Memo

Date: Tuesday, April 12, 2016

Project: Passaic Tidal Closure Structure

To: John Dromsky-Reed

From: Wes Jacobs
Bogdan Bogdanovic


This memorandum presents the results of our preliminary (planning level) designs and cost study of the Passaic River closure gate structures in the tidal areas of Kearney, Newark, and Harrison, NJ.

1. INTRODUCTION

This study addresses the design of closure gates in typical reaches along the Passaic River extending from Kearny to Harrison, NJ. The design and cost element defined herein represents a 30-percent level conceptual design using the latest revision inventory document of the closure gates titled “Passaic River-Final Closure Gate Inventory” dated March 10, 2016 (see Appendix A). The closure gates were grouped into several different categories based on gate openings, heights and types. The gate types used were predominantly swing gates with the exception of roller gates for openings of 50 feet or larger. The gates are assumed a mix of closures to span railroads, highways and pedestrian crossings.

Through coordination with technical staff from AECOM, as well as standard engineering practice, the 30% design includes four basic load cases which are loadings that typically control floodwall/closure gate structures designs. A full array of load cases will need to be investigated in the final design phase. The load cases included in the 30% design are:

- Construction + Wind: Dead load of the concrete monolith and steel gate, a conservative wind load of 50 psf, no earthen backfill, no uplift, no construction surcharge. A 33% overstress is permitted for this load case.
- Flood stage at still water (SWL) at 2 feet below top of gate structure with debris impact loading of 500lbs/ft applied at the SWL. A 33% overstress is permitted for this load case.
- Flood stage at water to top of gate (TOG). Wave force is not included. A 33% overstress is permitted for this load case.
- Flood stage at SWL at 2 feet below top of gate structure. A 0% overstress is permitted for this load case.

The gate members (girders, intercostals, and skin plates), concrete monolith (abutments/footings), and foundations were sized to carry these anticipated loads as mentioned above for all different gate categories which have been selected. Secondary gate features such as any hinge assemblies, connections, casters, trolleys, or hanger systems were conceptually shown based on previous similar projects and engineering judgment. Calculations were not performed to size these types of features. Wave loadings are expected to be minimal due to topographic conditions and lack of proximity/exposure.
to full coastal storm surge associated with hurricanes. It is also assumed, per technical discussions, that there will be no unbalanced loading or downdrag forces seen by the gates at this level of design. This will require more in-depth analysis and can be fully vetted during later design stages. Complex pile group analysis, therefore, was not be required. Seismic forces were not considered to govern and were not applied at this level of design.

For the 30% design effort the following codes and standards will be used, as well as the applicable portions of the HSDRRSGD (Hurricane Storm Damage Risk Reduction System Design Guidelines) and the existing project GDM:

- EM 1110-2-2705 – Structural Design of Closure Structures for Local Flood Protection Projects
- EM 1110-2-2104 – Strength Design for Concrete Hydraulic Structures
- EM 1110-2-2105 – Strength Design for Hydraulic Steel Structures

Once the preliminary gate designs were compiled for all different gate selections, costs were developed based on the major contributing “bid” items that would typically be present in final documents such as: concrete monolith structure (abutments and footings), structural steel gate (gate overall weight plus detail factor), concrete reinforcing for monolith structure, and pile foundation (total pile length for the gates). Items such as steel embeds, seals, turnbuckles, casters, hinge assemblies, access ladders, etc. were included in the structural steel gate item. Unit prices were based on recent, similar construction projects and adjusted for any regional effects and applied to the various bid item quantities.

2. DISCUSSION AND RESULTS

The final closure gate inventory has 64 closure gate structures that fluctuate in gate opening width and gate height. The gate heights for all 64 closure gates were determined based on the design water elevation of 14 feet and their respective existing grade elevations. In addition, evaluations were completed for gate heights 2 feet and 4 feet above the 14 foot elevation.

