SOUTH FLORIDA WATER MANAGEMENT DISTRICT

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SPILLWAY REFURBISHMENTS S72, S75 AND S82

CORRECTED FINAL DESIGN REPORT

PROJECT NO. 100831

JANUARY 2014

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

SPILLWAY REFURBISHMENTS S72/S75/S82

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1.0 BACKGROUND

To support the continued operation of the Central and South Florida System, aging structures require maintenance and repairs. In 2011, during a major gate overhaul at S84, District staff noticed severe concrete deterioration and exposed rebar on the spillway walls and weir. Based on these observations refurbishments of this structure, as well as seven other structures (S68, S70, S71, S72, S75, S82 and S83) in the Indian Prairie Basin were recommended. Construction on these structures will be performed over fiscal years 2014, 2015 and 2016 as shown in **Figure 1**. Spillway refurbishment contracts will be grouped based on the canals on which they operate and to facilitate the District's ability to re-route flows to the adjacent canals while construction is taking place. The subject of this design report is the FY14 project schedule for the refurbishments of spillways S72, S75 and S82.

Figure 1. Indian Prairie Basin Spillway Refurbishment Project Schedule

Each structure has been inspected and deficiencies requiring repair have been identified. In general the repairs will include repair to spalled concrete, replacement of gates, recoating of wing walls, adding stainless steel plating at the weir crest and stainless steel angles along the corners of the gate recesses, installing new hand and guard rails, adding staff gauges/stilling wells and any other structure specific deficiencies identified. This work will be strictly repair and maintenance issues and will not change the performance, intent or operations of the original structures.

To complete these repairs the District will need to provide bypass pumping and alternative flow routing during the construction process which will impact the District's typical operations. To minimize these impacts to the surrounding community the District will make every attempt to maintain flows and levels in the canals consistent with typical operating protocol. All work will be performed during the dry season to limit by-pass pumping requirements as much as possible.

1.1 OBJECTIVE

The objective of this project is to refurbish spillways S72, S75 and S82 in order to extend the useful service life of these structures. Aerial photos of each structure are shown in **Figures 2 - 4**. Construction for this project is planned to begin in October 2014 and run through the dry season with a planned substantial completion date for May 2015.

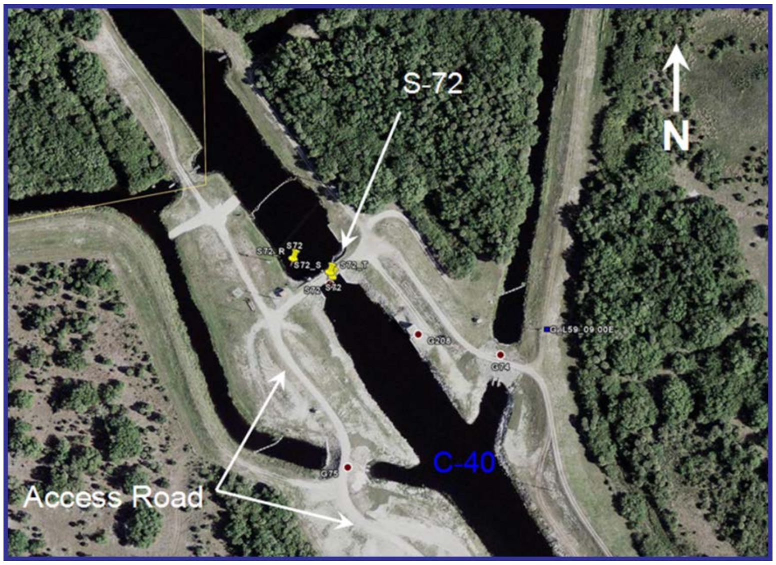

Figure 2. Aerial photo of S72

Figure 3. Aerial photo of S75

Figure 4. Aerial photo of S82

1.2 SCOPE OF WORK

The general scope of work for the proposed improvements includes but may not be limited to the following tasks by the construction contractor:

- Drive temporary steel sheet pile cofferdam to allow dewatering of the structure. For the S72 structure a phased dewatering (i.e. maintain operational functionality to one bay at all times) will be required.
- The removal of 3 inches of surface concrete from the bay walls and bottom slab (including

ogee weir) to the limits shown, the anchoring of wire mesh to the exposed surface area, and the application of 3 inches of self-consolidating concrete (SCC) with a crystalline concrete waterproofing (CCW) admixture.

- Repair the existing operating platform and bay walls that have spalled and/or pitted concrete surfaces.
- Perform lead paint abatement, sandblast and recoat all steel sheet pile wing walls, from the ground elevation to the pile cap elevation. Replace pile caps with new coated pile caps.
- Install 1/8 inch stainless steel plate along the weir crest as shown on the plans.
- Remove and replace existing roller gate and rail system in its entirety with stainless steel (Type 304). All bolts and fasteners shall by Type 316 stainless steel. Remove and replace existing hoist cable.
- Furnish and install new staff gauges downstream and upstream of the structure.
- Armor the gate recesses with stainless steel plates and stainless steel channels. All needle beam grooves will be armored with stainless steel angles and plates.
- Recoating of the concrete superstructures at the limits shown.
- Remove and replace existing stilling wells with in-channel stilling wells supported on concrete piles.
- Remove and replace standard railings and guardrails on the bridge decks. Recoat railings on the operating platforms.
- Provide a temporary pumped bypass at S82 to provide water supply during the dry season.
- Develop and implement Stormwater Pollution Prevention Plans. Notify Florida Department of Environmental Protection (FDEP) on intent to use Generic National Pollutant Discharge Elimination System (NPDES) Permit.

In addition to the scope of work noted above the District is currently evaluating extending riprap to the structures based on bathymetric surveys and modeling. If improvements are identified during this effort than riprap improvements will be added via addendum.

2.0 PROJECT APPROACH

The project approach is to provide South Florida Water Management District (SFWMD) the necessary repairs to the structure in order to allow for the successful operation of the Central and South Florida Flood Control System. Specifications will be the main vehicle for communicating requirements to the bidding contractors with drawings supplementing them.

2.1 APPLICABLE DESIGN GUIDELINES AND STANDARDS

Development of the design for the structure repairs includes the following guidelines and standards: South Florida Water Management District Engineering Design Guidelines (i.e., District Standard Details, Technical Specifications, AutoCAD Standards, and District Operation and Maintenance (O&M)

Guidelines) (latest edition, including updates)

- South Florida Water Management District Engineering Design Criteria Memorandums (DCMs)
- South Florida Water Management District Engineering Submittal Requirements (latest edition, including updates).
- United States Army Corps of Engineers (USACE) Standards
- Florida Department of Environmental Protection Requirements
- Florida Department of Environmental Protection Requirements
- Florida Department of Transportation Design Standards for Design, Construction, Maintenance and Utility Operations on the State Highway System (latest edition, including updates)
- Florida Department of Transportation Standard Specifications for Road and Bridge Construction (latest edition, including updates)

2.2 DEVIATIONS TO APPLICABLE DESIGN GUIDELINES AND STANDARDS

The District Engineering Submittal Requirements call for all plans, reports, calculations, etc. to be in NAVD 88; however, the elevations referenced in the original record drawings for the structure were expressed in NGVD 29. To avoid any confusion during the design and construction of the project, it was determined by both the District and Project Team to reference all elevations for the structure repairs in NGVD 29 on all plans, reports, calculations, etc.

If any additional deviations to the applicable design guidelines and standards are to develop within the future for this project, they will be documented accordingly within this section of the design report.

2.3 SPECIAL COORDINATION ISSUES

Special coordination issues for the structure repairs include the following:

- Spillway refurbishment contracts will be grouped based on the canals on which they operate and to facilitate the District’s ability to re-route flows to the adjacent canals while construction is taking place. Special coordination with the District’s Water Control Operations group has been performed and a bypass pump and flow diversion plan was created. This plan is summarized in Section 5 of this report.
- Water supply to stakeholders in the affected area will be supplied, in part, through contractor required by pass pumping operations. The contractor will be required to coordinate with the District, via the District’s project manager, to provide water supply at the District requested capacity and times.
- The downstream side of S75 and S72 is subject to manatee visits; therefore, monitoring for manatee activities during construction shall be implemented. As such, the Contractor shall avoid any injury or harassment to the manatees. The District has a specification that lists requirements with regard to avoiding and protecting manatees.

- During prior construction activities downstream of S72 an oil sheen was discovered and investigated. The results found no contamination above the target contamination levels. However, as a precaution, the District will provide mandatory inspections by District staff during the cofferdam installation and dewatering effort to monitor for contamination.

Please note the District owns the underlying project lands; therefore, no additional lands are required for the project. The structure repairs do not impact or alter any right-of-way permits. No utilities are involved with the project or require modification. There is no public use issues associated with the structures.

2.4 BASIS OF DESIGN

While each of the items listed in the original scope of work was descriptive of the work to be performed, the Project Team still performed their own investigations in order to determine if the course of action was the preeminent repair option. Listed below are some key points from the Project Team's investigation of finalizing the repair design for the structure. The results of the investigation are based on sound engineering principles, provide value to the project, and meet the overall project goal of extending the useful service life of the structure.

- The original project scope called for the limits of the concrete removal to be from the base of the structure up to approximately 1 to 2 feet above the upstream and downstream high water elevations. Field visits have confirmed that the eroded concrete does not need to be repaired this high.
- The need for extending and repairing riprap at each structure was coordinated between Water Control Operations, Hydro-data Management and the Design group. Because of the single bay dewatering at S72 as well as the possible need to divert flows through the C-40 canal during the FY16 spillway refurbishments (S70 and S71) it was decided to assess the need to provide additional riprap at the structure to increase the Maximum Allowable Gate Openings (MAGO) at the S72 and S75 structures. Hydro-data management performed bathymetry studies and developed at computational fluid dynamic (CFD) model to determine if stream velocities were likely to exceed scouring velocities. This analysis is still being performed, along with a survey of riprap extents at all three structures. If a determination is made that additional riprap is advantageous to the project the design will be provided as an addendum to the contract.
- Enhanced repair materials were explored for use in the repair design for the structure. In October 2012 a draft technical memorandum (see Attachment 1) on the concrete deterioration and repairs the findings indicate that durability of the concrete is inversely proportional to its permeability. Hence, the use of self-consolidating

concrete, supplementary cementing materials, permeability reducing admixtures, and low water-cement ratio (<0.45) are recommended. The supplementary cementing materials are silica fume and fly ash, and the permeability reducing admixtures are the crystalline waterproofing materials. In a recent report by the USACE, it recommended for the use of granite aggregate and silica fume. In this concrete repair project, the design will require the use of self-consolidating concrete, granite aggregate, silica fume, crystalline concrete waterproofing and reduced water-cement ration of less than 0.45.

- Concrete deterioration was observed at both ends of the concrete bridge deck that was likely caused by vehicle traffic. The design will include the repair of the concrete edges and construction of an approach slab.

- The original project scope called for the replacement of all standard railings located throughout the structure. Railings at S72 and S75 along the bridge deck had angled railings to provide additional clearance for traffic along the bridge. These angled railings are to be replaced in kind at S72 and S75, and new angled railings are to be provided at S82. All railings on the operator platforms will be removed and replaced.

- The Project Team looked into alternative materials for the concrete replacement. A technical report was prepared by District staff to evaluate the existing conditions of the concrete as well as recommend a concrete mix design. The technical report recommended using cast-in-place SCC with a CCW admixture. This recommendation will be used for all three spillways.

- The Project Team looked into potentially repairing the structure walls and bottom slab with a 3-inch overbuild. At an additional cost, the 3-inch overbuild would provide extra concrete cover for added protection over the proposed reinforcing. However, there is a possibility that the extra 3-inch cover over the reinforcing might reduce the ability of the reinforcing to hold together surface cracking. Standard cover for reinforcing exposed to weather is 2 inches. As cover increases, the potential for crack width also increases. This could potentially result in future cracking of the structure, which in turn would not justify the additional cost of the overbuild. Therefore, it was ultimately decided to repair the structure walls and bottom slab to the existing structure outlines. In addition, District Operations requested the repairs be made to the outline of the existing structure so as not to impact the hydraulics of the structure.

- Stainless steel gates replace the existing carbon steel gates to increase the life of the gates.

- The Okeechobee Field Station had initially requested the design of a staging area to support the cranes used in the gate removal process. During the design of these staging areas it was discovered that the retaining walls of the spillways were not designed to handle surcharge loads and therefore could not support the weight of the cranes. The staging areas are not included in the design.

- The most recent available Structural Integrity Reports were reviewed and discussed with field station staff to help determine the scope of the repairs at each structure.

3.0 PERMITTING REQUIREMENTS

The structure refurbishments will require the review and approval of permits at both the federal and state level. The federal and state permits required for the proposed repair work are as follows:

- Noticed General Environmental Resource Permit to Water Management Districts to Conduct Minor Activities (Issued by FDEP)
- Nationwide General Permit 3 (NWP3) (Issued by USACE)
- 408 Determination (Determined by USACE)

The District has assumed the lead role in preparing and submitting the required documents for the above listed permits. The above listed permits are dependent upon the results of agency consultation and the potential requirement of a field survey, if determined necessary by the review agency.

The Contractor is responsible for obtaining all required local permits. In addition, the Contractor shall obtain a *Notice of Intent (NOI) to Use Generic Permit for Stormwater Discharge from Large and Small Construction Activities* from FDEP prior to commencement of construction. In order for the stormwater discharge associated with construction activity to be authorized under the generic permit, the following items are necessary:

- Meet the eligibility requirements in Part I.B. of this permit
- Develop and implement a stormwater pollution prevention plan (SWPPP) in accordance with the requirements of Part V of this permit
- Submit a completed Notice of Intent (NOI) in accordance with the requirements of Part III of this permit, including submittal of the appropriate processing fee as established in paragraph 62-4.050(4)(d), F.A.C.

For activities that require removal of surface or ground water as part of construction, the Contractor shall obtain all required permits. If the Contractor intends to commence dewatering activities prior to a permit being issued, then the District shall submit a notification to the FDEP

Office of Ecosystem Projects (OEP). This will allow the Contractor to work under the conditions of a "No Notice" until the dewatering permit is issued. Please note all dewatering modifications are subject to review and approval by the Department before the modification is considered final and effective.

4.0 SEQUENCING OF CONSTRUCTION PACKAGES

An internal District meeting was held on May 11, 2012 with District Operations to determine the sequencing and bypass flow requirements for the structure repairs on the S68, S70, S71, S72, S75, S82, S83, and S84 structures. All eight structures are located within the Indian Prairie Basin and shown below in **Figure 5**.

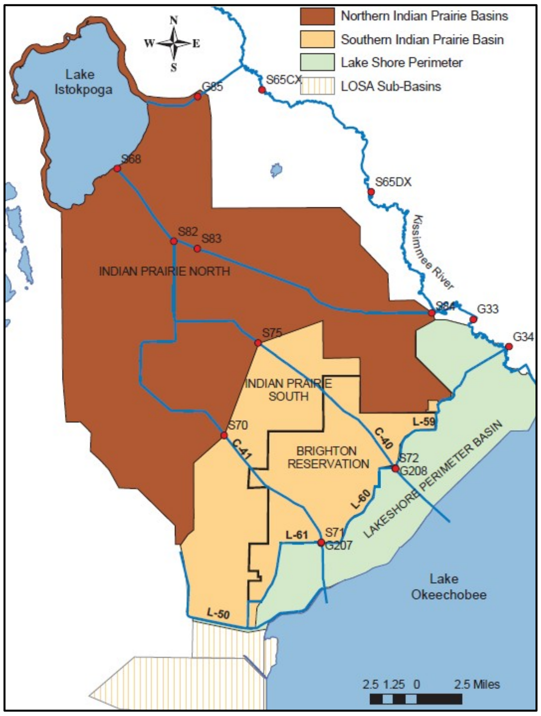

Figure 5. Indian Prairie Basin

The S70, S71, S75 and S84 structure refurbishment projects were originally designed by Carollo Engineers, Inc. while the S68, S72, S82, and S83 structure refurbishments will be designed by the District's Engineering Unit. After Carollo's final design was accepted the District repackaged the design for construction of the FY14 package for spillways S72, S75 and S82. As part of the repackaging effort the District completed the design of S82 and the updated the original S72 and S75 designs (gate design, concrete material and methods, stilling well detail, etc.). The contract documents have been repackaged to include one set of plans and specs for all three structures and the contract will be awarded to a single contractor. Pre-qualifications will be included in the advertisement to ensure the project is awarded to a contractor with the experience and manpower to complete all three structures in a single dry season. A preliminary construction schedule is provided in **Attachment 2.**

Similar efforts will be performed for design and contracting of the FY15 refurbishments (S68, S83 and S84) and the FY16 refurbishments (S70 and S71).

5.0 BYPASS PUMPING AND FLOW ROUTING

Coordination between the design and operational disciplines for this project has identified water supply and flow diversion needs during the construction period. **Figure 6** provides a schematic of the Indian Prairie Basin's structures and waterways that will be affected by this project as well as each structure's design capacity. S72, S75 and S82 will all be under construction simultaneously. S72 will require a phased dewatering with one of the spillway's two gates to remain fully operational at all times. S75 will be taken offline and S82 can be either phased dewatering or taken offline based on the contractor's option. Although the contract is intended to be performed only during the dry season, a contingency for construction into the wet season is identified as part of this plan.

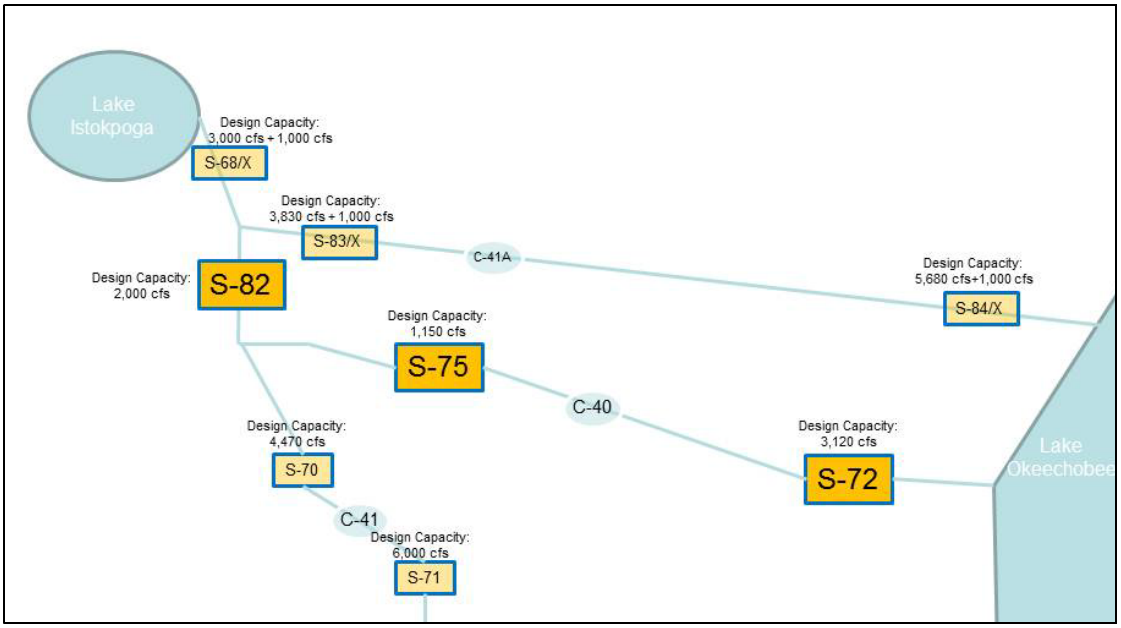

Figure 6. Schematic of Indian Prairie Basin structure and waterways

5.1 DRY SEASON BYPASS AND FLOW DIVERSION PLAN

Based on historical data it has been estimated that drainage requirements during the dry season from storm events can be diverted through C41A, C41 and the open gate at S72 up to a 1-in-5 year dry season storm event. If a storm event occurs in excess of the capacity to divert or reroute the flows then sheet piles may have to be pulled and flow allowed through the structure. This would stop work and would likely damage work in progress. The Contractor might be entitled to a claim in this event.

Figure 7 illustrates the dry season water supply plan during construction. Typically, water supply is provided to the basin from flow through the S82 spillway and the G208 pump station (which delivers water from Lake Okeechobee to the C40 canal upstream of S72). Hours of pumping for water supply for the portion of the basin downstream of S82 and upstream of S75 were estimated by Water Control Operations and summarized in **Table 1**.

Table 1. S82 Pumping Hours Water Supply Requirements

Median Dry Season Water Supply Volume	4,388 ac ft
Bypass Pump Capacity Required	300 cfs
Calculated Pump Run-Time	177 hours
Contract Pump Run-Time Requirement*	200 hours
Required Dates Bypass Must Be Operable	Nov 1 thru substantial completion

* Contract run-time requirement was increased from the calculated value to provide a round number estimate. This increase is well below the variability observed in the data.

The Contractor's responsibility shall be defined in the contract documents to provide water supply capacity of 300 cfs for 200 hours of operations. Should water supply needs exceed the contractual requirements the District will assume the costs for additional pumping. The District will assume responsibility for all required water supply between S75 and S72. The G208 pump station has a capacity of 135 cfs and will remain operational throughout construction for water supply. The District will provide any additional capacity if needed at the District's expense.

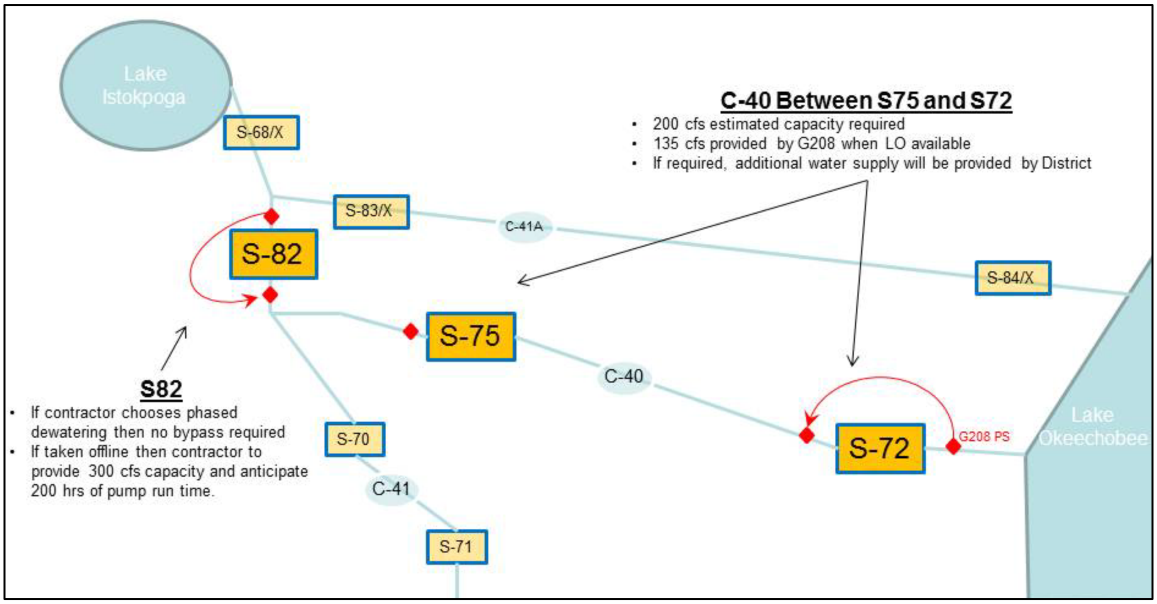

Figure 7. Dry Season Water Supply Plan

5.2 WET SEASON DRAINAGE CONTINGENCY PLAN

Contract time will terminate on May 1, however, a contingency plan for wet season drainage is presented herein. Wet season flows for the 1-in-5 year storm event were estimated by Water Control Operations and presented in **Figure 8**.

The wet season drainage plan will rely largely on diverting flow through the C-41 and the C-41A canals and attenuating large flows in Lake Istokpoga as opposed to bypass pumping. Lake Istokpoga will be kept slightly below its regulation schedule to provide additional detention storage. Spillway structures east of S82 (S83, S83X, S84 and S84X along the C-41A canal) could provide additional capacity to relieve a portion of the wet season required flows. Bypass pumps for water supply at S82 will be required to remain in place for additional drainage capacity. Flows downstream of S82 and upstream of S75 will be diverted through the C41 canal. For flows downstream of S75 the District performed computational flow dynamics (CFD) modeling which identified a capacity of 1,200 cfs that can be safely passed through one bay for a short term (storm event duration) without causing significant scouring. If bathymetric surveys indicate erosion problem downstream of the structures, additional canal and revetment improvements may be included in the contract to control the scour problem. Extending the rip-rap protection area beyond the original design will further increase the flow capacity of the structures, which will aid bypass operations for future projects when structures in the C-41 canal undergo refurbishment. The difference between the design storm event (1,500 cfs) and the single-bay capacity at S72 (1,200 cfs) will be handled through the liquidated damages assessed to the contractor.

The probability of meeting or exceeding the flows calculated for the 1-in-5 storm event increases as construction moves further into the wet season. Water storage capacity in soils, canals and Lake Istokpoga will diminish as the wet weather season progresses. This leads to increased frequency of high flows and increased probability of exceeding design storm flows during the peak wet season months. This creates a situation where the risks associated with contract delays increase with the length of the delay. In recognition of this situation the contract will establish a tiered liquidated damage amount which will be lower in May and increase in June. Should flows exceed an amount that can feasibly be bypassed then flooding the construction site will be required to pass flow and the contractor will assume the costs for delays and damages. Tier 1 liquidated damages for this project will be $10,000/day between May 1 and May 31 and $/day after May 31. Tier 2 liquidated damages will be $20,000/day. These costs were calculated based on documentation provided in **Attachment 3**.

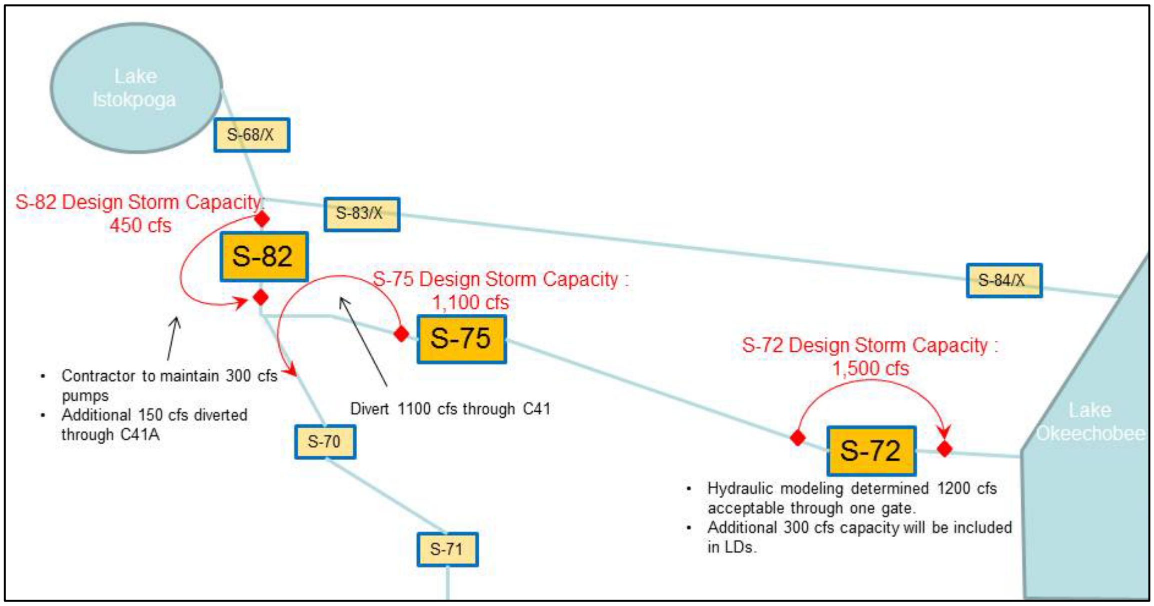

Figure 8. Wet Season Flow Routing and Bypass Pumping Plan

6.0 CONSTRUCTABILITY REVIEW SUMMARY

This project involves rehabilitation work on an existing operating facility. The rehabilitation work consists of a number of issues, including the following: weather, manatees, turbidity reduction, possible petroleum contamination and dewatering of construction areas. The rehabilitation work and the issues associated with the work are described in detail below.

6.1 WEATHER

The rehabilitation work for these spillways will be heavily dependent on the weather. While scheduling work during the dry season is expected, the weather and schedule cannot be guaranteed. If an extremely large storm event occurs or construction is delayed, it is possible that the bypass operations might not be adequate. This situation has been discussed in Section 5, Bypass Pumping and Flow Routing. Wet weather could also potentially cause problems to the unpaved road that provides access.

6.2 MANATEES

The downstream side of S72 and S75 is subject to manatee visits. As such, the Contractor shall avoid any injury or harassment to the manatees. The District has a specification that lists requirements with regard to avoiding and protecting manatees. In this specification, it states that if a manatee comes within 50 feet of a work area, all work shall stop until the manatee moves away. There are also guidelines for boats operating near the manatees.

6.3 TURBIDITY REDUCTION

Turbidity controls shall be maintained around the work area such that all turbidity generated during construction activities is confined within the work area. Effective means of turbidity control is necessary within C-40 and will be accomplished by the use of floating turbidity curtains. A double layer will be required in the event one of the curtains requires repair. Silt fencing will be required for areas up gradient of the canal to prevent siltation from accumulating within the riprap adjacent to C-40. All turbidity control devices and/or preventative operation procedures shall remain in place until all turbidity has subsided and the turbidity level at the construction zone meets state standards.

The Contractor shall conduct all construction activities in accordance with the water quality conditions as set forth within the permits. The Contractor shall maintain turbidity monitoring equipment and trained personnel during all construction activities that could potentially result in project-generated turbidity levels being discharged beyond the work area and into the receiving water body. Turbidity levels shall not exceed 29 NTUs above background in Class III receiving waters.

A further location for excessive turbidity is where the water supply or bypass pumps will be discharging. The Contractor for the will be required to still pump discharges and dissipate the energy such that scouring of the downstream canal sides and bottom is prevented.

6.4 POSSIBLE PETROLEUM CONTAMINATION AT S72

During construction activities in the dry season of 2010 an oil sheen was observed while driving a pile on the downstream side of the structure. URS was contracted to provide an environmental assessment of the area. URS dug several test pits and sampled for environmental contaminants. No contaminants were discovered above the target clean-up levels the report suggested that the impacts were from old, degraded petroleum and of limited aerial extent. URS recommended that no further assessment or corrective actions are warranted but could be if additional impacted material is encountered.

Due to these events the District will require inspections provided by District staff during the cofferdam and dewatering activities on the site. Should these inspections reveal any additionally impacted material the District will conduct environmental assessments and remediation as required to ensure environmental integrity of the construction activities.

6.5 DEWATERING CONSTRUCTION AREAS

Dewatering of construction areas will be accomplished by the installation of sheet piles both upstream and downstream of the gate structure. The area between the sheet piles will be dewatered and the flow will be discharged to the upstream side of the structure into appropriate turbidity barriers. This will prevent any turbidity generated by the operation from immediately flowing downstream and should keep it confined to the area adjacent to the structure. It is anticipated that the Contractor will be either required to provide a sump to pump out accumulated groundwater or, based upon their geotechnical evaluation, well points between the sheet piles and the structure to maintain a dry working surface.

For activities that require removal of surface or ground water as part of construction, the Contractor shall obtain all required permits. If the Contractor intends to commence dewatering activities prior to a permit being issued, then the District shall submit a notification to the Florida Department of Environmental Protection (FDEP) Office of Ecosystem Projects (OEP). This will allow the Contractor to work under the conditions of a "No Notice" until the dewatering permit is issued. Please note all dewatering modifications are subject to review and approval by the Department before the modification is considered final and effective.

After dewatering of the construction area, the work to refurbish the structure, installation of standard railings, replacement of staff gauges, and replacement of the gates may be accomplished under normal construction conditions. All workers in the dewatered area should wear life preservers, at least until the site is stabilized. Safety issues may dictate that life preservers or other emergency egress methods be enforced throughout this stage of the work.

When the work is completed and the District has accepted the work, the dewatered area shall be refilled as follows:

1. The bypass pumps shall remain in service.
2. The structure gate shall remain closed.
3. A portion of the upstream sheet pile shall be removed.
4. The energy of the water in the upstream area shall be allowed to dissipate.
5. The remainder of the upstream sheet pile may be removed.
6. A portion of the downstream sheet pile shall be removed.
7. The gate shall be opened slowly and the water shall be allowed to still.
8. The remainder of the downstream sheet pile may be removed.
9. The gates shall be placed under remote control.
10. The bypass pumps and piping may be removed from service.
11. The turbidity barriers shall remain in service until the District determines that the turbidity within the canal is acceptable.

Phased dewatering will be required at the S72 structure and optional at the S82 structure. Phased dewatering will be performed by installation of a cofferdam that will dewater only one bay of the structure while leaving the other bay fully operational. Phased dewatering will the contractor the bypass dry weather storm flows through the open bay of the spillway without the use of bypass pumps. The District has provided the design of the cofferdam for the phased dewatering at S72 in the plans.

6.6 REHABILITATION OF STRUCTURE

The rehabilitation of the concrete structure has many unknowns. The limits of the repairs were conservatively estimated, yet some adjustment of the limits might be required, either more or less repairs. The concrete that shows visible damage might be more sound than expected, making demolition difficult. It might be required to do field modifications to the design to avoid removing sound concrete. Alternatively, the opposite might be the case and the concrete damage might extend into the structure more deeply than the design indicates, meaning more material and effort for the Contractor.

Figure 9. Sulfate Attack on Concrete

Another aspect of the concrete repair is the condition of the existing reinforcing. It is possible that aside from surface corrosion, the reinforcing is acceptable. It is also possible that once the exterior concrete is removed, the reinforcing is damaged worse than expected. If that is the case, the District will have to determine whether or not the damage requires repair.

Part of the rehabilitation involves “armor-plating” the ogee weir. While the existing shape will be required to be matched, there is a slight possibility that its function will change slightly. Extensive surveying should be required to make sure that the new weir shape matches the design.

The sheet pile wing walls and their caps need to be repainted. In the era that the structure was built, heavily leaded paint was normally used. The District has lead abatement guidelines. Workers need to be adequately trained and protected from inhaling lead particles. The work area must be tented and ventilated. Lead particles and fumes containing lead must be properly contained. Lead containing waste must be disposed of properly. All these procedures increase complexity, schedule, and cost.

Figure 10. Wing Wall Corrosion

The gate replacement has unique issues. While suppliers have assured the design team that stainless steel channels are available, they might be rolled overseas, creating a long lead-time. This will have to be factored into the schedule. Alternatively, the District can order and procure the long lead-time material and provide it to the gate supplier. As the gates are mechanical items, there is always a risk that fit-up and function might be a problem. Extensive testing will be required until the District is satisfied with the gate's operation. The seals are being replaced, so leakage might be more than expected.

Finally, the needle beam grooves are being rehabilitated. New stainless plates, seats and angles are being installed. The District should require that the existing needle beams and bulkheads be tested with this new hardware prior to final completion.

Figure 11. Steel Corrosion

All materials provided by the Contractor shall be in accordance with the District's Standard Specifications and Standard Construction Drawings.

6.7 RESTORATION OF AREAS

Restoration of areas subject to erosion shall be accomplished by the Contractor. The Contractor shall be required to prevent siltation of the canal during the efforts. Existing riprap in the area for restoration shall be removed; compacted backfill shall be placed to restore eroded areas; and, new geotextile fabric and bedding stone shall be placed. Eighteen inches of riprap shall be placed over the bedding stone.

Areas for restoration without existing riprap shall be repaired with compacted backfill and sodded.

Areas for restoration have been identified on the Drawings; however, the District may determine other areas during the construction activity for additional work.

The Contractor shall restore areas where materials were staged and parking areas to a pre-construction or better level. These disturbed areas shall be sodded.

Attachment 1

Technical Memorandum

Concrete Deterioration and Repairs

MEMORANDUM

TO: Greg Cantelo, P.E., Section Administrator - Engineering Design, Engineering & Construction Bureau

FROM: Jose Guardiario, P.G., P.E., Principal Engineer, Engineering Design, Engineering & Construction Bureau

DATE: October 10, 2012

SUBJECT: Concrete Deterioration and Repairs

Since the early 2000s, several 50-year old water control structures and navigational locks with deteriorated concrete surfaces have been repaired by the South Florida Water Management District (District). The repairs included removal of two to three inches of deteriorated concrete by hydroblasting, installation of welded wire mesh and application of shotcrete, a mixture of Portland Type II MS cement and sand mix, over the prepared surface.

In April 2012, dewatering operations (Figure 1) during the construction work to modify the Nubbin Slough Stormwater Treat Area (STA) Intake Bay exposed pitted concrete surfaces on Pump Station S-385 and the adjoining concrete weir which were constructed in 2007. The early deterioration of the concrete surfaces of a 5-year old concrete structure raised concerns on the type of reaction that caused pitting. In response to this discovery, a site visit was conducted on May 24, 2012 with Shawn Gao, Rob Baskin, Roy Sapp, and Joe Albers.

This investigation included review of various technical papers that pertain to deterioration and repair of concrete, and reports on petrographic examinations and field inspections of various District concrete water control structures.

FINDINGS

1. The extent of concrete deterioration at the Nubbin Slough STA Pump Station S-385 and the adjoining concrete weir varies with depth of water, as shown in Figure 2. Concrete pitting is more pronounced on areas subject to water fluctuations. Furthermore, pitting is more severe at the weir compared to that at the pump intake bay. Concrete surfaces on areas constantly submerged (i.e., below +15.0 ft NGVD29) show minimal amount of concrete pitting (Figure 3).

   Closer examination of the concrete surfaces reveals that the cement matrix is dissolved exposing the fine silica sand aggregate. The coarse limestone aggregates near the concrete surface are also dissolved thus rendering a pitted surface as shown in Figure 4.

   Scraping the concrete surface with a masonry hammer showed delamination of a thin veneer of deteriorated concrete and exposed a hard, dense concrete surface (Figure 5).

During the field inspection, it was observed that the limestone riprap downstream of the weir also exhibited smooth surfaces (Figure 6) which may be due to chemical attack by acidic waters.

2. Field inspections on older water control structures, such as Spillway Structures S-63A, and S-72, and Navigational Locks S65D, S65A, and S65 reveal that concrete pitting extends from the maximum water elevation down to the surface of the base slab.

   Review of photographs from various inspection reports[1] and site visits during the repairs of the concrete structures (Figure 7) indicate the pits on the concrete surface were remnants of the dissolved coarse limestone aggregates.

   Photographs from a July 2007 underwater inspection report by Malcolm Pirnie on S-72 indicate that the degree of concrete deterioration diminishes at deeper depths of the structure[2] (Figure 8).

3. In 2005, the District Operations and Maintenance staff repaired the deteriorated concrete surface of the S-65A Spillway Structure. Repairs included pressure cleaning of the concrete surface and application of a dry shotcrete mix. However, a few years after the repair, the applied shotcrete was found to be delaminating.

   Petrographic examination by CTL Group on concrete cores that were obtained by Dunkelberger Engineering and Testing in 2008 indicates that both the concrete substrate underlain by the shotcrete and the shotcrete surface exhibit carbonation.[3] The cementatious paste in both the concrete substrate and shotcrete do not exhibit deposit, paste alteration, or crack pattern that are typically associated with external or internal sulfate attack.[4] The shotcrete matrix is locally weak and crumbly in regions where it exhibits high sand and void volumes and low paste content.[5]

4. In October 2009, a few months after the concrete repair on the S-63A Spillway Structure was completed, an underwater video survey showed apparent deterioration of the newly repaired concrete. In response to this discovery, the structure was dewatered and inspected. A report by Ardaman and Associates, Inc. attribute the shotcrete surface deficiencies to the quality of workmanship in shotcrete application.[6]

   There were no shrinkage cracks, poor strength and delamination in the concrete surface. Water quality analyses of samples taken from the canal indicate a pH of 6. Although the

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[1] Malcolm Pirnie, Inc., *Chapter 2-20, Structure Inspection Program, Final Inspection Report for Structure S-72*, July 19, 2007; CTL Group, *Petrographic Examination of Concrete Cores from Water Control Structure, S-65A, Polk County, Florida*, April 16, 2008.

[2] Malcolm Pirnie, *Chapter 2-20, Structure Inspection Program, Final Inspection Report for Structure S-7*.

[3] CTL Group, *Petrographic Examination of Concrete Cores from Water Control Structure, S-65A*, 2.

[4] CTL Group, *Petrographic Examination of Concrete Cores from Water Control Structure, S-65A*, 3.

[5] CTL Group, *Petrographic Examination of Concrete Cores from Water Control Structure, S-65A*, 2.

[6] Ardaman & Associates, Inc., *Repairs to SFWMD Structure S-63A, Kissimmee, Florida*, October 2009.

Langelier Saturation Index (LSI) indicates corrosive water, there were no deficiencies attributed to the water quality.[7]

5. In August to October 2010, i.e., during the concrete repairs of Navigational Locks S-65, S-65A, S-65D and S-61, multiple site visits where conducted to verify the conditions of the hydroblasted concrete surface prior to installation of shotcrete. The results indicate that the concrete surface preparation using mechanically-operated hydroblasting equipment, with 15,000 to 45,000 pounds per square inch pressure, resulted to highly irregular surface with amplitudes greater than 2 inches[8] as shown on Figures 9 and 10. In certain areas, the fine grained concrete matrix has been removed by as much as 2 inches deep while the width is narrow which may result of inadequate filling of the voids.[9]

   One of the recommendations was to specify that the concrete repair surface shall have an adequate surface roughness determined as three peak-to-valley measurements of 5 mm within 150 mm, in accordance with AASHTO-AGC-ARTBA Joint Committee Task Force 37 Report, Guide Specifications for Shotcrete Repair of Highway Bridges, February 1998.[10]

6. Review of the tensile bond strength (pull-off) tests on the cores drilled into the concrete substrate with shotcrete overlay at S-61 and S-65A indicate that the tensile bond varies from 0 psi to 271 psi (Table 1) which is less than the 300 psi requirement specified in the specifications.

7. Review of the visual grading of the shotcrete cores obtained from S-59, S-62 and S-65A, as tabulated in Table 2, indicate a grade varying from Grade 1 to Grade 3. Figures 11 through 13 show voids in the shotcrete cores from various concrete repair projects. The voids vary from 1/16” to 5/8” in dimension.

8. In January 2012, in response to reports that Navigational Locks S-65 and S-65A have cracks and water flowing through them, a field investigation was done inside these locks. Multiple cracks were observed ranging from hairline cracks to crack as wide as 1/8-inch wide (Figures 14 and 15). Although acoustical testing revealed no conclusive indication of voids or delamination, the thick shotcrete layer applied after deep hydroblasting,[11] may have prevented detection of voids.[12]

9. In July 2012, a site visit was conducted on the on-going S-193 Navigational Lock concrete repair. Field observations indicate that there is a significant difference between two cast-in-place concrete surfaces as shown in Figure 16. The 1935 concrete surface

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[7] Ardaman & Associates, Inc., *Repairs to SFWMD Structure S-63A*.

[8] South Florida Water Management District, *Memorandum on S-65A Concrete Repair*, August 13, 2010; South Florida Water Management District, *Memorandum on S-65A and S-65A and S-61 Repair Core Sampling and Layout*, October 8, 2010.

[9] SFWMD, *Memorandum on S-65A Concrete Repair*.

[10] SFWMD, *Memorandum on S-65A Concrete Repair*.

[11] SFWMD, *Memorandum on S-65A Concrete Repair;* SFWMD, *Memorandum on S-65A and S-65A and S-61 Repair Core Sampling and Layout*.

[12] South Florida Water Management District, *Memorandum on S-65 and S-65A Concrete Repair Cracks*, February 14, 2012

where the coarse aggregates consist of shell fragments show the fragments protruding from the cement matrix while the 1970 concrete surface where the coarse aggregates consist of limestone fragments show a pitted surface where the limestone fragments are dissolved.

Further observations indicate that the some surfaces of the 1970 concrete showed delamination of the deteriorated concrete when scraped with a masonry hammer (Figure 17).

DISCUSSION

Concrete Deterioration

Field observations of existing District water control structures indicate deterioration and pitting of the concrete surfaces occurring from the maximum water elevation and extending down to the surface of the base slab, with the intensity of concrete deterioration decreasing with depth (Figures 2 and 3). Based on these observations, it is certain that the cause of concrete deterioration is water-borne and is related to water quality.

The observed concrete deterioration involves dissolution of the cement matrix and the near-surface large limestone aggregates, thus exposing the fine silica sand aggregates and producing pitted surfaces, respectively (Figure 4). Flaking of a thin veneer of deteriorated concrete (Figures 5 and 12) occurred when the concrete surface was scraped with a masonry hammer at the Nubbin Slough STA Pump Station S-385 and the Navigational Lock S-193.

At Navigational Lock S-193, two types of deteriorated concrete surfaces were noted (Figure 13), wherein, the 1935 concrete surface exhibited shell fragments protruding above a dissolved concrete matrix while the 1970 concrete surface exhibited dissolved limestone aggregate pits. The protrusion of the shell fragments above the dissolved concrete matrix is a manifestation of dense, low-permeability shell fragments compared to the highly permeable coarse limestone aggregates which is prone to chemical attack compared to the cement matrix.

Petrographic examinations of the concrete cores from S-65A indicate that the shotcrete surfaces exhibit carbonation. One core showed carbonation at the interface of the concrete substrate and shotcrete[13] which indicates that pressure cleaning of the concrete surface was insufficient in removing the deteriorated concrete substrate. The findings indicate that there were no evidences of internal or external sulfate attack, such as deposits and cracking. The deposits associated with sulfate attack are the formation of ettringite which results in cracking and spalling of concrete.[14]

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[13] CTL Group, *Petrographic Examination of Concrete Cores from Water Control Structure, S-65A.*

[14] Mario Collepardi, *Ettringite Formation and Sulfate Attack on Concrete*, International Concrete Research & Information, June 1, 2001

The carbonation on the S-65A shotcrete surface three years after it was placed is indicative of the aggressiveness of the water. This aggressiveness of water was also observed in the early deterioration of the 5-year old Nubbin Slough STA Pump Station S-385 cast-in-place concrete.

External chemical attack on concrete occurs mainly through the action of aggressive ions, such as chlorides, sulfates, or of carbon dioxide and many other natural or industrial liquids and gases.[15] At ambient temperature the rate of chemical attack varies[16] as shown in Table 3.

Statistical analysis of the water quality from selected water control structures (Table 4) indicate that the mean pH (Table 5) varies from 6.39 at TCNS 228 in Nubbin Slough to 7.50 at the S-5A Pump Station, with pH values dropping as low as 5.60 at S-65D Spillway Structure. The low pH values at water control structures S193, S65, S65A, S65D, and Pump Station S385, which are located around and north of Lake Okeechobee has a good correlation with the deterioration of concrete surfaces. Pump Station S-5A, which is located southeast of Lake Okeechobee, does not exhibit any deterioration of the concrete surface. The mean pH value at S-5A is 7.50.

The observed concrete deterioration of District water control structures is supported by various literatures which indicate concrete can be attacked by liquids with pH below 6.5 with the severity increasing as the pH drops below 5.5.[17] ACI 201-2R_01, ACI 815.1R and A.M. Neville list the various acids that cause severe attack on concrete.

Concrete Durability

The durability of concrete structures is of prime importance in allowing continued performance of its intended function, i.e., maintaining its required strength and serviceability during its expected service life by withstanding deterioration.[18] The deterioration of concrete is caused by external and internal factors whether it is physical, mechanical, or chemical.

With the exception of mechanical damage, adverse impacts to the durability of concrete involve transport of fluids through the concrete. The three fluids principally relevant to the durability of concrete are water, carbon dioxide and oxygen. The transport of these fluids depends primarily on the ease these move into and through the concrete, which is the permeability of concrete.[19]

Aside from permeability, which refers to flow under a pressure differential, the movement of fluid through concrete is also through diffusion, i.e., movement under a differential in concentration, and sorption, i.e., through capillary movement.[20,21] Both diffusivity and capillary

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[15] A. M. Neville, *Properties of Concrete*, (New York: John Wiley & Sons, Inc. 4th Edition), 483.

[16] ACI 201.2R-01 Guide to Durable Concrete, Reported by ACI Committee 201, effective September 6, 2000

[17] A.M. Neville, *Properties of Concrete*, 506; Portland Cement Association, Concrete Technology, Durability, Acid Resistance, http://www.cement.org/tech/cct_dur_acid.asp, accessed September 17, 2012; Wolfgang Breit, Acid Resistance of Concrete, Proceedings of the International RILEM Symposium on Concrete Science and Engineering: A Tribute to Arnon Bentur, 2004; ACI 515-1R A Guide for the Use of Waterproofing, Dampproofing, Protective, and Decorative Barrier Systems for Concrete, Reported by ACI Committee 515, 1985.

[18] A. M. Neville, *Properties of Concrete*, 482.

[19] A. M. Neville, *Properties of Concrete*, 483.

[20] A. M. Neville, *Properties of Concrete*, 484-485.

[21] ACI 212.3R-10 Report on Chemical Admixtures for Concrete, Reported by ACI Committee 212, November 2010, 46.

porosity of concrete is linearly related to the intrinsic permeability of concrete[22] which is a function of its porosity and the size, distribution, shape, tortousity and continuity of the pores.

The permeability of concrete is affected by the amount of water/cement ratio, length of wet-curing period, and properties of the cement paste. A low water/cement ratio, longer wet-curing period and higher strength of concrete lowers the permeability. It also decreases rapidly with the progress in hydration.[23]

The ease in movement of fluids into the concrete is relevant to the durability of concrete.[24] That said, a lower permeability increases the durability of concrete. ACI 201.2R-01, Guide to Durable Concrete, identifies several factors that reduce the permeability of concrete, such as addition of slags and pozzolans. These admixtures reduce the permeability by 1/10th to 1/100th of a comparable concrete with low water-cement ratio, proper proportioning, well consolidation and adequate curing.[25]

Although a well-proportioned and properly cured concrete with low water-cement ratio will result in a finished product that has low-permeability and good durability, the addition of supplementary cementing materials (SCM) such as fly ash, silica fume, and slag have gained acceptance in improving durability and reducing permeability.[26] In addition to the SCMs, permeability-reducing admixtures (PRAs) have been developed to improve concrete durability by controlling water and moisture movement[27]. There are two subcategories of PRAs, one is for concrete exposed to nonhydrostatic conditions (PRAN) and the other for concrete exposed to hydrostatic conditions (PRAH). The two products that reduce the porosity and increase the density of concrete are the SCMs and crystalline materials, which consist of proprietary chemicals that are hydrophilic and generate pore-blocking deposits calcium silicate hydrates in microcracks and capillaries[28]. These products can be used alone or in combination to provide varying performance[29]. Crystalline admixtures result in significant reduction in permeability when added to the fly ash mixture (Figure 18).[30]

Rapid chloride permeability (ASTM C1202) test results of shotcrete mix design with crystalline admixture for the S-193 concrete repair project indicate a significant reduction in the permeability; i.e., from a standard of 400 coulombs to 120 coulombs, which is rated as “very low”.

The use of crystalline admixtures in concrete allows crystalline deposits to develop throughout the depth of concrete, becoming a permanent part of concrete that resist water penetration against hydrostatic pressure. As hairline cracks develop over the life of the concrete structure, the

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[22] A. M. Neville, *Properties of Concrete*, 495.
[23] A. M. Neville, *Properties of Concrete*, 492-493.
[24] A. M. Neville, *Properties of Concrete*, 495.
[25] ACI 201.2R-01 Guide to Durable Concrete, 11-19.
[26] ACI 212.3R-10 Report on Chemical Admixtures for Concrete, 46.
[27] ACI 212.3R-10 Report on Chemical Admixtures for Concrete, 46.
[28] ACI 212.3R-10 Report on Chemical Admixtures for Concrete, 46-47.
[29] ACI 212.3R-10 Report on Chemical Admixtures for Concrete, 46.
[30] ACI 212.3R-10 Report on Chemical Admixtures for Concrete, 47.

crystalline admixture continues to activate in the presence of moisture and seal additional gaps[31] thus prolonging the life of the concrete structure.

Concrete Surface Preparation

Although the concrete to be repaired with shotcrete should be prepared in similar manner identical to the preparation for replacement of concrete, the surface preparation for shotcrete repair is more critical than for replacement concrete, wherein it is necessary that the concrete substrate shall be clean and sound.[32] The ACI, USACE and USBR codes and guidelines do not specify the amplitude of the prepared concrete surface except for the dimensions when preparing the surface around steel reinforcement. These codes and guidelines specify that for concrete surfaces, all deteriorated, loose, and unsound existing concrete surfaces shall be removed either by chipping, scarifying, sandblasting, hydroblasting or other mechanical methods, and that abrupt changes in repair thickness should be avoided.[33]

In most of the District concrete repair projects, hydroblasting has been the Contractors' preferred method in removing the deteriorated concrete surfaces. In Spillway Structure S-63A, hydroblasting was done manually with the use of a high pressure wand coupled with chipping hammers. In other District structures, the existing deteriorated concrete surfaces were removed with high pressure mechanically-operated hydroblasting equipment that resulted to deep pits as shown in Figures 9 and 10. The District Technical Specifications specify for a 15,000 to 45,000 psi pressure when removing existing deteriorated concrete surface by hydroblasting.

The presence of deep pits raises a concern on the possibility of leaving voids during shotcrete operations as a result of rebound and the presence of aggregates that has a maximum size of 3/8 inch. The presence of 3/8 inch aggregates may result to bridging and prevent filling of the deep voids. Figure 12 proves that the presence of voids at the interface between the concrete substrate and the shotcrete is to be expected particularly when there are deep pits.

The AASHTO-AGC-ARTBA Joint Committee Task Force 37 Report, Guide Specifications for Shotcrete Repair of Highway Bridges, dated February 1998, specifies that the repair surface shall have an adequate surface roughness determined as 1.) three peak-to-valley measurements of 5 mm within 150 mm, 2.) five peak-to-valley measurements of 4 mm within 150 mm , or 3.) an International Concrete Repair Institute (ICRI) concrete surface preparation (CSP) profile of CSP 9 (very rough).[34] The surface roughness requirement of three peak-to-valley measurements of 5 mm within 150 mm has been incorporated in the District Technical Specifications.

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[31] ACI 212.3R-10 Report on Chemical Admixtures for Concrete, 47.

[32] USBR Technical Service Center, Guide to Concrete Repair, 56.

[33] USBR Technical Service Center, Guide to Concrete Repair, 56; ACI 506R-90, Guide to Shotcrete, Reported by ACI Committee 506, Reapproved 1995, 21; USACE EM 1110-2-2002, Engineering and Design, Evaluation and Repair of Concrete Structures, June 30, 1995, 5-17; AASHTO-AGC-ARTBA Inspectors' Guide for Shotcrete Repair of Bridges, Task Force 37 Report, December 1999

[34] AASHTO-AGC-ARTBA Inspectors' Guide for Shotcrete Repair of Bridges, Task Force 37 Report, December 1999.

