October 30, 2015

REPORT

CHARLESTON SEAWALL REPAIRS:

The Low Battery Seawall Rehabilitation Project

JMT Project No. 14-1139-001

Submitted to:
City of Charleston, South Carolina

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For:

City of Charleston

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Engineering Division

October 30, 2015

By:

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Executive Summary

This report serves to summarize JMT and the team's findings of the condition of the Low Battery Seawall along Murray Boulevard in Charleston, South Carolina and to recommend a course of action and alternatives. The engineering and survey teams performed a number of onsite inspections and material testing to determine the condition and structural capacity of the existing structure. As expected for a century old wall that is exposed to extreme elements, the wall is exhibiting signs of serious deterioration and loss of structural capacity.

The identified areas of concern, in order of priority, from our investigation are:

1. The timber pile and concrete foundation connection was designed to be completely buried, protecting the timber from exposure to air, to prevent rot, and for keeping marine boring worms away. That connection has now been exposed to air and seawater above the mean low water line due to scour along the wall face, deterioration of wall joints, and the migration of material from behind the wall through various voids in the wall face. This exposure has led to greater degradation of this connection. Without repair, it is anticipated that this portion of the structure will degrade exponentially. This deterioration of the foundation/wall interface is what poses the greatest threat to overall wall stability. It reduces its ability to resist lateral loading during extreme events and should be addressed by the upcoming repair work.

2. Several construction joints in the wall face have opened and have permitted moving water behind the wall. This has led to erosion and soil settlement behind the wall causing settlement of the sidewalk and road as well as being a leading contributor to the deterioration of the foundation/wall interface. The joints should be repaired and sealed appropriately.

3. Our investigation determined that there was heavy deterioration of the waterside face of the wall with certain areas having experienced accelerated decay. Possible reasons for the selective accelerated decay were, its relative location along the wall, differential water velocities and/or chemical contaminates. A reinstatement of the entire face by removal of unsound concrete should be considered to prevent further deterioration of the underlying sound concrete forming the main wall structure.

4. The wall coping and handrail post connections at the top of wall were severely deteriorated. The coping was cracked and leaching rust the entire length of the Low Battery. The base of the posts, whether concrete or granite, were cracked, exposing the connection to the elements causing deterioration. The structural capacity of these barriers has been compromised by this cracking and deterioration, therefore cannot be assumed to be adequate for its intended pedestrian and possibly any vehicular loading. Complete replacement of the wall coping and railings should be considered.

5. The sidewalk cross slope and flatness does not conform to ADA requirements which could expose the City to litigation and injury claims. Corrective action should be taken to address the existing conditions as well as deter future settlement.

Based on our testing and investigation, we have determined that The Low Battery Seawall was in overall poor condition. However, this rating was mainly due to the exposure and noted deterioration of the timber pile foundation/wall interface. Corrective action to this aspect of the wall, whether it be a total reconstruction or possibly by underpinning of the foundations, would substantially improve its structural condition and load carrying capacity.

Although a complete rebuild of the wall is always an option to ensure the extended service life of the wall has been addressed for the foreseeable future, it is also the most costly and most disruptive method of addressing wall concerns. It is our belief that consideration should be given to the design of a minimally invasive procedure to install new/additional foundation supports for the wall, as well as to improve the concrete condition of the wall. Any viable construction method of strengthening should be substantially more economical compared to the complete demolition and reconstruction of the existing wall.

