as noted above in the project write-up. Social considerations involved the intense work required to meet with citizens, shoreline residents and associations to involve them in the decision making process to protect and enhance the aesthetics and value of their shoreline properties. Economic decisions and value engineering was employed throughout the design process in order to determine the most cost effective solution to this challenging project. Numerous design decisions throughout project included a cost evaluation and consideration of alternate design methods. Sustainable considerations were likewise considered an essential part and priority to this project. The project was designed to provide long term protection with minimal future disruption or maintenance requirements that could impact the wetlands or bottom lands of Lake Erie. In addition, significant coordination with the USACE and MDEQ was performed to limit work within the sensitive lake environment. Greenbelt and yard areas were enhanced. The design was performed to eliminate the need for shoreline riprap, which would have reduced or eliminated the environmentally and aesthetically important beach areas along Lake Erie. Strict SESC measures were included in the design to prevent degradation of the lake and shoreline.

- Complexity – This was a highly complex construction project from initial concept through the design and construction stages. As described above, many complex structural and hydraulic considerations were involved throughout the design of the project. Design of the soldier pile and methods to construct, given the fluctuating ground and lake levels, provided greater engineering challenges. Access to work along the shoreline, protection of the environment and providing cost effective and reasonable work areas for the contractor were difficult and challenging engineering decisions. Finally, designing closure pours and other unique elements on the meandering shoreline provided the structural engineers with many complex design decisions.

- Exceeding owner/client needs – The RDA Board and Director have expressed their great satisfaction with this project. The project came in under budget which further added to their satisfaction. In addition, the shoreline residents and beach associations have all voiced their approval of the design and aesthetics of the project. MSG and the RDA have worked diligently with all shoreline residents to address concerns related to the individual property owners, which was a unique and challenging part of the overall project.