All gates were grouped into several scenarios based on gate openings and heights as shown in table 1. The Kearny, Newark and Flanking areas consist of H-pile foundation whereas the Harrison area consists of concrete micro pile foundation. Any opening width equal to 10-feet or smaller was grouped with the 10-foot gate opening. The 20-foot gate opening was grouped with a series of opening widths ranging from 15 to 20 feet. The majority of opening widths in the inventory was for the 30-foot width. The 30-foot gate opening was grouped from 25 to 30 feet. The 35-foot, 40-foot, 45-foot and 50-foot gate openings were grouped individually, since their gate opening width is considered to be on the larger end of the swinging gate spectrum.

Once the gates were grouped as described above, the smallest gate height and the tallest gate height for each respective group was determined and a 2-feet incremental height increase was implemented starting from the minimum to the maximum gate heights. Typically gates for openings larger than 38 feet would be considered at the threshold for the swing gates. Roller gates predominantly are seen for openings larger than 38 feet. The gate opening width identified in the flanking area of the final closure structure inventory ranged from 40 to 150 feet. After further assessment of the gate openings in the flanking area, the roller gate option will not be feasible due to the limited space in this area which does not facilitate the construction of the larger concrete monolith structure. Therefore the 150 feet opening was divided into three swing gates with an opening of 50 feet. The inventory list also includes four gate widths opening of 50 feet which have been grouped together as roller gates since the vicinity permitted a
larger concrete monolith structure. The same grouping procedure described above was followed with respect to gate heights.

Table 1. Gate Grouping Scenarios

<table>
<thead>
<tr>
<th>GATE OPENING (Feet)</th>
<th>SWING GATE(H-Pile Foundation)</th>
<th>GATE HEIGHTS(Feet)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>GATE HEIGHTS(Feet)</td>
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<tr>
<td>10</td>
<td>6</td>
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<td>2</td>
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<td>11</td>
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<td>45</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>50</td>
<td>6</td>
<td>8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SWING GATE(Micro Pile Foundation, Harrison Area)</th>
<th>GATE HEIGHTS(Feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>11</td>
</tr>
<tr>
<td>40</td>
<td>2</td>
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<thead>
<tr>
<th>GATE OPENING (Feet)</th>
<th>SWING GATE(Micro Pile Foundation, Harrison Area)</th>
<th>GATE HEIGHTS(Feet)</th>
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<tr>
<td>50</td>
<td>10</td>
<td>12</td>
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The structural design of the swing/roller gate includes the layout and design of the major structural elements of the concrete monolith structure and floodgate. This includes the gate steel members, the concrete gate bay walls and support columns, base slab and the pile foundations. The structural steel gate members include top and bottom girders spanning horizontally between concrete bay columns, vertical intercostal framing spaced at approximately 2 feet on center and spanning between top and bottom girders, steel skin plate spanning between the vertical intercostal, and steel cross bracing and horizontal bracing. The concrete monoliths are comprised of two concrete gate bay walls/columns on either side which are formed into the base slab and pile foundation. The concrete monoliths are supported by the pile foundations. Steel H-piles and concrete micro piles were applied during design for consistency with the floodwall team. It is assumed that each gate monolith structure will be flanked by the floodwall structures in the adjacent reaches. The floodgate drawings in Appendix B are preliminary in nature and not to be used for construction. The sections and views on the drawings are grouped as described above in table 1. Based on the gate width and heights, the design elements will vary in size, location and spacing accordingly.