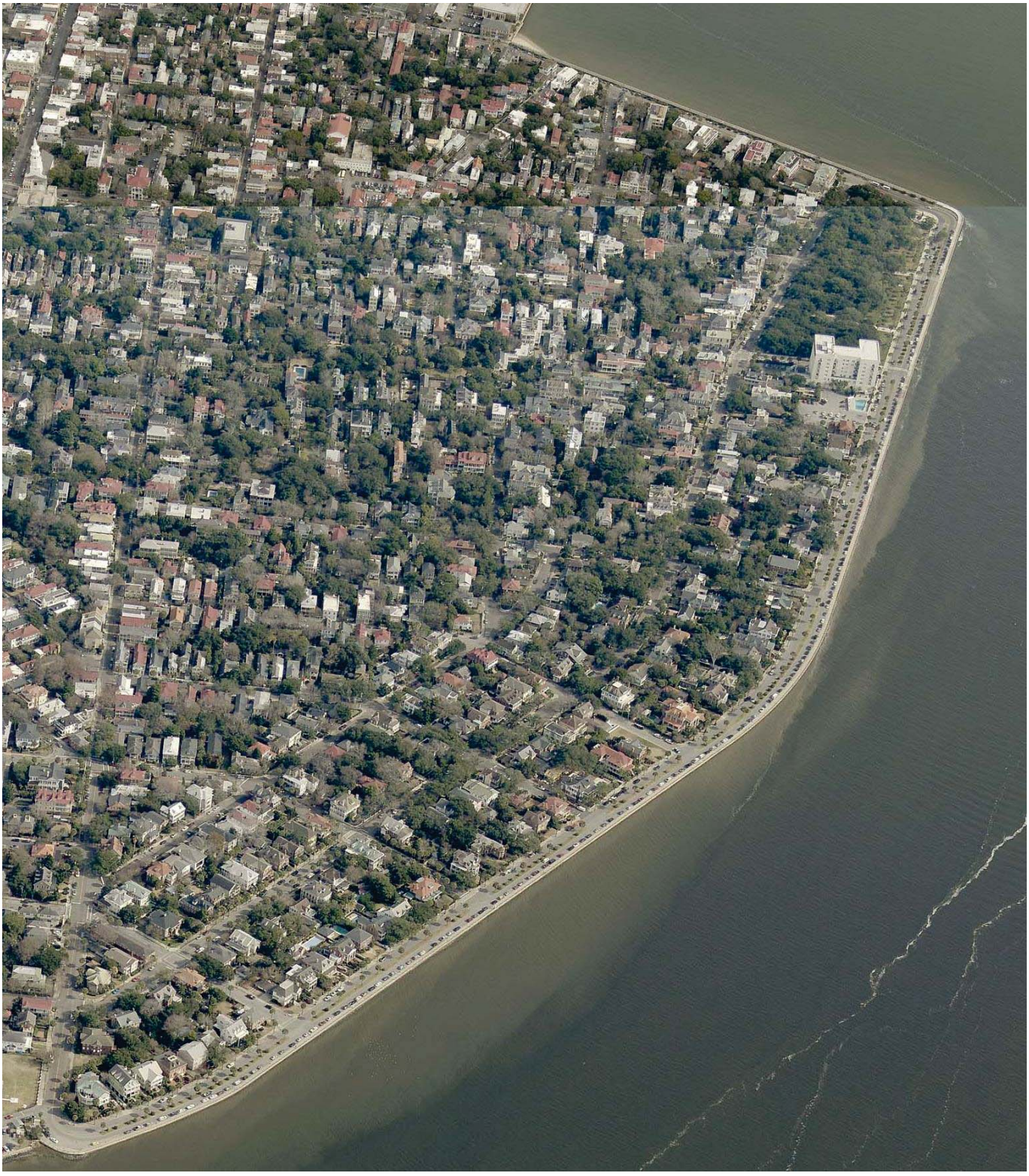
In addition to the foundation renovation, prevention of soil washout behind the wall is also an important step to maintaining the integrity of the structure and reducing maintenance costs associated with the road and sidewalk. Based on the prior work at "the turn", it is believed that there will not be environmental permitting, architectural or historical/ aesthetic issues with making the needed improvements to the visible portion of the wall.

The sidewalk and handrail are relatively straight-forward repair, but aesthetics and context would need to be considered. The coping and sidewalk should be repaired and the sidewalk grade raised or lowered in order to correct the cross slope for ADA compliance. A number of new technologies and products can be utilized to extend the life of the newly constructed concrete coping. Concrete additives can slow the rate of chloride penetration through the concrete, which is a primary cause of corrosion to the steel reinforcing. Another possibility is to use Fiber Reinforced Polymer rebar in the replacement coping and sidewalk, as well as for large spall repairs to the wall face. This eliminates the corrosion potential of the reinforcing steel, which creates the cracks and spalls.

The visual assessment of the seawall also identified several areas along the seaward wall face that exhibited diagonal cracking. Diagonal cracking in rigid structures, especially gravity structures such as this, tends to indicate a differential settlement issue with the foundation. This settlement, coupled with the age of the structure and the results of the material testing of the timber portions of the foundation, indicate that the foundation of the seawall at the Low Battery has reached the end of its service life and should be replaced.