Shotcrete Application

The various ACI codes provide guidance and specifications on shotcrete application; however, the results from various District concrete repair projects indicate that a difficulty exists in attaining the required bonding and grading. As indicated in ACI 506.4R and ACI 506.2R the quality of the shotcrete is highly dependent in nozzleman.[35] Although shotcrete core grades provided in ACI 506.2 specify that a Grade 1 surface shall be sound, without a sandy texture or voids as shown in Figure 19, this grade still exhibits voids that may contribute to a higher permeability, hence, a lower concrete durability. Figures 11 through 13 are examples of shotcrete cores that exhibit pores within the shotcrete layer and its interface with the concrete substrate. These cores were obtained from Spillway Structure S-59 and Navigational Locks S-61 and S-65A.

The results of pull-off tests (ASTM C 1583-04) from S-59 and S65A, as tabulated in Table 2, indicate several bond strengths that are less than 100 psi, i.e., way lower than the minimum 300 psi specified in the Technical Specifications. According to Brennan, the commonly specified direct tensile bond strength values for shotcrete to properly prepared shotcrete substrates range from 100 to 150 psi.[36]

RECOMMENDATIONS

Based on the above-mentioned findings, it is recommended that the District use crystalline admixtures in concrete mix designs for the construction and repair of all water control structures that are underwater.

Although shotcrete mix designs have been used in the repair of deteriorated concrete surfaces in District water control structures, the presence of deep voids created during hydroblasting and the use of shotcrete mix design with 3/8-inch aggregates may have resulted in voids between the existing concrete substrate and the shotcrete layer as exhibited in a shotcrete core from Spillway Structure S-59. The presence of voids allows water to accumulate and seep through the shrinkage cracks. To evaluate the extensiveness of the voids, it is recommended that non-destructive tests, such as impulse response and impact echo tests be performed on water control structures that were recently repaired.

If test results indicate that voids are present in the interface between the concrete substrate and shotcrete, injection ports shall be installed at equal spacing of six-inch intervals along the alignment of the cracks or as required by the manufacturer. Set the ports in an approved epoxy gel applied to the entire length of the crack and build up around the ports. Use a hydraulic pumping system to inject an epoxy gel, such as BASF Concresive Standard LVI® or equal, and

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[35] ACI 506.4R-94 A Guide for Evaluation of Shotcrete, Reported by ACI Committee 506, 1994, 2; ACI 506.2R-95 Specification for Shotcrete, Reported by ACI Committee 506, 1995, 3.
[36] Edward Brennan, *Technical Tip: Testing Shotcrete for Bond,* Shotcrete, Winter 2005, 18-19.

ensure that the gel flows to each port. Repeatedly inject the ports to ensure that the epoxy gel has filled all voids.

Upon completion of the repairs, the entire concrete surface shall be coated with crystalline waterproofing system, such as Xypex®, Penetron® or equal. Brush application shall be at a rate of 2.0 pounds per square yard with 3 parts powder mixed to 1 part water or as specified by the manufacturer. Spray application shall be 1.5 pounds per square yard with 5 parts powder mixed to 3 parts water or as specified by the manufacturer.

Considering that the presence of voids in shotcrete is inevitable, it is recommended that shotcrete should not be used for repair of deteriorated concrete surfaces in water control structures. Cast-in-place concrete, such as super-plasticized concrete or self-consolidating concrete shall be used.

Furthermore, with the costly hydroblasting and subsequent chipping of the concrete surface to attain a surface roughness profile of three peak-to valley depth measurements of 5 mm (0.20 inches) within 150 mm (5.9 inches) of measured length[37], the use of self consolidating concrete (SCC), which easily fills deep voids created during hydroblasting and eliminates the possibility of leaving unfilled voids between the existing concrete substrate and the repaired section, is highly recommended.

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[37] AASHTO-AGC-ARTBA Inspectors’ Guide for Shotcrete Repair of Bridges.

Figure 1. View of the dewatered Nubbin Slough Stormwater Treatment Area S-385 Pump Station Intake Canal for the construction of the upstream weir. May 4, 2012.

Figure 2. Photographs showing the variation on the extent of deteriorated concrete surface at the Pump Station S-385 intake bay (left) and weir (right). May 24, 2012.

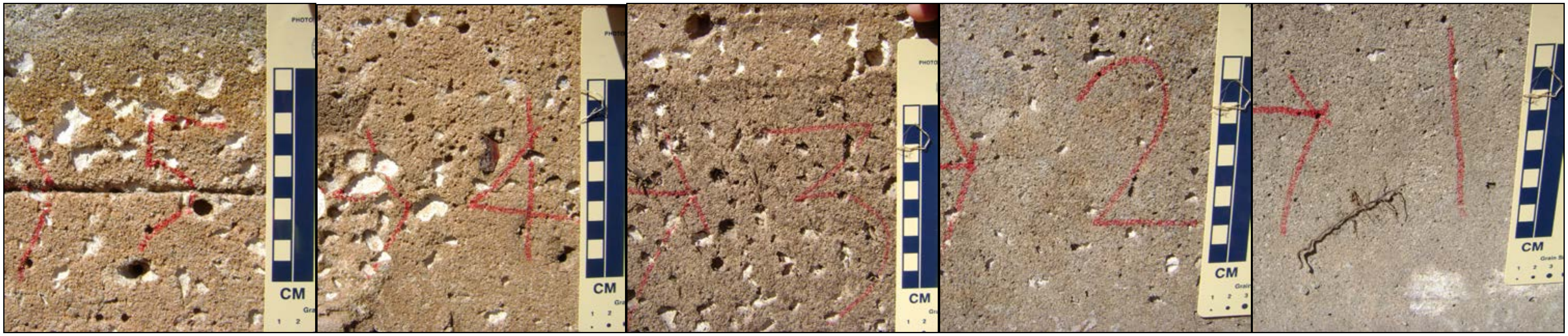

Figure 3. Variation in concrete pitting with water depth at the Nubbin Slough STA S-385 Pump Station. Measurements are at 1-foot intervals from the surface of the concrete slab (+12.0 ft. NGVD29). Concrete pitting diminishes at depth. May 24, 2012.

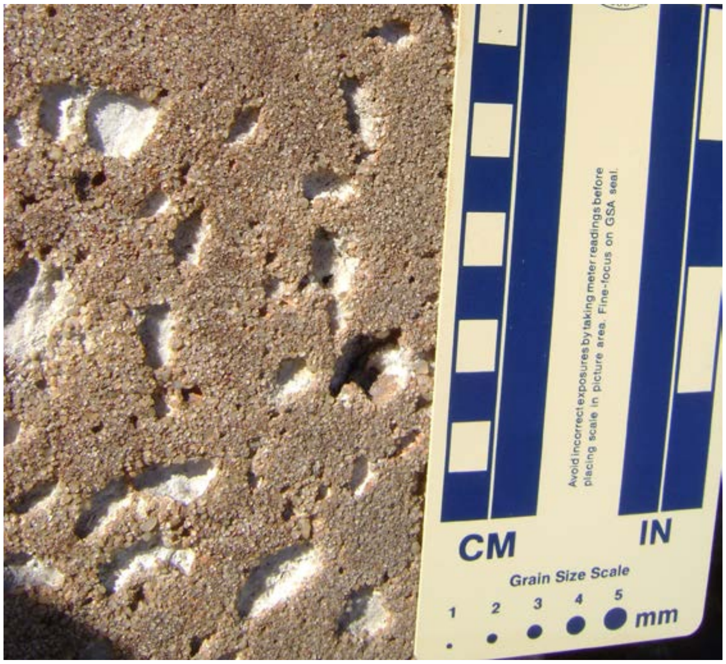

Figure 4. View of the deteriorated Nubbin Slough STA S-385 Pump Station concrete surface showing dissolution of the cement matrix and coarse limestone aggregates. May 24, 2012.

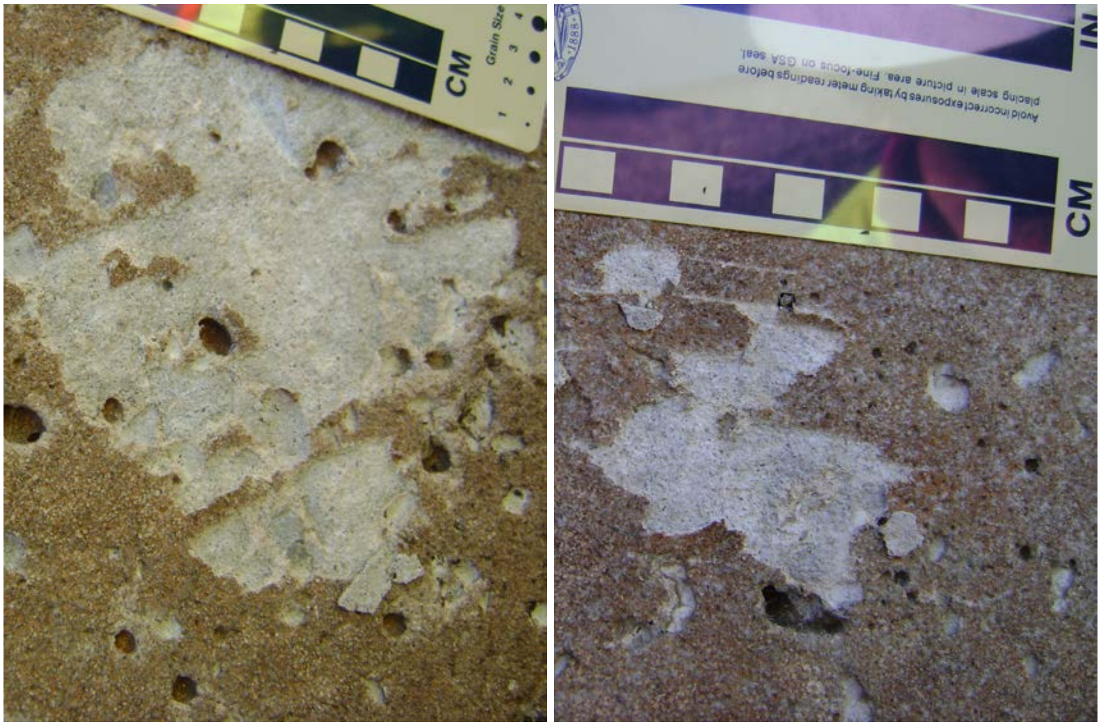

Figure 5. View of thin veneer of deteriorated S-385 concrete after scraping the concrete surface with masonry hammer. Take note of the holes which are remnants of the dissolved coarse limestone aggregates. May 24, 2012.

Figure 6. Photographs of limestone rubble riprap located downstream of the Nubbin Slough STA S-385 Pump Station Weir. Take note of the limestone rubble near the water surface showing smooth surfaces which may be attributed to acidic water. May 24, 2012.

Figure 7. View of the partially hydroblasted concrete surface of the S65D Navigation Lock. The upper portion of the photograph shows the pitted concrete surface. The holes are remnants of dissolved coarse limestone aggregates. August 4, 2010.

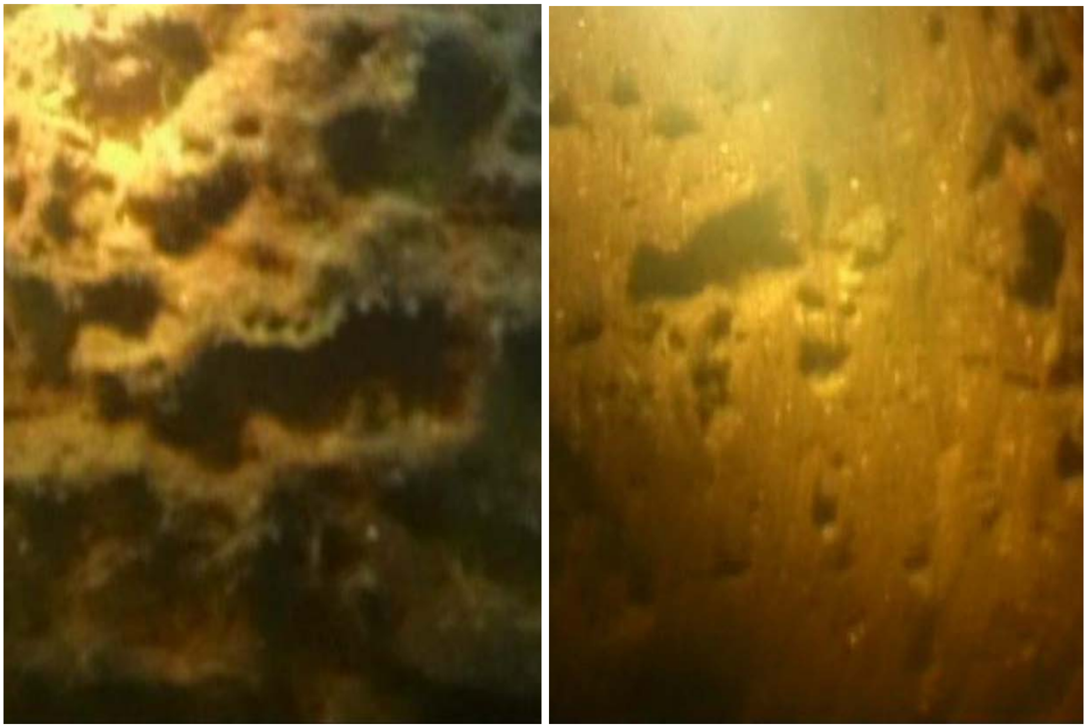

Figure 8. View of the pitted S72 Spillway Structure concrete abutment wall (left) showing ½' to 1" deep holes, and the weir/slab (right) showing lesser amount of pitting[38]. After Malcolm Pirnie, February 9, 2007.

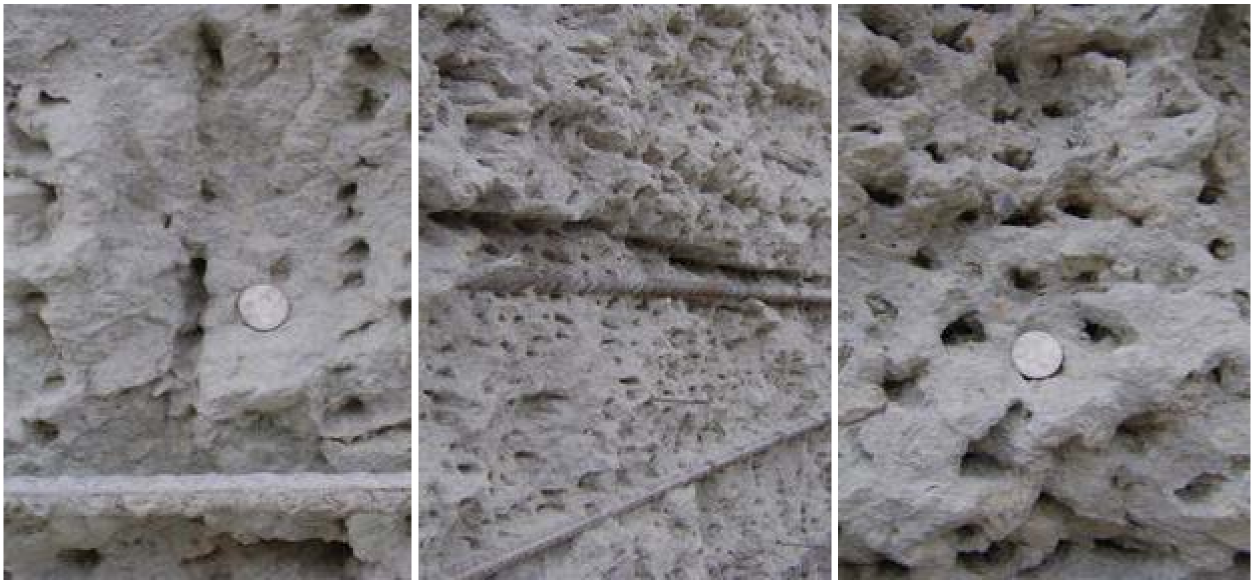

Figure 9. View of the hydroblasted concrete surfaces at the Navigational Lock S-61 Boat Lock indicating deep voids/pits that are aligned resulting from high pressure mechanically-operated hydroblasting equipment.

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[38] Malcolm Pirnie, Underwater Photo 1 and Photo 3.

Figure 10. Photographs of the hydroblasted concrete surfaces at the Navigation Lock S-65A showing significant amount of the fine grained concrete matrix being removed thus resulting to deep narrow voids.

Figure 11. Photograph of the shotcrete cores from S-61 Navigational Lock that indicate voids and separation through the concrete substrate and shotcrete interface.[39]

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[39] Ardaman & Associates, Inc., *Report of Shotcrete Bond Testing, Structure S-61 Land Navigational Lock, Osceola County, Florida*, October 28, 2010.

Figure 12. Photograph of a shotcrete core from S-59 Spillway Structure showing 1/16" to 1/2" voids. Some voids occur at the concrete substrate and shotcrete interface.[40]

Figure 13. Photograph of a shotcrete core from S-65A Navigational Lock showing 1/16" to 5/8" voids.[41]

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[40] Ardaman & Associates, Inc., *Report of Shotcrete Core grading, Structure S-59 Land Navigational Lock, Osceola County, Florida*, March 24, 2011.

Figure 14. Photograph of the cracked shotcrete surface at S65A. Crack width ranges from hairline to 1/8-inch wide. After South Florida Water Management District, Memorandum on S-65 and S-65A Concrete Repair Cracks, February 14, 2012.

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[41] Ardaman & Associates, Inc., *Report of Shotcrete Core Grading, Structure S-65A Land Navigational Lock, Osceola County*, *Florida*, January 25, 2010.

Figure 15. Photograph of spider cracks on the shotcrete surface within a ladder recess at S-65A. After South Florida Water Management District, Memorandum on S-65 and S-65A Concrete Repair Cracks, February 14, 2012

Figure 16. Comparison between the deteriorated concrete surface on the 1970 concrete (left) and the 1935 concrete (right). The 1970 concrete exhibit pits from dissolved limestone fragments while the 1935 concrete exhibits partially dissolved shell fragments in a dissolved cement-fine aggregate matrix. July 31, 2012.

Figure 17. View of the deteriorated S-193 Navigational Lock Structure concrete after scraping the concrete surface with masonry hammer. Take note of the holes which are remnants of the dissolved coarse limestone aggregates from the 1970 concrete. July 31, 2012.

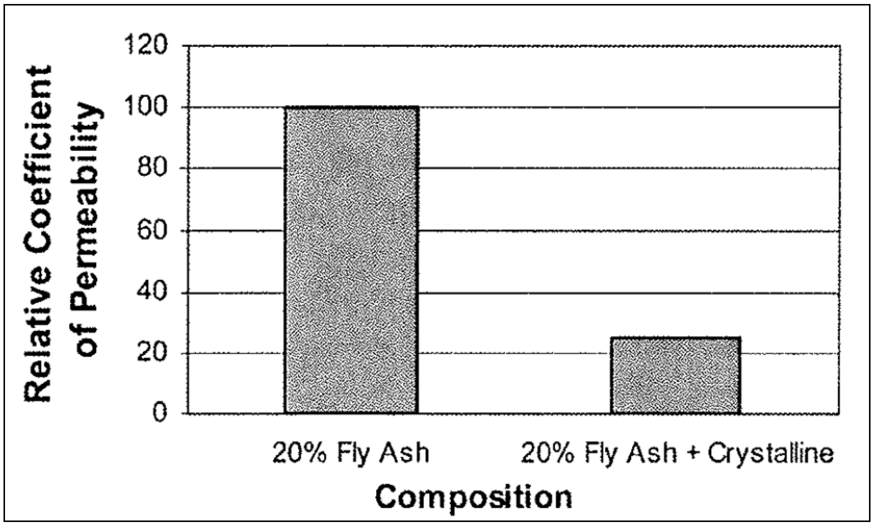


Figure 18. Permeability of concrete containing 20% Type F fly ash and crystalline admixture. After ACI 212.3R-10 Report on Chemical Admixtures for Concrete, Figure 15.3, p 48.

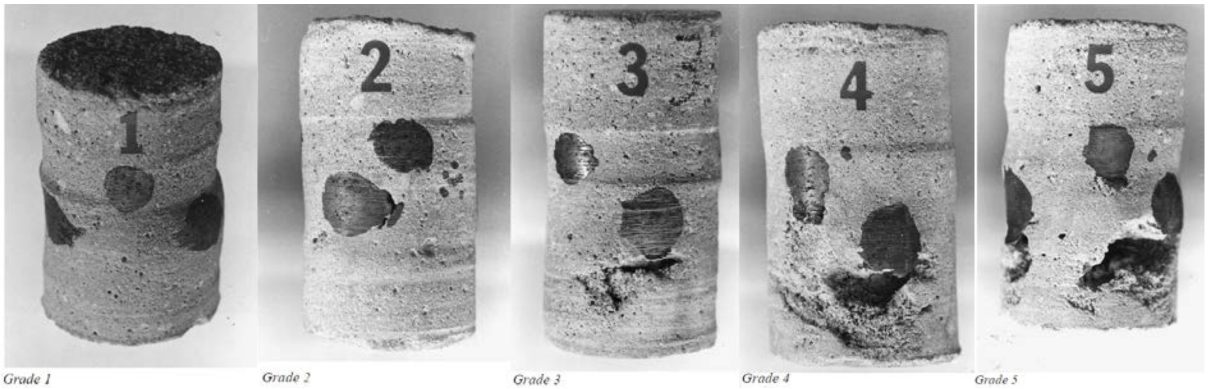


Figure 19. Examples of various grade classification specified in ACI 506.2R-95 Specification for Shotcrete, Reported by ACI Committee 506, 1995, pp 5-7.

Core Sample Number	Tensile Bond (psi)	Remarks
S-61-1	0	100% substrate
S-61-2A	100	60% substrate
S-61-2B	53	90% substrate
S-61-3	271	40% substrate
S-61-4	150	80% substrate
S-65A-1	104	Bond line between the shotcrete and base concrete
S-65A-2	123	Bond line between the shotcrete and base concrete
S-65A-3	8	Bond line between the shotcrete and base concrete
S-65A-4	26	Bond line between the shotcrete and base concrete

Table 1. Tensile bond strength test, ASTM C1583-04, Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength of Concrete Repair and Overlay Methods by Direct Tension (Pull-off Method), results from cores through the shotcrete and into the concrete substrate.

Core Sample Number	Core Grade	Remarks
S-59-1	3	Core shows 1/16” to 1/2” voids
S-59-2	3	Core shows 1/16” to 5/16” voids
S-59-6	3	Core shows 1/16” to 5/8” voids
S-59-9	3	Core shows 1/16” to 5/8” voids
S-62-2	2	Core shows 1/16” to 1/4” voids
S-62-3	2	Core shows 1/16” to 5/16” voids
S-62-4	2	Core shows 1/16” to 5/16” voids
S-62-6	2	Core shows 1/16” to 5/16” voids
S-65A-1	1	Core shows 1/16” to 1/4” voids
S-65A-2	1	Core shows 1/16” to 5/16” voids
S-65A-3	2	Core shows 1/16” to 5/8” voids
S-65A-4	2	Core shows 1/16” to 1/2” voids

Table 2. Shotcrete core grade results (ACI 506.2).

Rate of attack at ambient temperature	Inorganic acids	Organic acids	Alkaline solutions	Salt solutions	Miscellaneous
Rapid	Hydrochloric Nitric Sulfuric	Acetic Formic Lactic	—	Aluminum chloride	—
Moderate	Phosphoric	Tannic	Sodium hydroxide* > 20%	Ammonium nitrate Ammonium sulfate Sodium sulfate Magnesium sulfate Calcium sulfate	Bromine (gas) Sulfate liquor
Slow	Carbonic	—	Sodium hydroxide* 10 to 20%	Ammonium chloride Magnesium chloride Sodium cyanide	Chlorine (gas) Seawater Soft water
Negligible	—	Oxalic Tartaric	Sodium hydroxide* < 10% Sodium hypochlorite Ammonium hydroxide	Calcium chloride Sodium chloride Zinc nitrate Sodium chromate	Ammonia (liquid)

Table 3. Effect of commonly used chemicals on concrete. After Table 2.1, ACI 201.2R-01, Guide to Durable Concrete.

Station	Description
S5A	S-5A pumps (only) on W.P.B. Canal at Water Conservation Area 1
TCNS 228	Downstream of S385 Pump Station in Nubbin Slough. This station is located below Highway 710 at L63-N Canal.
S133	At pump station S133 on Herbert Hoover Dike on upstream side
S191	S-191 Spillway on Canal C-59 at Lake Okeechobee
S65	S-65 Spillway on Canal C-38 (Kissimmee River)
S65A	S-65A Spillway on Canal C-38 (Kissimmee River)
S65D	S-65D Spillway on Canal C-38 (Kissimmee River)
B09	Open water site located at south end of Lake Tohopekaliga.

Table 4. Description of various stations with water quality data used in the statistical analysis.

Statistics	S5A	TCNS 228	S133	S191	S65	S65A	S65D	B09
No. of Samples	509	76	122	224	241	240	243	101
Minimum	6.48	5.92	6.60	5.90	6.00	5.91	5.60	5.68
25th Percentile	7.40	6.30	7.30	7.10	6.80	6.67	6.60	7.10
Median (50th)	7.60	6.42	7.47	7.40	7.10	6.92	6.98	7.90
75th Percentile	7.80	6.69	7.70	7.70	7.51	7.40	7.30	8.70
Maximum	8.60	8.92	8.60	8.50	9.20	8.80	9.90	10.07
Mode	7.40	6.32	7.30	7.80	6.80	6.80	7.00	7.90
Mean from $[H^+]$	7.50	6.39	7.33	7.06	6.96	6.80	6.73	7.02
Average	7.59	6.52	7.47	7.36	7.21	7.06	7.00	7.92
Standard Deviation	0.28	0.44	0.35	0.47	0.54	0.54	0.56	0.93
Geometric Mean	7.59	6.51	7.46	7.35	7.19	7.04	6.98	7.86

Table 5. Summary Statistics of water pH by Nenad Iracenan, Principal Environmental Scientist, Water Quality Bureau, South Florida Water Management District, August 29, 2012

Attachment 2

Construction Schedule

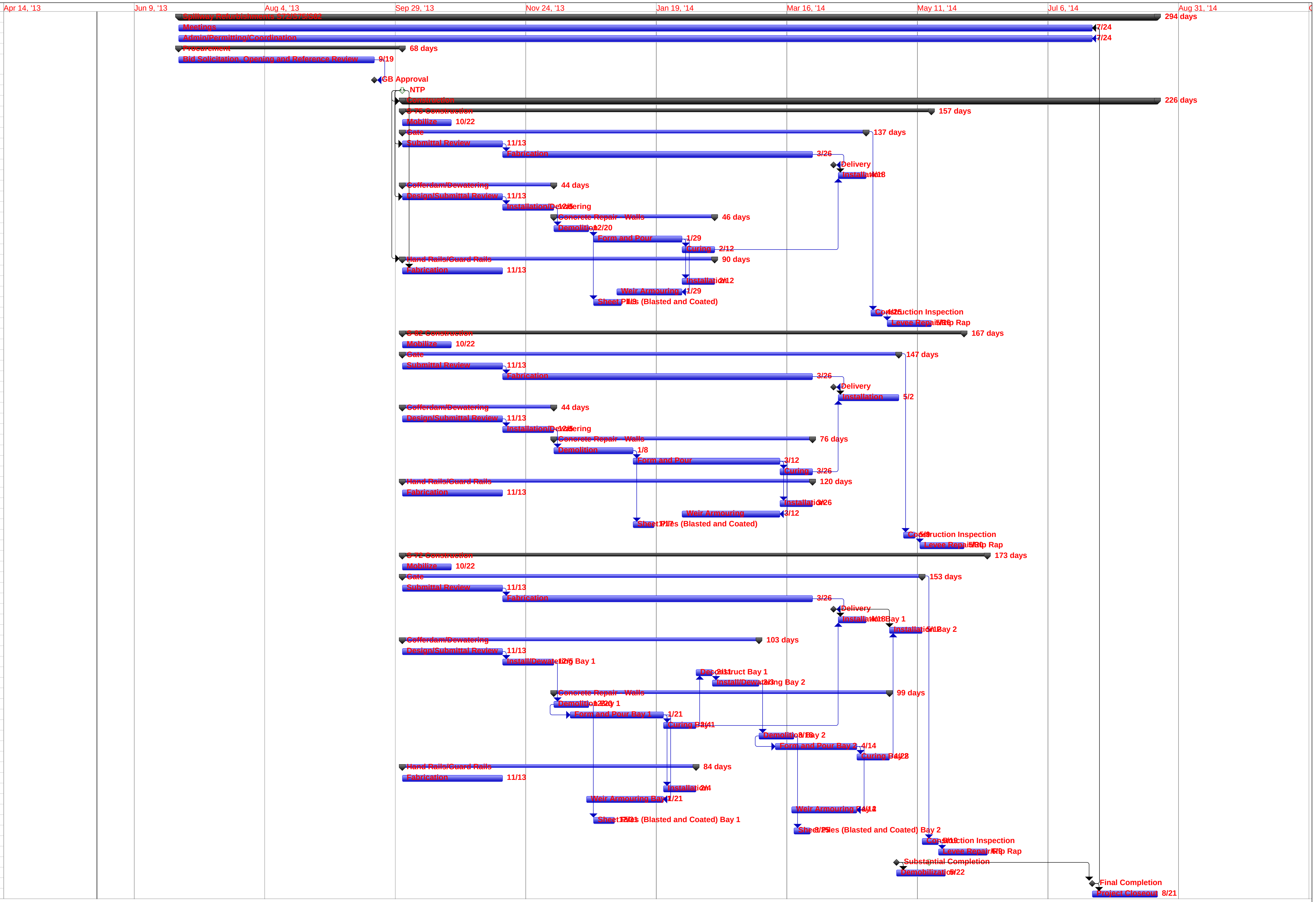
Construction Schedule Narrative

This schedule is based on an 8-hour, 5 day work week.

Substantial completion has been set to May 1, 2014. Substantial completion is defined as having the spillway fully operational. This does not require all construction activities to be complete. For instance the gates can be manually operated via cranes until the new gates are completely installed and repairs to the bridge deck will not impede operations. Therefore, the schedule shows construction activities extending beyond the substantial completion date, however, the concrete repair work and armoring in the spillway bays are completed by the substantial completion date based on this schedule.

The construction schedule is a conceptual schedule and it is ultimately up to the contractor to meet the completion dates. This schedule could be modified to accommodate alternative work hours (i.e. 10 hour work days or 6-day work weeks) and there are opportunities to perform certain tasks concurrently that may be consecutively noted in the schedule.

ID	ⓘ	Task Name	Duration	Start	Finish	Predecessors
1		**Spillway Refurbishments S72/S75/S82**	**294 days**	**Fri 6/28/13**	**Thu 8/21/14**	
2	▦	Meetings	274 days	Fri 6/28/13	Thu 7/24/14	82FF
3	▦	Admin/Permitting/Coordination	274 days	Fri 6/28/13	Thu 7/24/14	2FF
4		**Procurement**	**68 days**	**Fri 6/28/13**	**Tue 10/1/13**	
5	▦	Bid Solicitation, Opening and Reference Review	60 days	Fri 6/28/13	Thu 9/19/13	
6	▦	GB Approval	0 days	Thu 9/19/13	Thu 9/19/13	5FF
7	▦	NTP	0 days	Tue 10/1/13	Tue 10/1/13	
8		**Construction**	**226 days**	**Wed 10/2/13**	**Thu 8/21/14**	**7SS**
9		**S-75 Construction**	**157 days**	**Wed 10/2/13**	**Fri 5/16/14**	
10		Mobilize	15 days	Wed 10/2/13	Tue 10/22/13	
11		**Gate**	**137 days**	**Wed 10/2/13**	**Fri 4/18/14**	
12		Submittal Review	30 days	Wed 10/2/13	Wed 11/13/13	7SS
13		Fabrication	90 days	Thu 11/14/13	Wed 3/26/14	12
14		Delivery	0 days	Fri 4/4/14	Fri 4/4/14	13FF+7 days
15		Installation	10 days	Mon 4/7/14	Fri 4/18/14	22,14
16		**Cofferdam/Dewatering**	**44 days**	**Wed 10/2/13**	**Thu 12/5/13**	
17		Design/Submittal Review	30 days	Wed 10/2/13	Wed 11/13/13	7SS
18		Installation/Dewatering	14 days	Thu 11/14/13	Thu 12/5/13	17
19		**Concrete Repair - Walls**	**46 days**	**Fri 12/6/13**	**Wed 2/12/14**	
20		Demolition	11 days	Fri 12/6/13	Fri 12/20/13	18
21		Form and Pour	25 days	Mon 12/23/13	Wed 1/29/14	20
22		Curing	10 days	Thu 1/30/14	Wed 2/12/14	21
23		**Hand Rails/Guard Rails**	**90 days**	**Wed 10/2/13**	**Wed 2/12/14**	**7SS**
24		Fabrication	30 days	Wed 10/2/13	Wed 11/13/13	7
25		Installation	10 days	Thu 1/30/14	Wed 2/12/14	21
26		Weir Armouring	20 days	Thu 1/2/14	Wed 1/29/14	21FF
27		Sheet Piles (Blasted and Coated)	7 days	Mon 12/23/13	Fri 1/3/14	20
28		Construction Inspection	5 days	Mon 4/21/14	Fri 4/25/14	11
29		Levee Repair/Rip Rap	15 days	Mon 4/28/14	Fri 5/16/14	28
30		**S-82 Construction**	**167 days**	**Wed 10/2/13**	**Fri 5/30/14**	
31		Mobilize	15 days	Wed 10/2/13	Tue 10/22/13	
32		**Gate**	**147 days**	**Wed 10/2/13**	**Fri 5/2/14**	
33		Submittal Review	30 days	Wed 10/2/13	Wed 11/13/13	
34		Fabrication	90 days	Thu 11/14/13	Wed 3/26/14	33
35		Delivery	0 days	Fri 4/4/14	Fri 4/4/14	34FF+7 days
36		Installation	20 days	Mon 4/7/14	Fri 5/2/14	35,43
37		**Cofferdam/Dewatering**	**44 days**	**Wed 10/2/13**	**Thu 12/5/13**	
38		Design/Submittal Review	30 days	Wed 10/2/13	Wed 11/13/13	
39		Installation/Dewatering	14 days	Thu 11/14/13	Thu 12/5/13	38
40		**Concrete Repair - Walls**	**76 days**	**Fri 12/6/13**	**Wed 3/26/14**	
41		Demolition	21 days	Fri 12/6/13	Wed 1/8/14	39
42		Form and Pour	45 days	Thu 1/9/14	Wed 3/12/14	41
43		Curing	10 days	Thu 3/13/14	Wed 3/26/14	42
44		**Hand Rails/Guard Rails**	**120 days**	**Wed 10/2/13**	**Wed 3/26/14**	
45		Fabrication	30 days	Wed 10/2/13	Wed 11/13/13	
46		Installation	10 days	Thu 3/13/14	Wed 3/26/14	42
47		Weir Armouring	30 days	Thu 1/30/14	Wed 3/12/14	42FF
48		Sheet Piles (Blasted and Coated)	7 days	Thu 1/9/14	Fri 1/17/14	41
49		Construction Inspection	5 days	Mon 5/5/14	Fri 5/9/14	32
50		Levee Repair/Rip Rap	15 days	Mon 5/12/14	Fri 5/30/14	49
51		**S-72 Construction**	**173 days**	**Wed 10/2/13**	**Mon 6/9/14**	
52		Mobilize	15 days	Wed 10/2/13	Tue 10/22/13	
53		**Gate**	**153 days**	**Wed 10/2/13**	**Mon 5/12/14**	
54		Submittal Review	30 days	Wed 10/2/13	Wed 11/13/13	
55		Fabrication	90 days	Thu 11/14/13	Wed 3/26/14	54
56		Delivery	0 days	Fri 4/4/14	Fri 4/4/14	55FF+7 days
57		Installation Bay 1	10 days	Mon 4/7/14	Fri 4/18/14	56,67
58		Installation Bay 2	10 days	Tue 4/29/14	Mon 5/12/14	56,70
59		**Cofferdam/Dewatering**	**103 days**	**Wed 10/2/13**	**Mon 3/3/14**	
60		Design/Submittal Review	30 days	Wed 10/2/13	Wed 11/13/13	
61		Install/Dewatering Bay 1	14 days	Thu 11/14/13	Thu 12/5/13	60
62		Deconstruct Bay 1	5 days	Wed 2/5/14	Tue 2/11/14	67
63		Install/Dewatering Bay 2	14 days	Wed 2/12/14	Mon 3/3/14	62
64		**Concrete Repair - Walls**	**99 days**	**Fri 12/6/13**	**Mon 4/28/14**	
65		Demolition Bay 1	11 days	Fri 12/6/13	Fri 12/20/13	61
66		Form and Pour Bay 1	25 days	Fri 12/13/13	Tue 1/21/14	65SS+5 days
67		Curing Bay 1	10 days	Wed 1/22/14	Tue 2/4/14	66
68		Demolition Bay 2	11 days	Tue 3/4/14	Tue 3/18/14	63
69		Form and Pour Bay 2	25 days	Tue 3/11/14	Mon 4/14/14	68SS+5 days
70		Curing Bay 2	10 days	Tue 4/15/14	Mon 4/28/14	69
71		**Hand Rails/Guard Rails**	**84 days**	**Wed 10/2/13**	**Tue 2/4/14**	
72		Fabrication	30 days	Wed 10/2/13	Wed 11/13/13	
73		Installation	10 days	Wed 1/22/14	Tue 2/4/14	66
74		Weir Armouring Bay 1	20 days	Fri 12/20/13	Tue 1/21/14	66FF
75		Weir Armouring Bay 2	20 days	Tue 3/18/14	Mon 4/14/14	69FF
76		Sheet Piles (Blasted and Coated) Bay 1	5 days	Mon 12/23/13	Tue 12/31/13	65
77		Sheet Piles (Blasted and Coated) Bay 2	5 days	Wed 3/19/14	Tue 3/25/14	68
78		Construction Inspection	5 days	Tue 5/13/14	Mon 5/19/14	53
79		Levee Repair/Rip Rap	15 days	Tue 5/20/14	Mon 6/9/14	78
80	▦	Substantial Completion	0 days	Thu 5/1/14	Thu 5/1/14	
81		Demobilization	15 days	Fri 5/2/14	Thu 5/22/14	80
82		Final Completion	0 days	Thu 7/24/14	Thu 7/24/14	80FS+60 days
83		Project Closeout	20 days	Fri 7/25/14	Thu 8/21/14	82



Project: Spillway Refurbishments S72/
Date: Fri 5/24/13

Task	▬	Rolled Up Task	▬	Split	┈┈┈	Group By Summary	▬	Inactive Summary	▭	Manual Summary Rollup	▬	Finish-only	]
Milestone	◆	Rolled Up Milestone	◇	External Tasks	▬	Inactive Task	▭	Manual Task	▬	Manual Summary	▬	Progress	▬
Summary	▬	Rolled Up Progress	▬	Project Summary	▬	Inactive Milestone	◇	Duration-only	▬	Start-only	[	Deadline	⇩

Attachment 3

Liquidated Damage Assessment

Conceptual Cost Estimate For Bypass Pumping Operation

Description	Qty	Unit	Bare Mat.	Bare Labor	Bare Equip.	Total Cost Per Month
For 5 ft static head, (3) pumps of 42" Hyd each, package monthly rental cost, @145 CFS + one 24" pump of 25 CFS, includes Discharge Pipes, up to 100' long, at total of 460 CFS.	1	Month	$0	$0	$79,000	$79,000
For 15 ft static head, (3) pumps of 42" Hyd each, package monthly rental cost, @121 CFS Capacity Each, includes Discharge Pipes, up to 120' long, at total 361 total CFS.	1	Month	$0	$0	$75,000	$75,000
Transport and Install Screens & Bkheads, includes Removal	1	LS	$0.00	$0.00	$0.00	$30,000.00
Transport and Install Pumps, includes Removal	1	LS	$0.00	$0.00	$0.00	$40,000.00
Daily Fuel Consumption of (3) pumps, 42" Dia. each @ 5 ft head, using (350BHPx 0.34 lb/bhp - hr x ft^3/54lb x 7.48 gal.ft^3 = 16.48 gal/hr) = (16.48 gal/hr x 24 hr. x 3 pumps) = 1,189 gal/day x $4.00= $4,750/day, and one (1) pump of 24" dia. with daily fuel consumption of 120/gal * $4.00 = $480.	1	Month	$156,900	$0	$0	$156,900
Daily Fuel Consumption for (3) 42" Pumps @ 15 ft head, using (500BHPx 0.34 lb/bhp - hr x ft^3/54lb x 7.48 gal.ft^3 = 23.55gal/hr) = (23.55 gal/hr x 24 hr. x 3 pumps) = 1,695 gal/day x $4.00= $6,782/day x 30 days	1	Month	$203,460	$0	$0	$203,460
Monthly Pumps Operation Maintenance Cost:	1	LS	$0	$0	$0	$10,000
				Direct Cost		**$594,360**
				Mobilization/Demob.	10%	$59,436
	Total Project Construction Cost					**$653,796**
					Low Range -5%	**$621,106**
					High Range +5%	**$686,486**

4/15/2013

Estimator: Jack Ismalon

PROJECT: S-72, S-75 & S-82 REFURB. **TITLE: BYPASS PUMPING**

STATIC HEAD (FT)	5.00
INSIDE DIAMETER (IN)	41.5
PIPE LENGTH (FT)	100
TURBULENT FRICTION FACTOR	.0104
FITTING RESISTANCE COEFFICIENT	1.312
BEGINNING GPM	40,000
GPM INCREMENT	2,000
PUMP EFFICIENCY	85.0%

ASSUMPTIONS USED IN THIS SPREADSHEET:

1. FLUID BEING PUMPED IS WATER AT 60 DEG F.
2. DISCHARGE IS SUBMERGED; THEREFORE, TOTAL HEAD DOES NOT INCLUDE VELOCITY HEAD.
3. FRICTION FACTOR IS BASED ON A PIPE ROUGHNESS VALUE CORRESPONDING TO LIGHTLY RUSTED STEEL PIPE.

SELECT PROPELLER RPM FROM ONE OF THE FOLLOWING: 350, 370, 380, 420, 440 ***440***

GPM	CFS	VELOCITY (FT/SEC)	VELOCITY HEAD (FT)	STATIC HEAD (FT)	REYNOLDS NUMBER	FRICTION FACTOR	FRICTION HEAD (FT)	TOTAL HEAD (FT)	CALC GPM	BRAKE HP
40,000	89.12	9.5	1.40	5.00	2.3E+06	.0147	2.43	7.43	65,918	88.3
42,000	93.58	10.0	1.54	5.00	2.5E+06	.0147	2.68	7.68	65,940	95.8
44,000	98.03	10.4	1.69	5.00	2.6E+06	.0147	2.94	7.94	65,952	103.7
46,000	102.49	10.9	1.85	5.00	2.7E+06	.0147	3.21	8.21	65,952	112.2
48,000	106.94	11.4	2.01	5.00	2.8E+06	.0147	3.49	8.49	65,939	121.1
50,000	111.40	11.9	2.18	5.00	2.9E+06	.0146	3.79	8.79	65,910	130.5
52,000	115.86	12.3	2.36	5.00	3.0E+06	.0146	4.10	9.10	65,864	140.5
54,000	120.31	12.8	2.55	5.00	3.2E+06	.0146	4.42	9.42	65,799	151.1
56,000	124.77	13.3	2.74	5.00	3.3E+06	.0146	4.75	9.75	65,713	162.2
58,000	129.22	13.8	2.94	5.00	3.4E+06	.0146	5.09	10.09	65,603	173.9

65,000	144.82	15.4	3.69	5.00	3.8E+06	.0146	6.39	11.39	65,000	220.0
									145 CFS	

Attachment 4

Design Calculations

Ultimate Lateral Resistance for Driven Piles in Cohesionless Soils

Pile Dimensions:

e = Eccentricity of Loading (Height Above Grade)	18	ft	5.5	m
L = Embedded Length	17	ft	5.2	m
B = Diameter or Width of Pile	12	in	0.3	m
Pile Shape (1 = Circular Pile, 2 = Square Pile)	1			
Pile Method of Construction (1 = Jetted, 2 = Small Displacement, Driven, 3 = Large Displacement, Driven)	1			
Pile Type (1 = Rough Concrete, 2 = Smooth Concrete, 3 = Rough Steel, 4 = Smooth Steel, 5 = Wood)	1			

Soil Properties:

ϕ' = Effective Internal Friction Angle	30	deg		
γ = Effective Unit Weight of Soil	110	lbf/ft^3	17.58405	kN/m^3

Calculated Results:

					Note
η = Shape Factor	0.8				1
ξ = Shape Factor	1.0				1
K_p = Passive Earth Pressure Coefficient	3.00				2
K_0 = At-Rest Earth Pressure Coefficient	0.50				3
K = Lateral Earth Pressure Coefficient	0.30				4
δ = Interface Friction Angle	30				5
a = Depth to the Point of Rotation	12.0	ft	3.6	m	6
H_u = Ultimate Lateral Capacity of Pile	9.362	kips	41.6	kN	7

Reference:

"Ultimate Lateral Resistance to Piles in Cohensionless Soils," L. Zhang, F. Silva & R. Grismala, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Jan. 2005

Notes:

1. Table 1
2. $K_p = \tan^2(45° - \phi'/2)$
3. $K_0 = 1 - \sin\phi'$
4. Table 3
5. Table 4
6. Equation (12a): $a = (-(0.567L + 2.7e)+(5.30L^2 + 7.29e^2 +10.541eL)^{0.5})/2.1996$
7. Equation (12b): $H_u = 0.3 (\eta\ K_p^2 + \xi\ K \tan\delta)\ \gamma aB\ (2.7a - 1.7L)$

	S-72		S-75		S-82	
	Headwater	Tailwater	Headwater	Tailwater	Headwater	Tailwater
Walkway Elevation, NGVD29	22.00	21.00	30.00	30.00	34.00	34.00
High Water Elevation, NGVD29	21.50	18.90	27.10	22.60	32.40	30.20
Low water elevation	16.50	8.80	23.30	16.50	27.40	23.90
Toe of Slope, NGVD29	1.10	-0.70	9.60	7.50	16.70	16.70
Maximum Exposed Pile Length, ft	20.90	21.70	20.40	22.50	17.30	17.30
Maximum Walkway Length, ft	41.80	43.40	40.80	45.00	34.60	34.60
Distance between piles, ft	13.93	14.47	13.60	15.00	11.53	11.53
Bottom of stilling well, for 36-foot long platform	4.00	3.00	12.00	12.00	16.00	16.00
Length of stilling well below platform	18.00	18.00	18.00	18.00	18.00	18.00
Length of stilling well above platform	3.50	3.50	3.50	3.50	3.50	3.50
Total stilling well length	21.50	21.50	21.50	21.50	21.50	21.50
C1	16.00	15.00	24.00	24.00	28.00	28.00
C2	10.00	9.00	18.00	18.00	22.00	22.00
C3	4.00	3.00	12.00	12.00	16.00	16.00

Length above grade 1	6.00	6.00	6.00	6.00	6.00	6.00
Length above grade 2	12.00	12.00	12.00	12.00	12.00	12.00
Length above grade 3	18.00	18.00	18.00	18.00	18.00	18.00

Drag force due to water velocity

$$\boxed{F = \frac{\pi W V C_1 C_0 C_D C_B R_{MAX}}{2 g \Delta t}}$$

$$\boxed{W = \gamma h}$$

π	3.1416	
γ	62.4	lb/ft^3
V	25.6	ft/sec
C_1	1	
C_0	0.8	
C_D	1	
C_B	1	
R_{MAX}	1.5	
g	32.2	ft/sec^2
Δt	1	sec

Drag force due to water velocity1	561.08	561.08	561.08	561.08	561.08	561.08
Drag force due to water velocity2	1122.15	1122.15	1122.15	1122.15	1122.15	1122.15
Drag force due to water velocity3	1683.23	1683.23	1683.23	1683.23	1683.23	1683.23

Design Wind Load

$$\boxed{F = q_z G C_f A_f}$$

q_z	50.6 lb/ft^2						
G	0.85						
C_f	1.6						
$A_{fpile\ (12"x12")}$		5.50	12.20	6.70	13.50	6.60	10.10
$A_{fplatform}$	12' long x 2' wide	24	24	24	24	24	24

Design wind load	2030.072	2491.1392	2112.6512	2580.6	2105.7696	2346.6256
Total lateral pressure1	2591.15	2591.15	2591.15	2591.15	2591.15	2591.15
Total lateral pressure2	3152.22	3152.22	3152.22	3152.22	3152.22	3152.22
Total lateral pressure3	3713.30	3713.30	3713.30	3713.30	3713.30	3713.30
Design Lateral Pressure (@ FS = 2.5)1	6477.8712	6477.8712	6477.8712	6477.8712	6477.8712	6477.8712
Design Lateral Pressure (@ FS = 2.5)2	7880.5625	7880.5625	7880.5625	7880.5625	7880.5625	7880.5625
Design Lateral Pressure (@ FS = 2.5)3	9283.2537	9283.2537	9283.2537	9283.2537	9283.2537	9283.2537
Embedment Length, ft 1	12	12	12	12	12	12
Embedment Length, ft 2	15	15	15	15	15	15
Embedment Length, ft 3	17	17	17	17	17	17
D1	4.00	3.00	12.00	12.00	16.00	16.00
D2	-5.00	-6.00	3.00	3.00	7.00	7.00
D3	-13.00	-14.00	-5.00	-5.00	-1.00	-1.00

	S-72			**S-75**			**S-82**	
Elevation	**N/ft**	**Average**	**Elevation**	**N/ft**	**Average**	**Elevation**	**N/ft**	**Average**
11.6	2		23	2		33.8	3	
10.6	2		22	4		32.8	10	
9.6	3		21	3		31.8	11	
8.6	2		20	3		30.8	14	
7.6	2		19	6		29.8	6	
6.6	2		18	1		28.8	13	
5.6	5		17	5		27.8	16	
4.6	6		16	4		26.8	22	
3.6	4	**3**	15	5		25.8	25	
2.6	7		14	7		24.8	9	
1.6	10		13	2		23.8	20	
0.6	11		12	1	**4**	22.8	21	
-0.4	11		11	4		21.8	17	
-1.4			10	7		20.8	21	
-2.4	9		9	7		19.8	8	
-3.4	7		8	4		18.8	6	
-4.4	7		7	6		17.8	13	
-5.4	8	**6**	6	8		16.8	14	
-6.4			5	14		15.8	14	**16**
-7.4	7		4	17		14.8	2	
-8.4	9		3	5	**6**	13.8	2	
-9.4	16		2	6		12.8	9	
-10.4	17		1	8		11.8	16	
-11.4			0	14		10.8	23	
-12.4	5		-1	19		9.8	22	
-13.4	17		-2	3		8.8	24	
-14.4	23	**11**	-3	5		7.8	32	
			-4	7		6.8	43	**17**
			-5	8	**8**	5.8	40	

Maximum Operating Load (Head to Top of Gate)

			S72	S75	S82
Maximum Headwater Elev		ft	22.000	28.500	33.500
Weir Crest Elev		ft	9.900	17.000	26.700
Operating Head	h_d	ft	12.100	11.500	6.800
Gate Weight	$g_{\underline{w}}$	lbs	23,910.000	20,330.000	12,130.000
Gate Opening Width	g_w	ft	27.771	28.771	23.583
Gate Height	g_h	ft	12.063	10.000	7.219
Density of water	γ	pcf	62.400	62.400	62.400
Wheel diameter	D	in	15.000	15.000	12.000
Axel diameter	d	in	3.750	3.750	3.750
Wheel Bearing Coefficient	f_w		0.130	0.130	0.130
Seal Coef of friction	f_s	neoprene in SST	1.000	1.000	1.000
Seal load factor, lb/in	f_{lf}	1 3/4" bulb j-seal	3.000	3.000	3.000
Seal deflection	def	in/in	0.375	0.375	0.375
Seal area	s_a	in^2/in	2.000	2.000	2.000
Operating Head to centerline	$h_{dcl\,=}\,h_d\text{-}g_h/2$	ft	6.069	6.500	3.191
Water load	$Wl = h_{dcl}\gamma g_w g_h$	lb	126,855.726	116,694.500	33,894.368
Gate Weight	$g_{\underline{w}}$ x 1.2	lb	28,692.000	24,396.000	14,556.000
Roller friction	$R_f = Wl(d/D)f_w$	lb	4,122.811	3,792.571	1,376.959
Seal friction	$F_s = 2g_h f_{lf}(def/0.25)12$	lb	1,302.750	1,080.000	779.625
Water load on seals	$F_{wl} = h_{dlc}2g_h\gamma s_a f_s/12$	lb	1,522.649	1,352.000	479.072
Maximum Operating Load		**lb**	**35,640.210**	**30,620.571**	**17,191.656**
Existing Weight		lb	24,310.000	20,270.000	12,500.000
Percent Increase			-1.65%	0.30%	-2.96%

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Engineering Calculations

Everglades Restoration & Capital Projects

Submitted By H. Gao	Date	Project S72	Sheet of
Checked By	Description Downstream Cofferdam		Job No.

Change the canal bottom to $-4.0'$ NGVD.