The analysis of the steel gate and concrete monolith was performed based on the load cases noted in the introduction. The governing load case was typically the flood stage with water at the top of the gate. Loads were applied as hydrostatic pressures corresponding to the water surface elevations on the floodside. A debris impact uniform loading (500lbs/ft.) was applied at the appropriate water surface elevations. The skin plate was designed as a fixed end beam spanning between the vertical intercostals and the deflection was limited to 0.4 of the thickness to ensure that the flat plate theory is applicable. The horizontal girders were designed as larger wide flange simply supported beams spanning between the bearing points on the concrete columns making them true beam elements allowing for flexural stresses.
The vertical intercostals were designed as simple beams spanning between horizontal girders. The vertical intercostals consist of a WT section welded to the skin plate and were designed as a combined section utilizing the steel skin plate as the tension flange of the total combined section. The analysis of the reinforced concrete monolith walls and columns was performed considering fixed support at the interface of the bottom of the wall and top of slab. The wall analysis considered a 1 foot unit width of the wall acting as a cantilever and connected only to the base slab. The column analysis considered half of the gate width and width of the column loading on the column acting as a cantilever and connected only to the base slab. The entire analysis for the floodgate and concrete monolith was carried out by hand calculations for one gate width and height which than an excel spreadsheet program was developed to generated the analysis design for all chosen gate scenarios listed in table 1. The calculations are provided in Appendix C.

Opinions of probable cost (using unit prices from similar, recent projects) were developed based on the results of the analysis above. The cost estimate was broken down into four items corresponding to each individual gate width and height. The four cost items are the structural steel gate, concrete monolith structure, concrete reinforcing and pile foundation with a final total project cost. The cost breakdown for all listed scenarios is provided in table format in Appendix D. In addition, compiled cost curve graphs for each gate opening width based on total project cost versus gate height to gate opening width were developed and are shown below for each gate type.

Figure 1. Cost curve graph for swing gates

Figure 2. Cost curve graph for swing gates (micro pile, Harrison Area)
Figure 3. Cost curve graph for roller gates
The intent to these curves is to be able to achieve an approximate construction cost estimate based on the gate width opening for varying gate height to width ratio. Opinions of probable construction cost for each of the 64 gates in the inventory were developed from these cost curves and are reported in Appendix A. The closure gate costs, by reach, are reported in table 2.

Table 2. Summary of Closure Gate Costs By Project Reach

<table>
<thead>
<tr>
<th>Design Water Surface Elevation¹</th>
<th>Project Reach</th>
<th>Kearney</th>
<th>Newark</th>
<th>Harrison 1</th>
<th>Newark Flanking</th>
<th>TOTAL</th>
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<tbody>
<tr>
<td>14 ft (GDM)</td>
<td>$8,247,020</td>
<td>$4,023,917</td>
<td>$2,403,056</td>
<td>$1,558,707</td>
<td>$16,232,701</td>
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<td>16 ft (GDM + 2 ft)</td>
<td>$9,896,957</td>
<td>$5,402,250</td>
<td>$3,242,335</td>
<td>$2,108,385</td>
<td>$20,649,928</td>
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<tr>
<td>18 ft (GDM + 4 ft)</td>
<td>$11,556,451</td>
<td>$6,780,583</td>
<td>$3,956,389</td>
<td>$2,658,063</td>
<td>$24,951,486</td>
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¹ All elevations reference the NAVD 88 vertical datum.
Appendix A:
Passaic River-Final Closure Gate Inventory and Cost
<table>
<thead>
<tr>
<th>State No.</th>
<th>Material Reorder</th>
<th>GIS file description from GDM</th>
<th>Gate Type</th>
<th>Legal Height (ft)</th>
<th>Opening Width (ft)</th>
<th>Existing Height (ft)</th>
<th>Existing Gate (ft)</th>
<th>Compacted GDM Height (ft)</th>
<th>GDM Construction Cost</th>
<th>GDM Construction Cost (C)</th>
<th>GDM Construction Cost (G)</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Kearny 1 exercising 1/1/15-1/1/16</td>
<td>H/O for existing gate</td>
<td>GDM + 2 ft</td>
<td>7.1</td>
<td>30</td>
<td>H/O for 11/11/15</td>
<td>7.1</td>
<td>30</td>
<td>219,112</td>
<td>312,519</td>
<td>88,451</td>
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<tr>
<td>2</td>
<td>Kearny 1 1/11/15-1/1/16 exercising</td>
<td>H/O for existing gate</td>
<td>GDM + 2 ft</td>
<td>6.0</td>
<td>30</td>
<td>H/O for 11/11/15</td>
<td>6.0</td>
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<td>3</td>
<td>Kearny 2 exercising 1/1/15-1/1/16</td>
<td>H/O for existing gate</td>
<td>GDM + 2 ft</td>
<td>7.1</td>
<td>30</td>
<td>H/O for 11/11/15</td>
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<tr>
<td>4</td>
<td>Kearny 2 1/11/15-1/1/16 exercising</td>
<td>H/O for existing gate</td>
<td>GDM + 2 ft</td>
<td>6.0</td>
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<td>5</td>
<td>Kearny 3 exercising 1/1/15-1/1/16</td>
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<td>6</td>
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<td>Kearny 4 exercising 1/1/15-1/1/16</td>
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<tr>
<td>8</td>
<td>Kearny 4 1/11/15-1/1/16 exercising</td>
<td>H/O for existing gate</td>
<td>GDM + 2 ft</td>
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<td>30</td>
<td>H/O for 11/11/15</td>
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<td>9</td>
<td>Kearny 5 exercising 1/1/15-1/1/16</td>
<td>H/O for existing gate</td>
<td>GDM + 4 ft</td>
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<td>H/O for 11/11/15</td>
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<td>H/O for existing gate</td>
<td>GDM + 4 ft</td>
<td>8.0</td>
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<tr>
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<td>Kearny 6 exercising 1/1/15-1/1/16</td>
<td>H/O for existing gate</td>
<td>GDM + 4 ft</td>
<td>8.0</td>
<td>30</td>
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<td>H/O for existing gate</td>
<td>GDM + 4 ft</td>
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<td>H/O for 11/11/15</td>
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<td>GDM + 4 ft</td>
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<td>GDM + 4 ft</td>
<td>8.0</td>
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<td>H/O for 11/11/15</td>
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<td>Kearny 8 exercising 1/1/15-1/1/16</td>
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<td>GDM + 4 ft</td>
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<td>16</td>
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<td>GDM + 4 ft</td>
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</table>