JMT recommends the City consider a complete wall replacement or a strengthening rehabilitation effort emphasizing the following courses of action:

1. Retrofit the foundation of the existing concrete structure by underpinning as a less invasive method of stabilization and vertical and lateral capacity improvement.
2. Clean and repair the damage to the concrete wall face by resurfacing along with targeted complete concrete spall repairs and joint reinstatement.
3. Replace the entire length of the wall coping and handrail elements while preserving granite posts that are in good condition for re-incorporation into the new construction. Consider raising the elevation of the coping for possible increase in sea level during the foreseeable life of the wall.
4. Replace the concrete sidewalk while also reinstating proper fill behind the wall after the concrete face and joints have been repaired. Reestablishment of a typical 6 inch high concrete curb line should be considered to improve vehicle access and parking.
5. Repair any voids along the concrete skirt that runs along the seaward base of the wall to prevent future fill migration and to prevent detrimental exposure of foundation elements to environmental hazards.
6. Consideration of an overall seismic resiliency improvement approach to the new design, rather than a strict "code compliant" seismic design.



Aerial view of the Battery

1.0 Introduction

The Low Battery seawall was constructed as a part of a large land reclamation project undertaken in two phases around the turn of the 20th century. Phase one was constructed between 1909 and 1911 and extends from Tradd Street to King Street. The second phase, constructed between 1917 and 1919, extends from King Street to "the turn", at the intersection of what is now Murray Boulevard and East Battery Street. The concrete wall of the Low Battery was originally constructed on a timber deck supported by timber piles. The seaward face of the Low Battery was skirted with concrete panels attached to timber sheeting and batter piles. This system formed a retaining wall system to retain the landside fill. Upon completion of the wall, approximately 667,000 cubic yards of fill were pumped by dredges into the area behind the wall. Based on historical as-built drawings from 1909, this raised the 47 acres to approximately 8.5 feet above mean low water. The promenade along the wall now acts as a major tourist attraction for the City of Charleston bringing guests from all over the country and the world to the area.

After more than 100 years of exposure to aggressive environmental conditions, several powerful hurricanes, and numerous extreme high tides, the entire Battery wall has been left in a significantly degraded state. The High Battery at the turn recently underwent a total reconstruction due to concerns about deteriorated foundations. As a continuation of that project, The City of Charleston (the City) would like to now address the Low Battery.

The City contracted with Johnson, Mirmiran & Thompson (JMT), along with a team of skilled sub-consultants, to provide project management, structural assessment, planning, repair and replacement alternatives, and sidewalk improvement alternatives for the seawall along Murray Boulevard known as the Low Battery. The first phase of the project consisted of several types of site investigations to acquire pre-design information and to determine the specific condition of the Low Battery seawall for prioritization of reconstruction work. The investigations took place over the approximately 4,800 linear feet of the Low Battery seawall starting from the entrance of the Coast Guard Station, at the end of Murray and the beginning of Tradd Street, (Station 00+00) and continuing to the new construction at the turn (Station 48+26).

2.0 Services Provided

2.1 Roles & Responsibilities for the Condition Assessment

For Phase one of the project, JMT was to provide both the overall project management and the structural engineering component of the contract. This includes the structural field inspection, analysis and stability assessment of the existing structure, as well as schematic design of the alternative solutions. JMT also performed a 3D high definition scan of the street and accessible portions of the face of the wall.