Tip of sheetpile $-38'$

$M_{max} = 4.11 \times 10^5$ lb-ft

required section modulus:

$$\frac{M_{max}}{f_b} = \frac{4.11 \times 10^5 \times 12}{0.5 \times 50{,}000} = 197 \text{ in}^3.$$

└ use Grade 50 or higher.

```
PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 15-JANUARY-2014                                     TIME: 9:28:57

                           ****************
                           *  INPUT DATA  *
                           ****************

     I.--HEADING
    'S72 COFFER DAM WALL DESIGN -DOWNSTREAM STREAM CENTER

    II.--CONTROL
       CANTILEVER WALL DESIGN
       FACTOR OF SAFETY FOR ACTIVE PRESSURES  = 1.00
       FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.00

   III.--WALL DATA
       ELEVATION AT TOP OF WALL    = 26.00 FT.

    IV.--SURFACE POINT DATA

         IV.A.--RIGHTSIDE
            DIST. FROM     ELEVATION
            WALL (FT)        (FT)
                 0.00        -4.00
                50.00        -4.00

         IV.B.--LEFTSIDE
            DIST. FROM     ELEVATION
            WALL (FT)        (FT)
                 0.00        -4.00
                50.00        -4.00

     V.--SOIL LAYER DATA

        V.A.--RIGHTSIDE
            LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
            LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

                 ANGLE OF          ANGLE OF                              <-SAFETY->
  SAT.    MOIST  INTERNAL  COH-      WALL     ADH-    <--BOTTOM-->  <-FACTOR->
 WGHT.    WGHT.  FRICTION  ESION   FRICTION   ESION   ELEV.  SLOPE   ACT. PASS.
 (PCF)    (PCF)    (DEG)   (PSF)     (DEG)    (PSF)   (FT)  (FT/FT)
115.00   110.00    31.00    0.00     14.00     0.00  -18.40   0.00    DEF  DEF
110.00   105.00    30.00    0.00     11.00     0.00                   DEF  DEF

        V.B.--LEFTSIDE
            LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
            LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

                 ANGLE OF          ANGLE OF                              <-SAFETY->
  SAT.    MOIST  INTERNAL  COH-      WALL     ADH-    <--BOTTOM-->  <-FACTOR->
 WGHT.    WGHT.  FRICTION  ESION   FRICTION   ESION   ELEV.  SLOPE   ACT. PASS.
 (PCF)    (PCF)    (DEG)   (PSF)     (DEG)    (PSF)   (FT)  (FT/FT)
115.00   110.00    31.00    0.00     14.00     0.00  -18.40   0.00    DEF  DEF
110.00   105.00    30.00    0.00     11.00     0.00                   DEF  DEF

    VI.--WATER DATA
       UNIT WEIGHT          = 62.40 (PCF)
       RIGHTSIDE ELEVATION = 18.00 (FT)
       LEFTSIDE ELEVATION  = -4.00 (FT)
       SEEPAGE ELEVATION   = -4.00 (FT)
       SEEPAGE GRADIENT    = AUTOMATIC
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   VII.--VERTICAL SURCHARGE LOADS
        NONE

  VIII.--HORIZONTAL LOADS
        NONE




PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                           BY CLASSICAL METHODS
DATE: 15-JANUARY-2014                                          TIME: 9:29:01

                          **************************
                          *    SOIL PRESSURES FOR   *
                          * CANTILEVER WALL DESIGN *
                          **************************

   I.--HEADING
    'S72 COFFER DAM WALL DESIGN -DOWNSTREAM STREAM CENTER

  II.--SOIL PRESSURES

        RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

        LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

        SOIL PRESSURES ARE REPORTED FOR A SEEPAGE GRADIENT = 0.0001
        AND MAY CHANGE WITH AUTOMATIC ADJUSTMENT OF THE GRADIENT.

                                      <------NET------>
          NET     <---LEFTSIDE--->     (SOIL + WATER)     <--RIGHTSIDE--->
ELEV.    WATER    PASSIVE   ACTIVE    ACTIVE   PASSIVE    ACTIVE   PASSIVE
(FT)     (PSF)     (PSF)    (PSF)      (PSF)    (PSF)      (PSF)    (PSF)
 26.0      0.0       0.0      0.0        0.0      0.0        0.0      0.0
 25.0      0.0       0.0      0.0        0.0      0.0        0.0      0.0
 24.0      0.0       0.0      0.0        0.0      0.0        0.0      0.0
 23.0      0.0       0.0      0.0        0.0      0.0        0.0      0.0
 22.0      0.0       0.0      0.0        0.0      0.0        0.0      0.0
 21.0      0.0       0.0      0.0        0.0      0.0        0.0      0.0
 20.0      0.0       0.0      0.0        0.0      0.0        0.0      0.0
 19.0      0.0       0.0      0.0        0.0      0.0        0.0      0.0
 18.0      0.0       0.0      0.0        0.0      0.0        0.0      0.0
 17.0     62.4       0.0      0.0       62.4     62.4        0.0      0.0
 16.0    124.8       0.0      0.0      124.8    124.8        0.0      0.0
 15.0    187.2       0.0      0.0      187.2    187.2        0.0      0.0
 14.0    249.6       0.0      0.0      249.6    249.6        0.0      0.0
 13.0    312.0       0.0      0.0      312.0    312.0        0.0      0.0
 12.0    374.4       0.0      0.0      374.4    374.4        0.0      0.0
 11.0    436.8       0.0      0.0      436.8    436.8        0.0      0.0
 10.0    499.2       0.0      0.0      499.2    499.2        0.0      0.0
  9.0    561.6       0.0      0.0      561.6    561.6        0.0      0.0
  8.0    624.0       0.0      0.0      624.0    624.0        0.0      0.0
  7.0    686.4       0.0      0.0      686.4    686.4        0.0      0.0
  6.0    748.8       0.0      0.0      748.8    748.8        0.0      0.0
  5.0    811.2       0.0      0.0      811.2    811.2        0.0      0.0
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  4.0   873.6       0.0      0.0     873.6     873.6       0.0        0.0
  3.0   936.0       0.0      0.0     936.0     936.0       0.0        0.0
  2.0   998.4       0.0      0.0     998.4     998.4       0.0        0.0
  1.0  1060.8       0.0      0.0    1060.8    1060.8       0.0        0.0
  0.0  1123.2       0.0      0.0    1123.2    1123.2       0.0        0.0
 -1.0  1185.6       0.0      0.0    1185.6    1185.6       0.0        0.0
 -2.0  1248.0       0.0      0.0    1248.0    1248.0       0.0        0.0
 -3.0  1310.4       0.0      0.0    1310.4    1310.4       0.0        0.0
 -4.0  1372.8       0.0      0.0    1372.8    1372.8       0.0        0.0
 -5.0  1372.8     257.6     14.9    1130.1    1615.6      14.9      257.6
 -6.0  1372.8     515.1     29.7     887.4    1858.3      29.7      515.2
 -7.0  1372.8     772.7     44.6     644.6    2101.1      44.6      772.9
 -8.0  1372.8    1030.2     59.4     401.9    2343.8      59.4     1030.5
 -9.0  1372.7    1287.8     74.3     159.2    2586.6      74.3     1288.1
 -9.7  1372.7    1456.8     84.0       0.0    2745.8      84.0     1457.1
-10.0  1372.7    1545.4     89.1     -83.5    2829.3      89.1     1545.7
-11.0  1372.7    1802.9    104.0    -326.2    3072.1     104.0     1803.4
-12.0  1372.7    2060.5    118.8    -568.9    3314.9     118.8     2061.0
-13.0  1372.7    2318.0    133.7    -811.7    3557.6     133.7     2318.6
-14.0  1372.7    2575.6    148.5   -1054.4    3800.4     148.6     2576.2
-15.0  1372.7    2833.2    163.4   -1297.1    4043.1     163.4     2833.8
-16.0  1372.7    3090.7    178.2   -1539.8    4285.9     178.3     3091.5
-17.0  1372.6    3348.3    193.1   -1782.5    4528.6     193.1     3349.1
-18.0  1372.6    3605.9    207.9   -2025.2    4771.4     208.0     3606.7
-18.4  1372.6    4929.4    319.0   -3237.7    5983.8     319.0     4930.2
-19.0  1372.6    7153.8    490.2   -5290.9    8036.9     490.3     7154.5
-20.0  1372.6    7761.1    513.1   -5875.4    8621.5     513.1     7762.0
-21.0  1372.6    7925.0    528.1   -6024.3    8770.5     528.1     7925.9
-22.0  1372.6    8095.5    542.9   -6179.9    8926.1     543.0     8096.5
-23.0  1372.6    8271.2    557.7   -6340.8    9087.1     557.8     8272.2
-24.0  1372.6    8450.9    572.5   -6505.9    9252.1     572.5     8452.0
-25.0  1372.5    8634.0    587.1   -6674.2    9420.5     587.2     8635.1
-26.0  1372.5    8819.6    601.8   -6845.2    9591.5     601.8     8820.8
-27.0  1372.5    9007.4    616.4   -7018.4    9764.8     616.4     9008.6
-28.0  1372.5    9197.0    630.9   -7193.5    9939.9     631.0     9198.3
-29.0  1372.5    9388.0    645.4   -7370.0   10116.4     645.5     9389.4
-30.0  1372.5    9580.4    660.0   -7547.8   10294.3     660.1     9581.8
-31.0  1372.5    9773.7    674.4   -7726.7   10473.2     674.5     9775.2
-32.0  1372.5    9968.0    688.9   -7906.5   10653.0     689.0     9969.5
-33.0  1372.4   10149.9    703.4   -8074.0   10820.6     703.5    10151.5
-34.0  1372.4   10330.9    717.8   -8240.6   10987.2     717.9    10332.6
-35.0  1372.4   10524.9    732.3   -8420.1   11166.7     732.4    10526.6
-36.0  1372.4   10720.3    746.7   -8601.1   11347.7     746.8    10722.0
-37.0  1372.4   10916.1    761.1   -8782.5   11529.2     761.2    10917.9
-38.0  1372.4   11112.4    775.5   -8964.4   11711.1     775.6    11114.2
-39.0  1372.4   11309.1    789.9   -9146.7   11893.4     790.0    11311.0
-40.0  1372.4   11506.1    804.3   -9329.3   12076.0     804.4    11508.0
-41.0  1372.3   11703.4    818.7   -9512.2   12259.0     818.8    11705.3
-42.0  1372.3   11900.9    833.1   -9695.4   12442.2     833.2    11902.9
-43.0  1372.3   12098.7    847.5   -9878.8   12625.6     847.6    12100.8
-44.0  1372.3   12296.7    861.8  -10062.4   12809.3     862.0    12298.8
-45.0  1372.3   12494.9    876.2  -10246.2   12993.1     876.4    12497.0
-46.0  1372.3   12693.2    890.6  -10430.2   13177.1     890.7    12695.4
-47.0  1372.3   12891.7    904.9  -10614.3   13361.3     905.1    12894.0
-48.0  1372.3   13090.4    919.3  -10798.6   13545.6     919.5    13092.7
-49.0  1372.2   13289.1    933.7  -10983.1   13730.1     933.8    13291.5
-50.0  1372.2   13488.0    948.0  -11167.6   13914.7     948.2    13490.5
-51.0  1372.2   13687.0    962.4  -11352.2   14099.4     962.6    13689.5
-52.0  1372.2   13886.1    976.8  -11537.0   14284.1     976.9    13888.7
-53.0  1372.2   14085.3    991.1  -11721.8   14469.0     991.3    14087.9
-54.0  1372.2   14284.6   1005.5  -11906.7   14654.0    1005.6    14287.2
-55.0  1372.2   14483.9   1019.8  -12091.7   14839.0    1020.0    14486.6
-56.0  1372.2   14683.3   1034.2  -12276.8   15024.1    1034.4    14686.1
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-57.0  1372.1   14882.8   1048.5  -12461.9   15209.2   1048.7   14885.6
-58.0  1372.1   15082.3   1062.9  -12647.1   15394.5   1063.1   15085.2
-59.0  1372.1   15281.9   1077.2  -12832.4   15579.8   1077.4   15284.8
-60.0  1372.1   15481.6   1091.6  -13017.7   15765.1   1091.8   15484.5
-61.0  1372.1   15681.2   1105.9  -13203.0   15950.5   1106.1   15684.3
-62.0  1372.1   15881.0   1120.2  -13388.4   16135.9   1120.5   15884.1
-63.0  1372.1   16080.7   1134.6  -13573.9   16321.4   1134.8   16083.9
-64.0  1372.1   16280.6   1148.9  -13759.3   16506.9   1149.2   16283.7
-65.0  1372.0   16480.4   1163.3  -13944.9   16692.4   1163.5   16483.6
-66.0  1372.0   16680.3   1177.6  -14130.4   16878.0   1177.9   16683.6
-67.0  1372.0   16880.2   1192.0  -14316.0   17063.6   1192.2   16883.5
-68.0  1372.0   17080.1   1206.3  -14501.6   17249.2   1206.5   17083.5
-69.0  1372.0   17280.1   1220.6  -14687.2   17434.9   1220.9   17283.5
-70.0  1372.0   17480.1   1235.0  -14872.9   17620.6   1235.2   17483.6
-71.0  1372.0   17680.1   1249.3  -15058.6   17806.3   1249.6   17683.6
-72.0  1372.0   17880.1   1263.7  -15244.3   17992.0   1263.9   17883.7
-73.0  1371.9   18080.2   1278.0  -15430.0   18177.8   1278.3   18083.8
-74.0  1371.9   18280.3   1292.3  -15615.7   18363.6   1292.6   18284.0
-75.0  1371.9   18480.4   1306.7  -15801.5   18549.4   1306.9   18484.1
-76.0  1371.9   18680.5   1321.0  -15987.3   18735.2   1321.3   18684.3
-77.0  1371.9   18880.6   1335.4  -16173.1   18921.0   1335.6   18884.5
-78.0  1371.9   19080.7   1349.7  -16358.9   19106.9   1350.0   19084.7
-79.0  1371.9   19280.9   1364.0  -16544.7   19292.7   1364.3   19284.9
-80.0  1371.9   19481.1   1378.4  -16730.6   19478.6   1378.6   19485.1
-81.0  1371.8   19681.3   1392.7  -16916.5   19664.5   1393.0   19685.4
-82.0  1371.8   19881.5   1407.0  -17102.3   19850.4   1407.3   19885.6
-83.0  1371.8   20081.7   1421.4  -17288.2   20036.3   1421.7   20085.9
-84.0  1371.8   20281.9   1435.7  -17474.1   20222.3   1436.0   20286.2
-85.0  1371.8   20482.2   1450.0  -17660.0   20408.2   1450.3   20486.5
-86.0  1371.8   20682.4   1464.4  -17845.9   20594.2   1464.7   20686.8
-87.0  1371.8   20882.7   1478.7  -18031.9   20780.1   1479.0   20887.1
-88.0  1371.8   21082.9   1493.0  -18217.8   20966.1   1493.4   21087.4
-89.0  1371.7   21283.2   1507.4  -18403.8   21152.1   1507.7   21287.7
-90.0  1371.7   21483.5   1521.7  -18589.7   21338.1   1522.0   21488.0
-91.0  1371.7   21683.8   1536.0  -18775.7   21524.1   1536.4   21688.4
-92.0  1371.7   21884.1   1550.4  -18961.7   21710.1   1550.7   21888.7
-93.0  1371.7   22084.4   1564.7  -19147.7   21896.1   1565.0   22089.1
-94.0  1371.7   22284.7   1579.0  -19333.6   22082.1   1579.4   22289.5
-95.0  1371.7   22485.0   1593.4  -19519.6   22268.1   1593.7   22489.8
          * STANDARD WEDGE SOLUTION DOES NOT EXIST FOR INDICATED PRESSURE
            FOR THIS ELEVATION.







PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                             BY CLASSICAL METHODS
DATE: 15-JANUARY-2014                                          TIME: 9:29:02

                            *****************************
                            *   SUMMARY OF RESULTS FOR  *
                            *   CANTILEVER WALL DESIGN  *
                            *****************************


   I.--HEADING
    'S72 COFFER DAM WALL DESIGN -DOWNSTREAM STREAM CENTER
```

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II.--SUMMARY

     RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

     LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

     *****WARNING:  STANDARD WEDGE SOLUTION DOES NOT EXIST
                    AT ALL ELEVATIONS.  SEE COMPLETE OUTPUT.

WALL BOTTOM ELEV. (FT)     :      -37.48
      PENETRATION (FT)     :       33.48

MAX. BEND. MOMENT (LB-FT)  :  4.1149E+05
      AT ELEVATION (FT)    :      -21.82

MAX. SCALED DEFL. (LB-IN^3):  6.9417E+11
      AT ELEVATION (FT)    :       26.00

SEEPAGE GRADIENT           :     0.3288

          NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                 ELASTICITY IN PSI TIMES PILE MOMENT
                 OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                 IN INCHES.
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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
                        BY CLASSICAL METHODS
DATE: 15-JANUARY-2014                                      TIME: 9:29:02

                      ****************************
                      * COMPLETE OF RESULTS FOR  *
                      *  CANTILEVER WALL DESIGN  *
                      ****************************

   I.--HEADING
   'S72 COFFER DAM WALL DESIGN -DOWNSTREAM STREAM CENTER

  II.--RESULTS0. (LB))

                BENDING                          SCALED          NET
  ELEVATION     MOMENT           SHEAR         DEFLECTION      PRESSURE
    (FT)        (LB-FT)           (LB)          (LB-IN^3)        (PSF)
    26.00     0.0000E+00           0.           6.9417E+11        0.00
    25.00    -3.3528E-08           0.           6.7853E+11        0.00
    24.00    -3.3528E-08           0.           6.6290E+11        0.00
    23.00    -3.3528E-08           0.           6.4726E+11        0.00
    22.00    -3.3528E-08           0.           6.3163E+11        0.00
    21.00    -3.3528E-08           0.           6.1600E+11        0.00
    20.00    -3.3528E-08           0.           6.0036E+11        0.00
    19.00    -3.3528E-08           0.           5.8473E+11        0.00
    18.00    -3.3528E-08           0.           5.6910E+11        0.00
    17.00     1.0400E+01          31.           5.5346E+11       62.40
    16.00     8.3200E+01         125.           5.3783E+11      124.80
    15.00     2.8080E+02         281.           5.2220E+11      187.20
    14.00     6.6560E+02         499.           5.0656E+11      249.60
    13.00     1.3000E+03         780.           4.9093E+11      312.00
    12.00     2.2464E+03        1123.           4.7530E+11      374.40
    11.00     3.5672E+03        1529.           4.5968E+11      436.80
    10.00     5.3248E+03        1997.           4.4406E+11      499.20
```

```
      9.00    7.5816E+03         2527.        4.2845E+11         561.60
      8.00    1.0400E+04         3120.        4.1285E+11         624.00
      7.00    1.3842E+04         3775.        3.9727E+11         686.40
      6.00    1.7971E+04         4493.        3.8172E+11         748.80
      5.00    2.2849E+04         5273.        3.6619E+11         811.20
      4.00    2.8538E+04         6115.        3.5071E+11         873.60
      3.00    3.5100E+04         7020.        3.3527E+11         936.00
      2.00    4.2598E+04         7987.        3.1990E+11         998.40
      1.00    5.1095E+04         9017.        3.0460E+11        1060.80
      0.00    6.0653E+04        10109.        2.8939E+11        1123.20
     -1.00    7.1334E+04        11263.        2.7428E+11        1185.60
     -2.00    8.3200E+04        12480.        2.5930E+11        1248.00
     -3.00    9.6314E+04        13759.        2.4446E+11        1310.40
     -4.00    1.1074E+05        15101.        2.2979E+11        1372.80
     -5.00    1.2650E+05        16385.        2.1531E+11        1195.30
     -6.00    1.4345E+05        17491.        2.0104E+11        1017.80
     -7.00    1.6142E+05        18420.        1.8703E+11         840.31
     -8.00    1.8023E+05        19172.        1.7329E+11         662.81
     -9.00    1.9971E+05        19746.        1.5987E+11         485.31
    -10.00    2.1966E+05        20143.        1.4679E+11         307.81
    -11.00    2.3993E+05        20362.        1.3409E+11         130.31
    -11.73    2.5490E+05        20410.        1.2503E+11           0.00
    -12.00    2.6033E+05        20403.        1.2181E+11         -47.18
    -13.00    2.8068E+05        20267.        1.0997E+11        -224.68
    -14.00    3.0080E+05        19954.        9.8624E+10        -402.18
    -15.00    3.2053E+05        19463.        8.7794E+10        -579.68
    -16.00    3.3967E+05        18795.        7.7518E+10        -757.17
    -17.00    3.5806E+05        17949.        6.7829E+10        -934.67
    -18.00    3.7551E+05        16925.        5.8758E+10       -1112.17
    -18.40    3.8215E+05        16209.        5.5310E+10       -2470.64
    -19.00    3.9130E+05        14076.        5.0336E+10       -4639.12
    -20.00    4.0300E+05         9260.        4.2590E+10       -4992.21
    -21.00    4.0975E+05         4220.        3.5539E+10       -5088.80
    -22.00    4.1141E+05         -921.        2.9196E+10       -5192.19
    -23.00    4.0787E+05        -6167.        2.3563E+10       -5300.87
    -24.00    3.9904E+05       -11525.        1.8634E+10       -5413.73
    -25.00    3.8478E+05       -16997.        1.4393E+10       -5529.93
    -26.00    3.6500E+05       -22586.        1.0817E+10       -5648.84
    -27.00    3.3957E+05       -28295.        7.8709E+09       -5769.96
    -28.00    3.0837E+05       -34127.        5.5105E+09       -5892.90
    -28.14    3.0362E+05       -34939.        5.2285E+09       -5910.04
    -29.00    2.7151E+05       -39268.        3.6821E+09       -4128.83
    -30.00    2.3052E+05       -42364.        2.3223E+09       -2063.26
    -31.00    1.8747E+05       -43394.        1.3606E+09           2.32
    -32.00    1.4442E+05       -42359.        7.2283E+08        2067.89
    -33.00    1.0344E+05       -39258.        3.3491E+08        4133.46
    -34.00    6.6596E+04       -34092.        1.2633E+08        6199.04
    -35.00    3.5947E+04       -26860.        3.3724E+07        8264.61
    -36.00    1.3564E+04       -17563.        4.4246E+06       10330.18
    -37.00    1.5099E+03        -6200.        5.0794E+04       12395.76
    -37.45    5.1873E+00         -372.        5.7987E-01       13331.55
    -37.48    0.0000E+00            0.        0.0000E+00       13389.09

          NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                 ELASTICITY IN PSI TIMES PILE MOMENT
                 OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                 IN INCHES.

  III.--WATER AND SOIL PRESSURES

                              <-------------SOIL PRESSURES------------->
                     WATER    <----LEFTSIDE----->      <---RIGHTSIDE---->
 ELEVATION        PRESSURE    PASSIVE       ACTIVE      ACTIVE       PASSIVE
```

```
  (FT)          (PSF)        (PSF)         (PSF)        (PSF)        (PSF)
 26.00            0.           0.            0.           0.           0.
 25.00            0.           0.            0.           0.           0.
 24.00            0.           0.            0.           0.           0.
 23.00            0.           0.            0.           0.           0.
 22.00            0.           0.            0.           0.           0.
 21.00            0.           0.            0.           0.           0.
 20.00            0.           0.            0.           0.           0.
 19.00            0.           0.            0.           0.           0.
 18.00            0.           0.            0.           0.           0.
 17.00           62.           0.            0.           0.           0.
 16.00          125.           0.            0.           0.           0.
 15.00          187.           0.            0.           0.           0.
 14.00          250.           0.            0.           0.           0.
 13.00          312.           0.            0.           0.           0.
 12.00          374.           0.            0.           0.           0.
 11.00          437.           0.            0.           0.           0.
 10.00          499.           0.            0.           0.           0.
  9.00          562.           0.            0.           0.           0.
  8.00          624.           0.            0.           0.           0.
  7.00          686.           0.            0.           0.           0.
  6.00          749.           0.            0.           0.           0.
  5.00          811.           0.            0.           0.           0.
  4.00          874.           0.            0.           0.           0.
  3.00          936.           0.            0.           0.           0.
  2.00          998.           0.            0.           0.           0.
  1.00         1061.           0.            0.           0.           0.
  0.00         1123.           0.            0.           0.           0.
 -1.00         1186.           0.            0.           0.           0.
 -2.00         1248.           0.            0.           0.           0.
 -3.00         1310.           0.            0.           0.           0.
 -4.00         1373.           0.            0.           0.           0.
 -5.00         1332.         157.            9.          21.         358.
 -6.00         1291.         314.           18.          41.         716.
 -7.00         1250.         471.           27.          62.        1074.
 -8.00         1209.         628.           36.          83.        1432.
 -9.00         1168.         786.           45.         103.        1790.
-10.00         1127.         943.           54.         124.        2148.
-11.00         1086.        1100.           63.         145.        2507.
-11.73         1055.        1215.           70.         160.        2769.
-12.00         1045.        1257.           72.         165.        2865.
-13.00         1003.        1414.           82.         186.        3223.
-14.00          962.        1571.           91.         206.        3581.
-15.00          921.        1728.          100.         227.        3939.
-16.00          880.        1885.          109.         248.        4297.
-17.00          839.        2042.          118.         268.        4655.
-18.00          798.        2200.          127.         289.        5013.
-18.40          782.        3655.          236.         402.        6205.
-19.00          757.        5975.          402.         579.        8333.
-20.00          716.        6319.          415.         611.        9204.
-21.00          675.        6396.          424.         632.        9455.
-22.00          634.        6479.          433.         653.        9713.
-23.00          593.        6568.          442.         674.        9975.
-24.00          552.        6661.          450.         695.       10242.
-25.00          511.        6757.          459.         716.       10512.
-26.00          470.        6855.          467.         737.       10785.
-27.00          429.        6956.          475.         757.       11060.
-28.00          388.        7059.          484.         778.       11336.
-28.14          347.        7073.          485.         781.       11375.
-29.00          306.        7163.          492.         799.       11614.
-30.00          265.        7268.          501.         819.       11894.
-31.00          224.        7375.          509.         840.       12174.
-32.00          183.        7482.          517.         861.       12455.
```