**Notes:**
1. Data provided by GDM.
2. Reordered by GDM.
3. Taken from 1/27/90 GDM drawings.
4. Construction includes the following materials, exclusively: structural steel gate; concrete monolith structure; concrete reinforcing; pile foundation.
Appendix B: Typical Flood-Gate and Monolith Concrete Structure Drawings
1) WEST KEARNY AREA (H-PILE)

**Gate Monolith Plan**

- Flood Side
- Protected Side
- Vertical Seal
- Latch Device (Typ)
- Column Support
- C/L of Piles
- C/L of Rows
- C/L Expansion Joint
- Gate Track
- Gate Opening
- Gate Stop (Typ)
- Seal Plate
- Wall
- C/L GATE OPENING

**Gate Monolith Plan**

- Flood Side
- Protected Side
- C/L of COLUMNS
- C/L GATE OPENING
- Gate Stop (Typ)
- Winch Pedestal (Typ)
- Gate Track
- Seal Plate
- Vertical Seal (Typ)
- Gate Stop (Typ)
- C/L GATE OPENING

**Foundation and Pile Plan**

- Column
- C/L GATE OPENING
- L 6x6x3/8 (Typ)
- L 4x4x3/8 (Typ)
- 6" Stabilization Slab
- Flood Side Elevation

**Concrete Monolith Dimensions**

- Gate Opening Width (W) = 56"
- Pile Dimensions and Information
- Lift Dimensions (Typ)
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ROLLER GATE FLOOD SIDE ELEVATION

CLOSED POSITION

PROTECTED SIDE

W = GATE OPENING WIDTH

SECTION

SCALE: 1/2" = 1'-0"

NOTE: LATCHING DEVICES NOT SHOWN FOR CLARITY.
### EASTWELL OF KEARNY, NEWARK AND HARRISON AREA (H-PILE)

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<th>Gage Height (m)</th>
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### HARRISON AREA (MICROPILES)

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**NOTE:** All information is preliminary and subject to change. Refer to the official document for the most accurate data.