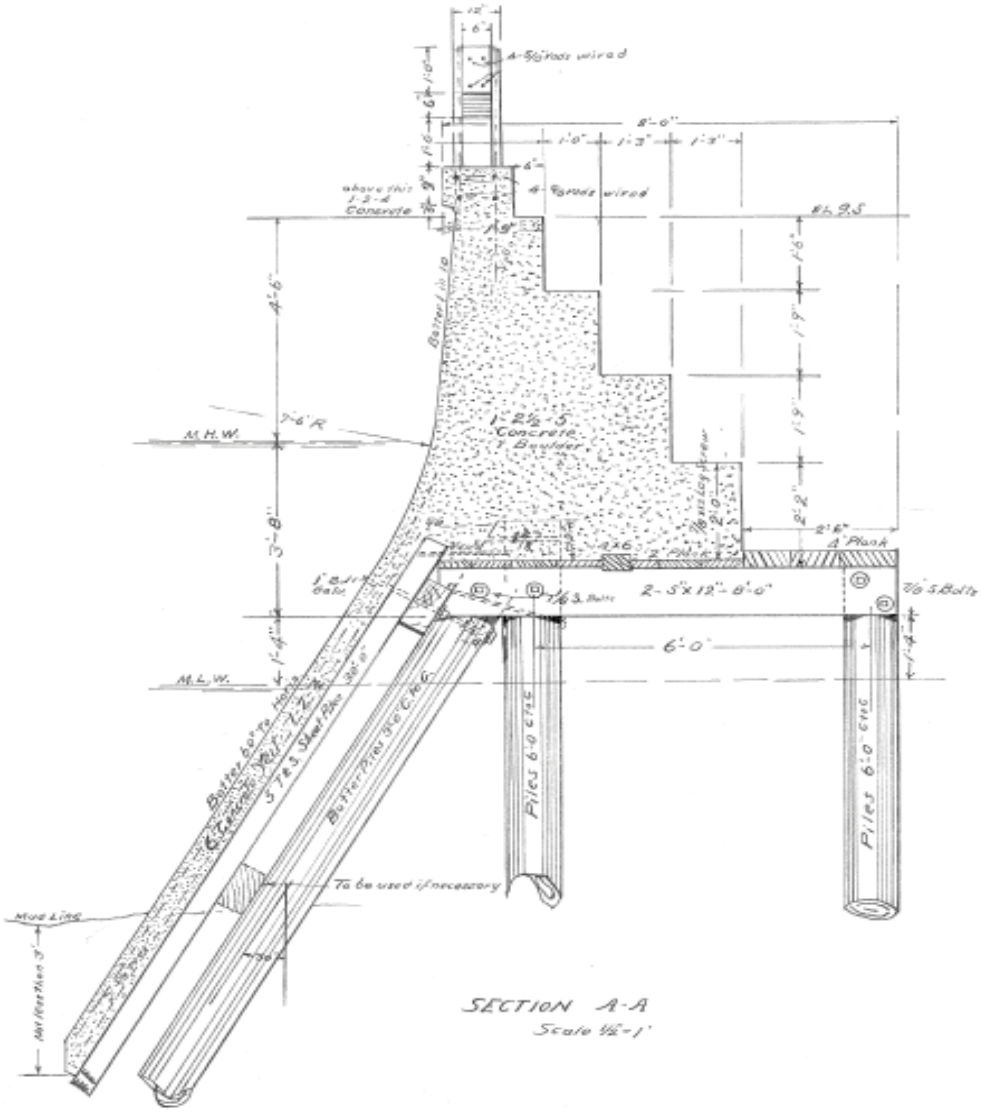
Due to the significance of the wall and the importance of the foundation, JMT added both Schnabel Engineering and Terracon to provide geotechnical engineering expertise. Schnabel provided the analysis of the geotechnical information and expertise in the rehabilitation of similar structures of the same era. Terracon provided the materials testing and field geotechnical investigation. All of the geotechnical data and analysis is included Appendix B of this report. Wood Advisory Services provided all of the timber microbial and decay testing and analysis.

GEL Engineering, LLC (GEL) supplied all of the boundary, topographic, and hydrographic surveying, as well as subsurface utility engineering (SUE) services. This information was used to orient the 3D scanning performed by JMT.

Tidewater Environmental (now a JMT company) will provide all of the permitting research and coordination once a preferred alternative is selected by the City. Liollio Architecture, in collaboration with Brockington and Associates, will add the historical narrative necessary for gaining project approval and depict the historical significance of the wall.

2.2 Historic Research:

JMT searched through the City of Charleston Archives to uncover as much historical information on the Low Battery wall as there was available. A number of drawings from the original construction were collected and analyzed for significance to the project. The pertinent information that was collected is included in Appendix D of this report. Based on the field findings, the most accurate original depiction of the Low Battery seawall is shown below.



Original depiction of the Low Battery wall as constructed in the early 1900's. Reference: The City Archives