```
-33.00         142.      7579.      525.      881.      12722.
-34.00         101.      7678.      534.      902.      12986.
-35.00          60.      7786.      542.      923.      13265.
-36.00          19.      7895.      550.      943.      13547.
-37.00           0.      8004.      558.      964.      13830.
-37.45           0.      8065.      563.      972.      13946.
-37.48           0.      8164.      570.      981.      14063.
-39.00           0.      8364.      584.      996.      14256.
```

S72, S75, S82 Gate Design Notes

1. All materials used for gate fabrication are 304/304L stainless steel unless otherwise noted.
2. Gate dimensions and elevations are based on existing as-built drawings - field verify all dimensions prior to fabrication.
3. Gate elevations shown are based on NGVD 29.
4. Hot-rolled channels were used for vertical stiffeners in the existing gates; flat plate was utilized for vertical stiffeners in new gate design.

S72, S75 & S82 Gate Information Summary

Structure	**S72**	**S75**	**S82**
# Gates	2	1	2
Gate Dims[1]			
Width, ft.	27'-9-1/4"	28'-9-1/4"	23'-7"
Height-Upper, ft.	6'-6"	~	~
Height-Lower, ft.	5'-6 5/8"	10'-0"	7'-2 5/8"
T/Gate EL, ft. [1]	21.90	26.93	33.90
B/Gate EL, ft. [1]	9.84	16.93	26.68
Maximum Water EL, ft. [2]	22.00	28.50	33.50
Weir Crest EL, ft. [1]	9.90	17.00	26.70
C/C Rails, ft. [1]	28'-3 1/2"	29'-3 1/2"	24'-2"
ASCE Rail [1]	60#	60#	40#
Clr. Opg, ft. [1]	27'-0"	28'-0"	23'-0"
Skin Plate, in. [1]	3/8"	3/8"	3/8"
Horiz Mbrs. (exist.) [1]	C18x42.7	C18x58	C15x40
Spacing	varies	varies	varies
Vert Mbrs. (exist.) [1]	C18x42.7	C18x42.7	C15x33.9
Spacing	@ 6'-2"	@ 6'-5"	@ 5'-1"

NOTES

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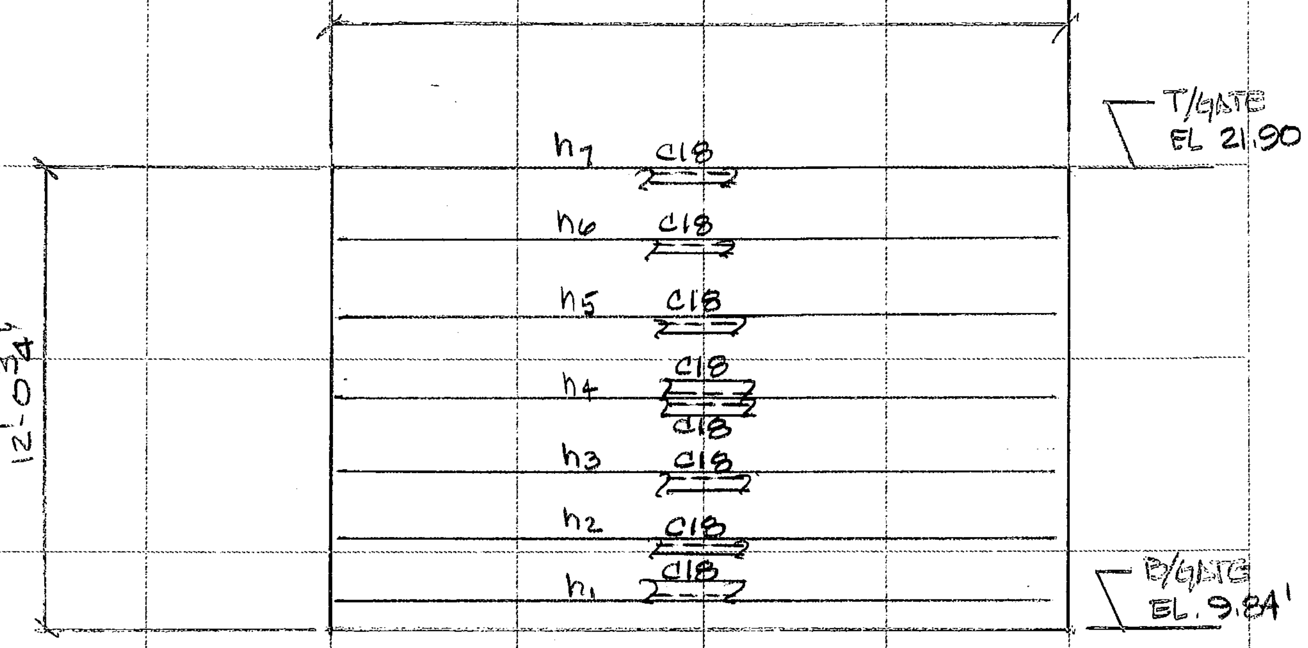
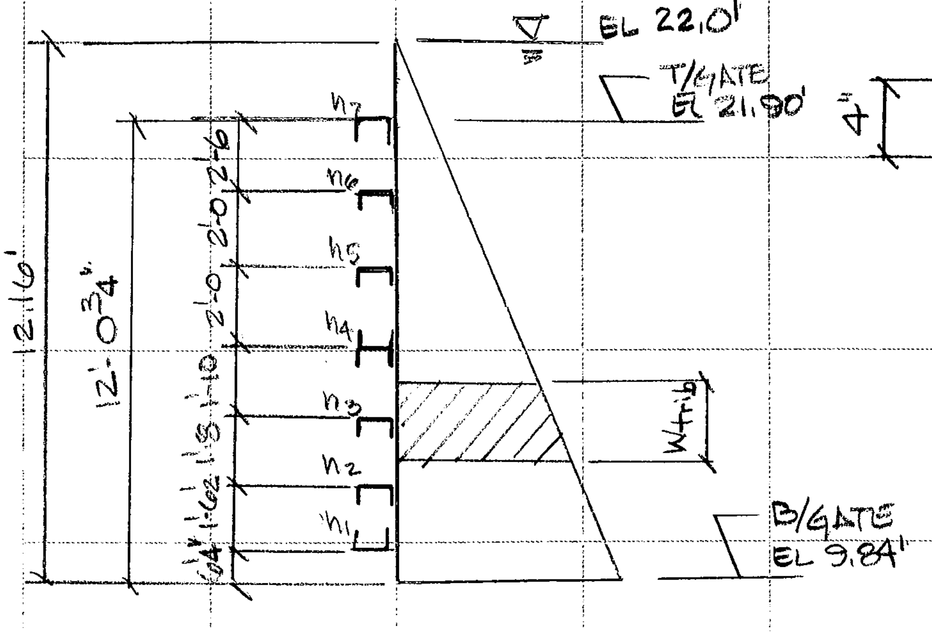
[1] Refer to As-Built Dwgs

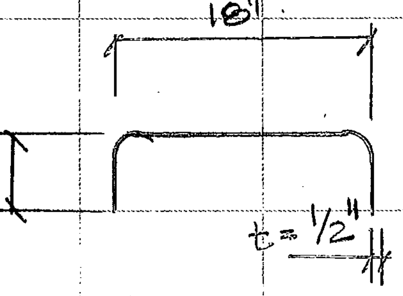
[2] From Jose G. 3/22/13, Water El. @ Gate S75 revised 4/11/13

Submitted By J. SKAGGS	Date 5/15/13	Project S72, S75, S82 STRUCT REPAIRS	Sheet of
Checked By	Description S72 GATE DESIGN		Job No.



S72 GATE - ELEVATION





C18 CHANNEL

S72 GATE - SIDE VIEW

Gate Horizontal Channel Design: **h2** Structure: S72

Developed by V. Loehrlein, rev. 8/24/12: (2) Gates

Calc by: J Skaggs Date: 5/15/13

Structure	S72	
gate width	27'-9 1/4"	27.77 ft.
upper gate, Hu	6'-6"	6.50 ft.
lower gate, Hl	5'-6 3/4"	5.56 ft.
bent plate t	1/2"	0.50 in.
channel depth d	18"	18 in.
channel flange	4"	4 in.
skin pl t	3/8"	0.38 in.
top of gate el.		21.90 ft.
design water el.		22.00 ft.
bott. of gate el.		9.84 ft.
horiz mbr spacing		
s7	2'-6"	2.50 ft.
s6	2'-0"	2.00 ft.
s5	2'-0"	2.00 ft.
s4	1'-10"	1.83 ft.
s3	1'-8"	1.67 ft.
s2	1'-6 1/2"	1.54 ft.
s1	0'-6 1/4"	0.52 ft.
design head @ h2, H=		10.10 ft.
$w_{trib.}=(s_2+s_3)/2$		1.61 ft.

COLD-FORMED

Determine section modulus of bent plate: **C 18**

INPUTS

t= 0.50 (in.) thickness of bent plate
d= 18 (in.) depth
b= 4 (in.) flange width minus t

RESULTS

r_m 1.25 (in.) mid-line radius, assume 2.5 x t (recommended)
c_1= 0.4245 (in.) centroid of inner quarter circle at fillet (to be subtracted)
c_2= 0.6365 (in.) centroid of outer quarter circle at fillet
A_1= 0.785 (in.^{2}) Area of inner quarter circle at fillet (to be subtracted)
A_2= 1.767 (in.^{2}) Area of outer quarter circle at fillet
length= 23.93 (in.) total plate length along centerline before bending
A= 11.96 (in.^{2}) Area
I= 467.40 (in.^{4}) moment of inertia
S= 51.93 (in.^{3}) Section modulus
Weight/ft. 40.62 (plf)

Including a cover plate (composite section)

INPUTS

t= 0.38 (in.) thickness of skin plate
w= 19.26 (in.) effective width. Note that the max. b/t = 238/SQRT F_y. See calc. below
use c-c channel spacing or value below plus flange width (whichever is less)
F_y= 28 (ksi) yield stress (use 28 ksi for S.S.)

RESULTS

$w_{allow.}$ 16.87 (in.) Max. allowable tributary width of cover plate between welds
new c.g. 6.20 (in.) revised center of gravity distance from skin face
I= 816.64 (in.^{4}) moment of inertia
S= 67.06 (in.^{3}) Section modulus
$S_{comp.}/S_{orig.}$= 1.29 ratio of composite section (channel plus skin plate) to channel only

Horizontal Member Design: **h2**

INPUTS

H= 10.10 (ft.) design head at horiz member, h2
L= 27.77 (ft.) width of gate
$w_{trib.}$= 1.61 (ft.) tributary width of water pressure
S= 67.06 (in^3) Insert calculated value from above
F_y= 28 (ksi) yield stress

RESULTS

p= 1011.54 (lb./ft.) pressure on horiz. member = 62.4*H*$w_{trib.}$
M= 97.51 (ft.-k) Moment (unfactored) = p*L^2/8
M= 1170.10 (in.-k)Moment (unfactored) - convert M to in-kip
$\phi F_{y=}$ 25.2 (ksi) LRFD allowable yield stress = 0.9*F_y
f_y= 24.43 (ksi) factored extreme fiber stress = 1.4 * M/S
S.R.= 0.97 stress ratio (should be < 1.0) = fy/ϕFy
$S_{req'd}$= 65.01 (in.^{3}) Required section modulus = M/ϕFy

Δ= 0.57 (in.) deflection at midsapn of horiz member

Gate Horizontal Channel Design: **h3** Structure: S72

Developed by V. Loehrlein, rev. 8/24/12: (2) Gates

Calc by: J Skaggs Date: 5/15/13

Structure	S72	
gate width	27'-9 1/4"	27.77 ft.
upper gate, Hu	6'-6"	6.50 ft.
lower gate, Hl	5'-6 3/4"	5.56 ft.
bent plate t	1/2"	0.50 in.
channel depth d	18"	18 in.
channel flange	4"	4 in.
skin pl t	3/8"	0.38 in.
top of gate el.		21.90 ft.
design water el.		22.00 ft.
bott. of gate el.		9.84 ft.
horiz mbr spacing		
s7	2'-6"	2.50 ft.
s6	2'-0"	2.00 ft.
s5	2'-0"	2.00 ft.
s4	1'-10"	1.83 ft.
s3	1'-8"	1.67 ft.
s2	1'-6 1/2"	1.54 ft.
s1	0'-6 1/4"	0.52 ft.
design head @ h3, H=		8.43 ft.
$w_{trib.}=(s_3+s_4)/2$		1.75 ft.

COLD-FORMED

Determine section modulus of bent plate: **C 18**

INPUTS

t= 0.50 (in.) thickness of bent plate
d= 18 (in.) depth
b= 4 (in.) flange width minus t

RESULTS

r_m 1.25 (in.) mid-line radius, assume 2.5 x t (recommended)
c_1= 0.4245 (in.) centroid of inner quarter circle at fillet (to be subtracted)
c_2= 0.6365 (in.) centroid of outer quarter circle at fillet
A_1= 0.785 (in.^{2}) Area of inner quarter circle at fillet (to be subtracted)
A_2= 1.767 (in.^{2}) Area of outer quarter circle at fillet
length= 23.93 (in.) total plate length along centerline before bending
A= 11.96 (in.^{2}) Area
I= 467.40 (in.^{4}) moment of inertia
S= 51.93 (in.^{3}) Section modulus
Weight/ft. 40.62 (plf)

Including a cover plate (composite section)

INPUTS

t= 0.38 (in.) thickness of skin plate
w= 21 (in.) effective width. Note that the max. b/t = 238/SQRT F_y. See calc. below
use c-c channel spacing or value below plus flange width (whichever is less)
F_y= 28 (ksi) yield stress (use 28 ksi for S.S.)

RESULTS

$w_{allow.}$ 16.87 (in.) Max. allowable tributary width of cover plate between welds
new c.g. 6.20 (in.) revised center of gravity distance from skin face
I= 816.64 (in.^{4}) moment of inertia
S= 67.06 (in.^{3}) Section modulus
$S_{comp.}/S_{orig.}$= 1.29 ratio of composite section (channel plus skin plate) to channel only

Horizontal Member Design: **h3**

INPUTS

H= 8.43 (ft.) design head at horiz member, h3
L= 27.77 (ft.) width of gate
$w_{trib.}$= 1.75 (ft.) tributary width of water pressure
S= 67.06 (in^3) Insert calculated value from above
F_y= 28 (ksi) yield stress

RESULTS

p= 920.56 (lb./ft.) pressure on horiz. member = 62.4*H*$w_{trib.}$
M= 88.74 (ft.-k) Moment (unfactored) = p*L^2/8
M= 1064.86 (in.-k)Moment (unfactored) - convert M to in-kip
$\phi F_{y=}$ 25.2 (ksi) LRFD allowable yield stress = 0.9*F_y
f_y= 22.23 (ksi) factored extreme fiber stress = 1.4 * M/S
S.R.= 0.88 stress ratio (should be < 1.0) = fy/ϕFy
$S_{req'd}$= 59.16 (in.^{3}) Required section modulus = M/ϕFy

Δ= 0.52 (in.) deflection at midsapn of horiz member

Gate Horizontal Channel Design: **h4** Structure: S72

Developed by V. Loehrlein, rev. 8/24/12: (2) Gates

Calc by: J Skaggs Date: 5/15/13

COLD-FORMED

Structure	S72	
gate width	27'-9 1/4"	27.77 ft.
upper gate, Hu	6'-6"	6.50 ft.
lower gate, Hl	5'-6 3/4"	5.56 ft.
bent plate t	1/2"	0.50 in.
channel depth d	18"	18 in.
channel flange	4"	4 in.
skin pl t	3/8"	0.38 in.
top of gate el.		21.90 ft.
design water el.		22.00 ft.
bott. of gate el.		9.84 ft.
horiz mbr spacing		
s7	2'-6"	2.50 ft.
s6	2'-0"	2.00 ft.
s5	2'-0"	2.00 ft.
s4	1'-10"	1.83 ft.
s3	1'-8"	1.67 ft.
s2	1'-6 1/2"	1.54 ft.
s1	0'-6 1/4"	0.52 ft.
design head @ h4, H=		6.60 ft.
$w_{trib.}=(s_4+s_5)/2$		1.92 ft.

Determine section modulus of bent plate: **C 18**

INPUTS

t=	0.50	(in.) thickness of bent plate
d=	18	(in.) depth
b=	4	(in.) flange width minus t

RESULTS

r_m	1.25	(in.) mid-line radius, assume 2.5 x t (recommended)
c_1=	0.4245	(in.) centroid of inner quarter circle at fillet (to be subtracted)
c_2=	0.6365	(in.) centroid of outer quarter circle at fillet
A_1=	0.785	(in.^{2}) Area of inner quarter circle at fillet (to be subtracted)
A_2=	1.767	(in.^{2}) Area of outer quarter circle at fillet
length=	23.93	(in.) total plate length along centerline before bending
A=	11.96	(in.^{2}) Area
I=	467.40	(in.^{4}) moment of inertia
S=	51.93	(in.^{3}) Section modulus
Weight/ft.	40.62	(plf)

Including a cover plate (composite section)

INPUTS

t=	0.38	(in.) thickness of skin plate
w=	22.98	(in.) effective width. Note that the max. b/t = 238/SQRT F_y. See calc. below
		use c-c channel spacing or value below plus flange width (whichever is less)
F_y=	28	(ksi) yield stress (use 28 ksi for S.S.)

RESULTS

$w_{allow.}$	16.87	(in.) Max. allowable tributary width of cover plate between welds
new c.g.	6.20	(in.) revised center of gravity distance from skin face
I=	816.64	(in.^{4}) moment of inertia
S=	67.06	(in.^{3}) Section modulus
$S_{comp.}/S_{orig.}$=	1.29	ratio of composite section (channel plus skin plate) to channel only

Horizontal Member Design: **h4**

INPUTS

H=	6.60	(ft.) design head at horiz member, h4
L=	27.77	(ft.) width of gate
$w_{trib.}$=	1.92	(ft.) tributary width of water pressure
S=	67.06	(in^3) Insert calculated value from above
F_y=	28	(ksi) yield stress

RESULTS

p=	788.67	(lb./ft.) pressure on horiz. member = 62.4*H*$w_{trib.}$
M=	76.03	(ft.-k) Moment (unfactored) = p*L^2/8
M=	912.31	(in.-k)Moment (unfactored) - convert M to in-kip
$\phi F_{y=}$	25.2	(ksi) LRFD allowable yield stress = 0.9*F_y
f_y=	19.05	(ksi) factored extreme fiber stress = 1.4 * M/S
S.R.=	0.76	stress ratio (should be < 1.0) = fy/ϕFy
$S_{req'd}$=	50.68	(in.^{3}) Required section modulus = M/ϕFy
Δ=	0.45	(in.) deflection at midsapn of horiz member

Gate Horizontal Channel Design: **h5** Structure: S72

Developed by V. Loehrlein, rev. 8/24/12: (2) Gates

Calc by: J Skaggs Date: 5/15/13

COLD-FORMED

Determine section modulus of bent plate: **C 18**

Structure	S72	
gate width	27'-9 1/4"	27.77 ft.
upper gate, Hu	6'-6"	6.50 ft.
lower gate, Hl	5'-6 3/4"	5.56 ft.
bent plate t	1/2"	0.50 in.
channel depth d	18"	18 in.
channel flange	4"	4 in.
skin pl t	3/8"	0.38 in.
top of gate el.		21.90 ft.
design water el.		22.00 ft.
bott. of gate el.		9.84 ft.
horiz mbr spacing		
s7	2'-6"	2.50 ft.
s6	2'-0"	2.00 ft.
s5	2'-0"	2.00 ft.
s4	1'-10"	1.83 ft.
s3	1'-8"	1.67 ft.
s2	1'-6 1/2"	1.54 ft.
s1	0'-6 1/4"	0.52 ft.
design head @ h5, H=		4.60 ft.
$w_{trib.}=(s_5+s_6)/2$		2.00 ft.

INPUTS

t= 0.50 (in.) thickness of bent plate

d= 18 (in.) depth

b= 4 (in.) flange width minus t

RESULTS

r_m 1.25 (in.) mid-line radius, assume 2.5 x t (recommended)

c_1= 0.4245 (in.) centroid of inner quarter circle at fillet (to be subtracted)

c_2= 0.6365 (in.) centroid of outer quarter circle at fillet

A_1= 0.785 (in.^{2}) Area of inner quarter circle at fillet (to be subtracted)

A_2= 1.767 (in.^{2}) Area of outer quarter circle at fillet

length= 23.93 (in.) total plate length along centerline before bending

A= 11.96 (in.^{2}) Area

I= 467.40 (in.^{4}) moment of inertia

S= 51.93 (in.^{3}) Section modulus

Weight/ft. 40.62 (plf)

Including a cover plate (composite section)

INPUTS

t= 0.38 (in.) thickness of skin plate

w= 24 (in.) effective width. Note that the max. b/t = 238/SQRT F_y. See calc. below

use c-c channel spacing or value below plus flange width (whichever is less)

F_y= 28 (ksi) yield stress (use 28 ksi for S.S.)

RESULTS

$w_{allow.}$ 16.87 (in.) Max. allowable tributary width of cover plate between welds

new c.g. 6.20 (in.) revised center of gravity distance from skin face

I= 816.64 (in.^{4}) moment of inertia

S= 67.06 (in.^{3}) Section modulus

$S_{comp.}/S_{orig.}$= 1.29 ratio of composite section (channel plus skin plate) to channel only

Horizontal Member Design: **h5**

INPUTS

H= 4.60 (ft.) design head at horiz member, h5

L= 27.77 (ft.) width of gate

$w_{trib.}$= 2.00 (ft.) tributary width of water pressure

S= 67.06 (in^3) Insert calculated value from above

F_y= 28 (ksi) yield stress

RESULTS

p= 574.08 (lb./ft.) pressure on horiz. member = 62.4*H*$w_{trib.}$

M= 55.34 (ft.-k) Moment (unfactored) = p*L^2/8

M= 664.07 (in.-k)Moment (unfactored) - convert M to in-kip

$\phi F_{y=}$ 25.2 (ksi) LRFD allowable yield stress = 0.9*F_y

f_y= 13.86 (ksi) factored extreme fiber stress = 1.4 * M/S

S.R.= 0.55 stress ratio (should be < 1.0) = fy/ϕFy

$S_{req'd}$= 36.89 (in.^{3}) Required section modulus = M/ϕFy

Δ= 0.32 (in.) deflection at midsapn of horiz member

Gate Horizontal Channel Design: **h6** Structure: S72

Developed by V. Loehrlein, rev. 8/24/12: (2) Gates

Calc by: J Skaggs Date: 5/15/13

Structure	S72	
gate width	27'-9 1/4"	27.77 ft.
upper gate, Hu	6'-6"	6.50 ft.
lower gate, Hl	5'-6 3/4"	5.56 ft.
bent plate t	1/2"	0.50 in.
channel depth d	18"	18 in.
channel flange	4"	4 in.
skin pl t	3/8"	0.38 in.
top of gate el.		21.90 ft.
design water el.		22.00 ft.
bott. of gate el.		9.84 ft.
horiz mbr spacing		
s7	2'-6"	2.50 ft.
s6	2'-0"	2.00 ft.
s5	2'-0"	2.00 ft.
s4	1'-10"	1.83 ft.
s3	1'-8"	1.67 ft.
s2	1'-6 1/2"	1.54 ft.
s1	0'-6 1/4"	0.52 ft.
design head @ h6, H=		2.60 ft.
$w_{trib.}=(s_6+s_7)/2$		2.25 ft.

COLD-FORMED

Determine section modulus of bent plate: **C 18**

INPUTS

t= 0.50 (in.) thickness of bent plate

d= 18 (in.) depth

b= 4 (in.) flange width minus t

RESULTS

r_m 1.25 (in.) mid-line radius, assume 2.5 x t (recommended)

c_1= 0.4245 (in.) centroid of inner quarter circle at fillet (to be subtracted)

c_2= 0.6365 (in.) centroid of outer quarter circle at fillet

A_1= 0.785 (in.^{2}) Area of inner quarter circle at fillet (to be subtracted)

A_2= 1.767 (in.^{2}) Area of outer quarter circle at fillet

length= 23.93 (in.) total plate length along centerline before bending

A= 11.96 (in.^{2}) Area

I= 467.40 (in.^{4}) moment of inertia

S= 51.93 (in.^{3}) Section modulus

Weight/ft. 40.62 (plf)

Including a cover plate (composite section)

INPUTS

t= 0.38 (in.) thickness of skin plate

w= 27 (in.) effective width. Note that the max. b/t = 238/SQRT F_y. See calc. below

use c-c channel spacing or value below plus flange width (whichever is less)

F_y= 28 (ksi) yield stress (use 28 ksi for S.S.)

RESULTS

$w_{allow.}$ 16.87 (in.) Max. allowable tributary width of cover plate between welds

new c.g. 6.20 (in.) revised center of gravity distance from skin face

I= 816.64 (in.^{4}) moment of inertia

S= 67.06 (in.^{3}) Section modulus

$S_{comp.}/S_{orig.}$= 1.29 ratio of composite section (channel plus skin plate) to channel only

Horizontal Member Design: **h6**

INPUTS

H= 2.60 (ft.) design head at horiz member, h6

L= 27.77 (ft.) width of gate

$w_{trib.}$= 2.25 (ft.) tributary width of water pressure

S= 67.06 (in^3) Insert calculated value from above

F_y= 28 (ksi) yield stress

RESULTS

p= 365.04 (lb./ft.) pressure on horiz. member = 62.4*H*$w_{trib.}$

M= 35.19 (ft.-k) Moment (unfactored) = p*L^2/8

M= 422.26 (in.-k)Moment (unfactored) - convert M to in-kip

$\phi F_{y=}$ 25.2 (ksi) LRFD allowable yield stress = 0.9*F_y

f_y= 8.82 (ksi) factored extreme fiber stress = 1.4 * M/S

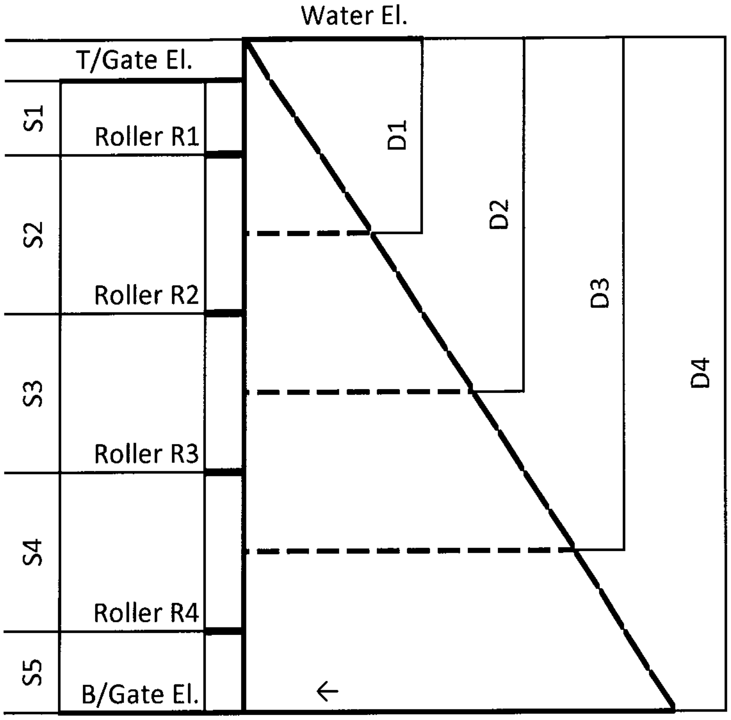
S.R.= 0.35 stress ratio (should be < 1.0) = fy/ϕFy

$S_{req'd}$= 23.46 (in.^{3}) Required section modulus = M/ϕFy

Δ= 0.21 (in.) deflection at midsapn of horiz member

Gate Roller Loads Structure: S72 (2) Gates
Calc by: J Skaggs Date: 5/15/13

Structure	S72	
gate width	27'-9 1/4"	27.77 ft.
upper gate, Hu	6'-6"	6.50 ft.
lower gate, Hl	5'-6 3/4"	5.56 ft.
top of gate el.		21.90 ft.
design water el.		22.00 ft.
bott. of gate el.		9.84 ft.
roller spacing		
S1	1'-4 1/4"	1.35 ft.
S2	4'-0"	4.00 ft.
S3	2'-4"	2.33 ft.
S4	3'-3"	3.25 ft.
S5	1'-1 1/2"	1.13 ft.



Distance from water surface to midway between two rollers(or gate bottom),

D= ht of water above gate + distance to midway between rollers

D1	3.45 ft	=ht of water + (s1+s2/2)
D2	6.62 ft	=ht of water + (s1+s2+s3/2)
D3	9.41 ft	=ht of water + (s1+s2+s3+s4/2)
D4	12.16 ft	=ht of water + (s1+s2+s3+s4+s5)

Roller load, R = D*D/2 * 62.4#/ft$^{3\,*}$gate width/ 2 rollers

R1	5156 lbs	=(D1*D1)/2*62.4*gate width/2
R2	13800 lbs	=(D2*D2-D1*D1)/2*62.4*gate width/2
R3	19363 lbs	=(D3*D3-D2*D2)/2*62.4*gate width/2
R4	25738 lbs	=(D4*D4-D3*D3)/2*62.4*gate width/2

GATE S-72 (2 REQ'D) - Material Take-Off	QTY	DIM.	UNITS	DIM.	UNITS	UNIT WT (a)	UNITS	TOTAL WEIGHT
SKIN PLATE - 3/8"	1	27.75	FT	12.06	FT	15.75	#/FT^2	5270
VERTICAL END CHANNEL - C18	2	12.06	FT			45.50	#/FT	1098
VERTICAL INTERIOR CHANNEL - C18	2	12.06	FT			45.50	#/FT	1098
VERTICAL STIFFENER PLATE, 3/8"	5	12.06	FT	1.50	FT	15.75	#/FT^2	1424
HORIZONTAL CHANNEL - C18	8	27.75	FT			45.50	#/FT	10102
BOTT STIFF PL-3/8" X 1'-6" (TAPER)	26	0.45	FT^2			7.14	#/EA	84
VIBRATION PL-1/2"	1	1.33	FT	27.00	FT	21.00	#/FT^2	754
TOP SEAL PL - 3/8"	1	1.75	IN	27.75	FT	15.75	#/FT^2	64
TOP SEAL PL - 3/4"	1	2.00	IN	27.75	FT	31.51	#/FT^2	146
SIDE SEAL PL - 3/8"	2	1.75	IN	11.67	FT	15.75	#/FT^2	54
SIDE SEAL PL - 3/4"	2	2.00	IN	11.67	FT	31.51	#/FT^2	123
BOTTOM SEAL PL- 1/2"	1	3.75	IN	26.83	FT	21.00	#/FT^2	176
BOTTOM SEAL BAR - 1-1/2"	1	1.50	IN	26.83	FT	63.00	#/FT^2	211
LIFT BRACKET								
PL - 1"	2	1.69	FT^2			42.00	#/FT^2	142
PAD EYES - 13/16"	4	5.00	IN	5.00	IN	34.13	#/FT^2	24
WEB PL - 1"	4	3.50	IN	1.50	FT	42.00	#/FT^2	73
WHEEL ASSEMBLIES								
WHEELS - 1'-3" DIA.	8	15.00	IN	4.75	IN	504.00	#/FT^3	1958
AXLES -	8	3.75	IN	2.75	FT	504.00	#/FT^3	850
RUBBER SEAL								
TOP SEAL	1	3.86	IN^2	27.00	FT	74.00	#/FT^3	54
SIDE SEAL	2	3.86	IN^3	12.06	FT	74.00	#/FT^3	48
BOTTOM SEAL	1	4.00	IN^4	27.00	FT	74.00	#/FT^3	56
BOLTS SIDE SEAL								
TOP/ BOTTOM SEAL	2	27.00				43.00	#/100	70
SIDE SEALS	2	10.00				43.00	#/100	26
UPPER TO LOWER GATE SECT	1	27.00				43.00	#/100	23

TOTAL 23806

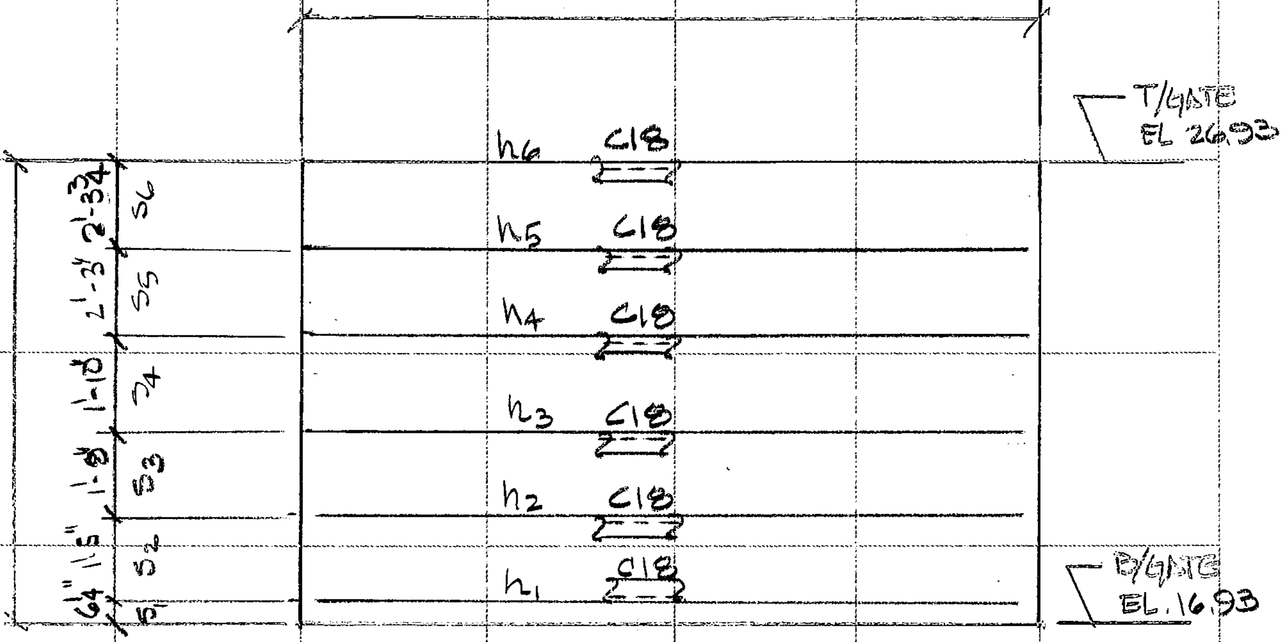
(a) Weights of plates and channels are based on density of 504#/ft^3

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

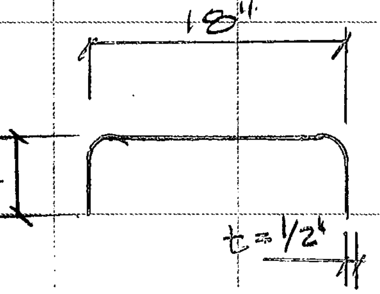
Engineering Calculations

Engineering & Construction Bureau

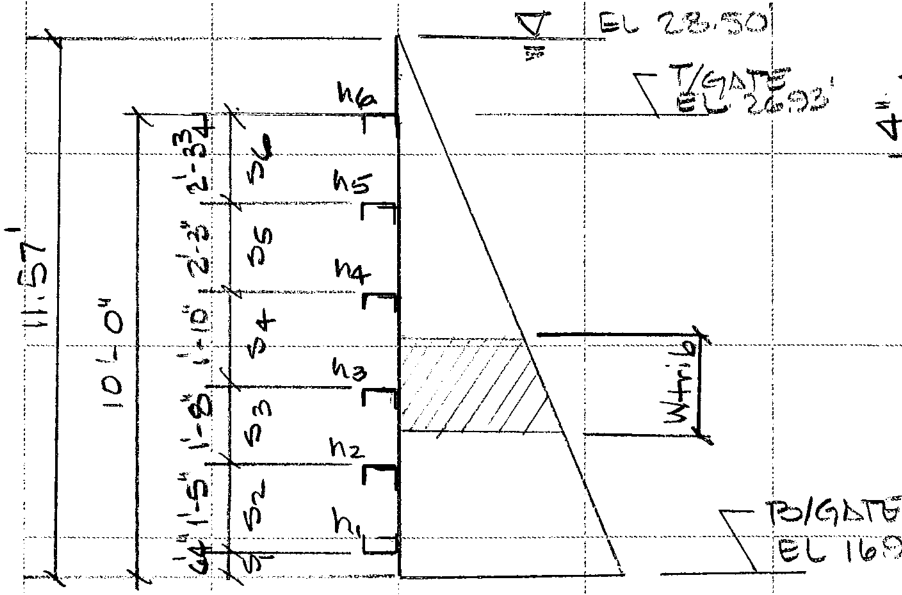
Submitted By	Date	Project	Sheet of
J. SKAGGS	5/15/13	S72, S75, S82 STRUCT REHAB	
Checked By	**Description**		**Job No.**
	S75 GATE DESIGN		



S75 GATE - ELEVATION



C18 CHANNEL



S75 GATE - SIDE VIEW

Gate Horizontal Channel Design: **h2** Structure: S75

Developed by V. Loehrlein, rev. 8/24/12: (1) Gate

Calc by: J Skaggs Date: 5/15/13

Structure	S75	
gate width	28'-9 1/4"	28.77 ft.
upper gate, Hu		
lower gate, Hl	10'-0"	10.00 ft.
bent plate t	1/2"	0.50 in.
channel depth d	18"	18 in.
channel flange	4"	4 in.
skin pl t	3/8"	0.375 in.
top of gate el.		26.93 ft.
design water el.		**28.50** ft.
bott. of gate el.		16.93 ft.
horiz mbr spacing		
s6	2'-3 3/4"	2.23 ft.
s5	2'-3"	2.25 ft.
s4	1'-10"	1.83 ft.
s3	1'-8"	1.67 ft.
s2	1'-5"	1.42 ft.
s1	0'-6 1/4"	0.52 ft.
design head @ h2, H=		9.63 ft.
$w_{trib.}=(s_2+s_3)/2$		1.55 ft.

COLD-FORMED

Determine section modulus of bent plate: **C 18**

INPUTS

t=	0.50	(in.) thickness of bent plate
d=	18	(in.) depth
b=	4	(in.) flange width minus t

RESULTS

r_m	1.25	(in.) mid-line radius, assume 2.5 x t (recommended)
c_1=	0.4245	(in.) centroid of inner quarter circle at fillet (to be subtracted)
c_2=	0.6365	(in.) centroid of outer quarter circle at fillet
A_1=	0.785	(in.^{2}) Area of inner quarter circle at fillet (to be subtracted)
A_2=	1.767	(in.^{2}) Area of outer quarter circle at fillet
length=	23.93	(in.) total plate length along centerline before bending
A=	11.96	(in.^{2}) Area
I=	467.40	(in.^{4}) moment of inertia
S=	51.93	(in.^{3}) Section modulus
Weight/ft.	40.62	(plf)

Including a cover plate (composite section)

INPUTS

t=	0.375	(in.) thickness of skin plate
w=	18.54	(in.) effective width. Note that the max. b/t = 238/SQRT F_y. See calc. below
		use c-c channel spacing or value below plus flange width (whichever is less)
F_y=	28	(ksi) yield stress (use 28 ksi for S.S.)

RESULTS

$w_{allow.}$	16.87	(in.) Max. allowable tributary width of cover plate between welds
new c.g.	6.20	(in.) revised center of gravity distance from skin face
I=	816.64	(in.^{4}) moment of inertia
S=	67.06	(in.^{3}) Section modulus
$S_{comp.}/S_{orig.}$=	1.29	ratio of composite section (channel plus skin plate) to channel only

Horizontal Member Design: h2

INPUTS

H=	9.63	(ft.) design head at horiz member, h2
L=	28.77	(ft.) width of gate
$w_{trib.}$=	1.55	(ft.) tributary width of water pressure
S=	67.06	(in^3) Insert calculated value from above
F_y=	28	(ksi) yield stress

RESULTS

p=	928.41	(lb./ft.) pressure on horiz. member = $62.4*H*w_{trib.}$
M=	96.06	(ft.-k) Moment (unfactored) = p*L^2/8
M=	1152.68	(in.-k)Moment (unfactored) - convert M to in-kip
$\phi F_{y=}$	25.2	(ksi) LRFD allowable yield stress = $0.9*F_y$
f_y=	24.06	(ksi) factored extreme fiber stress = 1.4 * M/S
S.R.=	0.95	stress ratio (should be < 1.0) = fy/ϕFy
$S_{req'd}$=	64.04	(in.^{3}) Required section modulus = M/ϕFy
Δ=	0.60	(in.) deflection at midsapn of horiz member

Gate Horizontal Channel Design: **h3** Structure: S75

Developed by V. Loehrlein, rev. 8/24/12: (1) Gate

Calc by: J Skaggs Date: 5/15/13

Structure	S75	
gate width	28'-9 1/4"	28.77 ft.
upper gate, Hu		
lower gate, Hl	10'-0"	10.00 ft.
bent plate t	1/2"	0.50 in.
channel depth d	18"	18 in.
channel flange	4"	4 in.
skin pl t	3/8"	0.375 in.
top of gate el.		26.93 ft.
design water el.		**28.50** ft.
bott. of gate el.		16.93 ft.
horiz mbr spacing		
s6	2'-3 3/4"	2.23 ft.
s5	2'-3"	2.25 ft.
s4	1'-10"	1.83 ft.
s3	1'-8"	1.67 ft.
s2	1'-5"	1.42 ft.
s1	0'-6 1/4"	0.52 ft.
design head @ h3, H=		7.96 ft.
$w_{trib.}=(s_3+s_4)/2$		1.75 ft.

COLD-FORMED

Determine section modulus of bent plate: **C 18**

INPUTS

t= 0.50 (in.) thickness of bent plate

d= 18 (in.) depth

b= 4 (in.) flange width minus t

RESULTS

r_m 1.25 (in.) mid-line radius, assume 2.5 x t (recommended)

c_1= 0.4245 (in.) centroid of inner quarter circle at fillet (to be subtracted)

c_2= 0.6365 (in.) centroid of outer quarter circle at fillet

A_1= 0.785 (in.^{2}) Area of inner quarter circle at fillet (to be subtracted)

A_2= 1.767 (in.^{2}) Area of outer quarter circle at fillet

length= 23.93 (in.) total plate length along centerline before bending

A= 11.96 (in.^{2}) Area

I= 467.40 (in.^{4}) moment of inertia

S= 51.93 (in.^{3}) Section modulus

Weight/ft. 40.62 (plf)

Including a cover plate (composite section)

INPUTS

t= 0.375 (in.) thickness of skin plate

w= 21 (in.) effective width. Note that the max. b/t = 238/SQRT F_y. See calc. below
use c-c channel spacing or value below plus flange width (whichever is less)

F_y= 28 (ksi) yield stress (use 28 ksi for S.S.)

RESULTS

$w_{allow.}$ 16.87 (in.) Max. allowable tributary width of cover plate between welds

new c.g. 6.20 (in.) revised center of gravity distance from skin face

I= 816.64 (in.^{4}) moment of inertia

S= 67.06 (in.^{3}) Section modulus

$S_{comp.}/S_{orig.}$= 1.29 ratio of composite section (channel plus skin plate) to channel only

Horizontal Member Design: **h3**

INPUTS

H= 7.96 (ft.) design head at horiz member, h3

L= 28.77 (ft.) width of gate

$w_{trib.}$= 1.75 (ft.) tributary width of water pressure

S= 67.06 (in^3) Insert calculated value from above

F_y= 28 (ksi) yield stress

RESULTS

p= 869.23 (lb./ft.) pressure on horiz. member = $62.4 * H * w_{trib.}$

M= 89.93 (ft.-k) Moment (unfactored) = p*L^2/8

M= 1079.21 (in.-k)Moment (unfactored) - convert M to in-kip

$\phi F_{y=}$ 25.2 (ksi) LRFD allowable yield stress = $0.9 * F_y$

f_y= 22.53 (ksi) factored extreme fiber stress = 1.4 * M/S

S.R.= 0.89 stress ratio (should be < 1.0) = fy/ϕFy

$S_{req'd}$= 59.96 (in.^{3}) Required section modulus = M/ϕFy

Δ= 0.57 (in.) deflection at midsapn of horiz member

Gate Horizontal Channel Design: **h4** Structure: S75

Developed by V. Loehrlein, rev. 8/24/12: (1) Gate

Calc by: J Skaggs Date: 5/15/13

Structure	S75	
gate width	28'-9 1/4"	28.77 ft.
upper gate, Hu		
lower gate, Hl	10'-0"	10.00 ft.
bent plate t	1/2"	0.50 in.
channel depth d	18"	18 in.
channel flange	4"	4 in.
skin pl t	3/8"	0.375 in.
top of gate el.		26.93 ft.
design water el.		**28.50** ft.
bott. of gate el.		16.93 ft.
horiz mbr spacing		
s6	2'-3 3/4"	2.23 ft.
s5	2'-3"	2.25 ft.
s4	1'-10"	1.83 ft.
s3	1'-8"	1.67 ft.
s2	1'-5"	1.42 ft.
s1	0'-6 1/4"	0.52 ft.
design head @ h4, H=		6.13 ft.
$w_{trib.}=(s_4+s_5)/2$		2.04 ft.

COLD-FORMED

Determine section modulus of bent plate: **C 18**

INPUTS

t=	0.50	(in.) thickness of bent plate
d=	18	(in.) depth
b=	4	(in.) flange width minus t

RESULTS

r_m	1.25	(in.) mid-line radius, assume 2.5 x t (recommended)
c_1=	0.4245	(in.) centroid of inner quarter circle at fillet (to be subtracted)
c_2=	0.6365	(in.) centroid of outer quarter circle at fillet
A_1=	0.785	(in.^{2}) Area of inner quarter circle at fillet (to be subtracted)
A_2=	1.767	(in.^{2}) Area of outer quarter circle at fillet
length=	23.93	(in.) total plate length along centerline before bending
A=	11.96	(in.^{2}) Area
I=	467.40	(in.^{4}) moment of inertia
S=	51.93	(in.^{3}) Section modulus
Weight/ft.	40.62	(plf)

Including a cover plate (composite section)

INPUTS

t=	0.375	(in.) thickness of skin plate
w=	24.48	(in.) effective width. Note that the max. b/t = 238/SQRT F_y. See calc. below
		use c-c channel spacing or value below plus flange width (whichever is less)
F_y=	28	(ksi) yield stress (use 28 ksi for S.S.)

RESULTS

$w_{allow.}$	16.87	(in.) Max. allowable tributary width of cover plate between welds
new c.g.	6.20	(in.) revised center of gravity distance from skin face
I=	816.64	(in.^{4}) moment of inertia
S=	67.06	(in.^{3}) Section modulus
$S_{comp.}/S_{orig.}$=	1.29	ratio of composite section (channel plus skin plate) to channel only

Horizontal Member Design: **h4**

INPUTS

H=	6.13	(ft.) design head at horiz member, h4
L=	28.77	(ft.) width of gate
$w_{trib.}$=	2.04	(ft.) tributary width of water pressure
S=	67.06	(in^3) Insert calculated value from above
F_y=	28	(ksi) yield stress

RESULTS

p=	780.32	(lb./ft.) pressure on horiz. member = 62.4*H*$w_{trib.}$
M=	80.74	(ft.-k) Moment (unfactored) = p*L^2/8
M=	968.83	(in.-k)Moment (unfactored) - convert M to in-kip
$\phi F_{y=}$	25.2	(ksi) LRFD allowable yield stress = 0.9*F_y
f_y=	20.23	(ksi) factored extreme fiber stress = 1.4 * M/S
S.R.=	0.80	stress ratio (should be < 1.0) = fy/ϕFy
$S_{req'd}$=	53.82	(in.^{3}) Required section modulus = M/ϕFy
Δ=	0.51	(in.) deflection at midsapn of horiz member

Gate Horizontal Channel Design: h5 Structure: S75

Developed by V. Loehrlein, rev. 8/24/12: (1) Gate

Calc by: J Skaggs Date: 5/15/13

Structure	S75	
gate width	28'-9 1/4"	28.77 ft.
upper gate, Hu		
lower gate, Hl	10'-0"	10.00 ft.
bent plate t	1/2"	0.50 in.
channel depth d	18"	18 in.
channel flange	4"	4 in.
skin pl t	3/8"	0.375 in.
top of gate el.		26.93 ft.
design water el.		**28.50** ft.
bott. of gate el.		16.93 ft.
horiz mbr spacing		
s6	2'-3 3/4"	2.31 ft.
s5	2'-3"	2.25 ft.
s4	1'-10"	1.83 ft.
s3	1'-8"	1.67 ft.
s2	1'-5"	1.42 ft.
s1	0'-6 1/4"	0.52 ft.
design head @ h5, H=		3.88 ft.
$w_{trib.}=(s_5+s_6)/2$		2.28 ft.

COLD-FORMED

Determine section modulus of bent plate: **C 18**

INPUTS

t= 0.50 (in.) thickness of bent plate

d= 18 (in.) depth

b= 4 (in.) flange width minus t

RESULTS

r_m 1.25 (in.) mid-line radius, assume 2.5 x t (recommended)

c_1= 0.4245 (in.) centroid of inner quarter circle at fillet (to be subtracted)

c_2= 0.6365 (in.) centroid of outer quarter circle at fillet

A_1= 0.785 (in.^{2}) Area of inner quarter circle at fillet (to be subtracted)

A_2= 1.767 (in.^{2}) Area of outer quarter circle at fillet

length= 23.93 (in.) total plate length along centerline before bending

A= 11.96 (in.^{2}) Area

I= 467.40 (in.^{4}) moment of inertia

S= 51.93 (in.^{3}) Section modulus

Weight/ft. 40.62 (plf)

Including a cover plate (composite section)

INPUTS

t= 0.375 (in.) thickness of skin plate

w= 27.36 (in.) effective width. Note that the max. b/t = 238/SQRT F_y. See calc. below
use c-c channel spacing or value below plus flange width (whichever is less)

F_y= 28 (ksi) yield stress (use 28 ksi for S.S.)

RESULTS

$w_{allow.}$ 16.87 (in.) Max. allowable tributary width of cover plate between welds

new c.g. 6.20 (in.) revised center of gravity distance from skin face

I= 816.64 (in.^{4}) moment of inertia

S= 67.06 (in.^{3}) Section modulus

$S_{comp.}/S_{orig.}$= 1.29 ratio of composite section (channel plus skin plate) to channel only

Horizontal Member Design: h5

INPUTS

H= 3.88 (ft.) design head at horiz member, h5

L= 28.77 (ft.) width of gate

$w_{trib.}$= 2.28 (ft.) tributary width of water pressure

S= 67.06 (in^3) Insert calculated value from above

F_y= 28 (ksi) yield stress

RESULTS

p= 552.02 (lb./ft.) pressure on horiz. member = $62.4*H*w_{trib.}$

M= 57.11 (ft.-k) Moment (unfactored) = p*L^2/8

M= 685.37 (in.-k)Moment (unfactored) - convert M to in-kip

$\phi F_{y=}$ 25.2 (ksi) LRFD allowable yield stress = $0.9*F_y$

f_y= 14.31 (ksi) factored extreme fiber stress = 1.4 * M/S

S.R.= 0.57 stress ratio (should be < 1.0) = fy/ϕFy

$S_{req'd}$= 38.08 (in.^{3}) Required section modulus = M/ϕFy

Δ= 0.36 (in.) deflection at midsapn of horiz member

GATE S-75 (1 REQ'D) - Material Take-Off	QTY	DIM.	UNITS	DIM.	UNITS	UNIT WT	UNITS	TOTAL WEIGHT
SKIN PLATE - 3/8"	1	28.83	FT	10.00	FT	15.75	#/FT^{2}	4540
VERTICAL END CHANNEL - C18	2	10.00	FT			45.50	#/FT	910
VERTICAL INTERIOR CHANNEL - C18	2	10.00	FT			45.50	#/FT	910
VERTICAL STIFFENER PLATE, 3/8"	5	10.00	FT	1.50	FT	15.75	#/FT^{2}	1181
HORIZONTAL CHANNEL - C18	6	28.75	FT			45.50	#/FT	7849
BOTT STIFF PL-3/8" X 1'-6" (TAPER)	27	0.45	FT^{2}			7.14	#/EA	87
VIBRATION PL-1/2"	1	1.33	FT^{2}	28.00	FT	21.00	#/FT^{2}	782
TOP SEAL PL - 3/8"	1	1.75	IN	28.83	FT	15.75	#/FT^{2}	66
TOP SEAL PL - 3/4"	1	2.00	IN	28.83	FT	31.51	#/FT^{2}	151
SIDE SEAL PL - 3/8"	2	1.75	IN	9.58	FT	15.75	#/FT^{2}	44
SIDE SEAL PL - 3/4"	2	2.00	IN	9.58	FT	31.51	#/FT^{2}	101
BOTTOM SEAL PL- 1/2"	1	3.75	IN	27.83	FT	21.00	#/FT^{2}	183
BOTTOM SEAL BAR - 1-1/2"	1	1.50	IN	27.83	FT	63.00	#/FT^{2}	219
LIFT BRACKET								
PL - 1"	2	1.69	FT^{2}			42.00	#/FT^{2}	142
PAD EYES - 13/16"	4	5.00	IN	5.00	IN	34.13	#/FT^{2}	24
WEB PL - 1"	4	3.50	IN	1.50	FT	42.00	#/FT^{2}	73
WHEEL ASSEMBLIES								
WHEELS - 1'-3" DIA.	8	15.00	IN	4.75	IN	504.00	#/FT^{3}	1958
AXLES -	8	3.75	IN	2.75	FT	504.00	#/FT^{3}	850
RUBBER SEAL								
TOP SEAL	1	3.86	IN^{2}	28.00	FT	74.00	#/FT^{3}	56
SIDE SEAL	2	3.86	IN^{3}	10.00	FT	74.00	#/FT^{3}	40
BOTTOM SEAL	1	4.00	IN^{4}	28.00	FT	74.00	#/FT^{3}	58
BOLTS SIDE SEAL								
TOP/ BOTTOM SEAL	2	28.00				43.00	#/100	72
SIDE SEALS	2	10.00				43.00	#/100	26

Note: Total weight shown does not include any allowance for welds

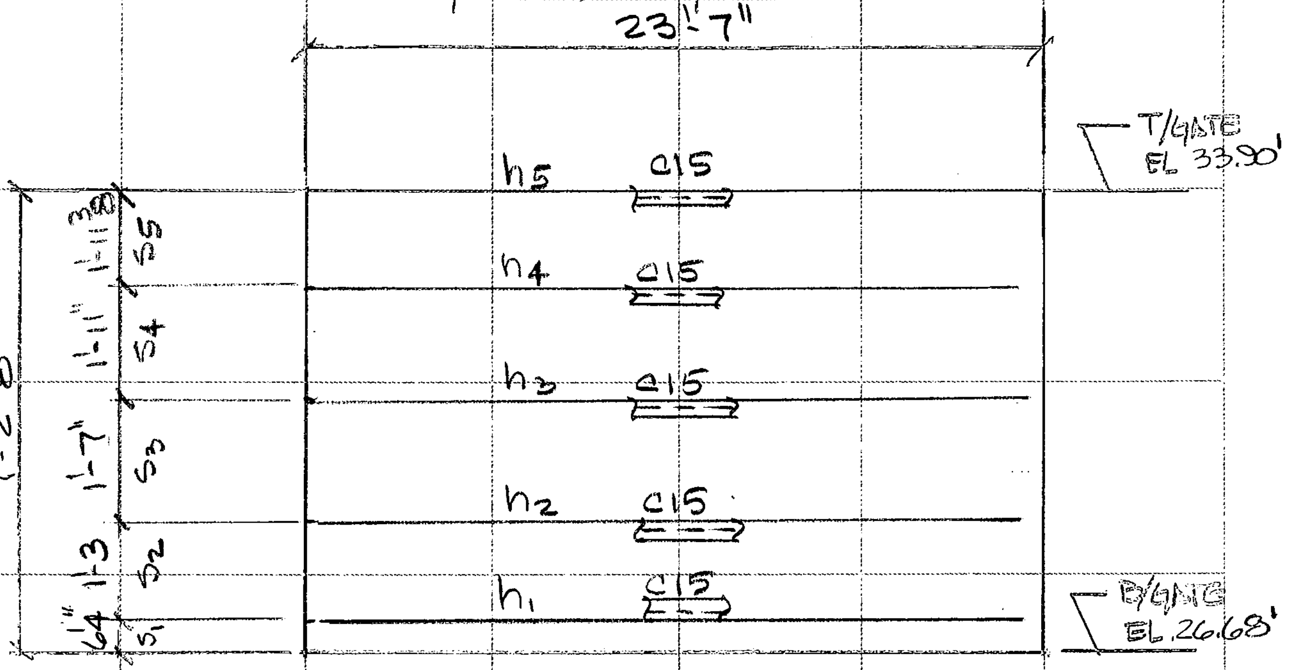
TOTAL 20223

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

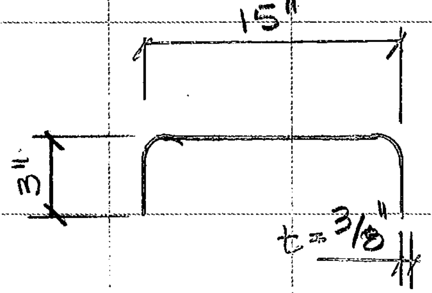
Engineering Calculations

Engineering & Construction Bureau

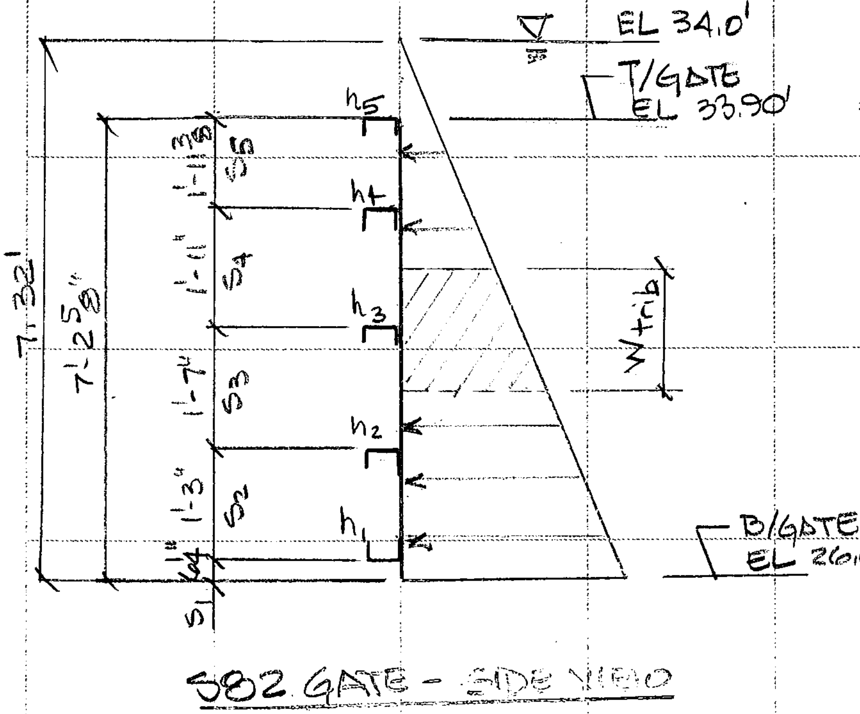
Submitted By J. SKAGGS	Date 5/15/13	Project S72, S75, S82 STRUCT REFURB	Sheet of
Checked By	Description S82 GATE DESIGN		Job No.



S82 GATE - ELEVATION



C15 CHANNEL



S82 GATE - SIDE VIEW

Gate Horizontal Channel Design: **h2** Structure: S82

Developed by V. Loehrlein, rev. 8/24/12: (2) Gates

Calc by: J Skaggs Date: 5/15/13

COLD-FORMED

Determine section modulus of bent plate: **C 15**

INPUTS

t= 0.38 (in.) thickness of bent plate
d= 15 (in.) depth
b= 3 (in.) flange width minus t

RESULTS

r_m 0.9375 (in.) mid-line radius, assume 2.5 x t (recommended)
c_1= 0.318375 (in.) centroid of inner quarter circle at fillet (to be subtracted)
c_2= 0.477375 (in.) centroid of outer quarter circle at fillet
A_1= 0.441563 (in.^{2}) Area of inner quarter circle at fillet (to be subtracted)
A_2= 0.993938 (in.^{2}) Area of outer quarter circle at fillet
length= 19.44 (in.) total plate length along centerline before bending
A= 7.29 (in.^{2}) Area
I= 193.74 (in.^{4}) moment of inertia
S= 25.83 (in.^{3}) Section modulus
Weight/ft. 24.76 (plf)

Structure	S82	
gate width	23'-7"	23.58 ft.
upper gate, Hu	~	~ ft.
lower gate, Hl	7'-2 5/8"	7.22 ft.
bent plate t	3/8"	0.38 in.
channel depth d	15"	15 in.
channel flange	3"	3 in.
skin pl t	3/8"	0.38 in.
top of gate el.		33.90 ft.
design water el.		34.00 ft.
bott. of gate el.		26.68 ft.
horiz mbr spacing		
h7	~	~ ft.
h6	~	~ ft.
h5	1'-11 3/8"	1.95 ft.
h4	1'-11"	1.92 ft.
h3	1'-7"	1.58 ft.
h2	1'-3"	1.25 ft.
h1	0'-6 1/4"	0.52 ft.
design head @ h2, H=		5.55 ft.
$w_{trib.}=(h_2+h_3)/2$		1.42 ft.

Including a cover plate (composite section)

INPUTS

t= 0.38 (in.) thickness of skin plate
w= 16.98 (in.) effective width. Note that the max. b/t = 238/SQRT F_y. See calc. below
use c-c channel spacing or value below plus flange width (whichever is less)
F_y= 28 (ksi) yield stress (use 28 ksi for S.S.)

RESULTS

$w_{allow.}$ 16.87 (in.) Max. allowable tributary width of cover plate between welds
new c.g. 4.30 (in.) revised center of gravity distance from skin face
I= 393.90 (in.^{4}) moment of inertia
S= 35.58 (in.^{3}) Section modulus
$S_{comp.}/S_{orig.}$= 1.38 ratio of composite section (channel plus skin plate) to channel only

Horizontal Member Design: **h2**

INPUTS

H= 5.55 (ft.) design head at horiz member, h2
L= 23.58 (ft.) width of gate
$w_{trib.}$= 1.42 (ft.) tributary width of water pressure
S= 35.58 (in^3) Insert calculated value from above
F_y= 28 (ksi) yield stress

RESULTS

p= 490.04 (lb./ft.) pressure on horiz. member=62.4xHx $w_{trib.}$
M= 34.06 (ft.-k) Moment (unfactored) = p*L^2/8
M= 408.71 (in.-k)Moment (unfactored) - convert M to in-kip
ϕF_y= 25.2 (ksi) LRFD allowable yield stress = 0.9*F_y
f_y= 16.08 (ksi) factored extreme fiber stress = 1.4 * M/S
S.R.= 0.64 stress ratio (should be < 1.0) = fy/ϕFy
$S_{req'd}$= 22.71 (in.^{3}) Required section modulus = M/ϕFy

Δ= 0.30 (in.) deflection at midsapn of horiz member

Gate Horizontal Channel Design: **h4** Structure: S82

Developed by V. Loehrlein, rev. 8/24/12: (2) Gates

Calc by: J Skaggs Date: 5/15/13

COLD-FORMED

Structure	S82	
gate width	23'-7"	23.58 ft.
upper gate, Hu	~	~ ft.
lower gate, Hl	7'-2 5/8"	7.22 ft.
bent plate t	3/8"	0.38 in.
channel depth d	15"	15 in.
channel flange	3"	3 in.
skin pl t	3/8"	0.38 in.
top of gate el.		33.90 ft.
design water el.		34.00 ft.
bott. of gate el.		26.68 ft.
horiz mbr spacing		
h7	~	~ ft.
h6	~	~ ft.
h5	1'-11 3/8"	1.95 ft.
h4	1'-11"	1.92 ft.
h3	1'-7"	1.58 ft.
h2	1'-3"	1.25 ft.
h1	0'-6 1/4"	0.52 ft.
design head @ h4, H=		2.05 ft.
$w_{trib.}=(h_4+h_5)/2$		1.94 ft.

Determine section modulus of bent plate: **C 15**

INPUTS

t= 0.38 (in.) thickness of bent plate

d= 15 (in.) depth

b= 3 (in.) flange width minus t

RESULTS

r_m 0.9375 (in.) mid-line radius, assume 2.5 x t (recommended)

c_1= 0.318375 (in.) centroid of inner quarter circle at fillet (to be subtracted)

c_2= 0.477375 (in.) centroid of outer quarter circle at fillet

A_1= 0.441563 (in.^{2}) Area of inner quarter circle at fillet (to be subtracted)

A_2= 0.993938 (in.^{2}) Area of outer quarter circle at fillet

length= 19.44 (in.) total plate length along centerline before bending

A= 7.29 (in.^{2}) Area

I= 193.74 (in.^{4}) moment of inertia

S= 25.83 (in.^{3}) Section modulus

Weight/ft. 24.76 (plf)

Including a cover plate (composite section)

INPUTS

t= 0.38 (in.) thickness of skin plate

w= 23.22 (in.) effective width. Note that the max. b/t = 238/SQRT F_y. See calc. below

use c-c channel spacing or value below plus flange width (whichever is less)

F_y= 28 (ksi) yield stress (use 28 ksi for S.S.)

RESULTS

$w_{allow.}$ 16.87 (in.) Max. allowable tributary width of cover plate between welds

new c.g. 4.30 (in.) revised center of gravity distance from skin face

I= 393.90 (in.^{4}) moment of inertia

S= 35.58 (in.^{3}) Section modulus

$S_{comp.}/S_{orig.}$= 1.38 ratio of composite section (channel plus skin plate) to channel only

Horizontal Member Design: **h4**

INPUTS

H= 2.05 (ft.) design head at horiz member, h4

L= 23.58 (ft.) width of gate

$w_{trib.}$= 1.94 (ft.) tributary width of water pressure

S= 35.58 (in^3) Insert calculated value from above

F_y= 28 (ksi) yield stress

RESULTS

p= 247.53 (lb./ft.) pressure on horiz. member=62.4xHx $w_{trib.}$

M= 17.20 (ft.-k) Moment (unfactored) = p*L^2/8

M= 206.44 (in.-k)Moment (unfactored) - convert M to in-kip

$\phi F_{y=}$ 25.2 (ksi) LRFD allowable yield stress = 0.9*F_y

f_y= 8.12 (ksi) factored extreme fiber stress = 1.4 * M/S

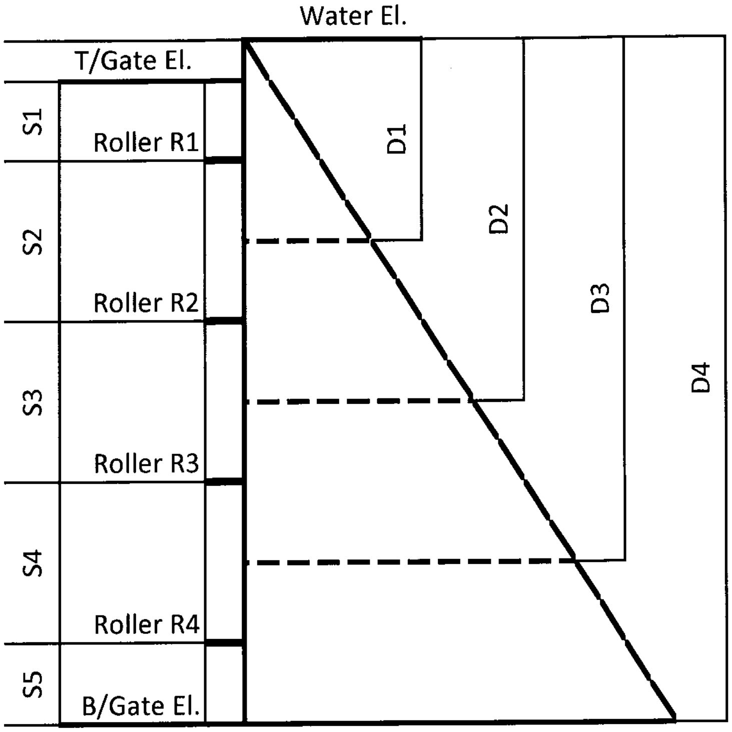
S.R.= 0.32 stress ratio (should be < 1.0) = fy/ϕFy

$S_{req'd}$= 11.47 (in.^{3}) Required section modulus = M/ϕFy

Δ= 0.15 (in.) deflection at midsapn of horiz member

Gate Roller Loads	Structure:	S82	(2) Gates
Calc by: J Skaggs	Date:	5/15/13	

Structure	S82	
gate width	23'-7"	23.58 ft.
upper gate, Hu		ft.
lower gate, Hl	7'-2 5/8"	7.22 ft.
top of gate el.		33.90 ft.
design water el.		34.00 ft.
bott. of gate el.		26.68 ft.
roller spacing		
S1	1'-0"	1.00 ft.
S2	1'-10"	1.83 ft.
S3	1'-7 1/4"	1.60 ft.
S4	1'-7"	1.58 ft.
S5	1'-2 3/8"	1.20 ft.



Distance from water surface to midway between two rollers(or gate bottom),

D= ht of water above gate + distance to midway between rollers

D1	2.02 ft	=ht of water + (s1+s2/2)
D2	3.73 ft	=ht of water + (s1+s2+s3/2)
D3	5.32 ft	=ht of water + (s1+s2+s3+s4/2)
D4	7.31 ft	=ht of water + (s1+s2+s3+s4+s5)

Roller load, R = D*D/2 * 62.4#/ft^3 * gate width/ 2 rollers

R1	1494 lbs	=(D1*D1)/2*62.4*gate width/2
R2	3624 lbs	=(D2*D2-D1*D1)/2*62.4*gate width/2
R3	5293 lbs	=(D3*D3-D2*D2)/2*62.4*gate width/2
R4	9245 lbs	=(D4*D4-D3*D3)/2*62.4*gate width/2

GATE S-82 (2 REQ'D) - Material Take-Off	QTY	DIM.	UNITS	DIM.	UNITS	UNIT WT	UNITS	TOTAL WEIGHT
SKIN PLATE - 3/8"	1	23.58	FT	7.17	FT	15.75	#/FT^2	2662
VERTICAL END CHANNEL - C15	2	7.17	FT			36.75	#/FT	527
VERTICAL INTERIOR CHANNEL - C15	2	7.17	FT			36.75	#/FT	527
VERTICAL STIFFENER PLATE, 3/8"	4	7.17	FT	1.25	FT	15.75	#/FT^2	565
HORIZONTAL CHANNEL - C15	5	23.58	FT			36.75	#/FT	4333
BOTT STIFF PL-3/8" X 1'-1 1/2" (TAPER)	22	0.33	FT^2			5.95	#/EA	43
TOP SEAL L5" X3" X 1/2"	1	22.67	FT			13.17	#/FT	298
TOP SEAL PL - 3/8" X 2-1/2"	1	2.50	IN	22.67	FT	15.75	#/FT^2	74
SIDE SEAL L5" X3" X 1/2"	2	7.00	FT			13.17	#/FT	184
SIDE SEAL PL - 3/8" X 2-1/2"	2	2.50	IN	7.00	FT	15.75	#/FT^2	46
BOTTOM SEAL PL- 1/2"	1	3.75	IN	22.58	FT	21.00	#/FT^2	148
BOTTOM SEAL BAR - 1-1/2"	1	1.50	IN	22.58	FT	63.00	#/FT^2	178
LIFT BRACKET								
PL - 1"	2	1.69	FT^2			42.00	#/FT^2	142
PAD EYES - 13/16"	4	5.00	IN	5.00	IN	34.13	#/FT^2	24
WEB PL - 1"	4	3.50	IN	1.26	FT	42.00	#/FT^2	61
WHEEL ASSEMBLIES								
WHEELS - 12" DIA.	8	12.00	IN	4.75	IN	504.00	#/FT^3	1253
AXLES - 3-3/4" DIA.	8	3.75	IN	2.75	FT	504.00	#/FT^3	850
RUBBER SEAL								
TOP SEAL	1	4.42	IN^2	22.67	FT	74.00	#/FT^3	51
SIDE SEAL	2	4.42	IN^3	7.00	FT	74.00	#/FT^3	32
BOTTOM SEAL	1	4.00	IN^4	22.67	FT	74.00	#/FT^3	47
BOLTS SIDE SEAL								
TOP/ BOTTOM SEAL	2	23.58				43.00	#/100	61
SIDE SEALS	2	7.00				43.00	#/100	18

Note: Total weight shown does not include any allowance for welds

TOTAL 12046

GATE S-72 **Material Take-Off** **(2 Req'd)**	**QTY**	**DIM.**	**UNITS**	**DIM.**	**UNITS**	**UNIT WT (a)**	**UNITS**	**TOTAL WEIGHT, lbs**
SKIN PLATE - 3/8"	1	27.75	FT	12.06	FT	15.75	#/FT^2	5270
VERTICAL END CHANNEL - C18	2	12.06	FT			45.50	#/FT	1098
VERTICAL INTERIOR CHANNEL - C18	2	12.06	FT			45.50	#/FT	1098
VERTICAL STIFFENER PLATE, 3/8"	5	12.06	FT	1.50	FT	15.75	#/FT^2	1424
HORIZONTAL CHANNEL - C18	8	27.75	FT			45.50	#/FT	10102
BOTT STIFF PL-3/8" X 1'-6" (TAPER)	26	0.45	FT^2			15.75	#/FT^2	184
VIBRATION PL-1/2"	1	1.33	FT	27.00	FT	21.00	#/FT^2	754
TOP SEAL PL - 3/8"	1	1.75	IN	27.75	FT	15.75	#/FT^2	64
TOP SEAL PL - 3/4"	1	2.00	IN	27.75	FT	31.51	#/FT^2	146
SIDE SEAL PL - 3/8"	2	1.75	IN	11.67	FT	15.75	#/FT^2	54
SIDE SEAL PL - 3/4"	2	2.00	IN	11.67	FT	31.51	#/FT^2	123
BOTTOM SEAL PL- 1/2"	1	3.75	IN	26.83	FT	21.00	#/FT^2	176
BOTTOM SEAL BAR - 1-1/2"	1	1.50	IN	26.83	FT	63.00	#/FT^2	211
LIFT BRACKET								
PL - 1"	2	1.69	FT^2			42.00	#/FT^2	142
PAD EYES - 13/16"	4	5.00	IN	5.00	IN	34.13	#/FT^2	24
WEB PL - 1"	4	3.50	IN	1.50	FT	42.00	#/FT^2	73
WHEEL ASSEMBLIES								
WHEELS - 1'-3" DIA.	8	15.00	IN	4.75	IN	504.00	#/FT^3	1958
AXLES	8	3.75	IN	2.75	FT	504.00	#/FT^3	850
RUBBER SEAL								
TOP SEAL	1	3.86	IN^2	27.00	FT	74.00	#/FT^3	54
SIDE SEAL	2	3.86	IN^2	12.06	FT	74.00	#/FT^3	48
BOTTOM SEAL	1	4.00	IN^2	27.00	FT	74.00	#/FT^3	56
BOLTS								
TOP/ BOTTOM SEAL	2	27.00				43.00	#/100	70
SIDE SEALS	2	11.00				43.00	#/100	28
UPPER TO LOWER GATE SECT	1	27.00				43.00	#/100	23

(a) Material weights are based on density of 504#/ft^3

TOTAL 23907

NOTES:

1. Total weight given is for each gate
2. Total weight does not include any allowance for welds

GATE S-75 **Material Take-Off** **(1 Req'd)**	**QTY**	**DIM.**	**UNITS**	**DIM.**	**UNITS**	**UNIT WT (a)**	**UNITS**	**TOTAL WEIGHT, lbs**
SKIN PLATE - 3/8"	1	28.83	FT	10.00	FT	15.75	#/FT^2	4540
VERTICAL END CHANNEL - C18	2	10.00	FT			45.50	#/FT	910
VERTICAL INTERIOR CHANNEL - C18	2	10.00	FT			45.50	#/FT	910
VERTICAL STIFFENER PLATE, 3/8"	5	10.00	FT	1.50	FT	15.75	#/FT^2	1181
HORIZONTAL CHANNEL - C18	6	28.75	FT			45.50	#/FT	7849
BOTT STIFF PL-3/8" X 1'-6" (TAPER)	27	0.45	FT^2			15.75	#/FT^2	191
VIBRATION PL-1/2"	1	1.33	FT^2	28.00	FT	21.00	#/FT^2	782
TOP SEAL PL - 3/8"	1	1.75	IN	28.83	FT	15.75	#/FT^2	66
TOP SEAL PL - 3/4"	1	2.00	IN	28.83	FT	31.51	#/FT^2	151
SIDE SEAL PL - 3/8"	2	1.75	IN	9.58	FT	15.75	#/FT^2	44
SIDE SEAL PL - 3/4"	2	2.00	IN	9.58	FT	31.51	#/FT^2	101
BOTTOM SEAL PL- 1/2"	1	3.75	IN	27.83	FT	21.00	#/FT^2	183
BOTTOM SEAL BAR - 1-1/2"	1	1.50	IN	27.83	FT	63.00	#/FT^2	219
LIFT BRACKET								
PL - 1"	2	1.69	FT^2			42.00	#/FT^2	142
PAD EYES - 13/16"	4	5.00	IN	5.00	IN	34.13	#/FT^2	24
WEB PL - 1"	4	3.50	IN	1.50	FT	42.00	#/FT^2	73
WHEEL ASSEMBLIES								
WHEELS - 1'-3" DIA.	8	15.00	IN	4.75	IN	504.00	#/FT^3	1958
AXLES -	8	3.75	IN	2.75	FT	504.00	#/FT^3	850
RUBBER SEAL								
TOP SEAL	1	3.86	IN^2	28.00	FT	74.00	#/FT^3	56
SIDE SEAL	2	3.86	IN^2	10.00	FT	74.00	#/FT^3	40
BOTTOM SEAL	1	4.00	IN^2	28.00	FT	74.00	#/FT^3	58
BOLTS								
TOP/ BOTTOM SEAL	2	28.00				43.00	#/100	72
SIDE SEALS	2	10.00				43.00	#/100	26

(a) Material weights are based on density of 504#/ft^3

TOTAL 20328

NOTES:

1. Total weight does not include any allowance for welds

GATE S-82 Material Take-Off (2 Req'd)	QTY	DIM.	UNITS	DIM.	UNITS	UNIT WT (a)	UNITS	TOTAL WEIGHT
SKIN PLATE - 3/8"	1	23.58	FT	7.17	FT	15.75	#/FT^2	2662
VERTICAL END CHANNEL - C15	2	7.17	FT			36.75	#/FT	527
VERTICAL INTERIOR CHANNEL - C15	2	7.17	FT			36.75	#/FT	527
VERTICAL STIFFENER PLATE, 3/8"	4	7.17	FT	1.25	FT	15.75	#/FT^2	565
HORIZONTAL CHANNEL - C15	5	23.58	FT			36.75	#/FT	4333
BOTT STIFF PL-3/8" X 1'-1 1/2" (TAPER)	22	0.34	FT^2			15.75	#/FT^2	118
TOP SEAL L5" X3" X 1/2"	1	22.67	FT			13.17	#/FT	298
TOP SEAL PL - 3/8" X 2-1/2"	1	2.50	IN	22.67	FT	15.75	#/FT^2	74
SIDE SEAL L5" X3" X 1/2"	2	7.00	FT			13.17	#/FT	184
SIDE SEAL PL - 3/8" X 2-1/2"	2	2.50	IN	7.00	FT	15.75	#/FT^2	46
BOTTOM SEAL PL- 1/2"	1	3.75	IN	22.58	FT	21.00	#/FT^2	148
BOTTOM SEAL BAR - 1-1/2"	1	1.50	IN	22.58	FT	63.00	#/FT^2	178
LIFT BRACKET								
PL - 1"	2	1.69	FT^2			42.00	#/FT^2	142
PAD EYES - 13/16"	4	5.00	IN	5.00	IN	34.13	#/FT^2	24
WEB PL - 1"	4	3.50	IN	1.26	FT	42.00	#/FT^2	61
WHEEL ASSEMBLIES								
WHEELS - 12" DIA.	8	12.00	IN	4.75	IN	504.00	#/FT^3	1253
AXLES - 3-3/4" DIA.	8	3.75	IN	2.75	FT	504.00	#/FT^3	850
RUBBER SEAL								
TOP SEAL	1	4.42	IN^2	22.67	FT	74.00	#/FT^3	51
SIDE SEAL	2	4.42	IN^3	7.00	FT	74.00	#/FT^3	32
BOTTOM SEAL	1	4.00	IN^4	22.67	FT	74.00	#/FT^3	47
BOLTS								
TOP SEAL	2	23.58				43.00	#/100	61
SIDE SEALS	4	7.00				43.00	#/100	36
BOTTOM SEAL	1	23.58				43.00	#/100	30

(a) Material weights are based on density of 504#/ft^3

TOTAL 12121

NOTES:

1. Total weight given is for each gate
2. Total weight does not include any allowance for welds

S-72 Gate Recess Liner, Material Take-Off (2 Gate Ass'y Req'd)	QTY	DIM.	UNITS	DIM.	UNITS	UNIT WT (a)	UNITS	TOTAL WEIGHT, lbs
GATE RECESS LINER								
PL 1/4"	2	5.08	FT	11.60	FT	10.50		1238
1/2" DIA X 2-5/8" NELSON STUDS	144		EA					
RAILS								
PL - 1/2" X 4-1/2"	4	4.50	IN	26.75	FT	21.00	$\#/FT^2$	843
BAR - 2-1/2" X 3-3/4"	4	3.75	IN	26.75	FT	105.00	$\#/FT^2$	3511
RAIL CLIPS								
PL - 7/8" X 1-3/4" X 1-3/4"	152	1.75	IN	1.75	IN	36.75	$\#/FT^2$	119
HILTI ADHESIVE ANCHORS								
1/2" DIA W/ 5" EMBED	80		EA					
SS BOLTS W/ DBL NUTS								
1/2" DIA X 5" LG SS BOLTS	72		EA					

(a) Material weights are based on density of $504\#/ft^3$

TOTAL 5710

NOTES:

1. Material quantities given are for one gate assembly
2. Total weight does not include any allowance for welds

S-75 Gate Recess Liner, Material Take-Off (1 Gate Ass'y Req'd)	**QTY**	**DIM.**	**UNITS**	**DIM.**	**UNITS**	**UNIT WT (a)**	**UNITS**	**TOTAL WEIGHT, lbs**
GATE RECESS LINER								
PL 1/4"	2	5.08	FT	9.50	FT	10.50	#/FT^2	1014
1/2" DIA X 2-5/8" NELSON STUDS	112		EA					
RAILS								
PL - 1/2" X 4-1/2"	4	4.50	IN	21.75	FT	21.00	#/FT^2	685
BAR - 2-1/2" X 3-3/4"	4	3.75	IN	21.75	FT	105.00	#/FT^2	2855
RAIL CLIPS								
PL - 7/8" X 1-3/4" X 1-3/4"	128	1.75	IN	1.75	IN	36.75	#/FT^2	100
HILTI ADHESIVE ANCHORS								
1/2" DIA W/ 5" EMBED	72		EA					
SS BOLTS W/ DBL NUTS								
1/2" DIA X 5" LG SS BOLTS	56		EA					

(a) Material weights are based on density of 504#/ft^3

TOTAL 4654

NOTES:

1. Material quantities given are for one gate assembly
2. Total weight does not include any allowance for welds

S-82 Gate Recess Liner, Material Take-Off (2 Gate Ass'y Req'd)	**QTY**	**DIM.**	**UNITS**	**DIM.**	**UNITS**	**UNIT WT (a)**	**UNITS**	**TOTAL WEIGHT, lbs**
GATE RECESS LINER								
PL 1/4"	2	4.67	FT	6.52	FT	10.50	#/FT^2	640
1/2" DIA X 2-5/8" NELSON STUDS	80		EA					
RAILS								
PL - 1/2" X 4-1/2"	4	4.50	IN	21.45	FT	21.00	#/FT^2	676
BAR - 2-1/2" X 3-3/4"	4	3.75	IN	21.45	FT	105.00	#/FT^2	2815
RAIL CLIPS								
PL - 7/8" X 1-3/4" X 1-3/4"	128	1.75	IN	1.75	IN	36.75	#/FT^2	100
HILTI ADHESIVE ANCHORS								
1/2" DIA W/ 5" EMBED	88		EA					
SS BOLTS W/ DBL NUTS								
1/2" DIA X 5" LG SS BOLTS	40		EA					

(a) Material weights are based on density of 504#/ft^3

TOTAL 4231

NOTES:

1. Material quantities given are for one gate assembly
2. Total weight does not include any allowance for welds

PHASED DEWATERING STRUCTURE STABILITY CALCULCATIONS

1/3

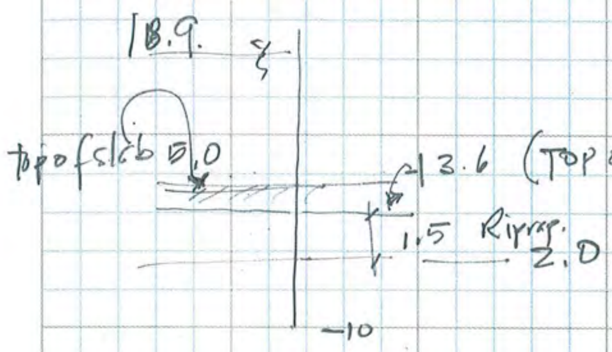
SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Engineering Calculations

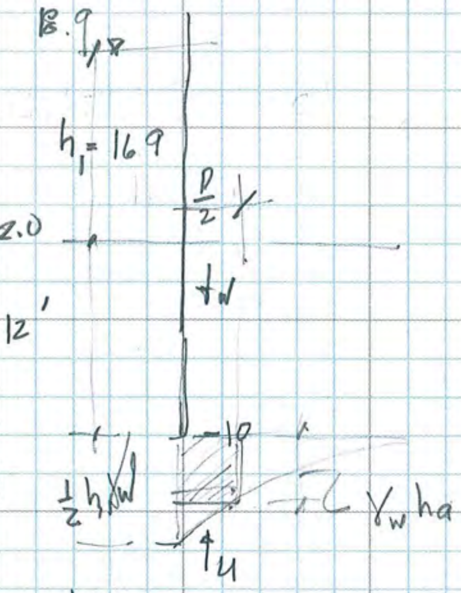
Engineering & Construction Bureau

Submitted By	Date	Project	Sheet of
Checked By	Description		Job No.

CHECK FOR PIPING



Rise of sand occurs D/2 from SSP (Terzaghi)



Excess hydrostatic pressure @ D/2 = $\gamma_w h_a$

$$FS = \frac{W'}{u} = \frac{(120pcf)(12')(\frac{12}{2}\times 1) - (62.4)(12)(\frac{12}{2}\cdot 1)}{62.4\,(16.9)(6)(1)}$$

$= 0.66 < 1.$ FAIL

TW

D = 19, FS = 1.03

D = 25, FS = 1.37

D = 36, FS = 1.97

HW

D = 27, FS. 1.28

2/3

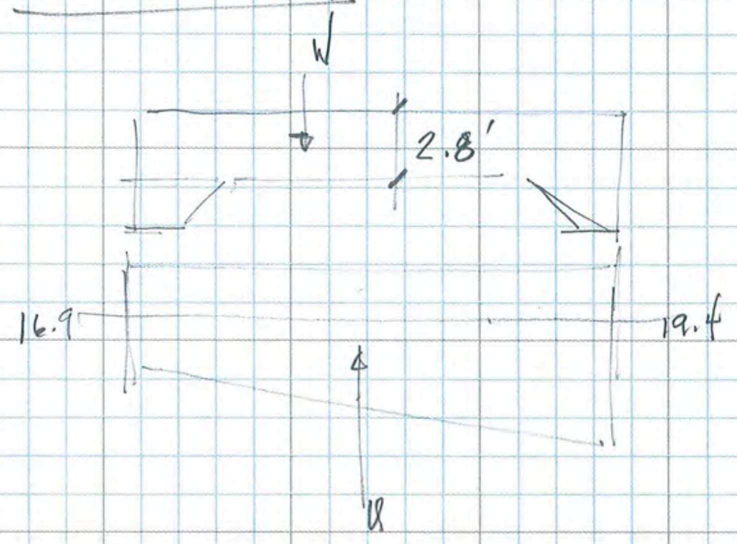
SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Engineering Calculations

Engineering & Construction Bureau

Submitted By	Date	Project	Sheet of
Checked By	**Description**		**Job No.**

CHECK FOR UPLIFT



$\gamma_c = 150\text{pcf}$

$\gamma_w = 62.4$

$$\frac{U}{LF} = \left(\frac{16.9 + 19.4}{2}\right)\left(52.75'\right)62.4) - 59,413$$

$$\frac{W_c}{LF} = \left[\overset{147.7}{(2.8')(52.75)} + \overset{34.65}{\tfrac{1}{2}(11.)(6.3)} + \overset{10.08}{\tfrac{1}{2}(6.3+4.9)(1.8)}\right]150$$

$$\frac{W_c}{LF} = 28,864.5$$

$\therefore$ FAIL !!

SOLUTION: DEWATER BY WELL POINT SYSTEM
TO LOWER GROUNDWATER
BELOW SLAB

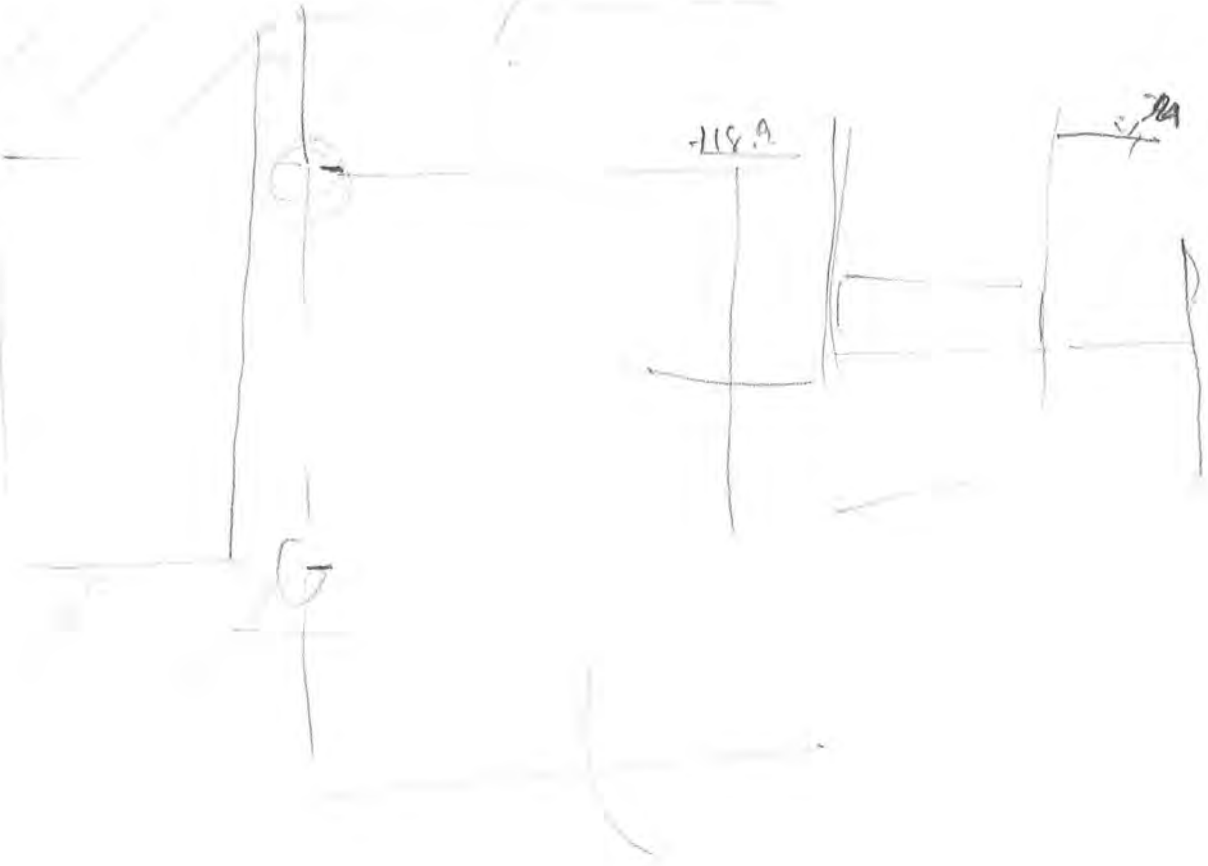
3/4

S-72 PHASED DEWATERING REVIEW COMMENTS

by Vincent Loehrlein

5/8/13

1. The downstream cutoff wall extends only about 10' below the apron. My quick calcs indicate this is not sufficient depth to prevent piping conditions originating from pressure under the slab when the bay is dewatered. Assuming medium density sand under the structure, the cutoff wall would need to extend at least another 7'. You could possibly achieve the necessary piping control by grouting along the cutoff wall. However, there are risks to this. Alternately, perhaps the work can be done in a seasonal time frame with lower water levels.
2. The structure apron slab was not specifically designed for dewatering in the manner proposed. Past dewatering efforts have either used the dewatering system designed or the entire site was dewatered, pulling down water pressures under the apron. With the proposed scheme, significant hydrostatic pressures will exist under the apron. The apron must be evaluated structurally for ability to tolerate these loads. Likewise, uplift stability would have to be evaluated.
3. The closure plate detail is structurally unstable on the downstream side. It will act as a cantilever so would need a moment connection at the base. One row of bolts does not accomplish this. A waler might suffice to provide the needed support at the top.
4. The riprap will have to be removed along the drive line in the canal. A detail is needed for how the filter cloth will be established or re-established along this drive line.



S-72 STEEL SHEET PILE CALCULCATIONS

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Engineering Calculations

Everglades Restoration & Capital Projects

Submitted By H. Gao

Date

Project S72

Sheet of

Checked By

Description Downstream Cofferdam

Job No.

Change the canal bottom to -4.0' NGVD.

Tip of sheetpile -38'

$M_{max} = 4.11 \times 10^5$ lb-ft

required section modulus:

$$\frac{M_{max}}{f_b} = \frac{4.11 \times 10^5 \times 12}{0.5 \times 50{,}000} = 197 \text{ in}^3.$$

└ use Grade 50 or higher.

```
                         downstream center WT=-4.0'.dat
 PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                            BY CLASSICAL METHODS
 DATE: 15-JANUARY-2014                                        TIME: 9:28:57

                              ****************
                              *  INPUT DATA  *
                              ****************

      I.--HEADING
     'S72 COFFER DAM WALL DESIGN -DOWNSTREAM STREAM CENTER

     II.--CONTROL
        CANTILEVER WALL DESIGN
        FACTOR OF SAFETY FOR ACTIVE PRESSURES  = 1.00
        FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.00

    III.--WALL DATA
        ELEVATION AT TOP OF WALL    = 26.00 FT.

     IV.--SURFACE POINT DATA

         IV.A.--RIGHTSIDE
            DIST. FROM     ELEVATION
            WALL (FT)        (FT)
                 0.00        -4.00
                50.00        -4.00

         IV.B.--LEFTSIDE
            DIST. FROM     ELEVATION
            WALL (FT)        (FT)
                 0.00        -4.00
                50.00        -4.00

      V.--SOIL LAYER DATA

         V.A.--RIGHTSIDE
            LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
            LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

                   ANGLE OF          ANGLE OF                              <-SAFETY->
  SAT.    MOIST   INTERNAL  COH-      WALL      ADH-     <--BOTTOM-->   <-FACTOR->
 WGHT.    WGHT.   FRICTION  ESION   FRICTION   ESION    ELEV.  SLOPE   ACT. PASS.
 (PCF)    (PCF)    (DEG)    (PSF)    (DEG)     (PSF)    (FT)  (FT/FT)
115.00   110.00    31.00     0.00    14.00      0.00   -18.40   0.00    DEF   DEF
110.00   105.00    30.00     0.00    11.00      0.00                    DEF   DEF

         V.B.--LEFTSIDE
            LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
            LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

                   ANGLE OF          ANGLE OF                              <-SAFETY->
  SAT.    MOIST   INTERNAL  COH-      WALL      ADH-     <--BOTTOM-->   <-FACTOR->
 WGHT.    WGHT.   FRICTION  ESION   FRICTION   ESION    ELEV.  SLOPE   ACT. PASS.
 (PCF)    (PCF)    (DEG)    (PSF)    (DEG)     (PSF)    (FT)  (FT/FT)
115.00   110.00    31.00     0.00    14.00      0.00   -18.40   0.00    DEF   DEF
110.00   105.00    30.00     0.00    11.00      0.00                    DEF   DEF

     VI.--WATER DATA
        UNIT WEIGHT          = 62.40 (PCF)
        RIGHTSIDE ELEVATION = 18.00 (FT)
        LEFTSIDE ELEVATION  = -4.00 (FT)
        SEEPAGE ELEVATION   = -4.00 (FT)
        SEEPAGE GRADIENT    = AUTOMATIC
```

```
    VII.--VERTICAL SURCHARGE LOADS
        NONE

   VIII.--HORIZONTAL LOADS
        NONE






PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                        BY CLASSICAL METHODS
DATE: 15-JANUARY-2014                                          TIME: 9:29:01

                        **************************
                        *    SOIL PRESSURES FOR    *
                        * CANTILEVER WALL DESIGN *
                        **************************

    I.--HEADING
     'S72 COFFER DAM WALL DESIGN -DOWNSTREAM STREAM CENTER

   II.--SOIL PRESSURES

        RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

        LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

        SOIL PRESSURES ARE REPORTED FOR A SEEPAGE GRADIENT = 0.0001
        AND MAY CHANGE WITH AUTOMATIC ADJUSTMENT OF THE GRADIENT.

                                           <------NET------>
          NET     <---LEFTSIDE--->     (SOIL + WATER)     <--RIGHTSIDE--->
ELEV.    WATER    PASSIVE   ACTIVE     ACTIVE   PASSIVE    ACTIVE   PASSIVE
(FT)     (PSF)     (PSF)    (PSF)      (PSF)     (PSF)     (PSF)     (PSF)
 26.0     0.0       0.0      0.0        0.0       0.0       0.0       0.0
 25.0     0.0       0.0      0.0        0.0       0.0       0.0       0.0
 24.0     0.0       0.0      0.0        0.0       0.0       0.0       0.0
 23.0     0.0       0.0      0.0        0.0       0.0       0.0       0.0
 22.0     0.0       0.0      0.0        0.0       0.0       0.0       0.0
 21.0     0.0       0.0      0.0        0.0       0.0       0.0       0.0
 20.0     0.0       0.0      0.0        0.0       0.0       0.0       0.0
 19.0     0.0       0.0      0.0        0.0       0.0       0.0       0.0
 18.0     0.0       0.0      0.0        0.0       0.0       0.0       0.0
 17.0    62.4       0.0      0.0       62.4      62.4       0.0       0.0
 16.0   124.8       0.0      0.0      124.8     124.8       0.0       0.0
 15.0   187.2       0.0      0.0      187.2     187.2       0.0       0.0
 14.0   249.6       0.0      0.0      249.6     249.6       0.0       0.0
 13.0   312.0       0.0      0.0      312.0     312.0       0.0       0.0
 12.0   374.4       0.0      0.0      374.4     374.4       0.0       0.0
 11.0   436.8       0.0      0.0      436.8     436.8       0.0       0.0
 10.0   499.2       0.0      0.0      499.2     499.2       0.0       0.0
  9.0   561.6       0.0      0.0      561.6     561.6       0.0       0.0
  8.0   624.0       0.0      0.0      624.0     624.0       0.0       0.0
  7.0   686.4       0.0      0.0      686.4     686.4       0.0       0.0
  6.0   748.8       0.0      0.0      748.8     748.8       0.0       0.0
  5.0   811.2       0.0      0.0      811.2     811.2       0.0       0.0
```

4.0	873.6	0.0	0.0	873.6	873.6	0.0	0.0
3.0	936.0	0.0	0.0	936.0	936.0	0.0	0.0
2.0	998.4	0.0	0.0	998.4	998.4	0.0	0.0
1.0	1060.8	0.0	0.0	1060.8	1060.8	0.0	0.0
0.0	1123.2	0.0	0.0	1123.2	1123.2	0.0	0.0
-1.0	1185.6	0.0	0.0	1185.6	1185.6	0.0	0.0
-2.0	1248.0	0.0	0.0	1248.0	1248.0	0.0	0.0
-3.0	1310.4	0.0	0.0	1310.4	1310.4	0.0	0.0
-4.0	1372.8	0.0	0.0	1372.8	1372.8	0.0	0.0
-5.0	1372.8	257.6	14.9	1130.1	1615.6	14.9	257.6
-6.0	1372.8	515.1	29.7	887.4	1858.3	29.7	515.2
-7.0	1372.8	772.7	44.6	644.6	2101.1	44.6	772.9
-8.0	1372.8	1030.2	59.4	401.9	2343.8	59.4	1030.5
-9.0	1372.7	1287.8	74.3	159.2	2586.6	74.3	1288.1
-9.7	1372.7	1456.8	84.0	0.0	2745.8	84.0	1457.1
-10.0	1372.7	1545.4	89.1	-83.5	2829.3	89.1	1545.7
-11.0	1372.7	1802.9	104.0	-326.2	3072.1	104.0	1803.4
-12.0	1372.7	2060.5	118.8	-568.9	3314.9	118.8	2061.0
-13.0	1372.7	2318.0	133.7	-811.7	3557.6	133.7	2318.6
-14.0	1372.7	2575.6	148.5	-1054.4	3800.4	148.6	2576.2
-15.0	1372.7	2833.2	163.4	-1297.1	4043.1	163.4	2833.8
-16.0	1372.7	3090.7	178.2	-1539.8	4285.9	178.3	3091.5
-17.0	1372.6	3348.3	193.1	-1782.5	4528.6	193.1	3349.1
-18.0	1372.6	3605.9	207.9	-2025.2	4771.4	208.0	3606.7
-18.4	1372.6	4929.4	319.0	-3237.7	5983.8	319.0	4930.2
-19.0	1372.6	7153.8	490.2	-5290.9	8036.9	490.3	7154.5
-20.0	1372.6	7761.1	513.1	-5875.4	8621.5	513.1	7762.0
-21.0	1372.6	7925.0	528.1	-6024.3	8770.5	528.1	7925.9
-22.0	1372.6	8095.5	542.9	-6179.9	8926.1	543.0	8096.5
-23.0	1372.6	8271.2	557.7	-6340.8	9087.1	557.8	8272.2
-24.0	1372.6	8450.9	572.5	-6505.9	9252.1	572.5	8452.0
-25.0	1372.5	8634.0	587.1	-6674.2	9420.5	587.2	8635.1
-26.0	1372.5	8819.6	601.8	-6845.2	9591.5	601.8	8820.8
-27.0	1372.5	9007.4	616.4	-7018.4	9764.8	616.4	9008.6
-28.0	1372.5	9197.0	630.9	-7193.5	9939.9	631.0	9198.3
-29.0	1372.5	9388.0	645.4	-7370.0	10116.4	645.5	9389.4
-30.0	1372.5	9580.4	660.0	-7547.8	10294.3	660.1	9581.8
-31.0	1372.5	9773.7	674.4	-7726.7	10473.2	674.5	9775.2
-32.0	1372.5	9968.0	688.9	-7906.5	10653.0	689.0	9969.5
-33.0	1372.4	10149.9	703.4	-8074.0	10820.6	703.5	10151.5
-34.0	1372.4	10330.9	717.8	-8240.6	10987.2	717.9	10332.6
-35.0	1372.4	10524.9	732.3	-8420.1	11166.7	732.4	10526.6
-36.0	1372.4	10720.3	746.7	-8601.1	11347.7	746.8	10722.0
-37.0	1372.4	10916.1	761.1	-8782.5	11529.2	761.2	10917.9
-38.0	1372.4	11112.4	775.5	-8964.4	11711.1	775.6	11114.2
-39.0	1372.4	11309.1	789.9	-9146.7	11893.4	790.0	11311.0
-40.0	1372.4	11506.1	804.3	-9329.3	12076.0	804.4	11508.0
-41.0	1372.3	11703.4	818.7	-9512.2	12259.0	818.8	11705.3
-42.0	1372.3	11900.9	833.1	-9695.4	12442.2	833.2	11902.9
-43.0	1372.3	12098.7	847.5	-9878.8	12625.6	847.6	12100.8
-44.0	1372.3	12296.7	861.8	-10062.4	12809.3	862.0	12298.8
-45.0	1372.3	12494.9	876.2	-10246.2	12993.1	876.4	12497.0
-46.0	1372.3	12693.2	890.6	-10430.2	13177.1	890.7	12695.4
-47.0	1372.3	12891.7	904.9	-10614.3	13361.3	905.1	12894.0
-48.0	1372.3	13090.4	919.3	-10798.6	13545.6	919.5	13092.7
-49.0	1372.2	13289.1	933.7	-10983.1	13730.1	933.8	13291.5
-50.0	1372.2	13488.0	948.0	-11167.6	13914.7	948.2	13490.5
-51.0	1372.2	13687.0	962.4	-11352.2	14099.4	962.6	13689.5
-52.0	1372.2	13886.1	976.8	-11537.0	14284.1	976.9	13888.7
-53.0	1372.2	14085.3	991.1	-11721.8	14469.0	991.3	14087.9
-54.0	1372.2	14284.6	1005.5	-11906.7	14654.0	1005.6	14287.2
-55.0	1372.2	14483.9	1019.8	-12091.7	14839.0	1020.0	14486.6
-56.0	1372.2	14683.3	1034.2	-12276.8	15024.1	1034.4	14686.1

```
-57.0  1372.1   14882.8   1048.5  -12461.9   15209.2    1048.7   14885.6
-58.0  1372.1   15082.3   1062.9  -12647.1   15394.5    1063.1   15085.2
-59.0  1372.1   15281.9   1077.2  -12832.4   15579.8    1077.4   15284.8
-60.0  1372.1   15481.6   1091.6  -13017.7   15765.1    1091.8   15484.5
-61.0  1372.1   15681.2   1105.9  -13203.0   15950.5    1106.1   15684.3
-62.0  1372.1   15881.0   1120.2  -13388.4   16135.9    1120.5   15884.1
-63.0  1372.1   16080.7   1134.6  -13573.9   16321.4    1134.8   16083.9
-64.0  1372.1   16280.6   1148.9  -13759.3   16506.9    1149.2   16283.7
-65.0  1372.0   16480.4   1163.3  -13944.9   16692.4    1163.5   16483.6
-66.0  1372.0   16680.3   1177.6  -14130.4   16878.0    1177.9   16683.6
-67.0  1372.0   16880.2   1192.0  -14316.0   17063.6    1192.2   16883.5
-68.0  1372.0   17080.1   1206.3  -14501.6   17249.2    1206.5   17083.5
-69.0  1372.0   17280.1   1220.6  -14687.2   17434.9    1220.9   17283.5
-70.0  1372.0   17480.1   1235.0  -14872.9   17620.6    1235.2   17483.6
-71.0  1372.0   17680.1   1249.3  -15058.6   17806.3    1249.6   17683.6
-72.0  1372.0   17880.1   1263.7  -15244.3   17992.0    1263.9   17883.7
-73.0  1371.9   18080.2   1278.0  -15430.0   18177.8    1278.3   18083.8
-74.0  1371.9   18280.3   1292.3  -15615.7   18363.6    1292.6   18284.0
-75.0  1371.9   18480.4   1306.7  -15801.5   18549.4    1306.9   18484.1
-76.0  1371.9   18680.5   1321.0  -15987.3   18735.2    1321.3   18684.3
-77.0  1371.9   18880.6   1335.4  -16173.1   18921.0    1335.6   18884.5
-78.0  1371.9   19080.7   1349.7  -16358.9   19106.9    1350.0   19084.7
-79.0  1371.9   19280.9   1364.0  -16544.7   19292.7    1364.3   19284.9
-80.0  1371.9   19481.1   1378.4  -16730.6   19478.6    1378.6   19485.1
-81.0  1371.8   19681.3   1392.7  -16916.5   19664.5    1393.0   19685.4
-82.0  1371.8   19881.5   1407.0  -17102.3   19850.4    1407.3   19885.6
-83.0  1371.8   20081.7   1421.4  -17288.2   20036.3    1421.7   20085.9
-84.0  1371.8   20281.9   1435.7  -17474.1   20222.3    1436.0   20286.2
-85.0  1371.8   20482.2   1450.0  -17660.0   20408.2    1450.3   20486.5
-86.0  1371.8   20682.4   1464.4  -17845.9   20594.2    1464.7   20686.8
-87.0  1371.8   20882.7   1478.7  -18031.9   20780.1    1479.0   20887.1
-88.0  1371.8   21082.9   1493.0  -18217.8   20966.1    1493.4   21087.4
-89.0  1371.7   21283.2   1507.4  -18403.8   21152.1    1507.7   21287.7
-90.0  1371.7   21483.5   1521.7  -18589.7   21338.1    1522.0   21488.0
-91.0  1371.7   21683.8   1536.0  -18775.7   21524.1    1536.4   21688.4
-92.0  1371.7   21884.1   1550.4  -18961.7   21710.1    1550.7   21888.7
-93.0  1371.7   22084.4   1564.7  -19147.7   21896.1    1565.0   22089.1
-94.0  1371.7   22284.7   1579.0  -19333.6   22082.1    1579.4   22289.5
-95.0  1371.7   22485.0   1593.4  -19519.6   22268.1    1593.7   22489.8
          * STANDARD WEDGE SOLUTION DOES NOT EXIST FOR INDICATED PRESSURE
            FOR THIS ELEVATION.
```

```
PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 15-JANUARY-2014                                      TIME: 9:29:02

                         ******************************
                         *   SUMMARY OF RESULTS FOR   *
                         *   CANTILEVER WALL DESIGN   *
                         ******************************

   I.--HEADING
    'S72 COFFER DAM WALL DESIGN -DOWNSTREAM STREAM CENTER
```

```
II.--SUMMARY

     RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

     LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

     *****WARNING:  STANDARD WEDGE SOLUTION DOES NOT EXIST
                    AT ALL ELEVATIONS.  SEE COMPLETE OUTPUT.

WALL BOTTOM ELEV. (FT)     :      -37.48
      PENETRATION (FT)     :       33.48

MAX. BEND. MOMENT (LB-FT)  :  4.1149E+05
      AT ELEVATION (FT)    :      -21.82

MAX. SCALED DEFL. (LB-IN^3):  6.9417E+11
      AT ELEVATION (FT)    :       26.00

SEEPAGE GRADIENT           :     0.3288

          NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                 ELASTICITY IN PSI TIMES PILE MOMENT
                 OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                 IN INCHES.
```

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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 15-JANUARY-2014                                        TIME: 9:29:02

                        ****************************
                        * COMPLETE OF RESULTS FOR  *
                        *  CANTILEVER WALL DESIGN  *
                        ****************************

    I.--HEADING
    'S72 COFFER DAM WALL DESIGN -DOWNSTREAM STREAM CENTER

   II.--RESULTS0. (LB))

               BENDING                          SCALED          NET
  ELEVATION    MOMENT           SHEAR         DEFLECTION     PRESSURE
    (FT)       (LB-FT)          (LB)          (LB-IN^3)        (PSF)
    26.00    0.0000E+00           0.         6.9417E+11         0.00
    25.00   -3.3528E-08           0.         6.7853E+11         0.00
    24.00   -3.3528E-08           0.         6.6290E+11         0.00
    23.00   -3.3528E-08           0.         6.4726E+11         0.00
    22.00   -3.3528E-08           0.         6.3163E+11         0.00
    21.00   -3.3528E-08           0.         6.1600E+11         0.00
    20.00   -3.3528E-08           0.         6.0036E+11         0.00
    19.00   -3.3528E-08           0.         5.8473E+11         0.00
    18.00   -3.3528E-08           0.         5.6910E+11         0.00
    17.00    1.0400E+01          31.         5.5346E+11        62.40
    16.00    8.3200E+01         125.         5.3783E+11       124.80
    15.00    2.8080E+02         281.         5.2220E+11       187.20
    14.00    6.6560E+02         499.         5.0656E+11       249.60
    13.00    1.3000E+03         780.         4.9093E+11       312.00
    12.00    2.2464E+03        1123.         4.7530E+11       374.40
    11.00    3.5672E+03        1529.         4.5968E+11       436.80
    10.00    5.3248E+03        1997.         4.4406E+11       499.20
```

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       9.00    7.5816E+03         2527.        4.2845E+11        561.60
       8.00    1.0400E+04         3120.        4.1285E+11        624.00
       7.00    1.3842E+04         3775.        3.9727E+11        686.40
       6.00    1.7971E+04         4493.        3.8172E+11        748.80
       5.00    2.2849E+04         5273.        3.6619E+11        811.20
       4.00    2.8538E+04         6115.        3.5071E+11        873.60
       3.00    3.5100E+04         7020.        3.3527E+11        936.00
       2.00    4.2598E+04         7987.        3.1990E+11        998.40
       1.00    5.1095E+04         9017.        3.0460E+11       1060.80
       0.00    6.0653E+04        10109.        2.8939E+11       1123.20
      -1.00    7.1334E+04        11263.        2.7428E+11       1185.60
      -2.00    8.3200E+04        12480.        2.5930E+11       1248.00
      -3.00    9.6314E+04        13759.        2.4446E+11       1310.40
      -4.00    1.1074E+05        15101.        2.2979E+11       1372.80
      -5.00    1.2650E+05        16385.        2.1531E+11       1195.30
      -6.00    1.4345E+05        17491.        2.0104E+11       1017.80
      -7.00    1.6142E+05        18420.        1.8703E+11        840.31
      -8.00    1.8023E+05        19172.        1.7329E+11        662.81
      -9.00    1.9971E+05        19746.        1.5987E+11        485.31
     -10.00    2.1966E+05        20143.        1.4679E+11        307.81
     -11.00    2.3993E+05        20362.        1.3409E+11        130.31
     -11.73    2.5490E+05        20410.        1.2503E+11          0.00
     -12.00    2.6033E+05        20403.        1.2181E+11        -47.18
     -13.00    2.8068E+05        20267.        1.0997E+11       -224.68
     -14.00    3.0080E+05        19954.        9.8624E+10       -402.18
     -15.00    3.2053E+05        19463.        8.7794E+10       -579.68
     -16.00    3.3967E+05        18795.        7.7518E+10       -757.17
     -17.00    3.5806E+05        17949.        6.7829E+10       -934.67
     -18.00    3.7551E+05        16925.        5.8758E+10      -1112.17
     -18.40    3.8215E+05        16209.        5.5310E+10      -2470.64
     -19.00    3.9130E+05        14076.        5.0336E+10      -4639.12
     -20.00    4.0300E+05         9260.        4.2590E+10      -4992.21
     -21.00    4.0975E+05         4220.        3.5539E+10      -5088.80
     -22.00    4.1141E+05         -921.        2.9196E+10      -5192.19
     -23.00    4.0787E+05        -6167.        2.3563E+10      -5300.87
     -24.00    3.9904E+05       -11525.        1.8634E+10      -5413.73
     -25.00    3.8478E+05       -16997.        1.4393E+10      -5529.93
     -26.00    3.6500E+05       -22586.        1.0817E+10      -5648.84
     -27.00    3.3957E+05       -28295.        7.8709E+09      -5769.96
     -28.00    3.0837E+05       -34127.        5.5105E+09      -5892.90
     -28.14    3.0362E+05       -34939.        5.2285E+09      -5910.04
     -29.00    2.7151E+05       -39268.        3.6821E+09      -4128.83
     -30.00    2.3052E+05       -42364.        2.3223E+09      -2063.26
     -31.00    1.8747E+05       -43394.        1.3606E+09          2.32
     -32.00    1.4442E+05       -42359.        7.2283E+08       2067.89
     -33.00    1.0344E+05       -39258.        3.3491E+08       4133.46
     -34.00    6.6596E+04       -34092.        1.2633E+08       6199.04
     -35.00    3.5947E+04       -26860.        3.3724E+07       8264.61
     -36.00    1.3564E+04       -17563.        4.4246E+06      10330.18
     -37.00    1.5099E+03        -6200.        5.0794E+04      12395.76
     -37.45    5.1873E+00         -372.        5.7987E-01      13331.55
     -37.48    0.0000E+00            0.        0.0000E+00      13389.09

            NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                   ELASTICITY IN PSI TIMES PILE MOMENT
                   OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                   IN INCHES.

   III.--WATER AND SOIL PRESSURES

                                 <-------------SOIL PRESSURES-------------->
                     WATER       <----LEFTSIDE----->      <---RIGHTSIDE---->
  ELEVATION        PRESSURE      PASSIVE       ACTIVE      ACTIVE      PASSIVE
```

```
                        downstream center WT=-4.0'.dat
  (FT)          (PSF)         (PSF)          (PSF)         (PSF)        (PSF)
 26.00             0.            0.             0.            0.           0.
 25.00             0.            0.             0.            0.           0.
 24.00             0.            0.             0.            0.           0.
 23.00             0.            0.             0.            0.           0.
 22.00             0.            0.             0.            0.           0.
 21.00             0.            0.             0.            0.           0.
 20.00             0.            0.             0.            0.           0.
 19.00             0.            0.             0.            0.           0.
 18.00             0.            0.             0.            0.           0.
 17.00            62.            0.             0.            0.           0.
 16.00           125.            0.             0.            0.           0.
 15.00           187.            0.             0.            0.           0.
 14.00           250.            0.             0.            0.           0.
 13.00           312.            0.             0.            0.           0.
 12.00           374.            0.             0.            0.           0.
 11.00           437.            0.             0.            0.           0.
 10.00           499.            0.             0.            0.           0.
  9.00           562.            0.             0.            0.           0.
  8.00           624.            0.             0.            0.           0.
  7.00           686.            0.             0.            0.           0.
  6.00           749.            0.             0.            0.           0.
  5.00           811.            0.             0.            0.           0.
  4.00           874.            0.             0.            0.           0.
  3.00           936.            0.             0.            0.           0.
  2.00           998.            0.             0.            0.           0.
  1.00          1061.            0.             0.            0.           0.
  0.00          1123.            0.             0.            0.           0.
 -1.00          1186.            0.             0.            0.           0.
 -2.00          1248.            0.             0.            0.           0.
 -3.00          1310.            0.             0.            0.           0.
 -4.00          1373.            0.             0.            0.           0.
 -5.00          1332.          157.             9.           21.         358.
 -6.00          1291.          314.            18.           41.         716.
 -7.00          1250.          471.            27.           62.        1074.
 -8.00          1209.          628.            36.           83.        1432.
 -9.00          1168.          786.            45.          103.        1790.
-10.00          1127.          943.            54.          124.        2148.
-11.00          1086.         1100.            63.          145.        2507.
-11.73          1055.         1215.            70.          160.        2769.
-12.00          1045.         1257.            72.          165.        2865.
-13.00          1003.         1414.            82.          186.        3223.
-14.00           962.         1571.            91.          206.        3581.
-15.00           921.         1728.           100.          227.        3939.
-16.00           880.         1885.           109.          248.        4297.
-17.00           839.         2042.           118.          268.        4655.
-18.00           798.         2200.           127.          289.        5013.
-18.40           782.         3655.           236.          402.        6205.
-19.00           757.         5975.           402.          579.        8333.
-20.00           716.         6319.           415.          611.        9204.
-21.00           675.         6396.           424.          632.        9455.
-22.00           634.         6479.           433.          653.        9713.
-23.00           593.         6568.           442.          674.        9975.
-24.00           552.         6661.           450.          695.       10242.
-25.00           511.         6757.           459.          716.       10512.
-26.00           470.         6855.           467.          737.       10785.
-27.00           429.         6956.           475.          757.       11060.
-28.00           388.         7059.           484.          778.       11336.
-28.14           347.         7073.           485.          781.       11375.
-29.00           306.         7163.           492.          799.       11614.
-30.00           265.         7268.           501.          819.       11894.
-31.00           224.         7375.           509.          840.       12174.
-32.00           183.         7482.           517.          861.       12455.
```

```
-33.00          142.      7579.        525.        881.      12722.
-34.00          101.      7678.        534.        902.      12986.
-35.00           60.      7786.        542.        923.      13265.
-36.00           19.      7895.        550.        943.      13547.
-37.00            0.      8004.        558.        964.      13830.
-37.45            0.      8065.        563.        972.      13946.
-37.48            0.      8164.        570.        981.      14063.
-39.00            0.      8364.        584.        996.      14256.
```

S72 Tailwater Cofferdam: Sheet Pile Wall Parallel to Canal			
	Width, inches	No. of Pairs	Legth, feet
HZ1180M D/ Combination C3	37.4	1	3.117
HZ1180M D/ AZ 26-700	131.81	9	98.858
Female Corner	20.81	1	1.734
		Total	103.709

S72 Headwater Cofferdam: Sheet Pile Wall Parallel to Canal			
	Width	No. of Pairs	Legth, feet
HZ1180M D/ Combination C3	37.4	1	3.117
HZ1180M D/ AZ 26-700	131.81	2	21.968
Female Corner	20.81	1	1.734
		Total	26.819

S72 Tail/Headwater Cofferdam: Sheet Pile Wall Perpendicular to Canal			
	Width	No. of Pairs	Legth, feet
Female Corner	27.56	1	2.297
HZ1180M D/ AZ 26-700	131.81	6	65.905
		Total	68.202

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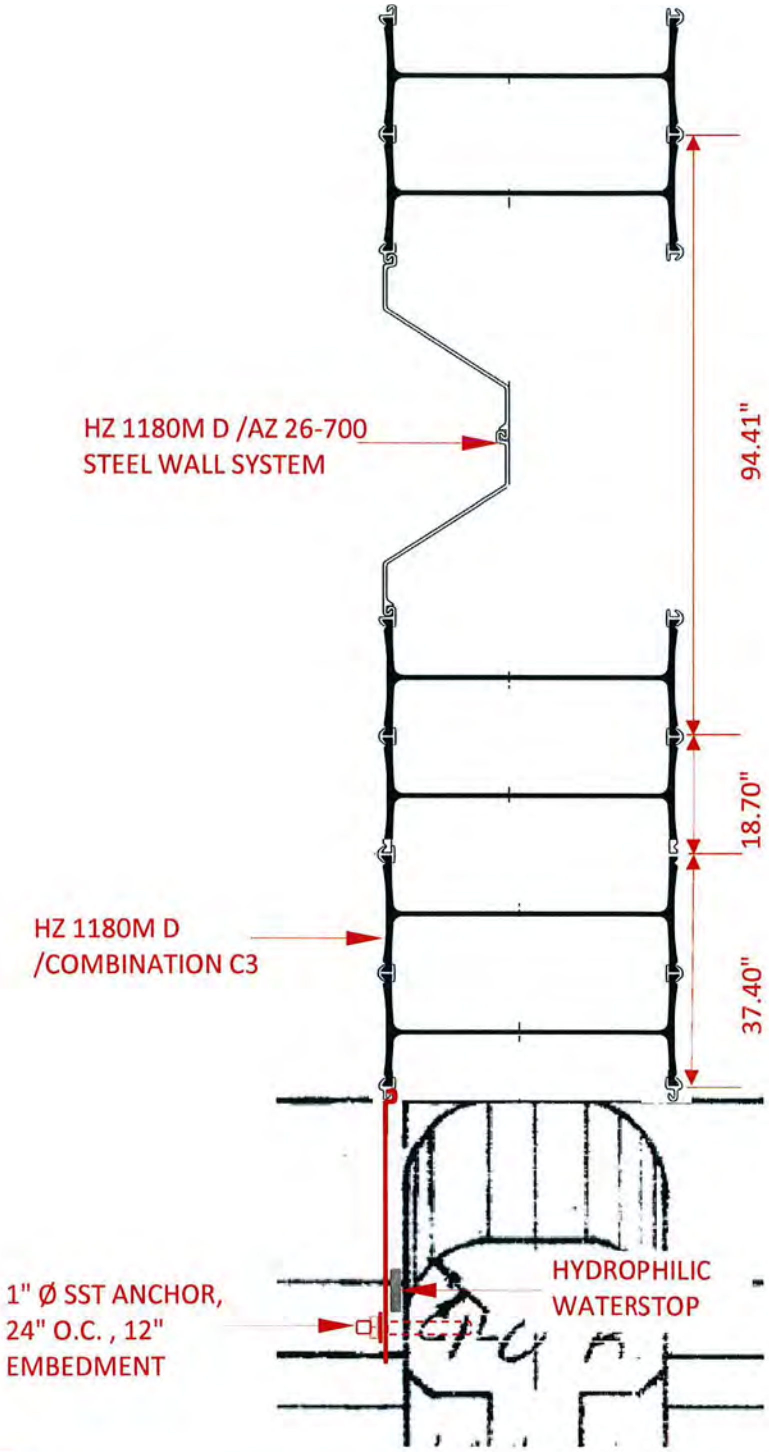

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C102 | C102

SHEET PILE - ABUTMENT CONNECTION

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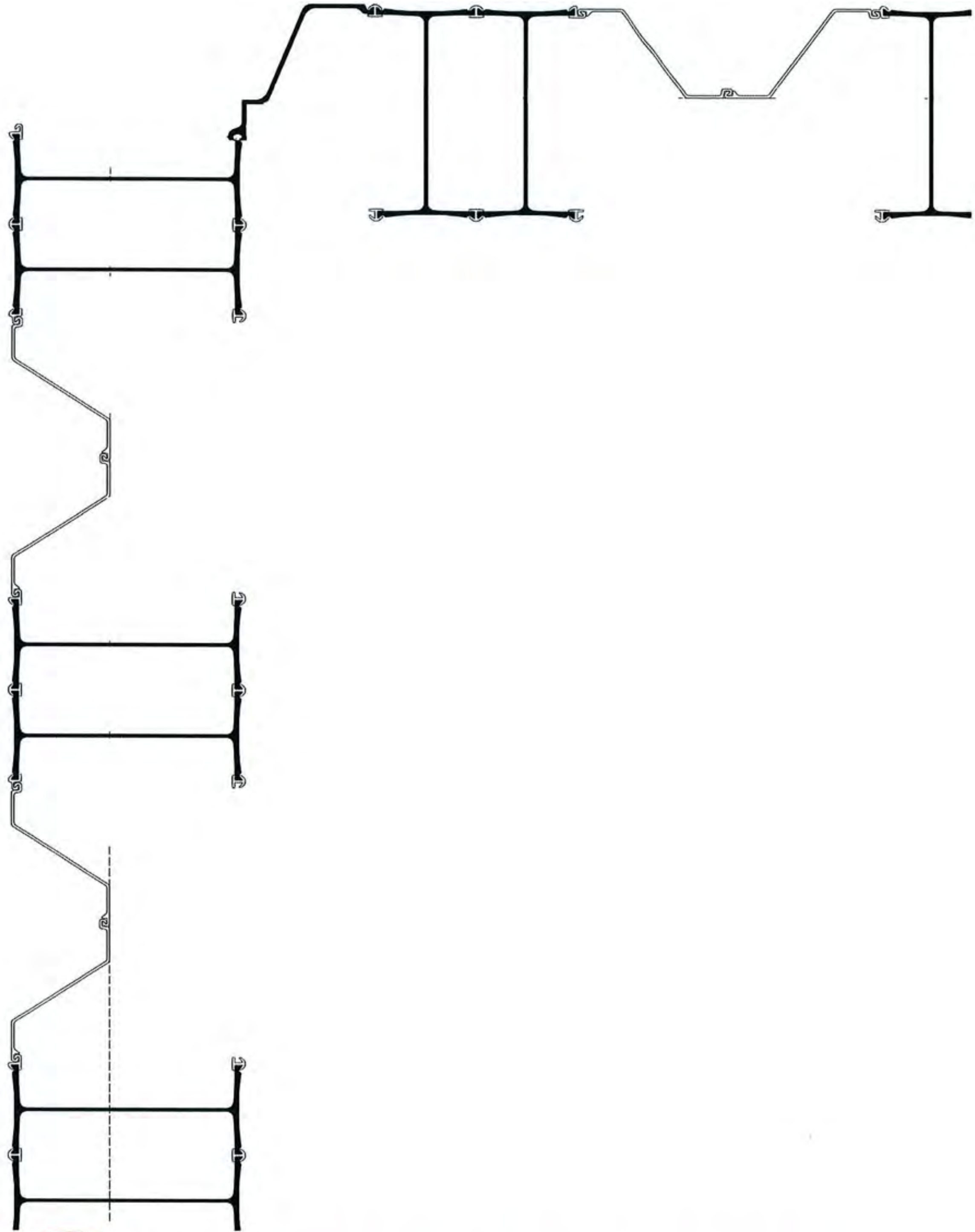

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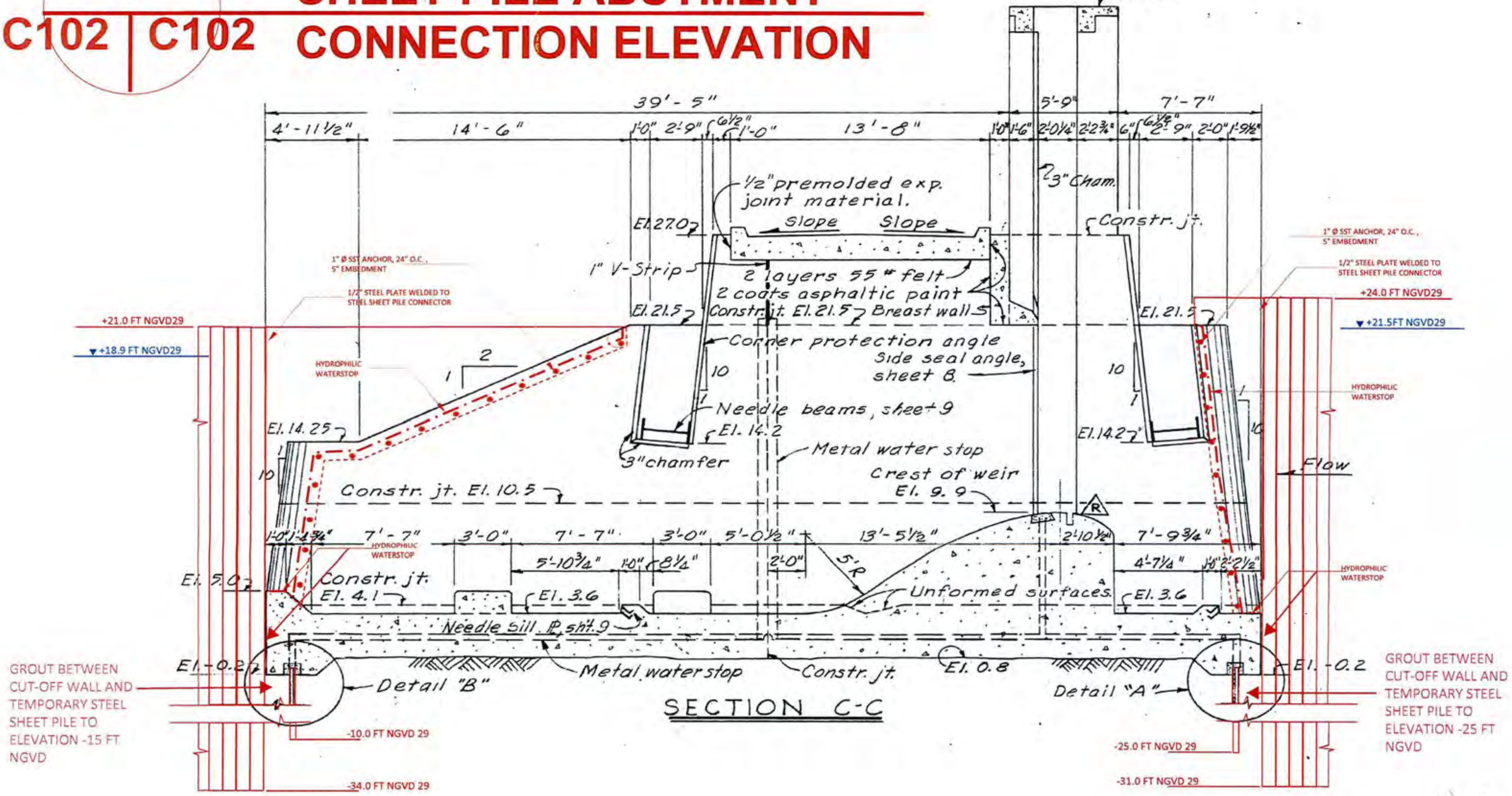
C102 | C102

SHEET PILE - CORNER CONNECTION

3

C102 | C102

SHEET PILE ABUTMENT CONNECTION ELEVATION



SECTION C-C

4/14

SOUTH FLORIDA WATER MANAGEMENT DISTRICT 5

Engineering Calculations

94

Everglades Restoration & Capital Projects

Submitted By H. Gao	Date	Project S72	Sheet of
Checked By	Description Cofferdam – upstream & Downstream		Job No.

* All Elevations are NGVD.

1. Stages:

* Optimum Headwater of upstream is between 20.2'–21.2'

The structure will reach the max. discharge rate 3800cfs @ 25.8'

Historic flow records show the max. stage in the past is 21.335'.

Not to be too conservtive, the cofferdam design chose upstream stage ~~21.5'~~ 22.

21.5 6/22/2000 Daily Mean Max.

**: Based on the historic records, Downstream stage is chosen as 18.0'

18.9 10/27/95 Daily Mean Max.

22.5

▽ 22.5 HW

+3.6

(18.9) TW

▽ 18.9 TW

− 0.7

(19.6)

2. Canal Bottom EL.

Based on the USACE as-built drawing, the upstream canal is +3.6' and downstream canal bottom is −0.7'.

Two ELs are used to consider the side slope elevation change:

Upstream	Downstream
+8.6'	+4.3'
+13.6'	+9.3'

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Submitted By H. Gao	Date	Project S72	Sheet of
Checked By	Description Cofferdam Design — upstream & Downstream		Job No.

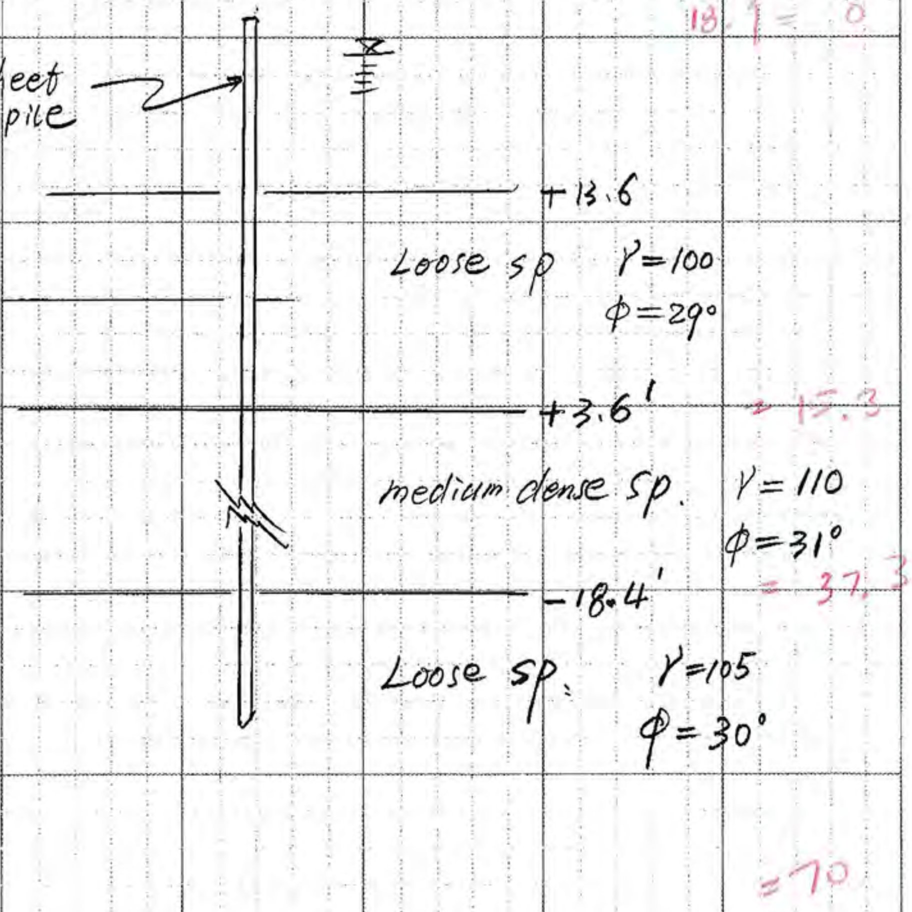
3. soil condition:

Based on USACE soil borings (CB #S-72-1, CB #S-72-2, CB #S-72-3) and

Nodarse soil borings (TB-1, TB-2).

The soil profile can be generated as:

Ka $= \tan^2(45-\frac{\phi}{2})$	Kp $= \tan^2(45+\frac{\phi}{2})$
0,35	2,88
0.32	3.12
0,33	3,0



S72 Cofferdam Summary

location		land ELs (ft. NGVD)	Max.Water Levels Behind (ft. NGVD)	Section Modulus Required (in3/ft)	Min. Penetration (ft)	Section Recommended	Max. Top Deflections (in.)
Upstream	Center Section	3.6	21.5	72.3	30	HZ 1080M D / AZ ~~19-700~~ 14-770 or stronger	2
	Middle Section	8.6	21.5	32.3	24	AZ 50 or stronger	2.5
	Upper Section	13.6	21.5	8.5	17	AZ 17 or stronger	1.3
Downstream	Center Section	-0.7	18	82.4	32	HZ 1180M D or stronger	2.3
	Middle Section	-0.7	18	33.3	24	AZ 50 or stronger	3
	Upper Section	-0.7	18	10.7	17	AZ 17 or stronger	2

Note: All sheet piles shall be conformed to ASTM A572, Grade 50.

Client: S-72 Temporay Cofferdam
Site: C-41 Canal

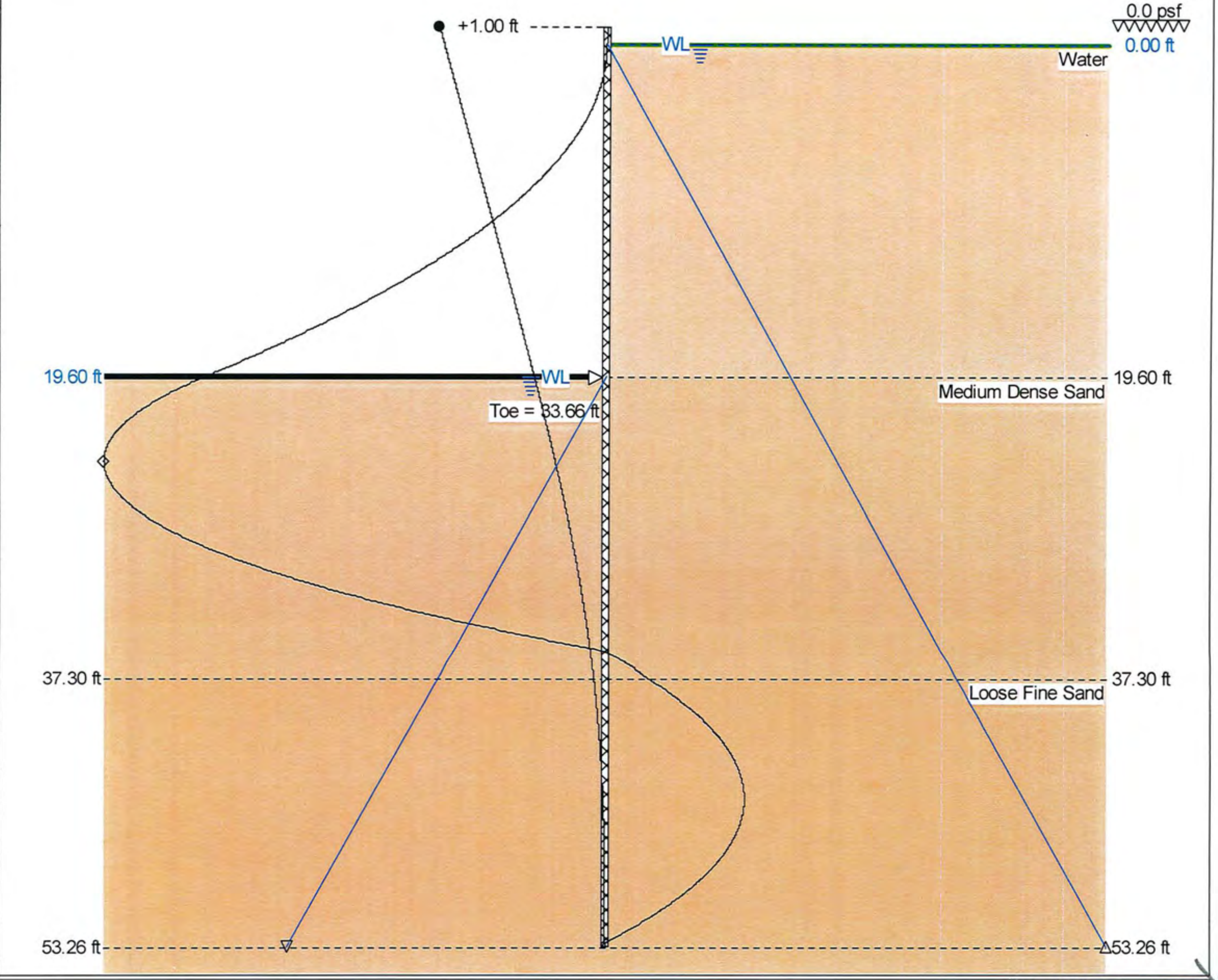
Page: 1
Date: 4.18.13

Sheet: HZ 1180M D M-26 AZ 26-700
Pressure: Rankine
Toe: Cantilever

	Maximum	d (ft)
◇	15062.9 lb/ft	24.59
●	1.6 in	-1.00
△	3325.2 psf	53.26
▽	2101.6 psf	53.26

TW
+2ft
-3ft

HW
+4ft
-31



SFWMD

SPW911, v2.20

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Client: S-72 Temporay Cofferdam
Site: C-41 Canal
Page: 2
Date: 4.18.13
Sheet: HZ 1180M D M-26 AZ 26-700
Pressure: Rankine
Toe: Cantilever

Input Data

Depth Of Excavation = 19.60 ft
Surcharge = 0.0 psf
Depth Of Active Water = 0.00 ft
Depth Of Passive Water = 19.60 ft
Water Density = 62.43 pcf
Minimum Fluid Density = 31.82 pcf

Soil Profile

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	ϕ(°)	δ(°)	K_a	K_{ac}	K_p	K_{pc}
0.00	Water	62.40	0.00	0.0	0.0	0.0	0.0	1.00	0.00	1.00	0.00
19.60	Medium Dense Sand	110.00	87.05	0.0	0.0	31.0	0.0	0.32	0.00	3.12	0.00
37.30	Loose Fine Sand	105.00	42.60	0.0	0.0	30.0	0.0	0.33	0.00	3.00	0.00

Solution

Sheet

Sheet Name	I (in⁴/ft)	E (psi)	Z (in³/ft)	f (psi)	Maximum Bending Moment (ftlb/ft)	Upstand (ft)	Toe (ft)	Pile Length (ft)
HZ 1180M D M-26 AZ 26-700	8323.00	3.04E+07	375.40	25000.0	781151.8	1.00	33.66	54.26

Maxima

	Maximum	Depth
Bending Moment	260463.6 ftlb/ft	35.72 ft
Deflection	1.6 in	-1.00 ft
Pressure	1223.6 psf	19.60 ft
Shear Force	15062.9 lb/ft	24.59 ft

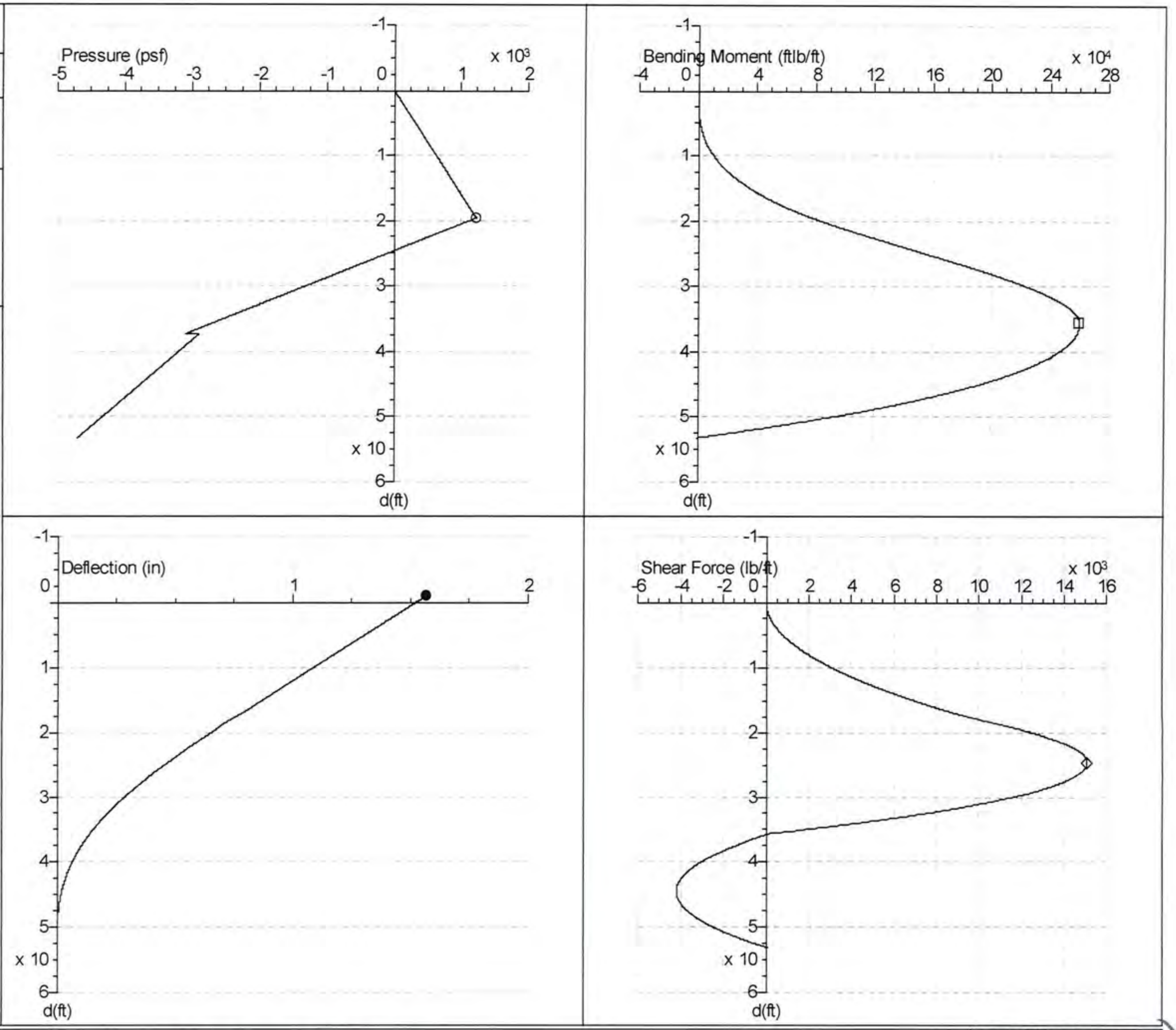
SFWMD

Client: S-72 Temporay Cofferdam
Site: C-41 Canal

Page: 3
Date: 4.18.13

Sheet: HZ 1180M D M-26 AZ 26-700
Pressure: Rankine
Toe: Cantilever

Maximum	d (ft)
○ 1223.6 psf	19.60
□ 260463.6 ftlb/ft	35.72
◇ 15062.9 lb/ft	24.59
● 1.6 in	-1.00



SFWMD

SPW911, v2.20

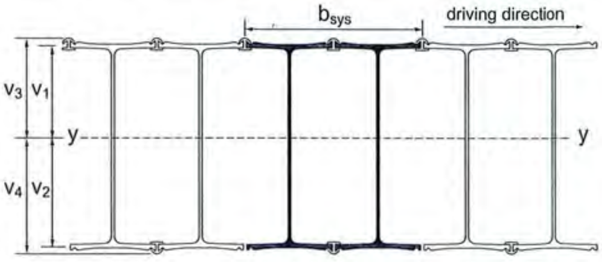
Email: pilebuck@pilebuck.com
Web: www.pilebuck.com

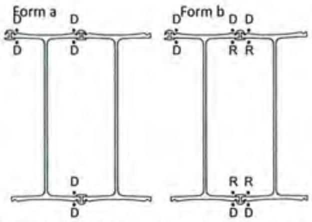
Client: S-72 Temporay Cofferdam
Site: C-41 Canal
Page: 4
Date: 4.18.13

Sheet: HZ 1180M D M-26 AZ 26-700
Pressure: Rankine
Toe: Cantilever

depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)
0.00	2.5	0.0	1.5	0.1	17.91	1120.4	60143.5	0.7	10079.0	35.82	-2738.0	260457.4	0.1	-89.2
0.47	30.7	1.2	1.5	8.3	18.38	1148.7	64805.2	0.7	10592.7	36.29	-2848.2	260259.1	0.1	-505.2
0.94	59.0	8.8	1.5	29.2	18.85	1179.7	70204.5	0.7	11172.5	36.77	-2969.4	259687.9	0.1	-905.3
1.41	90.0	31.2	1.5	66.9	19.33	1207.9	75366.1	0.7	11712.9	37.24	-3090.6	258738.2	0.1	-1216.7
1.89	118.2	70.7	1.4	114.7	19.80	1174.8	80774.3	0.7	12258.6	37.71	-2941.8	257398.6	0.1	-1594.7
2.36	149.3	142.3	1.4	181.9	20.27	1053.5	86999.0	0.6	12810.0	38.18	-2993.2	255901.6	0.1	-1930.6
2.83	177.5	239.2	1.4	256.4	20.74	943.3	92884.8	0.6	13259.0	38.65	-3044.7	254111.2	0.1	-2243.2
3.30	208.6	388.0	1.4	353.1	21.21	822.1	99581.1	0.6	13695.3	39.12	-3101.2	251702.7	0.1	-2560.2
3.77	236.8	567.8	1.4	454.5	21.68	711.8	105845.9	0.6	14039.6	39.59	-3152.7	249274.0	0.1	-2824.0
4.24	265.0	796.1	1.3	568.6	22.15	590.6	112904.4	0.6	14360.7	40.06	-3209.2	245705.1	0.1	-3087.2
4.71	296.1	1110.0	1.3	708.8	22.62	480.4	119448.9	0.5	14600.4	40.54	-3260.7	242577.6	0.1	-3302.1
5.18	324.3	1458.7	1.3	849.8	23.10	370.2	126091.6	0.5	14790.2	41.01	-3312.1	239138.3	0.1	-3493.8
5.66	355.4	1919.1	1.3	1019.5	23.57	248.9	133485.0	0.5	14941.4	41.48	-3368.7	234821.4	0.0	-3677.7
6.13	383.6	2413.8	1.3	1187.2	24.04	138.7	140260.6	0.5	15026.6	41.95	-3420.1	230702.0	0.0	-3820.5
6.60	414.7	3048.7	1.2	1386.4	24.51	17.5	147745.6	0.5	15062.7	42.42	-3476.7	225598.2	0.0	-3950.7
7.07	442.9	3714.7	1.2	1581.0	24.98	-92.8	154554.7	0.5	15043.1	42.89	-3528.1	220067.1	0.0	-4044.7
7.54	471.1	4471.3	1.2	1788.2	25.45	-203.0	161344.7	0.4	14973.8	43.36	-3584.7	214103.3	0.0	-4121.2
8.01	502.2	5415.0	1.2	2031.0	25.92	-324.2	168764.8	0.4	14839.9	43.84	-3636.1	208525.7	0.0	-4166.3
8.48	530.4	6380.6	1.2	2265.1	26.40	-434.4	175441.6	0.4	14665.9	44.31	-3687.6	202609.1	0.0	-4188.1
8.96	561.5	7568.2	1.1	2537.4	26.87	-555.7	182682.5	0.4	14416.9	44.78	-3744.2	195427.4	0.0	-4185.3
9.43	589.7	8768.1	1.1	2798.3	27.34	-665.9	189146.6	0.4	14138.3	45.25	-3795.6	187792.8	0.0	-4158.3
9.90	620.7	10227.6	1.1	3100.0	27.81	-787.1	196099.1	0.4	13774.2	45.72	-3852.2	179700.0	0.0	-4101.8
10.37	649.0	11687.4	1.1	3387.7	28.28	-897.3	202251.3	0.3	13390.8	46.19	-3903.6	172238.3	0.0	-4026.0
10.84	677.2	13279.9	1.0	3688.2	28.75	-1007.6	208220.0	0.3	12957.7	46.66	-3960.2	163271.5	0.0	-3915.7
11.31	708.3	15191.9	1.0	4033.4	29.22	-1128.8	214546.8	0.3	12423.6	47.13	-4011.6	155037.3	0.0	-3791.1
11.78	736.5	17081.8	1.0	4360.7	29.69	-1239.0	220056.9	0.3	11885.8	47.61	-4063.0	145177.9	0.0	-3643.2
12.26	767.5	19335.0	1.0	4735.5	30.17	-1360.3	225824.5	0.3	11236.6	48.08	-4119.6	134834.3	0.0	-3453.6
12.73	795.8	21547.9	1.0	5089.5	30.64	-1470.5	230776.6	0.3	10594.1	48.55	-4171.1	125382.5	0.0	-3256.9
13.20	824.0	23923.5	0.9	5456.4	31.11	-1591.7	235875.7	0.3	9829.8	49.02	-4227.6	114117.2	0.0	-3013.6
13.67	855.1	26731.6	0.9	5874.7	31.58	-1701.9	240170.3	0.2	9082.7	49.49	-4279.1	103850.7	0.0	-2768.0
14.14	883.3	29467.7	0.9	6268.3	32.05	-1812.2	244117.0	0.2	8285.7	49.96	-4335.6	91644.9	0.0	-2471.0
14.61	914.3	32686.2	0.9	6716.1	32.52	-1933.4	248029.5	0.2	7351.4	50.43	-4387.1	78929.6	0.0	-2176.6
15.08	942.6	35808.3	0.9	7136.6	32.99	-2043.6	251172.0	0.2	6449.8	50.91	-4438.5	67381.3	0.0	-1858.9
15.55	973.6	39465.3	0.8	7613.8	33.47	-2164.9	254145.3	0.2	5400.4	51.38	-4495.1	53696.3	0.0	-1482.6
16.03	1001.9	42998.8	0.8	8061.1	33.94	-2275.1	256384.4	0.2	4394.1	51.85	-4546.5	41291.3	0.0	-1116.0
16.50	1030.1	46737.1	0.8	8521.1	34.41	-2396.3	258309.1	0.2	3229.6	52.32	-4603.1	26617.5	0.0	-686.0
16.97	1061.1	51092.7	0.8	9041.9	34.88	-2506.5	259545.3	0.2	2118.6	52.79	-4654.5	13338.7	0.0	-270.6
17.44	1089.4	55280.0	0.8	9528.8	35.35	-2616.7	260268.9	0.1	957.8	53.26	-4700.8	-353.0	0.0	123.1

Combination C 23





D = discontinuous weld, a = 0.236" (6 mm), 10% of length (3.94" per 3.28', 100 mm/m) over the whole pile length + 19.68" (500 mm) continuous weld at top and toe
R = continuous weld, a = 0.236" (6 mm), length 19.68" (500 mm) at top and toe only

	Dimensions					PROPERTIES PER FOOT OF WALL					Coating Area	
SECTION	b_{sys} in mm	v_1 in mm	v_2 in mm	v_3 in mm	v_4 in mm	Sectional Area in^2/ft cm^2/m	Mass lb/ft^2 kg/m^2	Moment of Inertia in^4/ft cm^4/m	*Elastic Section Modulus in^3/ft cm3/m	**Elastic Section Modulus in^3/ft cm^3/m	Waterside ft^2/ft m^2/m	Landside ft^2/ft m^2/m
HZ 880M A	37.40 95.0	15.31 389.0	16.32 414.4	16.67 423.4	17.67 448.9	31.97 676.7	**108.81** **531.2**	6,126.0 836 540	**375.4** **20 185**	346.6 18 635	3.53 1.074	11.62 3.542
HZ 880M B	37.40 95.0	15.44 392.1	16.35 415.3	16.72 424.6	17.63 447.7	35.03 741.5	**119.21** **582.0**	6,641.1 906 880	**406.2** **21 840**	376.7 20 255	3.55 1.081	11.64 3.549
HZ 880M C	37.40 95.0	15.54 394.6	16.41 416.8	16.73 425.1	17.61 447.3	36.47 772.0	**124.12** **606.0**	7,012.4 957 590	**427.3** **22 975**	398.2 21 410	3.54 1.080	11.64 3.548
HZ 1080M A	37.00 94.0	20.09 510.4	21.14 537.0	21.45 544.8	22.50 571.4	40.19 850.8	**136.79** **667.9**	12,054.7 16 461 40	**570.2** **30 655**	535.9 28 810	3.50 1.066	13.02 3.969
HZ 1080M B	37.00 94.0	20.24 514.1	21.23 539.3	21.48 545.5	22.47 570.7	42.48 899.2	**144.57** **705.9**	13,045.2 17 814 00	**614.5** **33 035**	580.6 31 215	3.51 1.068	13.03 3.971
HZ 1080M C	37.00 94.0	20.40 518.3	21.30 541.1	21.52 546.7	22.42 569.6	46.52 984.8	**158.33** **773.0**	14,212.4 19 407 90	**667.1** **35 865**	633.8 34 075	3.52 1.072	13.04 3.974
HZ 1080M D	37.00 94.0	20.59 523.1	21.43 544.3	21.55 547.5	22.39 568.8	49.84 1054.9	**169.60** **828.1**	15,370.6 20 989 50	**717.2** **38 560**	686.4 36 905	3.52 1.073	13.04 3.975
HZ 1180M A	37.40 95.0	20.77 527.6	21.57 547.8	21.58 548.0	22.37 568.2	52.45 1 110.2	**178.50** **871.5**	16,231.2 22 164 70	**752.6** **40 460**	725.6 39 010	3.52 1.074	13.05 3.977
HZ 1180M B	37.40 95.0	20.86 529.9	21.63 549.5	21.59 548.3	22.36 567.9	54.05 1 144.1	**183.95** **898.1**	16,952.4 23 149 50	**783.6** **42 130**	758.2 40 765	3.54 1.078	13.08 3.988
HZ 1180M C	37.40 95.0	20.87 530.2	21.78 553.2	21.64 549.5	22.54 572.5	57.37 1 214.4	**195.26** **953.3**	18,147.9 24 782 00	**833.3** **44 800**	805.2 43 290	3.57 1.087	13.15 4.009
HZ 1180M D	37.40 95.0	20.97 532.7	21.84 554.7	21.65 550.0	22.52 572.0	59.68 1 263.2	**203.09** **991.6**	18,888.9 25 794 00	**864.9** **46 500**	838.8 45 095	3.61 1.099	13.18 4.018

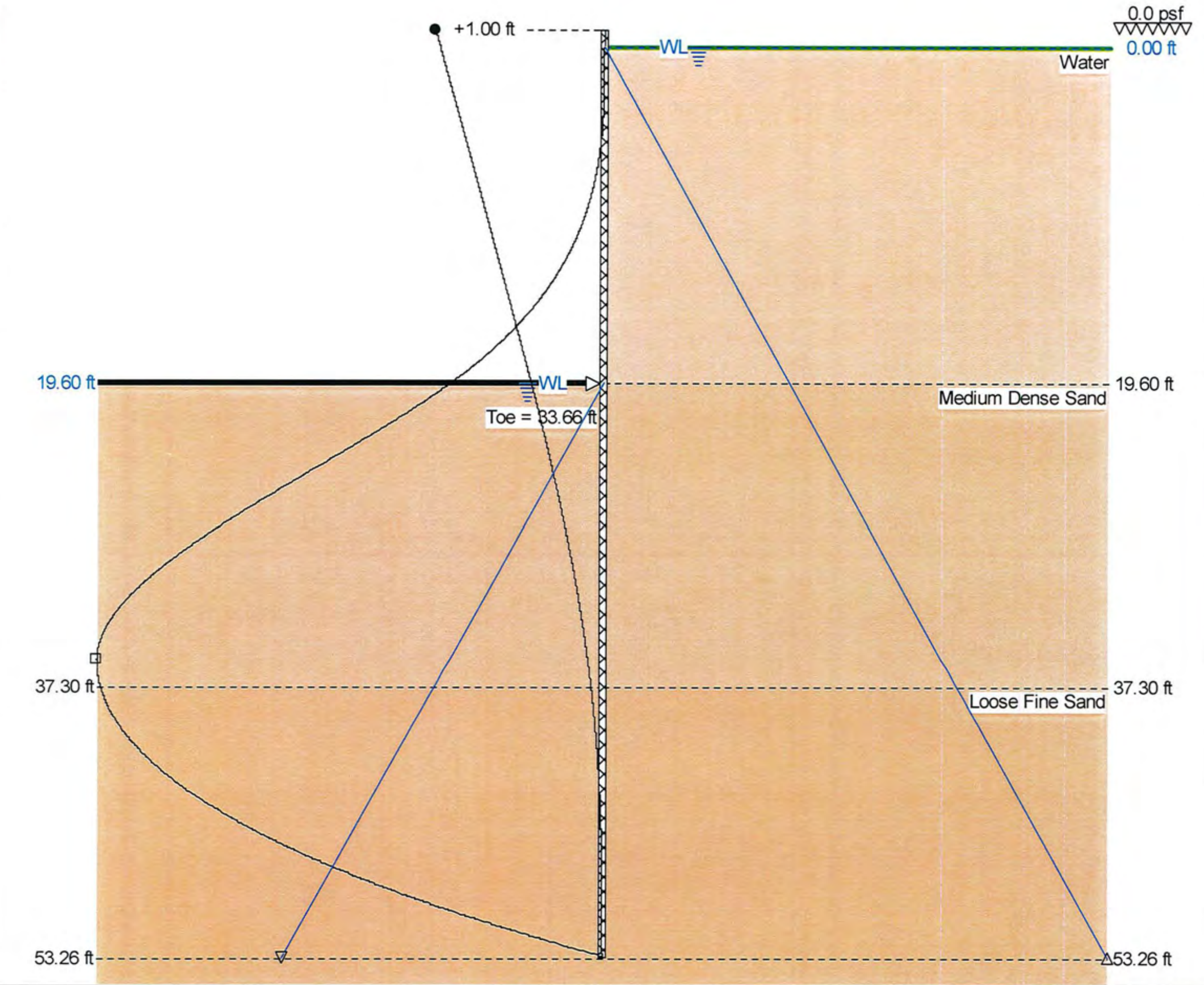
* Referring outside of HZM-flange (v_2). ** Referring outside of connector (v_3).

Client: S-72 Temporay Cofferdam
Site: C-41 Canal

Page: 1
Date: 4.18.13

Sheet: HZ 1180 D COMBINATION C23
Pressure: Rankine
Toe: Cantilever

	Maximum	d (ft)
□	260463.6ftlb/ft	35.72
●	0.7in	-1.00
△	3325.2psf	53.26
▽	2101.6psf	53.26



SFWMD

SPW911, v2.20

Client: S-72 Temporay Cofferdam
Site: C-41 Canal
Page: 2
Date: 4.18.13
Sheet: HZ 1180 D COMBINATION C23
Pressure: Rankine
Toe: Cantilever

Input Data

Depth Of Excavation = 19.60 ft
Surcharge = 0.0 psf
Depth Of Active Water = 0.00 ft
Depth Of Passive Water = 19.60 ft
Water Density = 62.43 pcf
Minimum Fluid Density = 31.82 pcf

Soil Profile

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	ϕ(°)	δ(°)	K_a	K_{ac}	K_p	K_{pc}
0.00	Water	62.40	0.00	0.0	0.0	0.0	0.0	1.00	0.00	1.00	0.00
19.60	Medium Dense Sand	110.00	87.05	0.0	0.0	31.0	0.0	0.32	0.00	3.12	0.00
37.30	Loose Fine Sand	105.00	42.60	0.0	0.0	30.0	0.0	0.33	0.00	3.00	0.00

Solution

Sheet

Sheet Name	I (in⁴/ft)	E (psi)	Z (in³/ft)	f (psi)	Maximum Bending Moment (ftlb/ft)	Upstand (ft)	Toe (ft)	Pile Length (ft)
HZ 1180 D COMBINATION C23	18888.90	3.04E+07	838.80	25000.0	1745418.4	1.00	33.66	54.26

Maxima

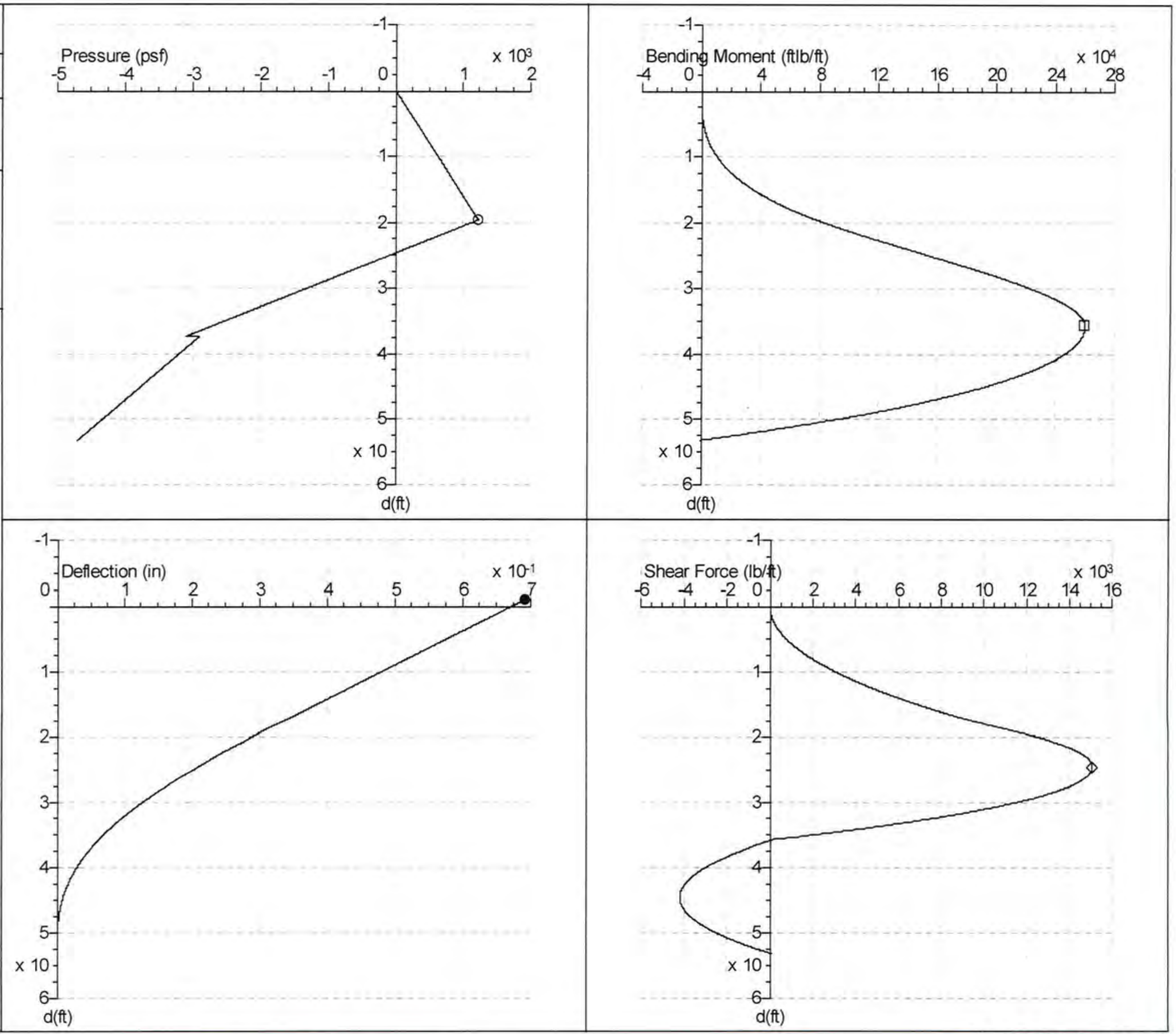
	Maximum	Depth
Bending Moment	260463.6 ftlb/ft	35.72 ft
Deflection	0.7 in	-1.00 ft
Pressure	1223.6 psf	19.60 ft
Shear Force	15062.9 lb/ft	24.59 ft

SFWMD

SPW911, v2.20

Client: S-72 Temporay Cofferdam
Site: C-41 Canal
Page: 3
Date: 4.18.13
Sheet: HZ 1180 D COMBINATION C23
Pressure: Rankine
Toe: Cantilever

	Maximum	d (ft)
○	1223.6 psf	19.60
□	260463.6 ftlb/ft	35.72
◇	15062.9 lb/ft	24.59
●	0.7 in	-1.00



SFWMD

SPW911, v2.20

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14/14

Client: S-72 Temporay Cofferdam
Site: C-41 Canal
Page: 4
Date: 4.18.13

Sheet: HZ 1180 D COMBINATION C23
Pressure: Rankine
Toe: Cantilever

depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)
0.00	2.5	0.0	0.7	0.1	17.91	1120.4	60143.5	0.3	10079.0	35.82	-2738.0	260457.4	0.1	-89.2
0.47	30.7	1.2	0.7	8.3	18.38	1148.7	64805.2	0.3	10592.7	36.29	-2848.2	260259.1	0.1	-505.2
0.94	59.0	8.8	0.7	29.2	18.85	1179.7	70204.5	0.3	11172.5	36.77	-2969.4	259687.9	0.1	-905.3
1.41	90.0	31.2	0.6	66.9	19.33	1207.9	75366.1	0.3	11712.9	37.24	-3090.6	258738.2	0.0	-1216.7
1.89	118.2	70.7	0.6	114.7	19.80	1174.8	80774.3	0.3	12258.6	37.71	-2941.8	257398.6	0.0	-1594.7
2.36	149.3	142.3	0.6	181.9	20.27	1053.5	86999.0	0.3	12810.0	38.18	-2993.2	255901.6	0.0	-1930.6
2.83	177.5	239.2	0.6	256.4	20.74	943.3	92884.8	0.3	13259.0	38.65	-3044.7	254111.2	0.0	-2243.2
3.30	208.6	388.0	0.6	353.1	21.21	822.1	99581.1	0.3	13695.3	39.12	-3101.2	251702.7	0.0	-2560.2
3.77	236.8	567.8	0.6	454.5	21.68	711.8	105845.9	0.3	14039.6	39.59	-3152.7	249274.0	0.0	-2824.0
4.24	265.0	796.1	0.6	568.6	22.15	590.6	112904.4	0.2	14360.7	40.06	-3209.2	245705.1	0.0	-3087.2
4.71	296.1	1110.0	0.6	708.8	22.62	480.4	119448.9	0.2	14600.4	40.54	-3260.7	242577.6	0.0	-3302.1
5.18	324.3	1458.7	0.6	849.8	23.10	370.2	126091.6	0.2	14790.2	41.01	-3312.1	239138.3	0.0	-3493.8
5.66	355.4	1919.1	0.6	1019.5	23.57	248.9	133485.0	0.2	14941.4	41.48	-3368.7	234821.4	0.0	-3677.7
6.13	383.6	2413.8	0.6	1187.2	24.04	138.7	140260.6	0.2	15026.6	41.95	-3420.1	230702.0	0.0	-3820.5
6.60	414.7	3048.7	0.5	1386.4	24.51	17.5	147745.6	0.2	15062.7	42.42	-3476.7	225598.2	0.0	-3950.7
7.07	442.9	3714.7	0.5	1581.0	24.98	-92.8	154554.7	0.2	15043.1	42.89	-3528.1	220067.1	0.0	-4044.7
7.54	471.1	4471.3	0.5	1788.2	25.45	-203.0	161344.7	0.2	14973.8	43.36	-3584.7	214103.3	0.0	-4121.2
8.01	502.2	5415.0	0.5	2031.0	25.92	-324.2	168764.8	0.2	14839.9	43.84	-3636.1	208525.7	0.0	-4166.3
8.48	530.4	6380.6	0.5	2265.1	26.40	-434.4	175441.6	0.2	14665.9	44.31	-3687.6	202609.1	0.0	-4188.1
8.96	561.5	7568.2	0.5	2537.4	26.87	-555.7	182682.5	0.2	14416.9	44.78	-3744.2	195427.4	0.0	-4185.3
9.43	589.7	8768.1	0.5	2798.3	27.34	-665.9	189146.6	0.2	14138.3	45.25	-3795.6	187792.8	0.0	-4158.3
9.90	620.7	10227.6	0.5	3100.0	27.81	-787.1	196099.1	0.2	13774.2	45.72	-3852.2	179700.0	0.0	-4101.8
10.37	649.0	11687.4	0.5	3387.7	28.28	-897.3	202251.3	0.2	13390.8	46.19	-3903.6	172238.3	0.0	-4026.0
10.84	677.2	13279.9	0.5	3688.2	28.75	-1007.6	208220.0	0.1	12957.7	46.66	-3960.2	163271.5	0.0	-3915.7
11.31	708.3	15191.9	0.5	4033.4	29.22	-1128.8	214546.8	0.1	12423.6	47.13	-4011.6	155037.3	0.0	-3791.1
11.78	736.5	17081.8	0.4	4360.7	29.69	-1239.0	220056.9	0.1	11885.8	47.61	-4063.0	145177.9	0.0	-3643.2
12.26	767.5	19335.0	0.4	4735.5	30.17	-1360.3	225824.5	0.1	11236.6	48.08	-4119.6	134834.3	0.0	-3453.6
12.73	795.8	21547.9	0.4	5089.5	30.64	-1470.5	230776.6	0.1	10594.1	48.55	-4171.1	125382.5	0.0	-3256.9
13.20	824.0	23923.5	0.4	5456.4	31.11	-1591.7	235875.7	0.1	9829.8	49.02	-4227.6	114117.2	0.0	-3013.6
13.67	855.1	26731.6	0.4	5874.7	31.58	-1701.9	240170.3	0.1	9082.7	49.49	-4279.1	103850.7	0.0	-2768.0
14.14	883.3	29467.7	0.4	6268.3	32.05	-1812.2	244117.0	0.1	8285.7	49.96	-4335.6	91644.9	0.0	-2471.0
14.61	914.3	32686.2	0.4	6716.1	32.52	-1933.4	248029.5	0.1	7351.4	50.43	-4387.1	78929.6	0.0	-2176.6
15.08	942.6	35808.3	0.4	7136.6	32.99	-2043.6	251172.0	0.1	6449.8	50.91	-4438.5	67381.3	0.0	-1858.9
15.55	973.6	39465.3	0.4	7613.8	33.47	-2164.9	254145.3	0.1	5400.4	51.38	-4495.1	53696.3	0.0	-1482.6
16.03	1001.9	42998.8	0.4	8061.1	33.94	-2275.1	256384.4	0.1	4394.1	51.85	-4546.5	41291.3	0.0	-1116.0
16.50	1030.1	46737.1	0.4	8521.1	34.41	-2396.3	258309.1	0.1	3229.6	52.32	-4603.1	26617.5	0.0	-686.0
16.97	1061.1	51092.7	0.3	9041.9	34.88	-2506.5	259545.3	0.1	2118.6	52.79	-4654.5	13338.7	0.0	-270.6
17.44	1089.4	55280.0	0.3	9528.8	35.35	-2616.7	260268.9	0.1	957.8	53.26	-4700.8	-353.0	0.0	123.1

SFWMD

SPW911, v2.20

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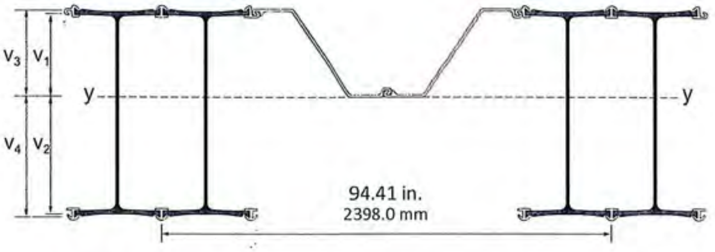
Combination HZ...M-26 / AZ 26-700



SECTION	PROPERTIES PER FOOT OF WALL				MASS OF COMBINATION WITH INTERMEDIARY SECTION				
	Sectional Area	Moment of Inertia	*Elastic Section Modulus	**Elastic Section Modulus	*** AZ 26-700			Coating Area	
					ℓAZ = 60% ℓHZ	ℓAZ = 80% ℓHZ	ℓAZ = ℓHZ	Waterside	Landside
	in^2/ft cm^2/m	in^4/ft cm^4/m	in^3/ft cm^3/m	in^3/ft cm^3/m	lb/ft^2 kg/m^2	lb/ft^2 kg/m^2	lb/ft^2 kg/m^2	ft^2/ft m^2/m	ft^2/ft m^2/m
HZ 880M A	18.94 400.9	2,970.4 405 620	**187.7** **10 090**	172.9 9 295	55.25 270	59.86 292	64.46 315	10.09 3.074	18.72 5.706
HZ 880M B	20.17 426.9	3,178.5 434 040	**199.9** **10 745**	185.0 9 945	59.45 290	64.04 313	68.64 335	10.11 3.081	18.74 5.713
HZ 880M C	20.74 438.9	3,324.8 454 020	**208.0** **11 185**	193.4 10 400	61.38 300	65.98 322	70.57 345	10.11 3.080	18.74 5.712
HZ 1080M A	22.11 468.1	5,492.6 750 050	**266.2** **14 310**	249.8 13 430	66.02 322	70.64 345	75.26 367	10.06 3.066	20.12 6.132
HZ 1080M B	23.01 487.0	5,879.9 802 940	**283.4** **15 235**	267.4 14 375	69.07 337	73.69 360	78.31 382	10.07 3.068	20.13 6.135
HZ 1080M C	24.63 521.3	6,349.5 867 060	**304.3** **16 360**	288.8 15 525	74.59 364	79.20 387	83.81 409	10.08 3.072	20.14 6.138
HZ 1080M D	25.95 549.2	6,810.8 930 050	**323.9** **17 415**	309.8 16 655	79.09 386	83.70 409	88.30 431	10.08 3.073	20.14 6.139
HZ 1180M A	27.00 571.4	7,156.2 977 220	**337.9** **18 165**	325.5 17 500	82.67 404	87.27 426	91.87 449	10.09 3.074	20.15 6.140
HZ 1180M B	27.63 584.7	7,439.8 1 015 950	**350.0** **18 815**	338.4 18 195	84.81 414	89.41 437	94.02 459	10.10 3.077	20.16 6.144
HZ 1180M C	29.22 618.4	8,021.5 1 095 390	**374.6** **20 140**	361.8 19 450	89.85 439	94.64 462	99.43 485	10.15 3.094	20.28 6.181
HZ 1180M D	30.15 638.2	8,323.0 1 136 560	**387.3** **20 825**	375.4 20 185	93.03 454	97.82 478	102.61 501	10.19 3.107	20.32 6.194

* Referring outside of HZM-flange (highest value of v_1; v_2), ** Referring outside of connector (highest value of v_3; v_4), *** Length of connectors = Length of AZ.

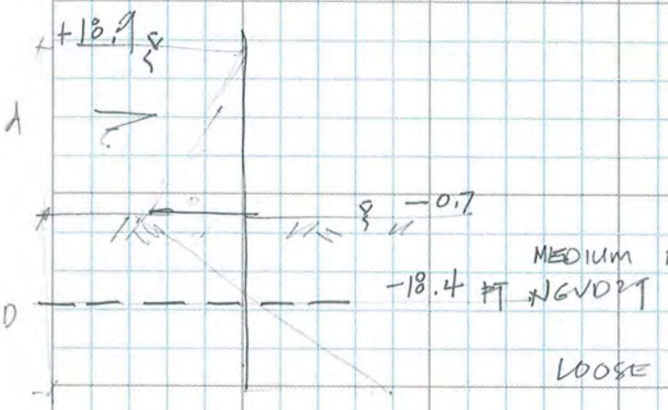
SOUTH FLORIDA WATER MANAGEMENT DISTRICT 17

Engineering Calculations

Engineering & Construction Bureau 7/74

Submitted By JOSE GUARDIARIO	Date 4/	Project S72 CONCRETE REPAIR	Sheet of
Checked By	Description S72 TEMP. COFFER DAM DESIGN		Job No.

	MAX WATER ELEV.	DEWATERED ELEV.	ΔH
HW	22.5 FT NGVD29	+3.6 FT NGVD29	18.9 FT
TW	18.9	-0.7	19.6 FT. ✓

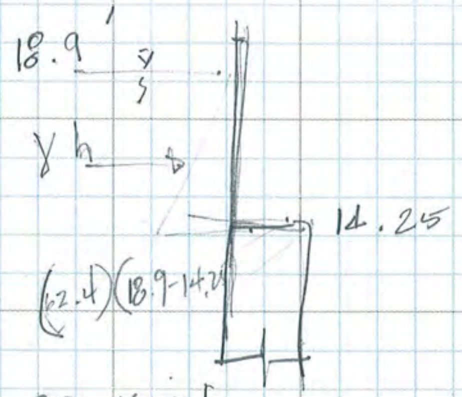


$\gamma_w = 62.4$ pcf

			K_a	K_p
MEDIUM DENSE SAND (SP)	$\gamma = 110$ pcf	$\phi = 31°$	0.32	3.12
LOOSE SAND (SP)	$\gamma = 105$ pcf	$\phi = 30°$	0.33	3.0

$$K_a = \tan^2\left(45 - \frac{\phi}{2}\right)$$

$$K_p = \tan^2\left(45 + \frac{\phi}{2}\right)$$



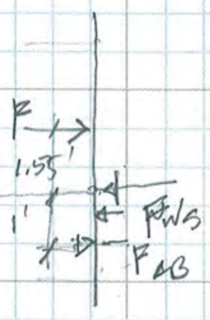
$p = \gamma h$

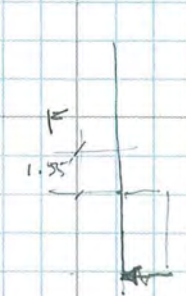
$p = (62.4)(18.9-14.25)$

p 290.16 psf

$F = \frac{1}{2}(18.9-14.25)(290.16)$

$F =$ 674.62 lb





$\Sigma M_A = 0$

$(674.62)(1.55) + 2000(0.5) = F_{AB}(1)$

$F_{AB} = 2045.661$

$= 4091.32$#

USE 3/4" BOLT @ 2' OC.

MIN. 8" EMBEDMENT

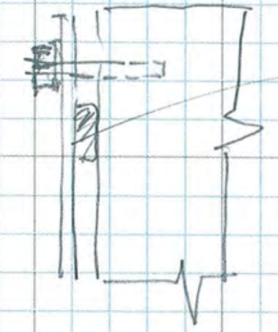
SOUTH FLORIDA WATER MANAGEMENT DISTRICT

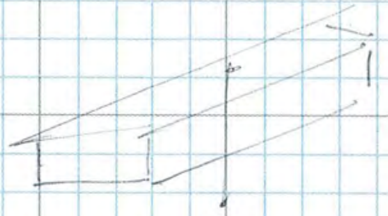
Engineering Calculations

Engineering & Construction Bureau

18/74

Submitted By: JOSE GUARDIARIO
Date: 4/22/2013
Project: 100813 CONCRETE REPAIRS
Sheet 1 of
Checked By:
Description: DEWATERING
Job No.





@ 1" INTERVAL

$P = \frac{80\#}{in^2}(1")(24")$

$P = 1920\ \#$ say $2000\#$ ✓

USING 2 strips

$2P = 4000\ \#s.$ ✓

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Engineering Calculations

Engineering & Construction Bureau

Submitted By: JOSE GUARDIARIO

Date: 04/23/2013

Project: 100813 CONCRETE REPAIRS

Sheet 2 of

Checked By:

Description: S72 COFFERDAM ANCHORBOLT

Job No.

USE 3/4" SST ANCHORS Embedment = 4 3/4 = hef

24" OC.

$f_{ut} = 101{,}500$ psi

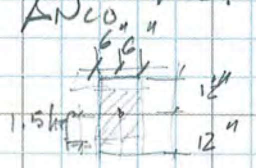
$f'_c = 3000$ psi

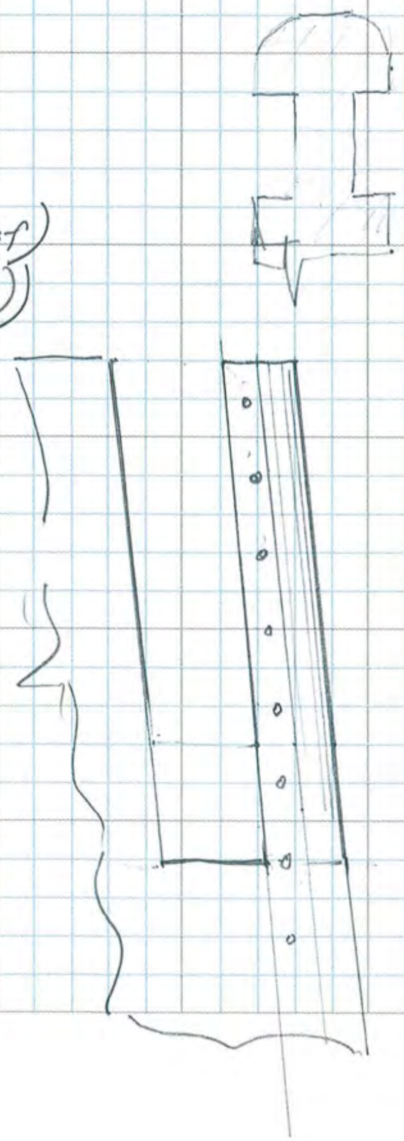
① steel capacity

$$\phi N_s = \phi n A_{se} f_{ut} = (0.75)(2)(0.237)(101{,}500) = 36{,}083.25$$

② concrete breakout strength of anchor in tension

$$N_{cbg} = \frac{A_{Nc}}{A_{Nco}} \Psi_{ec},\Psi_{ed,N}\Psi_{c,N}\Psi_{cp,N} N_b$$





$$A_{Nc} = (c_{a1} + 1.5h_{ef})(2 \times 1.5h_{ef})$$

$$= (6" + 1.5(4.75))(2 \times 1.5(4.75))$$

$$= 148 \text{ in}^2$$

$$A_{Nco} = 2(1.5h_{ef})2(1.5h_{ef})$$

$$= 9(4.75)^2$$

$$= 203 \text{ in}^2$$

$$N_b = k_c \lambda \sqrt{f'_c}\, h_{ef}^{1.5}$$

$k_c = 17$

$\lambda = 1.0$ for normal concrete

$$= 17(1.0)\sqrt{3000}\,(4.75)^{1.5}$$

$$N_b = \underline{9639.4 \text{ lb}}$$

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Engineering Calculations

Engineering & Construction Bureau

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Submitted By	Date	Project	Sheet 3 of
Checked By	Description		Job No.

Modification for eccentricity:

$\psi_{ec,N}$ = 1 no eccentricity

Modification factor for edge effects:

$\psi_{ed,N}$ $C_{a\,min} < 1.5\,h_{ef}$

$6\text{ in} < 1.5(4.75)$ use $\psi_{ed,N} = 0.7 + 0.3 \dfrac{6''}{1.5(4.75)} = 0.953$

Modification factor for post-installed anchors

$\psi_{cp,N}$ C_{ac} for torque-controlled anchors.

$C_{ac} = 4h_{ef} = 4(4.75) = 19$

$C_{amin} = 6\text{ in} < C_{ac} = 19$

$$\psi_{cp,N} = \frac{C_{a,min}}{C_{ac}} = \frac{6}{19} = 0.316$$

$$N_{cb} = \frac{A_{NC}}{A_{NC_0}} \psi_{ed,N} \psi_{c,N} \psi_{cp,N} N_b$$

$$= \left(\frac{171}{203}\right)(0.953)(0.316)(9639.4)$$

N_{cb} = 2445 lbs > 2000 lbs for 1 piece of waterstope ok.

③ Verify conc thickness spacing & edge distance

$S_{min} = h_{min} = 6d_a$ for torqued anchors

d_a = outside diameter of anchor = 0.75 in.

$h_{min} = 6(0.75) = 4.5$

$h = 38'' \geq h_{min} = 4.5''$ ∴ OK!!

$S = 24'' \geq h_{min} = 4.5''$ ∴ OK!!

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Engineering Calculations

Engineering & Construction Bureau

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Submitted By	Date	Project	Sheet 4 of
Checked By	Description		Job No.

$C_{min} = 8d_a = 8(0.75) = 6'' = 6'' = C$ ∴ ok!!!

Calculate A_{NCo} and A_{NC} for anchorage

$A_{NCo} = 9h_{ef}^2 = 9(4.75)^2 = 203\ in^2$

$A_{NC} = 148\ in^2$

$A_{NC} < A_{NCo}$

$148\ in^2 < 203\ in^2$ ∴ ok!!!

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

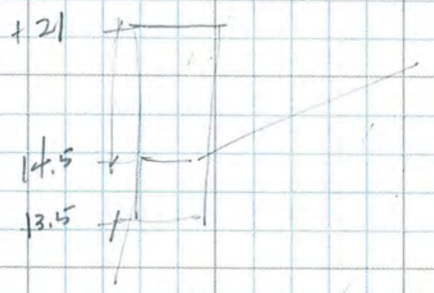
Engineering Calculations

Engineering & Construction Bureau

Submitted By	Date	Project	Sheet of
Checked By	Description		Job No.

Calculate for shear

$\gamma_{STEEL} = 490$ pcf



$$\frac{W}{LF} = (21-13.5)(1)\left(\frac{0.48}{12}\right)(490)$$

$$= 286.65 \text{ lbs}$$

Effective Area of 3/4"ϕ bolt = 0.237 in²

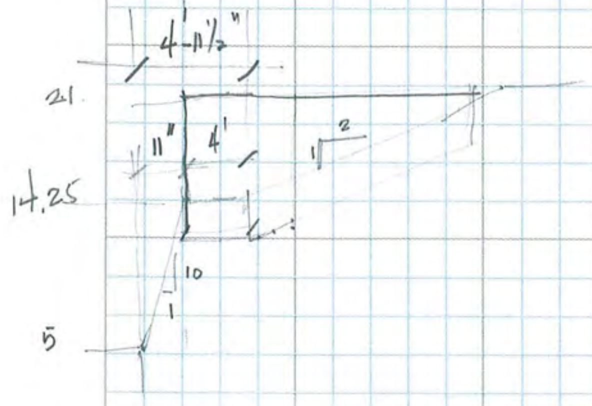
@ 2' interval

$$\text{Shear stress} = \frac{(286.65)(2)}{0.237 \text{ in}^2}$$

shear stress = 2419 psi

Steel shear strength = 13,675 psi >> 2419 psi

∴ OK!!



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DIVISION: 03 00 00—CONCRETE
Section: 03 16 00—Concrete Anchors

REPORT HOLDER:

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HiltiTechEng@us.hilti.com

EVALUATION SUBJECT:

HILTI KWIK BOLT TZ CARBON AND STAINLESS STEEL ANCHORS IN CRACKED AND UNCRACKED CONCRETE

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2012, 2009 and 2006 *International Building Code®* (IBC)
- 2012, 2009 and 2006 *International Residential Code®* (IRC)

Property evaluated:

Structural

2.0 USES

The Hilti Kwik Bolt TZ anchor (KB-TZ) is used to resist static, wind, and seismic tension and shear loads in cracked and uncracked normal-weight concrete and sand-lightweight concrete having a specified compressive strength, f'_c, of 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa).

The $^3/_8$-inch- and $^1/_2$-inch-diameter (9.5 mm and 12.7 mm) carbon steel KB-TZ anchors may be installed in the topside of cracked and uncracked normal-weight or sand-lightweight concrete-filled steel deck having a minimum member thickness, $h_{min,deck}$, as noted in Table 6 of this report and a specified compressive strength, f'_c, of 3,000 psi to 8,500 psi (20.7 MPa to 58.6 MPa).

The $^3/_8$-inch-, $^1/_2$-inch- and $^5/_8$-inch-diameter (9.5 mm, 12.7 mm and 15.9 mm) carbon steel KB-TZ anchors may be installed in the soffit of cracked and uncracked normal-weight or sand-lightweight concrete over metal deck having a minimum specified compressive strength, f'_c, of 3,000 psi (20.7 MPa).

The anchoring system complies with anchors as described in Section 1909 of the 2012 IBC and Section 1912 of the 2009 and 2006 IBC. The anchoring system is an alternative to cast-in-place anchors described in Section1908 of the 2012 IBC and Section 1911 of the 2009 and 2006 IBC. The anchors may also be used where an engineered design is submitted in accordance with Section R301.1.3 of the IRC.

3.0 DESCRIPTION

3.1 KB-TZ:

KB-TZ anchors are torque-controlled, mechanical expansion anchors. KB-TZ anchors consist of a stud (anchor body), wedge (expansion elements), nut, and washer. The anchor (carbon steel version) is illustrated in Figure 1. The stud is manufactured from carbon steel or AISI Type 304 or Type 316 stainless steel materials. Carbon steel KB-TZ anchors have a minimum 5 μm (0.0002 inch) zinc plating. The expansion elements for the carbon and stainless steel KB-TZ anchors are fabricated from Type 316 stainless steel. The hex nut for carbon steel conforms to ASTM A563-04, Grade A, and the hex nut for stainless steel conforms to ASTM F594.

The anchor body is comprised of a high-strength rod threaded at one end and a tapered mandrel at the other end. The tapered mandrel is enclosed by a three-section expansion element which freely moves around the mandrel. The expansion element movement is restrained by the mandrel taper and by a collar. The anchor is installed in a predrilled hole with a hammer. When torque is applied to the nut of the installed anchor, the mandrel is drawn into the expansion element, which is in turn expanded against the wall of the drilled hole.

3.2 Concrete:

Normal-weight and sand-lightweight concrete must conform to Sections 1903 and 1905 of the IBC.

3.3 Steel Deck Panels:

Steel deck panels must be in accordance with the configuration in Figures 5A, 5B and 5C and have a minimum base steel thickness of 0.035 inch (0.899mm). Steel must comply with ASTM A653/A653M SS Grade 33 and have a minimum yield strength of 33,000 psi (228 MPa).

4.0 DESIGN AND INSTALLATION

4.1 Strength Design:

4.1.1 General: Design strength of anchors complying with the 2012 IBC as well as Section R301.1.3 of the 2012 IRC, must be determined in accordance with ACI 318-11 Appendix D and this report.

Design strength of anchors complying with the 2009 IBC and Section R301.1.3 of the 2009 IRC must be determined in accordance with ACI 318-08 Appendix D and this report.

***Revised November 2012**

Design strength of anchors complying with the 2006 IBC and Section R301.1.3 of the 2006 IRC must be in accordance with ACI 318-05 Appendix D and this report.

Design parameters provided in Tables 3, 4, 5 and 6 of this report are based on the 2012 IBC (ACI 318-11) unless noted otherwise in Sections 4.1.1 through 4.1.12.The strength design of anchors must comply with ACI 318 D.4.1, except as required in ACI 318 D.3.3.

Strength reduction factors, ϕ, as given in ACI 318-11 D.4.3 and noted in Tables 3 and 4 of this report, must be used for load combinations calculated in accordance with Section 1605.2 of the IBC and Section 9.2 of ACI 318. Strength reduction factors, ϕ, as given in ACI 318-11 D.4.4 must be used for load combinations calculated in accordance with ACI 318 Appendix C. An example calculation in accordance with the 2012 IBC is provided in Figure 7. The value of f'_c used in the calculations must be limited to a maximum of 8,000 psi (55.2 MPa), in accordance with ACI 318-11 D.3.7.

4.1.2 Requirements for Static Steel Strength in Tension: The nominal static steel strength, N_{sa}, of a single anchor in tension must be calculated in accordance with ACI 318 D.5.1.2. The resulting N_{sa} values are provided in Tables 3 and 4 of this report. Strength reduction factors ϕ corresponding to ductile steel elements may be used.

4.1.3 Requirements for Static Concrete Breakout Strength in Tension: The nominal concrete breakout strength of a single anchor or group of anchors in tension, N_{cb} or N_{cbg}, respectively, must be calculated in accordance with ACI 318 D.5.2, with modifications as described in this section. The basic concrete breakout strength in tension, N_b, must be calculated in accordance with ACI 318 D.5.2.2, using the values of h_{ef} and k_{cr} as given in Tables 3, 4 and 6. The nominal concrete breakout strength in tension in regions where analysis indicates no cracking in accordance with ACI 318 D.5.2.6 must be calculated with k_{uncr} as given in Tables 3 and 4 and with $\Psi_{c,N} = 1.0$.

For carbon steel KB-TZ anchors installed in the soffit of sand-lightweight or normal-weight concrete on steel deck floor and roof assemblies, as shown in Figures 5A and 5B, calculation of the concrete breakout strength is not required.

4.1.4 Requirements for Static Pullout Strength in Tension: The nominal pullout strength of a single anchor in accordance with ACI 318 D.5.3.1 and D.5.3.2 in cracked and uncracked concrete, $N_{p,cr}$ and $N_{p,uncr}$, respectively, is given in Tables 3 and 4. For all design cases $\Psi_{c,P} = 1.0$. In accordance with ACI 318 D.5.3, the nominal pullout strength in cracked concrete may be calculated in accordance with the following equation:

$$N_{p,f'_c} = N_{p,cr}\sqrt{\frac{f'_c}{2,500}} \quad \text{(lb, psi)} \qquad \text{(Eq-1)}$$

$$N_{p,f'_c} = N_{p,cr}\sqrt{\frac{f'_c}{17.2}} \quad \text{(N, MPa)}$$

In regions where analysis indicates no cracking in accordance with ACI 318 D.5.3.6, the nominal pullout strength in tension may be calculated in accordance with the following equation:

$$N_{p,f'_c} = N_{p,uncr}\sqrt{\frac{f'_c}{2,500}} \quad \text{(lb, psi)} \qquad \text{(Eq-2)}$$

$$N_{p,f'_c} = N_{p,uncr}\sqrt{\frac{f'_c}{17.2}} \quad \text{(N, MPa)}$$

Where values for $N_{p,cr}$ or $N_{p,uncr}$ are not provided in Table 3 or Table 4, the pullout strength in tension need not be evaluated.

The nominal pullout strength in cracked concrete of the carbon steel KB-TZ installed in the soffit of sand-lightweight or normal-weight concrete on steel deck floor and roof assemblies, as shown in Figures 5A and 5B, is given in Table 5. In accordance with ACI 318 D.5.3.2, the nominal pullout strength in cracked concrete must be calculated in accordance with Eq-1, whereby the value of $N_{p,deck,cr}$ must be substituted for $N_{p,cr}$ and the value of 3,000 psi (20.7 MPa) must be substituted for the value of 2,500 psi (17.2 MPa) in the denominator. In regions where analysis indicates no cracking in accordance with ACI 318 5.3.6, the nominal strength in uncracked concrete must be calculated according to Eq-2, whereby the value of $N_{p,deck,uncr}$ must be substituted for $N_{p,uncr}$ and the value of 3,000 psi (20.7 MPa) must be substituted for the value of 2,500 psi (17.2 MPa) in the denominator. The use of stainless steel KB-TZ anchors installed in the soffit of concrete on steel deck assemblies is beyond the scope of this report.

4.1.5 Requirements for Static Steel Strength in Shear:

The nominal steel strength in shear, V_{sa}, of a single anchor in accordance with ACI 318 D.6.1.2 is given in Table 3 and Table 4 of this report and must be used in lieu of the values derived by calculation from ACI 318-11, Eq. D-29. The shear strength $V_{sa,deck}$ of the carbon-steel KB-TZ as governed by steel failure of the KB-TZ installed in the soffit of sand-lightweight or normal-weight concrete on steel deck floor and roof assemblies, as shown in Figures 5A and 5B, is given in Table 5.

4.1.6 Requirements for Static Concrete Breakout Strength in Shear: The nominal concrete breakout strength of a single anchor or group of anchors in shear, V_{cb} or V_{cbg}, respectively, must be calculated in accordance with ACI 318 D.6.2, with modifications as described in this section. The basic concrete breakout strength, V_b, must be calculated in accordance with ACI 318 D.6.2.2 based on the values provided in Tables 3 and 4. The value of ℓ_e used in ACI 318 Eq. D-24 must be taken as no greater than the lesser of h_{ef} or $8d_a$.

For carbon steel KB-TZ anchors installed in the soffit of sand-lightweight or normal-weight concrete on steel deck floor and roof assemblies, as shown in Figures 5A and 5B, calculation of the concrete breakout strength in shear is not required.

4.1.7 Requirements for Static Concrete Pryout Strength in Shear: The nominal concrete pryout strength of a single anchor or group of anchors, V_{cp} or V_{cpg}, respectively, must be calculated in accordance with ACI 318 D.6.3, modified by using the value of k_{cp} provided in Tables 3 and 4 of this report and the value of N_{cb} or N_{cbg} as calculated in Section 4.1.3 of this report.

For carbon steel KB-TZ anchors installed in the soffit of sand-lightweight or normal-weight concrete over profile steel deck floor and roof assemblies, as shown in Figures 5A and 5B, calculation of the concrete pry-out strength in accordance with ACI 318 D.6.3 is not required.

4.1.8 Requirements for Seismic Design:

4.1.8.1 General: For load combinations including seismic, the design must be performed in accordance with ACI 318 D.3.3. For the 2012 IBC, Section 1905.1.9 shall be omitted. Modifications to ACI 318 D.3.3 shall be applied under Section 1908.1.9 of the 2009 IBC, or Section 1908.1.16 of the 2006 IBC. The nominal steel strength and the nominal concrete breakout strength for anchors in tension, and the nominal concrete breakout strength and pryout strength for anchors in shear, must be calculated in accordance with ACI 318 D.5 and D.6, respectively, taking into account the corresponding values given in Tables 3, 4 and 5 of this report. The anchors may be installed in Seismic Design Categories A through F of the IBC. The anchors comply with ACI 318 D.1 as ductile steel elements and must be designed in accordance with ACI 318-11 D.3.3.4, D.3.3.5, D.3.3.6 or D.3.3.7, ACI 318-08 D.3.3.4, D.3.3.5 or D.3.3.6, or ACI 318-05 D.3.3.4 or D.3.3.5, as applicable.

4.1.8.2 Seismic Tension: The nominal steel strength and nominal concrete breakout strength for anchors in tension must be calculated in accordance with ACI 318 D.5.1 and ACI 318 D.5.2, as described in Sections 4.1.2 and 4.1.3 of this report. In accordance with ACI 318 D.5.3.2, the appropriate pullout strength in tension for seismic loads, $N_{p,eq}$, described in Table 4 or $N_{p,deck,cr}$ described in Table 5 must be used in lieu of N_p, as applicable. The value of $N_{p,eq}$ or $N_{p,deck,cr}$ may be adjusted by calculation for concrete strength in accordance with Eq-1 and Section 4.1.4 whereby the value of $N_{p,deck,cr}$ must be substituted for $N_{p,cr}$ and the value of 3,000 psi (20.7 MPa) must be substituted for the value of 2,500 psi (17.2 MPa) in the denominator. If no values for $N_{p,eq}$ are given in Table 3 or Table 4, the static design strength values govern.

4.1.8.3 Seismic Shear: The nominal concrete breakout strength and pryout strength in shear must be calculated in accordance with ACI 318 D.6.2 and D.6.3, as described in Sections 4.1.6 and 4.1.7 of this report. In accordance with ACI 318 D.6.1.2, the appropriate value for nominal steel strength for seismic loads, $V_{sa,eq}$ described in Table 3 and Table 4 or $V_{sa,deck}$ described in Table 5 must be used in lieu of V_{sa}, as applicable.

4.1.9 Requirements for Interaction of Tensile and Shear Forces: For anchors or groups of anchors that are subject to the effects of combined tension and shear forces, the design must be performed in accordance with ACI 318 D.7.

4.1.10 Requirements for Minimum Member Thickness, Minimum Anchor Spacing and Minimum Edge Distance: In lieu of ACI 318 D.8.1 and D.8.3, values of s_{min} and c_{min} as given in Tables 3 and 4 of this report must be used. In lieu of ACI 318 D.8.5, minimum member thicknesses h_{min} as given in Tables 3 and 4 of this report must be used. Additional combinations for minimum edge distance, c_{min}, and spacing, s_{min}, may be derived by linear interpolation between the given boundary values as described in Figure 4.

For carbon steel KB-TZ anchors installed on the top of normal-weight or sand-lightweight concrete over profile steel deck floor and roof assemblies, the anchor must be installed in accordance with Table 6 and Figure 5C.

For carbon steel KB-TZ anchors installed in the soffit of sand-lightweight or normal-weight concrete over profile steel deck floor and roof assemblies, the anchors must be installed in accordance with Figure 5A or 5B and shall have an axial spacing along the flute equal to the greater of $3h_{ef}$ or 1.5 times the flute width.

4.1.11 Requirements for Critical Edge Distance: In applications where $c < c_{ac}$ and supplemental reinforcement to control splitting of the concrete is not present, the concrete breakout strength in tension for uncracked concrete, calculated in accordance with ACI 318 D.5.2, must be further multiplied by the factor $\Psi_{cp,N}$ as given by Eq-1:

$$\Psi_{cp,N} = \frac{c}{c_{ac}} \qquad \text{(Eq-3)}$$

whereby the factor $\Psi_{cp,N}$ need not be taken as less than $\frac{1.5h_{ef}}{c_{ac}}$. For all other cases, $\Psi_{cp,N}$ = 1.0. In lieu of using ACI 318 D.8.6, values of c_{ac} must comply with Table 3 or Table 4 and values of $c_{ac,deck}$ must comply with Table 6.

4.1.12 Sand-lightweight Concrete: For ACI 318-11 and 318-08, when anchors are used in sand-lightweight concrete, the modification factor λ_a or λ, respectively, for concrete breakout strength must be taken as 0.6 in lieu of ACI 318-11 D.3.6 (2012 IBC) or ACI 318-08 D.3.4 (2009 IBC). In addition the pullout strength $N_{p,cr}$, $N_{p,uncr}$ and $N_{p,eq}$ must be multiplied by 0.6, as applicable.

For ACI 318-05, the values N_b, $N_{p,cr}$, $N_{p,uncr}$, $N_{p,eq}$ and V_b determined in accordance with this report must be multiplied by 0.6, in lieu of ACI 318 D.3.4.

For carbon steel KB-TZ anchors installed in the soffit of sand-lightweight concrete-filled steel deck and floor and roof assemblies, this reduction is not required. Values are presented in Table 5 and installation details are show in Figures 5A and 5B.

4.2 Allowable Stress Design (ASD):

4.2.1 General: Design values for use with allowable stress design (working stress design) load combinations calculated in accordance with Section 1605.3 of the IBC, must be established as follows:

$$T_{allowable,ASD} = \frac{\phi N_n}{\alpha}$$

$$V_{allowable,ASD} = \frac{\phi V_n}{\alpha}$$

where:

$T_{allowable,ASD}$ = Allowable tension load (lbf or kN).

$V_{allowable,ASD}$ = Allowable shear load (lbf or kN).

ϕN_n = Lowest design strength of an anchor or anchor group in tension as determined in accordance with ACI 318 D.4.1, and 2009 IBC Section 1908.1.9 or 2006 IBC Section 1908.1.16, as applicable (lbf or N).

ϕV_n = Lowest design strength of an anchor or anchor group in shear as determined in accordance with ACI 318 D.4.1, and 2009 IBC Section 1908.1.9 or 2006 IBC Section 1908.1.16, as applicable (lbf or N).

α = Conversion factor calculated as a weighted average of the load factors for the controlling load combination. In addition, α must include all applicable factors to account for nonductile failure modes and required over-strength.

The requirements for member thickness, edge distance and spacing, described in this report, must apply. An example of allowable stress design values for illustrative purposes in shown in Table 7.

4.2.2 Interaction of Tensile and Shear Forces: The interaction must be calculated and consistent with ACI 318 D.7 as follows:

For shear loads $V_{applied} \leq 0.2V_{allowable,ASD}$, the full allowable load in tension must be permitted.

For tension loads $T_{applied} \leq 0.2T_{allowable,ASD}$, the full allowable load in shear must be permitted.

For all other cases:

$$\frac{T_{applied}}{T_{allowable,ASD}} + \frac{V_{applied}}{V_{allowable,ASD}} \leq 1.2 \qquad \text{(Eq-4)}$$

4.3 Installation:

Installation parameters are provided in Tables 1 and 6 and Figures 2, 5A, 5B and 5C. Anchor locations must comply with this report and plans and specifications approved by the code official. The Hilti KB-TZ must be installed in accordance with manufacturer's published instructions and this report. In case of conflict, this report governs. Anchors must be installed in holes drilled into the concrete using carbide-tipped masonry drill bits complying with ANSI B212.15-1994. The minimum drilled hole depth is given in Table 1. Prior to installation, dust and debris must be removed from the drilled hole to enable installation to the stated embedment depth. The anchor must be hammered into the predrilled hole until h_{nom} is achieved. The nut must be tightened against the washer until the torque values specified in Table 1 are achieved. For installation in the soffit of concrete on steel deck assemblies, the hole diameter in the steel deck not exceed the diameter of the hole in the concrete by more than $^1/_8$ inch (3.2 mm). For member thickness and edge distance restrictions for installations into the soffit of concrete on steel deck assemblies, see Figures 5A and 5B.

4.4 Special Inspection:

Periodic special inspection is required in accordance with Section 1705.1.1 and Table 1705.3 of the 2012 IBC, or Section 1704.15 of the 2009 IBC and Table 1704.4 or Section 1704.13 of the 2006 IBC, as applicable. The special inspector must make periodic inspections during anchor installation to verify anchor type, anchor dimensions, concrete type, concrete compressive strength, anchor spacing, edge distances, concrete member thickness, tightening torque, hole dimensions, anchor embedment and adherence to the manufacturer's printed installation instructions. The special inspector must be present as often as required in accordance with the "statement of special inspection." Under the IBC, additional requirements as set forth in Sections 1705, 1706 and 1707 must be observed, where applicable.

5.0 CONDITIONS OF USE

The Hilti KB-TZ anchors described in this report comply with the codes listed in Section 1.0 of this report, subject to the following conditions:

5.1 Anchor sizes, dimensions, minimum embedment depths and other installation parameters are as set forth in this report.

5.2 The anchors must be installed in accordance with the manufacturer's published instructions and this report. In case of conflict, this report governs.

5.3 Anchors must be limited to use in cracked and uncracked normal-weight concrete and sand-lightweight concrete having a specified compressive strength, f'_c, of 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa), and cracked and uncracked normal-weight or sand-lightweight concrete over metal deck having a minimum specified compressive strength, f'_c, of 3,000 psi (20.7 MPa).

5.4 The values of f'_c used for calculation purposes must not exceed 8,000 psi (55.1 MPa).

5.5 Strength design values must be established in accordance with Section 4.1 of this report.

5.6 Allowable design values are established in accordance with Section 4.2.

5.7 Anchor spacing and edge distance as well as minimum member thickness must comply with Tables 3, 4, and 6, and Figures 4, 5A, 5B, and 5C.

5.8 Prior to installation, calculations and details demonstrating compliance with this report must be submitted to the code official. The calculations and details must be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed.

5.9 Since an ICC-ES acceptance criteria for evaluating data to determine the performance of expansion anchors subjected to fatigue or shock loading is unavailable at this time, the use of these anchors under such conditions is beyond the scope of this report.

5.10 Anchors may be installed in regions of concrete where cracking has occurred or where analysis indicates cracking may occur ($f_t > f_r$), subject to the conditions of this report.

5.11 Anchors may be used to resist short-term loading due to wind or seismic forces in locations designated as Seismic Design Categories A through F of the IBC, subject to the conditions of this report.

5.12 Where not otherwise prohibited in the code, KB-TZ anchors are permitted for use with fire-resistance-rated construction provided that at least one of the following conditions is fulfilled:

- Anchors are used to resist wind or seismic forces only.
- Anchors that support a fire-resistance-rated envelope or a fire- resistance-rated membrane are protected by approved fire-resistance- rated materials, or have been evaluated for resistance to fire exposure in accordance with recognized standards.
- Anchors are used to support nonstructural elements.

5.13 Use of zinc-coated carbon steel anchors is limited to dry, interior locations.

5.14 Special inspection must be provided in accordance with Section 4.4.

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5.15 Anchors are manufactured by Hilti AG under an approved quality control program with inspections by UL LLC (AA-668).

6.0 EVIDENCE SUBMITTED

6.1 Data in accordance with the ICC-ES Acceptance Criteria for Mechanical Anchors in Concrete Elements (AC193), dated March 2012 (ACI 355.2-07).

6.2 Quality control documentation.

7.0 IDENTIFICATION

The anchors are identified by packaging labeled with the manufacturer's name (Hilti, Inc.) and contact information, anchor name, anchor size, evaluation report number (ICC-ES ESR-1917), and the name of the inspection agency (UL LLC). The anchors have the letters KB-TZ embossed on the anchor stud and four notches embossed into the anchor head, and these are visible after installation for verification.

TABLE 1—SETTING INFORMATION (CARBON STEEL AND STAINLESS STEEL ANCHORS)

SETTING INFORMATION	Symbol	Units	Nominal anchor diameter (in.)													
			3/8			1/2				5/8				3/4		
Anchor O.D.	d_a $(d_o)^2$	In.	0.375			0.5				0.625				0.75		
		(mm)	(9.5)			(12.7)				(15.9)				(19.1)		
Nominal bit diameter	d_{bit}	In.	3/8			1/2				5/8				3/4		
Effective min. embedment	h_{ef}	In.	2			2	3-1/4			3-1/8	4			3-3/4	4-3/4	
		(mm)	(51)			(51)	(83)			(79)	(102)			(95)	(121)	
Nominal embedment	h_{nom}	in.	2-5/16			2-3/8	3-5/8			3-9/16	4-7/16			4-5/16	5-9/16	
		(mm)	(59)			(60)	(91)			(91)	(113)			(110)	(142)	
Min. hole depth	h_o	In.	2-5/8			2-5/8	4			3-3/4	4-3/4			4-1/2	5-3/4	
		(mm)	(67)			(67)	(102)			(95)	(121)			(114)	(146)	
Min. thickness of fastened part[1]	t_{min}	In.	1/4			3/4	1/4			3/8	3/4			1/8	1 5/8	
		(mm)	(6)			(19)	(6)			(9)	(19)			(3)	(41)	
Required Installation torque	T_{inst}	ft-lb	25			40				60				110		
		(Nm)	(34)			(54)				(81)				(149)		
Min. dia. of hole in fastened part	d_h	In.	7/16			9/16				11/16				13/16		
		(mm)	(11.1)			(14.3)				(17.5)				(20.6)		
Standard anchor lengths	ℓ_{anch}	In.	3	3-3/4	5	3-3/4	4-1/2	5-1/2	7	4-3/4	6	8-1/2	10	5-1/2	8	10
		(mm)	(76)	(95)	(127)	(95)	(114)	(140)	(178)	(121)	(152)	(216)	(254)	(140)	(203)	(254)
Threaded length (incl. dog point)	ℓ_{thread}	In.	7/8	1-5/8	2-7/8	1-5/8	2-3/8	3-3/8	4-7/8	1-1/2	2-3/4	5-1/4	6-3/4	1-1/2	4	6
		(mm)	(22)	(41)	(73)	(41)	(60)	(86)	(124)	(38)	(70)	(133)	(171)	(38)	(102)	(152)
Unthreaded length	ℓ_{unthr}	In.	2-1/8			2-1/8				3-1/4				4		
		(mm)	(54)			(54)				(83)				(102)		

[1] The minimum thickness of the fastened part is based on use of the anchor at minimum embedment and is controlled by the length of thread. If a thinner fastening thickness is required, increase the anchor embedment to suit.

[2] The notation in parenthesis is for the 2006 IBC.

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TABLE 4—DESIGN INFORMATION, STAINLESS STEEL KB-TZ

DESIGN INFORMATION	Symbol	Units	Nominal anchor diameter											
			3/8		1/2				5/8			3/4		
Anchor O.D.	$d_a(d_o)$	in. (mm)	0.375 (9.5)		0.5 (12.7)				0.625 (15.9)			0.75 (19.1)		
Effective min. embedment[1]	h_{ef}	in. (mm)	2 (51)		2 (51)		3-1/4 (83)		3-1/8 (79)	4 (102)		3-3/4 (95)		4-3/4 (121)
Min. member thickness	h_{min}	in. (mm)	4 (102)	5 (127)	4 (102)	6 (152)	6 (152)	8 (203)	5 (127)	6 (152)	8 (203)	6 (152)	8 (203)	8 (203)
Critical edge distance	c_{ac}	in. (mm)	4-3/8 (111)	3-7/8 (98)	5-1/2 (140)	4-1/2 (114)	7-1/2 (191)	6 (152)	7 (178)	8-7/8 (225)	6 (152)	10 (254)	7 (178)	9 (229)
Min. edge distance	c_{min}	in. (mm)	2-1/2 (64)		2-7/8 (73)		2-1/8 (54)		3-1/4 (83)	2-3/8 (60)		4-1/4 (108)		4 (102)
	for $s \geq$	in. (mm)	5 (127)		5-3/4 (146)		5-1/4 (133)		5-1/2 (140)	5-1/2 (140)		10 (254)		8-1/2 (216)
Min. anchor spacing	s_{min}	in. (mm)	2-1/4 (57)		2-7/8 (73)		2 (51)		2-3/4 (70)	2-3/8 (60)		5 (127)		4 (102)
	for $c \geq$	in. (mm)	3-1/2 (89)		4-1/2 (114)		3-1/4 (83)		4-1/8 (105)	4-1/4 (108)		9-1/2 (241)		7 (178)
Min. hole depth in concrete	h_o	in. (mm)	2-5/8 (67)		2-5/8 (67)		4 (102)		3-3/4 (98)	4-3/4 (121)		4-1/2 (117)		5-3/4 (146)
Min. specified yield strength	f_y	lb/in^2 (N/mm^2)	92,000 (634)		92,000 (634)				92,000 (634)			76,125 (525)		
Min. specified ult. Strength	f_{uta}	lb/in^2 (N/mm^2)	115,000 (793)		115,000 (793)				115,000 (793)			101,500 (700)		
Effective tensile stress area	$A_{se,N}$	in^2 (mm^2)	0.052 (33.6)		0.101 (65.0)				0.162 (104.6)			0.237 (152.8)		
Steel strength in tension	N_{sa}	lb (kN)	5,968 (26.6)		11,554 (51.7)				17,880 (82.9)			24,055 (107.0)		
Steel strength in shear	V_{sa}	lb (kN)	4,720 (21.0)		6,880 (30.6)				9,870 (43.9)			15,711 (69.9)		
Pullout strength in tension, seismic[2]	$N_{p,eq}$	lb (kN)	NA		2,735 (12.2)		NA		NA			NA		
Steel strength in shear, seismic[2]	$V_{sa,eq}$	lb (kN)	2,825 (12.6)		6,880 (30.6)				9,350 (41.6)			12,890 (57.3)		
Pullout strength uncracked concrete[3]	$N_{p,uncr}$	lb (kN)	2,630 (11.7)		NA		5,760 (25.6)		NA			NA		12,040 (53.6)
Pullout strength cracked concrete[3]	$N_{p,cr}$	lb (kN)	2,340 (10.4)		3,180 (14.1)		NA		NA	5,840 (26.0)		8,110 (36.1)		NA
Anchor category[4]			1		2		1							
Effectiveness factor k_{uncr} uncracked concrete			24											
Effectiveness factor k_{cr} cracked concrete[5]			17		24		17		17	17		24		17
$\Psi_{C,N} = k_{uncr}/k_{cr}$ [6]			1.0											
Strength reduction factor ϕ for tension, steel failure modes[7]			0.75											
Strength reduction factor ϕ for shear, steel failure modes[7]			0.65											
Strength reduction ϕ factor for tension, concrete failure modes, Condition B[8]			0.65		0.55		0.65							
Coefficient for pryout strength, k_{cp}			1.0				2.0							
Strength reduction ϕ factor for shear, concrete failure modes, Condition B[8]			0.70											
Axial stiffness in service load range[9]	β_{uncr}	lb/in.	120,000											
	β_{cr}	lb/in.	90,000											

For **SI:** 1 inch = 25.4 mm, 1 lbf = 4.45 N, 1 psi = 0.006895 MPa For pound-inch units: 1 mm = 0.03937 inches.

[1] See Fig. 2.

[2] See Section 4.1.8 of this report. NA (not applicable) denotes that this value does not control for design.

[3] For all design cases $\Psi_{c,P}$=1.0. NA (not applicable) denotes that this value does not control for design. See Section 4.1.4 of this report.

[4] See ACI 318-11 D.4.3.

[5] See ACI 318 D.5.2.2.

[6] For all design cases $\Psi_{c,N}$ =1.0. The appropriate effectiveness factor for cracked concrete (k_{cr}) or uncracked concrete (k_{uncr}) must be used.

[7] The KB-TZ is a ductile steel element as defined by ACI 318 D.1.

[8] For use with the load combinations of ACI 318 Section 9.2. Condition B applies where supplementary reinforcement in conformance with ACI 318-11 D.4.3 is not provided, or where pullout or pryout strength governs. For cases where the presence of supplementary reinforcement can be verified, the strength reduction factors associated with Condition A may be used.

[9] Mean values shown, actual stiffness may vary considerably depending on concrete strength, loading and geometry of application.

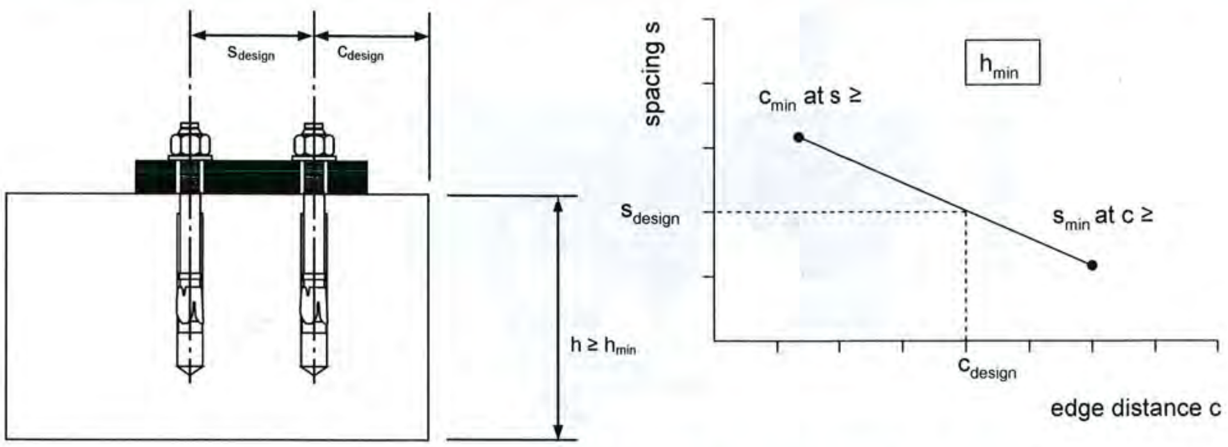


FIGURE 4—INTERPOLATION OF MINIMUM EDGE DISTANCE AND ANCHOR SPACING

TABLE 5—HILTI KWIK BOLT TZ (KB-TZ) CARBON STEEL ANCHORS TENSION AND SHEAR DESIGN DATA FOR INSTALLATION IN THE UNDERSIDE OF CONCRETE-FILLED PROFILE STEEL DECK ASSEMBLIES[1,6,7,8]

DESIGN INFORMATION	Symbol	Units	Loads According to Figure 5A					Loads According to Figure 5B			
			Anchor Diameter					Anchor Diameter			
			3/8	1/2		5/8		3/8	1/2		5/8
Effective Embedment Depth	h_{ef}	in.	2	2	3-1/4	3-1/8	4	2	2	3-1/4	3-1/8
Minimum Hole Depth	h_o	in.	2-5/8	2-5/8	4	3-3/4	4-3/4	2-5/8	2-5/8	4	3-3/4
Pullout Resistance, (uncracked concrete)[2]	$N_{p,deck,uncr}$	lb.	2,060	2,060	3,695	2,825	6,555	1,845	1,865	3,375	4,065
Pullout Resistance (cracked concrete)[3]	$N_{p,deck,cr}$	lb.	1,460	1,460	2,620	2,000	4,645	1,660	1,325	3,005	2,885
Steel Strength in Shear[4]	$V_{sa,deck}$	lb.	2,130	3,000	4,945	4,600	6,040	2,845	2,585	3,945	4,705
Steel Strength in Shear, Seismic[5]	$V_{sa,deck,eq}$	lb.	1,340	3,000	4,945	4,320	5,675	1,790	2,585	3,945	4,420

[1] Installation must comply with Sections 4.1.10 and 4.3 and Figure 5A and 5B of this report.
[2] The values listed must be used in accordance with Section 4.1.4 of this report.
[3] The values listed must be used in accordance with Section 4.1.4 and 4.1.8.2 of this report.
[4] The values listed must be used in accordance with Section 4.1.5 of this report.
[5] The values listed must be used in accordance with 4.1.8.3 of this report. Values are applicable to both static and seismic load combinations.
[6] The values for ϕ_p in tension and the values for ϕ_{sa} in shear can be found in Table 3 of this report.
[7] The characteristic pullout resistance for concrete compressive strengths greater than 3,000 psi may be increased by multiplying the value in the table by $(f'_c/3,000)^{1/2}$ for psi or $(f'_c/20.7)^{1/2}$ for MPa.
[8] Evaluation of concrete breakout capacity in accordance with ACI 318 D.5.2, D.6.2, and D.6.3 is not required for anchors installed in the deck soffit.

TABLE 6—HILTI KWIK BOLT TZ (KB-TZ) CARBON STEEL ANCHORS SETTING INFORMATION FOR INSTALLATION ON THE TOP OF CONCRETE-FILLED PROFILE STEEL DECK ASSEMBLIES ACCORDING TO FIGURE 5C[1,2,3,4]

DESIGN INFORMATION	Symbol	Units	Nominal anchor diameter	
			3/8	1/2
Effective Embedment Depth	h_{ef}	in.	2	2
Minimum concrete thickness[5]	$h_{min,deck}$	in.	3-1/4	3-1/4
Critical edge distance	$c_{ac,deck,top}$	in.	9	9
Minimum edge distance	$c_{min,deck,top}$	in.	3	4-1/2
Minimum spacing	$s_{min,deck,top}$	in.	4	6-1/2

[1] Installation must comply with Sections 4.1.10 and 4.3 and Figure 5C of this report.
[2] For all other anchor diameters and embedment depths refer to Table 3 and 4 for applicable values of h_{min}, c_{min}, and s_{min}.
[3] Design capacity shall be based on calculations according to values in Table 3 and 4 of this report.
[4] Applicable for $3^1/_4$-in ≤ $h_{min,deck}$ < 4-in. For $h_{min,deck}$ ≥ 4-inch use setting information in Table 3 of this report.
[5] Minimum concrete thickness refers to concrete thickness above upper flute. See Figure 5C.

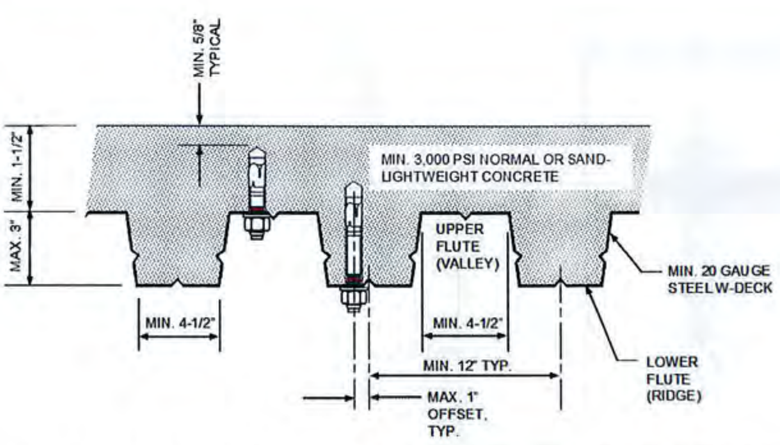


FIGURE 5A—INSTALLATION IN THE SOFFIT OF CONCRETE OVER METAL DECK FLOOR AND ROOF ASSEMBLIES[1]

[1]Anchors may be placed in the upper or lower flute of the steel deck profile provided the minimum hole clearance is satisfied. Anchors in the lower flute may be installed with a maximum 1-inch offset in either direction from the center of the flute.

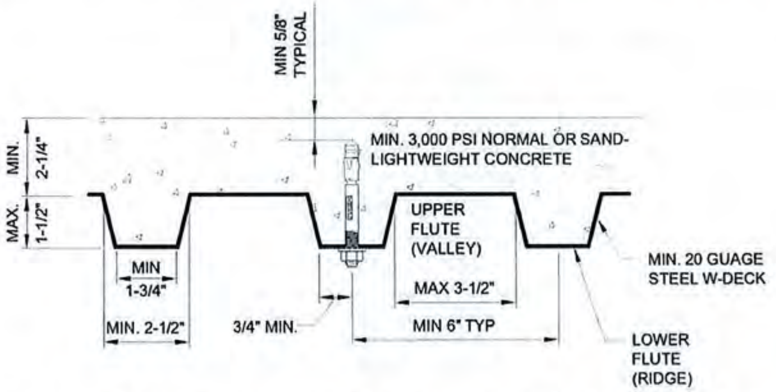


FIGURE 5B—INSTALLATION IN THE SOFFIT OF CONCRETE OVER METAL DECK FLOOR AND ROOF ASSEMBLIES – B DECK[1,2]

[1]Anchors may be placed in the upper or lower flute of the steel deck profile provided the minimum hole clearance is satisfied. Anchors in the lower flute may be installed with a maximum $^1/_8$-inch offset in either direction from the center of the flute. The offset distance may be increased proportionally for profiles with lower flute widths greater than those shown provided the minimum lower flute edge distance is also satisfied.

[2]Anchors may be placed in the upper flute of the steel deck profiles in accordance with Figure 5B provided the concrete thickness above the upper flute is minimum $3^1/_4$-inch and the minimum hole clearance of $^5/_8$-inch is satisfied.

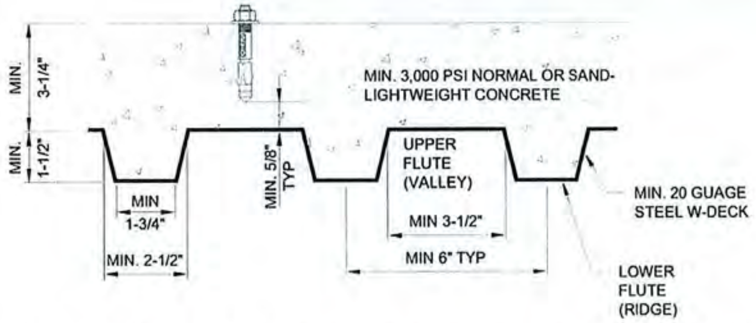


FIGURE 5C—INSTALLATION ON THE TOP OF CONCRETE OVER METAL DECK FLOOR AND ROOF ASSEMBLIES[1,2]

[1]Refer to Table 6 for setting information for anchors in to the top of concrete over metal deck.

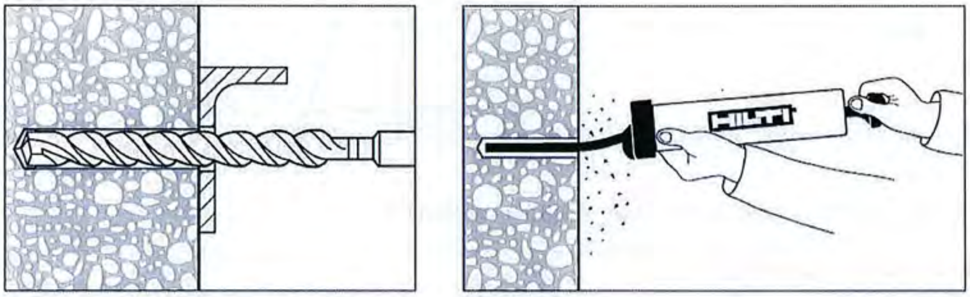
[2]Applicable for 3-1/4-in ≤ h_{min} < 4-in. For h_{min} ≥ 4-inch use setting information in Table 3 of this report.

TABLE 7—EXAMPLE ALLOWABLE STRESS DESIGN VALUES FOR ILLUSTRATIVE PURPOSES

Nominal Anchor diameter (in.)	Embedment depth (in.)	Allowable tension (lbf)	
		Carbon Steel	Stainless Steel
		f 'c = 2500 psi	
		Carbon Steel	Stainless Steel
3/8	2	1105	1155
1/2	2	1490	1260
	3-1/4	2420	2530
5/8	3-1/8	2910	2910
	4	4015	4215
3/4	3-3/4	3635	3825
	4-3/4	4690	5290

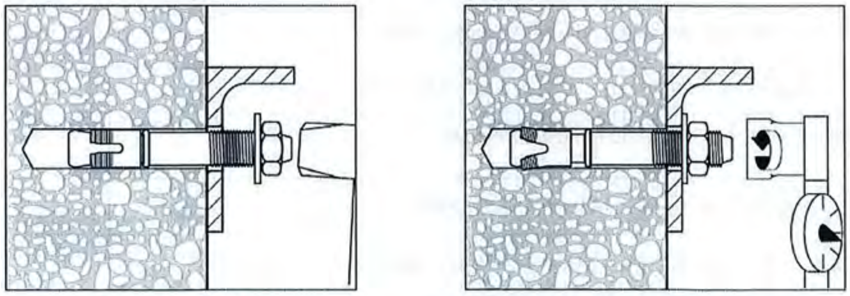
For **SI:** 1 lbf = 4.45 N, 1 psi = 0.00689 MPa 1 psi = 0.00689 MPa. 1 inch = 25.4 mm.

[1] Single anchors with static tension load only.
[2] Concrete determined to remain uncracked for the life of the anchorage.
[3] Load combinations from ACI 318 Section 9.2 (no seismic loading).
[4] 30% dead load and 70% live load, controlling load combination 1.2D + 1.6 L.
[5] Calculation of the weighted average for $\alpha = 0.3*1.2 + 0.7*1.6 = 1.48$.
[6] f'_c = 2,500 psi (normal weight concrete).
[7] $c_{a1} = c_{a2} \geq c_{ac}$
[8] $h \geq h_{min}$
[9] Values are for Condition B where supplementary reinforcement in accordance with ACI 318-11 D.4.3 is not provided



1. Hammer drill a hole to the same nominal diameter as the Kwik Bolt TZ. The hole depth must equal the anchor embedment listed in Table 1. The fixture may be used as a drilling template to ensure proper anchor location.

2. Clean hole.



3. Drive the Kwik Bolt TZ into the hole using a hammer. The anchor must be driven until the nominal embedment is achieved.

4. Tighten the nut to the required installation torque.

FIGURE 6—INSTALLATION INSTRUCTIONS

Given:

Two 1/2-inch carbon steel KB-TZ anchors under static tension load as shown.

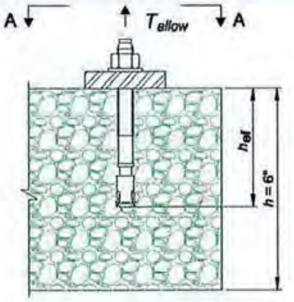
h_{ef} = 3.25 in.

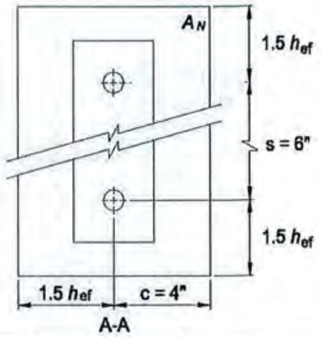
Normal weight concrete, f'_c = 3,000 psi

No supplementary reinforcement (Condition B per ACI 318-11 D.4.3 c)

Assume cracked concrete since no other information is available.

Needed: Using Allowable Stress Design (ASD) calculate the allowable tension load for this configuration.





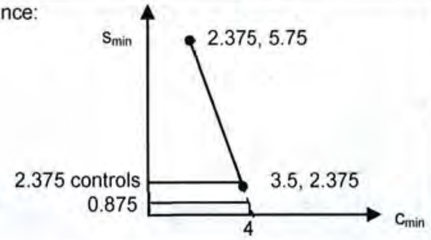
Calculation per ACI 318-11 Appendix D and this report.	Code Ref.	Report Ref.
Step 1. Calculate steel capacity: $\phi N_s = \phi n A_{se} f_{ut} = 0.75 \times 2 \times 0.101 \times 106{,}000 = 16{,}059 \text{lb}$ Check whether f_{uta} is not greater than $1.9 f_{ya}$ and 125,000 psi.	D.5.1.2 D.4.3 a	§4.1.2 Table 3
Step 2. Calculate concrete breakout strength of anchor in tension: $\mathrm{N_{cbg}} = \frac{\mathrm{A_{Nc}}}{\mathrm{A_{Nco}}} \psi_{ec,N} \psi_{ed,N} \psi_{c,N} \psi_{cp,N} N_b$	D.5.2.1	§ 4.1.3
Step 2a. Verify minimum member thickness, spacing and edge distance: h_{min} = 6 in. ≤ 6 in. $\therefore$ ok $\text{slope} = \frac{2.375 - 5.75}{3.5 - 2.375} = -3.0$ For $c_{min} = 4 \text{in} \Rightarrow$ $s_{min} = 5.75 - \left[(2.375 - 4.0)(-3.0)\right] = 0.875 < 2.375 \text{in} < 6 \text{in} \therefore \text{ok}$  	D.8	Table 3 Fig. 4
Step 2b. For A_N check $1.5h_{ef} = 1.5(3.25) = 4.88 \text{ in} > c \quad 3.0h_{ef} = 3(3.25) = 9.75 \text{ in} > s$	D.5.2.1	Table 3
Step 2c. Calculate A_{Nco} and A_{Nc} for the anchorage: $A_{Nco} = 9h_{ef}^2 = 9 \times (3.25)^2 = 95.1 in.^2$ $A_{Nc} = (1.5h_{ef} + c)(3h_{ef} + s) = [1.5 \times (3.25) + 4][3 \times (3.25) + 6] = 139.8 in.^2 < 2A_{Nco} \therefore ok$	D.5.2.1	Table 3
Step 2d. Determine $\psi_{ec,N}$: $e'_N = 0 \therefore \psi_{ec,N} = 1.0$	D.5.2.4	-
Step 2e. Calculate N_b:$N_b = k_{cr} \lambda_a \sqrt{f'_c} h_{ef}^{1.5} = 17 \times 1.0 \times \sqrt{3{,}000} \times 3.25^{1.5} = 5{,}456\ lb$	D.5.2.2	Table 3
Step 2f. Calculate modification factor for edge distance: $\psi_{ed,N} = 0.7 + 0.3 \frac{4}{1.5(3.25)} = 0.95$	D.5.2.5	Table 3
Step 2g. Calculate modification factor for cracked concrete: $\psi_{c,N}$ =1.00 (cracked concrete)	D.5.2.6	Table 3
Step 2h. Calculate modification factor for splitting: $\psi_{cp,N}$ =1.00 (cracked concrete)	-	§ 4.1.10 Table 3
Step 2i. Calculate ϕN_{cbg} : $\phi N_{cbg} = 0.65 \times \frac{139.8}{95.1} \times 1.00 \times 0.95 \times 1.00 \times 5{,}456 = 4{,}952$ lb	D.5.2.1 D.4.3 c)	§ 4.1.3 Table 3
Step 3. Check pullout strength: Table 3, $\phi n N_{pn,f'c} = 0.65 \times 2 \times 5{,}515 \text{ lb} \times \sqrt{\frac{3{,}000}{2{,}500}} = 7{,}852 \text{ lb} > 4{,}952 \therefore \text{OK}$	D.5.3.2 D.4.3 c)	§ 4.1.4 Table 3
Step 4. Controlling strength: $\phi N_{cbg} = 4{,}952 \text{ lb} < \phi n N_{pn} < \phi N_s \therefore \phi N_{cbg}$ controls	D.4.1.2	Table 3
Step 5. To convert to ASD, assume U = 1.2D + 1.6L: $T_{allow} = \frac{4{,}952}{1.48} = 3{,}346$ lb.	-	§ 4.2

FIGURE 7—EXAMPLE CALCULATION

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Engineering Calculations

Everglades Restoration & Capital Projects

Submitted By	Date	Project	Sheet of
H. Gao		S72	
Checked By	**Description**		**Job No.**
	Cofferdam — upstream & Downstream		

* All Elevations are NGVD.

1. Stages:

* Optimum Headwater of upstream is between 20.2'–21.2'

The structure will reach the max. discharge rate 3800 cfs @ 25.8'

Historic flow records show the max. stage in the past is 21.335'

Not-to be-too conservtive, the cofferdam design chose upstream stage 21.5'.

**: Based on the historic records. Downstream stage is chosen as 18.0'

2. Canal Bottom EL.

Based on the USACE as-built drawing, the upstream canal is +3.6' and downstream canal bottom is −0.7'.

Two ELs are used to consider the side slope elevation change:

Upstream	Downstream
+8.6'	+4.3'
+13.6'	+9.3'

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Engineering Calculations

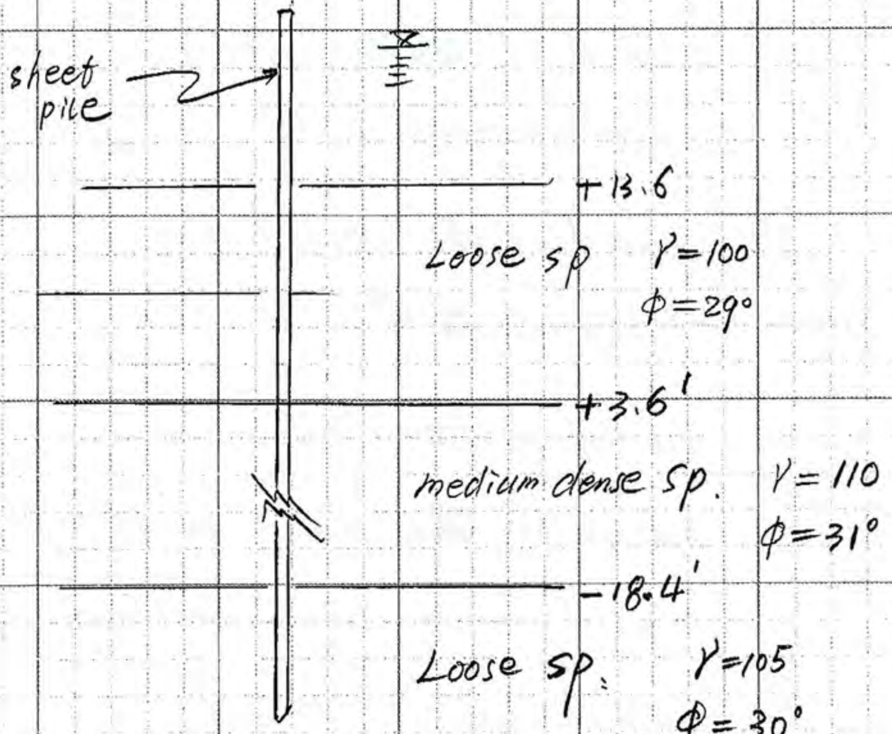
Everglades Restoration & Capital Projects

Submitted By H. Gao	Date	Project S72	Sheet of
Checked By	Description Cofferdam Design – Upstream & Downstream		Job No.

3. Soil condition:

Based on USACE soil borings (CB #S-72-1, CB #S-72-2, CB #S-72-3) and Nodarse soil borings (TB-1, TB-2).

The soil profile can be generated as:



```
                               downstream center.out
PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                              BY CLASSICAL METHODS
DATE: 9-JANUARY-2013                                          TIME: 9:45:42

                                ****************
                                *  INPUT DATA  *
                                ****************

      I.--HEADING
     'S72 COFFER DAM WALL DESIGN -DOWNSTREAM STREAM CENTER

     II.--CONTROL
        CANTILEVER WALL DESIGN
        FACTOR OF SAFETY FOR ACTIVE PRESSURES  = 1.00
        FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.00

    III.--WALL DATA
        ELEVATION AT TOP OF WALL     = 26.00 FT.

     IV.--SURFACE POINT DATA

          IV.A.--RIGHTSIDE
             DIST. FROM      ELEVATION
             WALL (FT)         (FT)
                 0.00         -0.70
                50.00         -0.70

          IV.B.--LEFTSIDE
             DIST. FROM      ELEVATION
             WALL (FT)         (FT)
                 0.00         -0.70
                50.00         -0.70

      V.--SOIL LAYER DATA

        V.A.--RIGHTSIDE
             LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
             LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

                ANGLE OF          ANGLE OF                             <-SAFETY->
 SAT.    MOIST  INTERNAL  COH-      WALL     ADH-     <--BOTTOM-->  <-FACTOR->
 WGHT.   WGHT.  FRICTION  ESION  FRICTION   ESION    ELEV.  SLOPE   ACT. PASS.
 (PCF)   (PCF)   (DEG)    (PSF)    (DEG)    (PSF)    (FT)  (FT/FT)
115.00  110.00   31.00     0.00    14.00     0.00   -18.40   0.00    DEF  DEF
110.00  105.00   30.00     0.00    11.00     0.00                    DEF  DEF

        V.B.--LEFTSIDE
             LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
             LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

                ANGLE OF          ANGLE OF                             <-SAFETY->
 SAT.    MOIST  INTERNAL  COH-      WALL     ADH-     <--BOTTOM-->  <-FACTOR->
 WGHT.   WGHT.  FRICTION  ESION  FRICTION   ESION    ELEV.  SLOPE   ACT. PASS.
 (PCF)   (PCF)   (DEG)    (PSF)    (DEG)    (PSF)    (FT)  (FT/FT)
115.00  110.00   31.00     0.00    14.00     0.00   -18.40   0.00    DEF  DEF
110.00  105.00   30.00     0.00    11.00     0.00                    DEF  DEF

     VI.--WATER DATA
        UNIT WEIGHT          = 62.40 (PCF)
        RIGHTSIDE ELEVATION  = 18.00 (FT)
        LEFTSIDE ELEVATION   = -0.70 (FT)
        NO SEEPAGE
```

28/14

```
VII.--VERTICAL SURCHARGE LOADS
     NONE

VIII.--HORIZONTAL LOADS
     NONE




PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                           BY CLASSICAL METHODS
DATE: 9-JANUARY-2013                                           TIME: 9:45:48

                           *************************
                           *    SOIL PRESSURES FOR  *
                           * CANTILEVER WALL DESIGN *
                           *************************

    I.--HEADING
     'S72 COFFER DAM WALL DESIGN -DOWNSTREAM STREAM CENTER

   II.--SOIL PRESSURES

        RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

        LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

                                        <------NET------>
          NET     <---LEFTSIDE--->    (SOIL + WATER)     <--RIGHTSIDE--->
 ELEV.   WATER    PASSIVE   ACTIVE    ACTIVE   PASSIVE    ACTIVE   PASSIVE
 (FT)    (PSF)     (PSF)    (PSF)     (PSF)     (PSF)     (PSF)     (PSF)
  26.0     0.0      0.0      0.0       0.0       0.0       0.0       0.0
  25.0     0.0      0.0      0.0       0.0       0.0       0.0       0.0
  24.0     0.0      0.0      0.0       0.0       0.0       0.0       0.0
  23.0     0.0      0.0      0.0       0.0       0.0       0.0       0.0
  22.0     0.0      0.0      0.0       0.0       0.0       0.0       0.0
  21.0     0.0      0.0      0.0       0.0       0.0       0.0       0.0
  20.0     0.0      0.0      0.0       0.0       0.0       0.0       0.0
  19.0     0.0      0.0      0.0       0.0       0.0       0.0       0.0
  18.0     0.0      0.0      0.0       0.0       0.0       0.0       0.0
  17.0    62.4      0.0      0.0      62.4      62.4       0.0       0.0
  16.0   124.8      0.0      0.0     124.8     124.8       0.0       0.0
  15.0   187.2      0.0      0.0     187.2     187.2       0.0       0.0
  14.0   249.6      0.0      0.0     249.6     249.6       0.0       0.0
  13.0   312.0      0.0      0.0     312.0     312.0       0.0       0.0
  12.0   374.4      0.0      0.0     374.4     374.4       0.0       0.0
  11.0   436.8      0.0      0.0     436.8     436.8       0.0       0.0
  10.0   499.2      0.0      0.0     499.2     499.2       0.0       0.0
   9.0   561.6      0.0      0.0     561.6     561.6       0.0       0.0
   8.0   624.0      0.0      0.0     624.0     624.0       0.0       0.0
   7.0   686.4      0.0      0.0     686.4     686.4       0.0       0.0
   6.0   748.8      0.0      0.0     748.8     748.8       0.0       0.0
   5.0   811.2      0.0      0.0     811.2     811.2       0.0       0.0
   4.0   873.6      0.0      0.0     873.6     873.6       0.0       0.0
   3.0   936.0      0.0      0.0     936.0     936.0       0.0       0.0
   2.0   998.4      0.0      0.0     998.4     998.4       0.0       0.0
   1.0  1060.8      0.0      0.0    1060.8    1060.8       0.0       0.0
```

```
  0.0   1123.2      0.0     0.0    1123.2    1123.2     0.0       0.0
 -0.7   1166.9      0.0     0.0    1166.9    1166.9     0.0       0.0
 -1.0   1166.9     77.3     4.5    1094.1    1239.7     4.5      77.3
 -1.7   1166.9    257.6    14.9     924.1    1409.6    14.9     257.6
 -2.0   1166.9    334.9    19.3     851.3    1482.4    19.3     334.9
 -3.0   1166.9    592.5    34.2     608.6    1725.2    34.2     592.5
 -4.0   1166.9    850.1    49.0     365.8    1967.9    49.0     850.1
 -5.0   1166.9   1107.6    63.9     123.1    2210.7    63.9    1107.6
 -5.5   1166.9   1238.3    71.4       0.0    2333.8    71.4    1238.3
 -6.0   1166.9   1365.2    78.7    -119.6    2453.4    78.7    1365.2
 -7.0   1166.9   1622.8    93.6    -362.4    2696.1    93.6    1622.8
 -8.0   1166.9   1880.4   108.4    -605.1    2938.9   108.4    1880.4
 -9.0   1166.9   2138.0   123.3    -847.8    3181.6   123.3    2138.0
-10.0   1166.9   2395.6   138.1   -1090.6    3424.3   138.1    2395.6
-11.0   1166.9   2653.2   153.0   -1333.3    3667.1   153.0    2653.2
-12.0   1166.9   2910.8   167.9   -1576.1    3909.8   167.9    2910.8
-13.0   1166.9   3168.4   182.7   -1818.8    4152.5   182.7    3168.4
-14.0   1166.9   3426.0   197.6   -2061.5    4395.3   197.6    3426.0
-15.0   1166.9   3683.6   212.4   -2304.3    4638.0   212.4    3683.6
-16.0   1166.9   3941.1   227.3   -2547.0    4880.8   227.3    3941.1
-17.0   1166.9   4198.7   242.1   -2789.7    5123.5   242.1    4198.7
-18.0   1166.9   4456.3   257.0   -3032.5    5366.2   257.0    4456.3
-18.4   1166.9   3934.3   260.9   -2506.5    4840.3   260.9    3934.3
-19.0   1166.9   3543.4   273.6   -2102.9    4436.7   273.6    3543.4
-20.0   1166.9   4426.3   299.6   -2959.8    5293.5   299.6    4426.3
-21.0   1166.9   4627.2   314.0   -3146.3    5480.1   314.0    4627.2
-22.0   1166.9   4828.3   328.4   -3333.0    5666.8   328.4    4828.3
-23.0   1166.9   5029.3   342.7   -3519.7    5853.5   342.7    5029.3
-24.0   1166.9   5230.5   357.1   -3706.5    6040.3   357.1    5230.5
-25.0   1166.9   5431.7   371.4   -3893.4    6227.1   371.4    5431.7
-26.0   1166.9   5632.9   385.8   -4080.3    6414.0   385.8    5632.9
-27.0   1166.9   5834.2   400.1   -4267.2    6600.9   400.1    5834.2
-28.0   1166.9   6035.5   414.5   -4454.1    6787.9   414.5    6035.5
-29.0   1166.9   6236.8   428.8   -4641.1    6974.8   428.8    6236.8
-30.0   1166.9   6438.1   443.2   -4828.1    7161.8   443.2    6438.1
-31.0   1166.9   6639.5   457.5   -5015.1    7348.8   457.5    6639.5
-32.0   1166.9   6840.8   471.9   -5202.1    7535.9   471.9    6840.8
-33.0   1166.9   7042.2   486.2   -5389.1    7722.9   486.2    7042.2
-34.0   1166.9   7243.6   500.5   -5576.2    7909.9   500.5    7243.6
-35.0   1166.9   7445.0   514.9   -5763.2    8097.0   514.9    7445.0
-36.0   1166.9   7645.1   529.2   -5949.0    8282.8   529.2    7645.1
-37.0   1166.9   7835.6   543.5   -6125.1    8458.9   543.5    7835.6
-38.0   1166.9   8026.8   557.9   -6302.1    8635.8   557.9    8026.8
-39.0   1166.9   8227.3   572.2   -6488.2    8822.0   572.2    8227.3
-40.0   1166.9   8427.8   586.6   -6674.4    9008.1   586.6    8427.8
-41.0   1166.9   8628.3   600.9   -6860.5    9194.3   600.9    8628.3
-42.0   1166.9   8828.8   615.2   -7046.7    9380.4   615.2    8828.8
-43.0   1166.9   9029.3   629.6   -7232.8    9566.6   629.6    9029.3
-44.0   1166.9   9229.8   643.9   -7419.0    9752.7   643.9    9229.8
-45.0   1166.9   9430.3   658.2   -7605.1    9938.9   658.2    9430.3
-46.0   1166.9   9630.8   672.6   -7791.3   10125.1   672.6    9630.8
-47.0   1166.9   9831.3   686.9   -7977.5   10311.3   686.9    9831.3
-48.0   1166.9  10031.8   701.2   -8163.7   10497.4   701.2   10031.8
-49.0   1166.9  10232.3   715.6   -8349.8   10683.6   715.6   10232.3
-50.0   1166.9  10432.8   729.9   -8536.0   10869.8   729.9   10432.8
-51.0   1166.9  10633.3   744.2   -8722.2   11056.0   744.2   10633.3
-52.0   1166.9  10833.8   758.6   -8908.4   11242.1   758.6   10833.8
-53.0   1166.9  11034.4   772.9   -9094.6   11428.3   772.9   11034.4
-54.0   1166.9  11234.9   787.2   -9280.8   11614.5   787.2   11234.9
-55.0   1166.9  11435.4   801.6   -9466.9   11800.7   801.6   11435.4
-56.0   1166.9  11635.9   815.9   -9653.1   11986.9   815.9   11635.9
-57.0   1166.9  11836.4   830.2   -9839.3   12173.1   830.2   11836.4
-58.0   1166.9  12037.0   844.6  -10025.5   12359.3   844.6   12037.0
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-59.0  1166.9   12237.5    858.9  -10211.7   12545.5    858.9   12237.5
-60.0  1166.9   12438.0    873.2  -10397.9   12731.7    873.2   12438.0
-61.0  1166.9   12638.5    887.6  -10584.1   12917.9    887.6   12638.5
-62.0  1166.9   12839.1    901.9  -10770.3   13104.1    901.9   12839.1
-63.0  1166.9   13039.6    916.2  -10956.5   13290.3    916.2   13039.6
-64.0  1166.9   13240.1    930.6  -11142.7   13476.5    930.6   13240.1
-65.0  1166.9   13440.7    944.9  -11328.9   13662.6    944.9   13440.7
-66.0  1166.9   13641.2    959.2  -11515.1   13848.8    959.2   13641.2
-67.0  1166.9   13841.7    973.6  -11701.3   14035.0    973.6   13841.7
-68.0  1166.9   14042.3    987.9  -11887.5   14221.2    987.9   14042.3
-69.0  1166.9   14242.8   1002.2  -12073.7   14407.4   1002.2   14242.8
-70.0  1166.9   14443.3   1016.6  -12259.9   14593.6   1016.6   14443.3
-71.0  1166.9   14643.9   1030.9  -12446.1   14779.9   1030.9   14643.9
-72.0  1166.9   14844.4   1045.2  -12632.3   14966.1   1045.2   14844.4
-73.0  1166.9   15044.9   1059.6  -12818.5   15152.3   1059.6   15044.9
-74.0  1166.9   15245.5   1073.9  -13004.7   15338.5   1073.9   15245.5
-75.0  1166.9   15446.0   1088.2  -13190.9   15524.7   1088.2   15446.0
-76.0  1166.9   15646.5   1102.5  -13377.1   15710.9   1102.5   15646.5
-77.0  1166.9   15847.1   1116.9  -13563.3   15897.1   1116.9   15847.1
-78.0  1166.9   16047.6   1131.2  -13749.5   16083.3   1131.2   16047.6
-79.0  1166.9   16248.1   1145.5  -13935.7   16269.5   1145.5   16248.1
-80.0  1166.9   16448.7   1159.9  -14121.9   16455.7   1159.9   16448.7
-81.0  1166.9   16649.2   1174.2  -14308.1   16641.9   1174.2   16649.2
```

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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 9-JANUARY-2013                                            TIME: 9:45:50

                       ****************************
                       *   SUMMARY OF RESULTS FOR  *
                       *   CANTILEVER WALL DESIGN  *
                       ****************************

  I.--HEADING
   'S72 COFFER DAM WALL DESIGN -DOWNSTREAM STREAM CENTER

  II.--SUMMARY

      RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

      LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

   WALL BOTTOM ELEV. (FT)      :        -32.00
        PENETRATION (FT)       :         31.30

   MAX. BEND. MOMENT (LB-FT)   :    2.2664E+05
        AT ELEVATION (FT)      :        -16.14

   MAX. SCALED DEFL. (LB-IN^3):     3.2993E+11
        AT ELEVATION (FT)      :         26.00

           NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                  ELASTICITY IN PSI TIMES PILE MOMENT
                  OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
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IN INCHES.



PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
                         BY CLASSICAL METHODS
DATE: 9-JANUARY-2013                                          TIME: 9:45:50

                        ****************************
                        * COMPLETE OF RESULTS FOR  *
                        *  CANTILEVER WALL DESIGN  *
                        ****************************

   I.--HEADING
   'S72 COFFER DAM WALL DESIGN -DOWNSTREAM STREAM CENTER

   II.--RESULTSO. (LB))

                 BENDING                          SCALED          NET
   ELEVATION     MOMENT           SHEAR         DEFLECTION      PRESSURE
     (FT)        (LB-FT)          (LB)          (LB-IN^3)        (PSF)
     26.00     0.0000E+00           0.          3.2993E+11         0.00
     25.00     5.5879E-09           0.          3.2162E+11         0.00
     24.00     5.5879E-09           0.          3.1331E+11         0.00
     23.00     5.5879E-09           0.          3.0500E+11         0.00
     22.00     5.5879E-09           0.          2.9668E+11         0.00
     21.00     5.5879E-09           0.          2.8837E+11         0.00
     20.00     5.5879E-09           0.          2.8006E+11         0.00
     19.00     5.5879E-09           0.          2.7175E+11         0.00
     18.00     5.5879E-09           0.          2.6344E+11         0.00
     17.00     1.0400E+01          31.          2.5513E+11        62.40
     16.00     8.3200E+01         125.          2.4681E+11       124.80
     15.00     2.8080E+02         281.          2.3850E+11       187.20
     14.00     6.6560E+02         499.          2.3019E+11       249.60
     13.00     1.3000E+03         780.          2.2188E+11       312.00
     12.00     2.2464E+03        1123.          2.1357E+11       374.40
     11.00     3.5672E+03        1529.          2.0527E+11       436.80
     10.00     5.3248E+03        1997.          1.9697E+11       499.20
      9.00     7.5816E+03        2527.          1.8868E+11       561.60
      8.00     1.0400E+04        3120.          1.8041E+11       624.00
      7.00     1.3842E+04        3775.          1.7215E+11       686.40
      6.00     1.7971E+04        4493.          1.6392E+11       748.80
      5.00     2.2849E+04        5273.          1.5572E+11       811.20
      4.00     2.8538E+04        6115.          1.4756E+11       873.60
      3.00     3.5100E+04        7020.          1.3944E+11       936.00
      2.00     4.2598E+04        7987.          1.3139E+11       998.40
      1.00     5.1095E+04        9017.          1.2341E+11      1060.80
      0.00     6.0653E+04       10109.          1.1552E+11      1123.20
     -0.70     6.8008E+04       10910.          1.1006E+11      1166.88
     -1.00     7.1332E+04       11249.          1.0774E+11      1094.06
     -1.70     7.9461E+04       11956.          1.0236E+11       924.14
     -2.00     8.3088E+04       12222.          1.0008E+11       851.32
     -3.00     9.5696E+04       12952.          9.2559E+10       608.58
     -4.00     1.0891E+05       13439.          8.5207E+10       365.85
     -5.00     1.2249E+05       13684.          7.8043E+10       123.11
     -5.51     1.2944E+05       13715.          7.4489E+10         0.00
     -6.00     1.3620E+05       13686.          7.1091E+10      -119.63
     -7.00     1.4978E+05       13445.          6.4374E+10      -362.37
     -8.00     1.6301E+05       12961.          5.7916E+10      -605.10
     -9.00     1.7562E+05       12234.          5.1739E+10      -847.84
    -10.00     1.8739E+05       11265.          4.5866E+10     -1090.58
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   -11.00     1.9807E+05         10053.        4.0317E+10      -1333.31
   -12.00     2.0742E+05          8599.        3.5109E+10      -1576.05
   -13.00     2.1519E+05          6901.        3.0260E+10      -1818.79
   -14.00     2.2114E+05          4961.        2.5782E+10      -2061.53
   -15.00     2.2503E+05          2778.        2.1686E+10      -2304.26
   -16.00     2.2662E+05           352.        1.7979E+10      -2547.00
   -17.00     2.2565E+05         -2316.        1.4663E+10      -2789.74
   -18.00     2.2190E+05         -5227.        1.1736E+10      -3032.48
   -18.40     2.1958E+05         -6335.        1.0674E+10      -2506.53
   -19.00     2.1536E+05         -7718.        9.1928E+09      -2102.94
   -20.00     2.0644E+05        -10249.        7.0211E+09      -2959.78
   -21.00     1.9468E+05        -13302.        5.2057E+09      -3146.35
   -22.00     1.7978E+05        -16542.        3.7263E+09      -3333.01
   -22.70     1.6730E+05        -18933.        2.8730E+09      -3464.39
   -23.00     1.6154E+05        -19908.        2.5570E+09      -3113.69
   -24.00     1.4028E+05        -22430.        1.6664E+09      -1930.71
   -25.00     1.1708E+05        -23769.        1.0180E+09       -747.73
   -26.00     9.3132E+04        -23926.        5.7174E+08        435.26
   -27.00     6.9621E+04        -22899.        2.8649E+08       1618.24
   -28.00     4.7728E+04        -20689.        1.2178E+08       2801.22
   -29.00     2.8637E+04        -17296.        3.9952E+07       3984.21
   -30.00     1.3530E+04        -12721.        8.1799E+06       5167.19
   -31.00     3.5898E+03         -6962.        5.3118E+05       6350.17
   -32.00    -5.7153E-02           -20.       -5.0836E-04       7533.16
   -32.00     0.0000E+00             0.        0.0000E+00       7536.36

              NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                     ELASTICITY IN PSI TIMES PILE MOMENT
                     OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                     IN INCHES.

  III.--WATER AND SOIL PRESSURES

                                 <------------SOIL PRESSURES------------->
                   WATER         <----LEFTSIDE----->       <---RIGHTSIDE---->
 ELEVATION       PRESSURE        PASSIVE       ACTIVE        ACTIVE      PASSIVE
   (FT)            (PSF)         (PSF)         (PSF)         (PSF)        (PSF)
   26.00              0.            0.            0.            0.           0.
   25.00              0.            0.            0.            0.           0.
   24.00              0.            0.            0.            0.           0.
   23.00              0.            0.            0.            0.           0.
   22.00              0.            0.            0.            0.           0.
   21.00              0.            0.            0.            0.           0.
   20.00              0.            0.            0.            0.           0.
   19.00              0.            0.            0.            0.           0.
   18.00              0.            0.            0.            0.           0.
   17.00             62.            0.            0.            0.           0.
   16.00            125.            0.            0.            0.           0.
   15.00            187.            0.            0.            0.           0.
   14.00            250.            0.            0.            0.           0.
   13.00            312.            0.            0.            0.           0.
   12.00            374.            0.            0.            0.           0.
   11.00            437.            0.            0.            0.           0.
   10.00            499.            0.            0.            0.           0.
    9.00            562.            0.            0.            0.           0.
    8.00            624.            0.            0.            0.           0.
    7.00            686.            0.            0.            0.           0.
    6.00            749.            0.            0.            0.           0.
    5.00            811.            0.            0.            0.           0.
    4.00            874.            0.            0.            0.           0.
    3.00            936.            0.            0.            0.           0.
    2.00            998.            0.            0.            0.           0.
    1.00           1061.            0.            0.            0.           0.
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   0.00        1123.      0.        0.        0.        0.
  -0.70        1167.      0.        0.        0.        0.
  -1.00        1167.     77.        4.        4.       77.
  -1.70        1167.    258.       15.       15.      258.
  -2.00        1167.    335.       19.       19.      335.
  -3.00        1167.    592.       34.       34.      592.
  -4.00        1167.    850.       49.       49.      850.
  -5.00        1167.   1108.       64.       64.     1108.
  -5.51        1167.   1238.       71.       71.     1238.
  -6.00        1167.   1365.       79.       79.     1365.
  -7.00        1167.   1623.       94.       94.     1623.
  -8.00        1167.   1880.      108.      108.     1880.
  -9.00        1167.   2138.      123.      123.     2138.
 -10.00        1167.   2396.      138.      138.     2396.
 -11.00        1167.   2653.      153.      153.     2653.
 -12.00        1167.   2911.      168.      168.     2911.
 -13.00        1167.   3168.      183.      183.     3168.
 -14.00        1167.   3426.      198.      198.     3426.
 -15.00        1167.   3684.      212.      212.     3684.
 -16.00        1167.   3941.      227.      227.     3941.
 -17.00        1167.   4199.      242.      242.     4199.
 -18.00        1167.   4456.      257.      257.     4456.
 -18.40        1167.   3934.      261.      261.     3934.
 -19.00        1167.   3543.      274.      274.     3543.
 -20.00        1167.   4426.      300.      300.     4426.
 -21.00        1167.   4627.      314.      314.     4627.
 -22.00        1167.   4828.      328.      328.     4828.
 -22.70        1167.   4970.      338.      338.     4970.
 -23.00        1167.   5029.      343.      343.     5029.
 -24.00        1167.   5230.      357.      357.     5230.
 -25.00        1167.   5432.      371.      371.     5432.
 -26.00        1167.   5633.      386.      386.     5633.
 -27.00        1167.   5834.      400.      400.     5834.
 -28.00        1167.   6035.      414.      414.     6035.
 -29.00        1167.   6237.      429.      429.     6237.
 -30.00        1167.   6438.      443.      443.     6438.
 -31.00        1167.   6639.      458.      458.     6639.
 -32.00        1167.   6841.      472.      472.     6841.
 -32.00        1167.   7042.      486.      486.     7042.
 -34.00        1167.   7244.      501.      501.     7244.
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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 9-JANUARY-2013                                            TIME: 9:51:26

                            ****************
                            *  INPUT DATA  *
                            ****************

    I.--HEADING
    'S72 COFFER DAM WALL DESIGN -downSTREAM MIDDLE

    II.--CONTROL
      CANTILEVER WALL DESIGN
      FACTOR OF SAFETY FOR ACTIVE PRESSURES  = 1.00
      FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.00

   III.--WALL DATA
      ELEVATION AT TOP OF WALL      = 26.00 FT.

    IV.--SURFACE POINT DATA

        IV.A.--RIGHTSIDE
          DIST. FROM      ELEVATION
          WALL (FT)         (FT)
             0.00           4.30
            50.00           4.30

        IV.B.--LEFTSIDE
          DIST. FROM      ELEVATION
          WALL (FT)         (FT)
             0.00           4.30
            50.00           4.30

     V.--SOIL LAYER DATA

        V.A.--RIGHTSIDE
          LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
          LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

                 ANGLE OF          ANGLE OF                          <-SAFETY->
 SAT.    MOIST   INTERNAL   COH-     WALL     ADH-    <--BOTTOM-->  <-FACTOR->
 WGHT.   WGHT.   FRICTION  ESION   FRICTION  ESION    ELEV.  SLOPE  ACT. PASS.
 (PCF)   (PCF)    (DEG)    (PSF)    (DEG)    (PSF)    (FT)  (FT/FT)
105.00  100.00    29.00     0.00    11.00     0.00     3.60   0.00   DEF  DEF
115.00  110.00    31.00     0.00    14.00     0.00   -18.40   0.00   DEF  DEF
110.00  105.00    30.00     0.00    11.00     0.00                   DEF  DEF

        V.B.--LEFTSIDE
          LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
          LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

                 ANGLE OF          ANGLE OF                          <-SAFETY->
 SAT.    MOIST   INTERNAL   COH-     WALL     ADH-    <--BOTTOM-->  <-FACTOR->
 WGHT.   WGHT.   FRICTION  ESION   FRICTION  ESION    ELEV.  SLOPE  ACT. PASS.
 (PCF)   (PCF)    (DEG)    (PSF)    (DEG)    (PSF)    (FT)  (FT/FT)
105.00  100.00    29.00     0.00    11.00     0.00     3.60   0.00   DEF  DEF
115.00  110.00    31.00     0.00    14.00     0.00   -18.40   0.00   DEF  DEF
110.00  105.00    30.00     0.00    11.00     0.00                   DEF  DEF

    VI.--WATER DATA
      UNIT WEIGHT            = 62.40 (PCF)
      RIGHTSIDE ELEVATION = 18.00 (FT)
      LEFTSIDE ELEVATION   = 4.30 (FT)
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      NO SEEPAGE

    VII.--VERTICAL SURCHARGE LOADS
      NONE

   VIII.--HORIZONTAL LOADS
      NONE




PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 9-JANUARY-2013                                          TIME: 9:51:29

                         **************************
                         *    SOIL PRESSURES FOR  *
                         * CANTILEVER WALL DESIGN *
                         **************************

    I.--HEADING
     'S72 COFFER DAM WALL DESIGN -downSTREAM MIDDLE

   II.--SOIL PRESSURES

        RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

        LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

                                       <------NET------>
         NET      <---LEFTSIDE--->     (SOIL + WATER)      <--RIGHTSIDE--->
ELEV.   WATER     PASSIVE   ACTIVE     ACTIVE   PASSIVE    ACTIVE   PASSIVE
(FT)    (PSF)      (PSF)    (PSF)      (PSF)     (PSF)     (PSF)     (PSF)
 26.0     0.0        0.0      0.0        0.0       0.0       0.0       0.0
 25.0     0.0        0.0      0.0        0.0       0.0       0.0       0.0
 24.0     0.0        0.0      0.0        0.0       0.0       0.0       0.0
 23.0     0.0        0.0      0.0        0.0       0.0       0.0       0.0
 22.0     0.0        0.0      0.0        0.0       0.0       0.0       0.0
 21.0     0.0        0.0      0.0        0.0       0.0       0.0       0.0
 20.0     0.0        0.0      0.0        0.0       0.0       0.0       0.0
 19.0     0.0        0.0      0.0        0.0       0.0       0.0       0.0
 18.0     0.0        0.0      0.0        0.0       0.0       0.0       0.0
 17.0    62.4        0.0      0.0       62.4      62.4       0.0       0.0
 16.0   124.8        0.0      0.0      124.8     124.8       0.0       0.0
 15.0   187.2        0.0      0.0      187.2     187.2       0.0       0.0
 14.0   249.6        0.0      0.0      249.6     249.6       0.0       0.0
 13.0   312.0        0.0      0.0      312.0     312.0       0.0       0.0
 12.0   374.4        0.0      0.0      374.4     374.4       0.0       0.0
 11.0   436.8        0.0      0.0      436.8     436.8       0.0       0.0
 10.0   499.2        0.0      0.0      499.2     499.2       0.0       0.0
  9.0   561.6        0.0      0.0      561.6     561.6       0.0       0.0
  8.0   624.0        0.0      0.0      624.0     624.0       0.0       0.0
  7.0   686.4        0.0      0.0      686.4     686.4       0.0       0.0
  6.0   748.8        0.0      0.0      748.8     748.8       0.0       0.0
  5.0   811.2        0.0      0.0      811.2     811.2       0.0       0.0
  4.3   854.9        0.0      0.0      854.9     854.9       0.0       0.0
  4.0   854.9       51.3      4.0      807.6     902.2       4.0      51.3
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   3.6    854.9     139.7     9.0     724.2     985.5      9.0     139.7
   3.3    854.9     216.8    13.0     651.1    1058.6     13.0     216.8
   3.0    854.9     291.8    17.4     580.6    1129.2     17.4     291.8
   2.0    854.9     548.9    32.3     338.2    1371.5     32.3     548.9
   1.0    854.9     806.4    47.2      95.6    1614.1     47.2     806.4
   0.6    854.9     907.9    53.0       0.0    1709.8     53.0     907.9
   0.0    854.9    1064.0    62.0    -147.1    1856.8     62.0    1064.0
  -1.0    854.9    1321.6    76.9    -389.8    2099.6     76.9    1321.6
  -2.0    854.9    1579.1    91.7    -632.5    2342.3     91.7    1579.1
  -3.0    854.9    1836.7   106.6    -875.3    2585.0    106.6    1836.7
  -4.0    854.9    2094.3   121.4   -1118.0    2827.8    121.4    2094.3
  -5.0    854.9    2351.9   136.3   -1360.7    3070.5    136.3    2351.9
  -6.0    854.9    2609.5   151.1   -1603.5    3313.2    151.1    2609.5
  -7.0    854.9    2867.1   166.0   -1846.2    3556.0    166.0    2867.1
  -8.0    854.9    3124.7   180.9   -2088.9    3798.7    180.9    3124.7
  -9.0    854.9    3382.3   195.7   -2331.7    4041.4    195.7    3382.3
 -10.0    854.9    3639.9   210.6   -2574.4    4284.2    210.6    3639.9
 -11.0    854.9    3897.4   225.4   -2817.1    4526.9    225.4    3897.4
 -12.0    854.9    4155.0   240.3   -3059.9    4769.6    240.3    4155.0
 -13.0    854.9    4412.6   255.1   -3302.6    5012.4    255.1    4412.6
 -14.0    854.9    4670.2   270.0   -3545.4    5255.1    270.0    4670.2
 -15.0    854.9    4927.8   284.8   -3788.1    5497.9    284.8    4927.8
 -16.0    854.9    5185.4   299.7   -4030.8    5740.6    299.7    5185.4
 -17.0    854.9    5443.0   314.5   -4273.6    5983.3    314.5    5443.0
 -18.0    854.9    5700.6   329.4   -4516.3    6226.1    329.4    5700.6
 -18.4    854.9    4866.6   330.2   -3681.6    5391.3    330.2    4866.6
 -19.0    854.9    4255.2   342.5   -3057.8    4767.6    342.5    4255.2
 -20.0    854.9    5550.3   375.8   -4319.6    6029.4    375.8    5550.3
 -21.0    854.9    5751.2   390.2   -4506.1    6215.9    390.2    5751.2
 -22.0    854.9    5952.2   404.6   -4692.7    6402.5    404.6    5952.2
 -23.0    854.9    6153.2   418.9   -4879.4    6589.1    418.9    6153.2
 -24.0    854.9    6354.2   433.3   -5066.1    6775.8    433.3    6354.2
 -25.0    854.9    6555.3   447.6   -5252.8    6962.6    447.6    6555.3
 -26.0    854.9    6756.5   462.0   -5439.6    7149.4    462.0    6756.5
 -27.0    854.9    6957.7   476.3   -5626.5    7336.2    476.3    6957.7
 -28.0    854.9    7158.9   490.7   -5813.3    7523.1    490.7    7158.9
 -29.0    854.9    7360.1   505.0   -6000.2    7710.0    505.0    7360.1
 -30.0    854.9    7561.4   519.4   -6187.2    7896.9    519.4    7561.4
 -31.0    854.9    7762.7   533.7   -6374.1    8083.9    533.7    7762.7
 -32.0    854.9    7964.0   548.1   -6561.1    8270.8    548.1    7964.0
 -33.0    854.9    8165.3   562.4   -6748.0    8457.8    562.4    8165.3
 -34.0    854.9    8366.7   576.8   -6935.0    8644.8    576.8    8366.7
 -35.0    854.9    8568.0   591.1   -7122.0    8831.8    591.1    8568.0
 -36.0    854.9    8769.4   605.4   -7309.1    9018.8    605.4    8769.4
 -37.0    854.9    8970.8   619.8   -7496.1    9205.9    619.8    8970.8
 -38.0    854.9    9172.1   634.1   -7683.1    9392.9    634.1    9172.1
 -39.0    854.9    9373.5   648.5   -7870.2    9579.9    648.5    9373.5
 -40.0    854.9    9571.6   662.8   -8053.9    9763.7    662.8    9571.6
 -41.0    854.9    9759.4   677.1   -8227.4    9937.1    677.1    9759.4
 -42.0    854.9    9950.0   691.5   -8403.7   10113.5    691.5    9950.0
 -43.0    854.9   10150.5   705.8   -8589.8   10299.6    705.8   10150.5
 -44.0    854.9   10351.0   720.1   -8775.9   10485.7    720.1   10351.0
 -45.0    854.9   10551.4   734.5   -8962.1   10671.8    734.5   10551.4
 -46.0    854.9   10751.9   748.8   -9148.2   10858.0    748.8   10751.9
 -47.0    854.9   10952.4   763.2   -9334.4   11044.1    763.2   10952.4
 -48.0    854.9   11152.9   777.5   -9520.5   11230.3    777.5   11152.9
 -49.0    854.9   11353.4   791.8   -9706.7   11416.4    791.8   11353.4
 -50.0    854.9   11553.9   806.2   -9892.8   11602.6    806.2   11553.9
 -51.0    854.9   11754.4   820.5  -10079.0   11788.8    820.5   11754.4
 -52.0    854.9   11954.9   834.8  -10265.2   11974.9    834.8   11954.9
 -53.0    854.9   12155.4   849.2  -10451.3   12161.1    849.2   12155.4
 -54.0    854.9   12355.9   863.5  -10637.5   12347.2    863.5   12355.9
 -55.0    854.9   12556.4   877.8  -10823.7   12533.4    877.8   12556.4
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-56.0    854.9    12756.9     892.2   -11009.8    12719.6       892.2   12756.9
-57.0    854.9    12957.4     906.5   -11196.0    12905.8       906.5   12957.4
-58.0    854.9    13157.9     920.8   -11382.2    13091.9       920.8   13157.9
-59.0    854.9    13358.4     935.2   -11568.4    13278.1       935.2   13358.4
-60.0    854.9    13558.9     949.5   -11754.5    13464.3       949.5   13558.9
-61.0    854.9    13759.4     963.8   -11940.7    13650.5       963.8   13759.4
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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 9-JANUARY-2013                                           TIME: 9:51:30

                         *****************************
                         *  SUMMARY OF RESULTS FOR   *
                         *  CANTILEVER WALL DESIGN   *
                         *****************************

    I.--HEADING
     'S72 COFFER DAM WALL DESIGN -downSTREAM MIDDLE

   II.--SUMMARY

        RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

        LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

   WALL BOTTOM ELEV. (FT)     :       -19.06
         PENETRATION (FT)     :        23.36

   MAX. BEND. MOMENT (LB-FT)  :   9.1694E+04
         AT ELEVATION (FT)    :        -7.25

   MAX. SCALED DEFL. (LB-IN^3):   7.7212E+10
         AT ELEVATION (FT)    :        26.00

             NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                    ELASTICITY IN PSI TIMES PILE MOMENT
                    OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                    IN INCHES.
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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 9-JANUARY-2013                                           TIME: 9:51:30

                         *****************************
                         * COMPLETE OF RESULTS FOR   *
                         *  CANTILEVER WALL DESIGN   *
                         *****************************

     I.--HEADING
     'S72 COFFER DAM WALL DESIGN -downSTREAM MIDDLE
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II.--RESULTS0. (LB))

                BENDING                                SCALED           NET
ELEVATION       MOMENT           SHEAR               DEFLECTION       PRESSURE
  (FT)          (LB-FT)           (LB)               (LB-IN^3)          (PSF)
  26.00       0.0000E+00            0.               7.7212E+10           0.00
  25.00       0.0000E+00            0.               7.4750E+10           0.00
  24.00       0.0000E+00            0.               7.2288E+10           0.00
  23.00       0.0000E+00            0.               6.9826E+10           0.00
  22.00       0.0000E+00            0.               6.7364E+10           0.00
  21.00       0.0000E+00            0.               6.4902E+10           0.00
  20.00       0.0000E+00            0.               6.2440E+10           0.00
  19.00       0.0000E+00            0.               5.9978E+10           0.00
  18.00       2.2352E-08            0.               5.7516E+10           0.00
  17.00       1.0400E+01           31.               5.5054E+10          62.40
  16.00       8.3200E+01          125.               5.2592E+10         124.80
  15.00       2.8080E+02          281.               5.0130E+10         187.20
  14.00       6.6560E+02          499.               4.7669E+10         249.60
  13.00       1.3000E+03          780.               4.5209E+10         312.00
  12.00       2.2464E+03         1123.               4.2751E+10         374.40
  11.00       3.5672E+03         1529.               4.0297E+10         436.80
  10.00       5.3248E+03         1997.               3.7850E+10         499.20
   9.00       7.5816E+03         2527.               3.5411E+10         561.60
   8.00       1.0400E+04         3120.               3.2986E+10         624.00
   7.00       1.3842E+04         3775.               3.0579E+10         686.40
   6.00       1.7971E+04         4493.               2.8196E+10         748.80
   5.00       2.2849E+04         5273.               2.5844E+10         811.20
   4.30       2.6742E+04         5856.               2.4221E+10         854.88
   4.00       2.8537E+04         6105.               2.3532E+10         807.58
   3.60       3.1041E+04         6412.               2.2620E+10         724.23
   3.30       3.2996E+04         6618.               2.1942E+10         651.13
   3.00       3.5010E+04         6803.               2.1269E+10         580.58
   2.00       4.2062E+04         7262.               1.9066E+10         338.24
   1.00       4.9453E+04         7479.               1.6937E+10          95.61
   0.61       5.2405E+04         7498.               1.6120E+10           0.00
   0.00       5.6940E+04         7453.               1.4893E+10        -147.09
  -1.00       6.4279E+04         7185.               1.2947E+10        -389.81
  -2.00       7.1228E+04         6674.               1.1112E+10        -632.53
  -3.00       7.7545E+04         5920.               9.4003E+09        -875.26
  -4.00       8.2987E+04         4923.               7.8224E+09       -1118.00
  -5.00       8.7311E+04         3684.               6.3877E+09       -1360.73
  -6.00       9.0274E+04         2202.               5.1037E+09       -1603.47
  -7.00       9.1633E+04          477.               3.9755E+09       -1846.20
  -8.00       9.1147E+04        -1491.               3.0054E+09       -2088.94
  -9.00       8.8571E+04        -3701.               2.1925E+09       -2331.68
 -10.00       8.3664E+04        -6154.               1.5323E+09       -2574.41
 -10.86       7.7414E+04        -8451.               1.0814E+09       -2782.58
 -11.00       7.6183E+04        -8838.               1.0162E+09       -2650.17
 -12.00       6.6175E+04       -11023.               6.3150E+08       -1720.46
 -13.00       5.4446E+04       -12279.               3.6086E+08        -790.76
 -14.00       4.1927E+04       -12605.               1.8418E+08         138.95
 -15.00       2.9546E+04       -12001.               7.9976E+07        1068.66
 -16.00       1.8235E+04       -10467.               2.6980E+07        1998.37
 -17.00       8.9214E+03        -8004.               5.7825E+06        2928.07
 -18.00       2.5361E+03        -4611.               4.2225E+05        3857.78
 -18.40       1.0102E+03        -2994.               6.4474E+04        4229.66
 -19.00       8.6790E+00         -289.               4.5238E+00        4787.49
 -19.06       0.0000E+00            0.               0.0000E+00        4843.22

         NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                ELASTICITY IN PSI TIMES PILE MOMENT
                OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
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                 IN INCHES.

    III.--WATER AND SOIL PRESSURES

                                <-------------SOIL PRESSURES------------->
                    WATER       <----LEFTSIDE----->       <---RIGHTSIDE---->
    ELEVATION     PRESSURE      PASSIVE       ACTIVE       ACTIVE      PASSIVE
      (FT)          (PSF)        (PSF)         (PSF)        (PSF)       (PSF)
      26.00            0.           0.            0.           0.          0.
      25.00            0.           0.            0.           0.          0.
      24.00            0.           0.            0.           0.          0.
      23.00            0.           0.            0.           0.          0.
      22.00            0.           0.            0.           0.          0.
      21.00            0.           0.            0.           0.          0.
      20.00            0.           0.            0.           0.          0.
      19.00            0.           0.            0.           0.          0.
      18.00            0.           0.            0.           0.          0.
      17.00           62.           0.            0.           0.          0.
      16.00          125.           0.            0.           0.          0.
      15.00          187.           0.            0.           0.          0.
      14.00          250.           0.            0.           0.          0.
      13.00          312.           0.            0.           0.          0.
      12.00          374.           0.            0.           0.          0.
      11.00          437.           0.            0.           0.          0.
      10.00          499.           0.            0.           0.          0.
       9.00          562.           0.            0.           0.          0.
       8.00          624.           0.            0.           0.          0.
       7.00          686.           0.            0.           0.          0.
       6.00          749.           0.            0.           0.          0.
       5.00          811.           0.            0.           0.          0.
       4.30          855.           0.            0.           0.          0.
       4.00          855.          51.            4.           4.         51.
       3.60          855.         140.            9.           9.        140.
       3.30          855.         217.           13.          13.        217.
       3.00          855.         292.           17.          17.        292.
       2.00          855.         549.           32.          32.        549.
       1.00          855.         806.           47.          47.        806.
       0.61          855.         908.           53.          53.        908.
       0.00          855.        1064.           62.          62.       1064.
      -1.00          855.        1322.           77.          77.       1322.
      -2.00          855.        1579.           92.          92.       1579.
      -3.00          855.        1837.          107.         107.       1837.
      -4.00          855.        2094.          121.         121.       2094.
      -5.00          855.        2352.          136.         136.       2352.
      -6.00          855.        2609.          151.         151.       2609.
      -7.00          855.        2867.          166.         166.       2867.
      -8.00          855.        3125.          181.         181.       3125.
      -9.00          855.        3382.          196.         196.       3382.
     -10.00          855.        3640.          211.         211.       3640.
     -10.86          855.        3861.          223.         223.       3861.
     -11.00          855.        3897.          225.         225.       3897.
     -12.00          855.        4155.          240.         240.       4155.
     -13.00          855.        4413.          255.         255.       4413.
     -14.00          855.        4670.          270.         270.       4670.
     -15.00          855.        4928.          285.         285.       4928.
     -16.00          855.        5185.          300.         300.       5185.
     -17.00          855.        5443.          315.         315.       5443.
     -18.00          855.        5701.          329.         329.       5701.
     -18.40          855.        4867.          330.         330.       4867.
     -19.00          855.        4255.          343.         343.       4255.
     -19.06          855.        5550.          376.         376.       5550.
     -21.00          855.        5751.          390.         390.       5751.
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                              downstream upper.out
PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                             BY CLASSICAL METHODS
DATE: 9-JANUARY-2013                                          TIME: 9:54:45

                               ****************
                               *  INPUT DATA  *
                               ****************

    I.--HEADING
    'S72 COFFER DAM WALL DESIGN -downSTREAM UPPER

    II.--CONTROL
       CANTILEVER WALL DESIGN
       FACTOR OF SAFETY FOR ACTIVE PRESSURES  = 1.00
       FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.00

   III.--WALL DATA
       ELEVATION AT TOP OF WALL     = 26.00 FT.

    IV.--SURFACE POINT DATA

        IV.A.--RIGHTSIDE
           DIST. FROM     ELEVATION
           WALL (FT)        (FT)
               0.00          9.30
              50.00          9.30

        IV.B.--LEFTSIDE
           DIST. FROM     ELEVATION
           WALL (FT)        (FT)
               0.00          9.30
              50.00          9.30

     V.--SOIL LAYER DATA

        V.A.--RIGHTSIDE
           LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
           LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

                ANGLE OF          ANGLE OF                              <-SAFETY->
 SAT.    MOIST  INTERNAL   COH-     WALL     ADH-    <--BOTTOM-->  <-FACTOR->
WGHT.    WGHT.  FRICTION   ESION  FRICTION   ESION   ELEV.   SLOPE  ACT. PASS.
(PCF)    (PCF)   (DEG)     (PSF)    (DEG)    (PSF)    (FT)  (FT/FT)
105.00  100.00   29.00     0.00    11.00     0.00     3.60    0.00   DEF  DEF
115.00  110.00   31.00     0.00    14.00     0.00   -18.40    0.00   DEF  DEF
110.00  105.00   30.00     0.00    11.00     0.00                    DEF  DEF

        V.B.--LEFTSIDE
           LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
           LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

                ANGLE OF          ANGLE OF                              <-SAFETY->
 SAT.    MOIST  INTERNAL   COH-     WALL     ADH-    <--BOTTOM-->  <-FACTOR->
WGHT.    WGHT.  FRICTION   ESION  FRICTION   ESION   ELEV.   SLOPE  ACT. PASS.
(PCF)    (PCF)   (DEG)     (PSF)    (DEG)    (PSF)    (FT)  (FT/FT)
105.00  100.00   29.00     0.00    11.00     0.00     3.60    0.00   DEF  DEF
115.00  110.00   31.00     0.00    14.00     0.00   -18.40    0.00   DEF  DEF
110.00  105.00   30.00     0.00    11.00     0.00                    DEF  DEF

    VI.--WATER DATA
       UNIT WEIGHT           = 62.40 (PCF)
       RIGHTSIDE ELEVATION = 18.00 (FT)
       LEFTSIDE ELEVATION  = 9.30 (FT)
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     NO SEEPAGE

   VII.--VERTICAL SURCHARGE LOADS
        NONE

  VIII.--HORIZONTAL LOADS
        NONE
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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                           BY CLASSICAL METHODS
DATE: 9-JANUARY-2013                                          TIME: 9:54:48

                           **************************
                           *    SOIL PRESSURES FOR  *
                           * CANTILEVER WALL DESIGN *
                           **************************

   I.--HEADING
    'S72 COFFER DAM WALL DESIGN -downSTREAM UPPER

  II.--SOIL PRESSURES

     RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

     LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

                                            <------NET------>
            NET     <---LEFTSIDE--->        (SOIL + WATER)      <--RIGHTSIDE--->
ELEV.      WATER    PASSIVE   ACTIVE       ACTIVE    PASSIVE     ACTIVE   PASSIVE
(FT)       (PSF)     (PSF)     (PSF)        (PSF)     (PSF)       (PSF)     (PSF)
 26.0       0.0        0.0      0.0          0.0        0.0        0.0        0.0
 25.0       0.0        0.0      0.0          0.0        0.0        0.0        0.0
 24.0       0.0        0.0      0.0          0.0        0.0        0.0        0.0
 23.0       0.0        0.0      0.0          0.0        0.0        0.0        0.0
 22.0       0.0        0.0      0.0          0.0        0.0        0.0        0.0
 21.0       0.0        0.0      0.0          0.0        0.0        0.0        0.0
 20.0       0.0        0.0      0.0          0.0        0.0        0.0        0.0
 19.0       0.0        0.0      0.0          0.0        0.0        0.0        0.0
 18.0       0.0        0.0      0.0          0.0        0.0        0.0        0.0
 17.0      62.4        0.0      0.0         62.4       62.4        0.0        0.0
 16.0     124.8        0.0      0.0        124.8      124.8        0.0        0.0
 15.0     187.2        0.0      0.0        187.2      187.2        0.0        0.0
 14.0     249.6        0.0      0.0        249.6      249.6        0.0        0.0
 13.0     312.0        0.0      0.0        312.0      312.0        0.0        0.0
 12.0     374.4        0.0      0.0        374.4      374.4        0.0        0.0
 11.0     436.8        0.0      0.0        436.8      436.8        0.0        0.0
 10.0     499.2        0.0      0.0        499.2      499.2        0.0        0.0
  9.3     542.9        0.0      0.0        542.9      542.9        0.0        0.0
  9.0     542.9       51.3      4.0        495.6      590.2        4.0       51.3
  8.3     542.9      171.0     13.3        385.2      700.5       13.3      171.0
  8.0     542.9      222.3     17.3        337.9      747.8       17.3      222.3
  7.0     542.9      393.3     30.7        180.2      905.5       30.7      393.3
  6.0     542.9      564.3     44.0         22.6     1063.2       44.0      564.3
  5.9     542.9      588.8     45.9          0.0     1085.8       45.9      588.8
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   5.0    542.9     735.3    57.3    -135.1    1220.8     57.3     735.3
   4.0    542.9     906.3    70.7    -292.7    1378.5     70.7     906.3
   3.6    542.9    1092.8    74.6    -475.3    1561.0     74.6    1092.8
   3.0    542.9    1353.8    80.0    -730.8    1816.6     80.0    1353.8
   2.0    542.9    1536.8    93.2    -900.7    1986.4     93.2    1536.8
   1.0    542.9    1791.3   108.1   -1140.3    2226.1    108.1    1791.3
   0.0    542.9    2045.0   123.0   -1379.2    2464.9    123.0    2045.0
  -1.0    542.9    2301.3   137.8   -1620.6    2706.4    137.8    2301.3
  -2.0    542.9    2558.3   152.7   -1862.7    2948.5    152.7    2558.3
  -3.0    542.9    2815.4   167.6   -2104.9    3190.7    167.6    2815.4
  -4.0    542.9    3072.6   182.4   -2347.2    3433.0    182.4    3072.6
  -5.0    542.9    3329.8   197.3   -2589.7    3675.4    197.3    3329.8
  -6.0    542.9    3587.2   212.2   -2832.1    3917.9    212.2    3587.2
  -7.0    542.9    3844.5   227.0   -3074.6    4160.4    227.0    3844.5
  -8.0    542.9    4101.9   241.9   -3317.2    4402.9    241.9    4101.9
  -9.0    542.9    4359.4   256.7   -3559.8    4645.5    256.7    4359.4
 -10.0    542.9    4616.8   271.6   -3802.4    4888.1    271.6    4616.8
 -11.0    542.9    4874.3   286.4   -4045.0    5130.8    286.4    4874.3
 -12.0    542.9    5131.8   301.3   -4287.6    5373.4    301.3    5131.8
 -13.0    542.9    5389.3   316.2   -4530.3    5616.0    316.2    5389.3
 -14.0    542.9    5646.8   331.0   -4772.9    5858.7    331.0    5646.8
 -15.0    542.9    5904.4   345.9   -5015.6    6101.4    345.9    5904.4
 -16.0    542.9    6161.9   360.7   -5258.3    6344.0    360.7    6161.9
 -17.0    542.9    6419.4   375.6   -5501.0    6586.7    375.6    6419.4
 -18.0    542.9    6677.0   390.4   -5743.7    6829.4    390.4    6677.0
 -18.4    542.9    5606.4   388.1   -4675.4    5761.2    388.1    5606.4
 -19.0    542.9    4834.6   399.9   -3891.8    4977.6    399.9    4834.6
 -20.0    542.9    6453.7   440.0   -5470.9    6556.6    440.0    6453.7
 -21.0    542.9    6654.6   454.3   -5657.4    6743.1    454.3    6654.6
 -22.0    542.9    6855.5   468.7   -5843.9    6929.7    468.7    6855.5
 -23.0    542.9    7056.5   483.1   -6030.6    7116.3    483.1    7056.5
 -24.0    542.9    7257.5   497.4   -6217.2    7303.0    497.4    7257.5
 -25.0    542.9    7458.6   511.8   -6404.0    7489.7    511.8    7458.6
 -26.0    542.9    7659.7   526.1   -6590.7    7676.5    526.1    7659.7
 -27.0    542.9    7860.9   540.5   -6777.5    7863.3    540.5    7860.9
 -28.0    542.9    8062.0   554.8   -6964.3    8050.1    554.8    8062.0
 -29.0    542.9    8263.2   569.2   -7151.2    8236.9    569.2    8263.2
 -30.0    542.9    8464.4   583.5   -7338.1    8423.8    583.5    8464.4
 -31.0    542.9    8665.7   597.9   -7525.0    8610.7    597.9    8665.7
 -32.0    542.9    8867.0   612.2   -7711.9    8797.6    612.2    8867.0
 -33.0    542.9    9068.2   626.5   -7898.8    8984.6    626.5    9068.2
 -34.0    542.9    9269.5   640.9   -8085.8    9171.5    640.9    9269.5
 -35.0    542.9    9470.8   655.2   -8272.7    9358.5    655.2    9470.8
 -36.0    542.9    9662.7   669.6   -8450.2    9536.0    669.6    9662.7
 -37.0    542.9    9850.3   683.9   -8623.5    9709.2    683.9    9850.3
 -38.0    542.9   10046.9   698.2   -8805.8    9891.5    698.2   10046.9
 -39.0    542.9   10247.3   712.6   -8991.8   10077.6    712.6   10247.3
 -40.0    542.9   10447.7   726.9   -9177.9   10263.6    726.9   10447.7
 -41.0    542.9   10648.1   741.3   -9364.0   10449.7    741.3   10648.1
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****************************
*  SUMMARY OF RESULTS FOR  *
*  CANTILEVER WALL DESIGN  *
****************************

  I.--HEADING
   'S72 COFFER DAM WALL DESIGN -downSTREAM UPPER

 II.--SUMMARY

     RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

     LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

 WALL BOTTOM ELEV. (FT)      :       -7.19
       PENETRATION (FT)      :       16.49

 MAX. BEND. MOMENT (LB-FT)   :  2.9389E+04
       AT ELEVATION (FT)     :        0.44

 MAX. SCALED DEFL. (LB-IN^3):  1.3083E+10
       AT ELEVATION (FT)     :       26.00

          NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                 ELASTICITY IN PSI TIMES PILE MOMENT
                 OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                 IN INCHES.
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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 9-JANUARY-2013                                          TIME: 9:54:49

                       ****************************
                       * COMPLETE OF RESULTS FOR  *
                       *  CANTILEVER WALL DESIGN  *
                       ****************************

   I.--HEADING
   'S72 COFFER DAM WALL DESIGN -downSTREAM UPPER

  II.--RESULTS0. (LB))

                BENDING                            SCALED          NET
  ELEVATION     MOMENT           SHEAR           DEFLECTION      PRESSURE
    (FT)        (LB-FT)          (LB)            (LB-IN^3)        (PSF)
    26.00     0.0000E+00           0.            1.3083E+10         0.00
    25.00     1.7462E-09           0.            1.2539E+10         0.00
    24.00     1.7462E-09           0.            1.1996E+10         0.00
    23.00     1.7462E-09           0.            1.1453E+10         0.00
    22.00     1.7462E-09           0.            1.0910E+10         0.00
    21.00     1.7462E-09           0.            1.0367E+10         0.00
    20.00     1.7462E-09           0.            9.8238E+09         0.00
    19.00     1.7462E-09           0.            9.2806E+09         0.00
    18.00     1.7462E-09           0.            8.7375E+09         0.00
    17.00     1.0400E+01          31.            8.1943E+09        62.40
    16.00     8.3200E+01         125.            7.6512E+09       124.80
    15.00     2.8080E+02         281.            7.1083E+09       187.20
    14.00     6.6560E+02         499.            6.5658E+09       249.60
    13.00     1.3000E+03         780.            6.0245E+09       312.00
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    12.00      2.2464E+03          1123.       5.4856E+09        374.40
    11.00      3.5672E+03          1529.       4.9505E+09        436.80
    10.00      5.3248E+03          1997.       4.4217E+09        499.20
     9.30      6.8484E+03          2362.       4.0569E+09        542.88
     9.00      7.5806E+03          2517.       3.9022E+09        495.58
     8.30      9.4551E+03          2826.       3.5461E+09        385.21
     8.00      1.0319E+04          2934.       3.3958E+09        337.91
     7.00      1.3396E+04          3193.       2.9074E+09        180.25
     6.00      1.6653E+04          3295.       2.4421E+09         22.58
     5.86      1.7125E+04          3296.       2.3776E+09          0.00
     5.00      1.9933E+04          3238.       2.0055E+09       -135.08
     4.00      2.3077E+04          3024.       1.6034E+09       -292.75
     3.60      2.4259E+04          2871.       1.4535E+09       -475.26
     3.00      2.5880E+04          2509.       1.2412E+09       -730.85
     2.00      2.7995E+04          1693.       9.2351E+08       -900.68
     1.00      2.9198E+04           673.       6.5410E+08      -1140.32
     0.00      2.9261E+04          -587.       4.3499E+08      -1379.15
    -1.00      2.7944E+04         -2087.       2.6623E+08      -1620.62
    -2.00      2.5007E+04         -3829.       1.4554E+08      -1862.69
    -2.61      2.2299E+04         -5016.       9.3220E+07      -2011.22
    -3.00      2.0222E+04         -5693.       6.7783E+07      -1485.35
    -4.00      1.4013E+04         -6498.       2.4760E+07       -125.75
    -5.00      7.6786E+03         -5944.       5.9329E+06       1233.85
    -6.00      2.5781E+03         -4030.       5.5242E+05       2593.45
    -7.00      7.0991E+01          -757.       3.5497E+02       3953.05
    -7.19      0.0000E+00            0.        0.0000E+00       4205.42

         NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                ELASTICITY IN PSI TIMES PILE MOMENT
                OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                IN INCHES.

III.--WATER AND SOIL PRESSURES

                           <-------------SOIL PRESSURES-------------->
                 WATER     <----LEFTSIDE----->     <---RIGHTSIDE---->
ELEVATION      PRESSURE    PASSIVE      ACTIVE      ACTIVE     PASSIVE
   (FT)          (PSF)      (PSF)        (PSF)       (PSF)       (PSF)
  26.00            0.         0.           0.          0.          0.
  25.00            0.         0.           0.          0.          0.
  24.00            0.         0.           0.          0.          0.
  23.00            0.         0.           0.          0.          0.
  22.00            0.         0.           0.          0.          0.
  21.00            0.         0.           0.          0.          0.
  20.00            0.         0.           0.          0.          0.
  19.00            0.         0.           0.          0.          0.
  18.00            0.         0.           0.          0.          0.
  17.00           62.         0.           0.          0.          0.
  16.00          125.         0.           0.          0.          0.
  15.00          187.         0.           0.          0.          0.
  14.00          250.         0.           0.          0.          0.
  13.00          312.         0.           0.          0.          0.
  12.00          374.         0.           0.          0.          0.
  11.00          437.         0.           0.          0.          0.
  10.00          499.         0.           0.          0.          0.
   9.30          543.         0.           0.          0.          0.
   9.00          543.        51.           4.          4.         51.
   8.30          543.       171.          13.         13.        171.
   8.00          543.       222.          17.         17.        222.
   7.00          543.       393.          31.         31.        393.
   6.00          543.       564.          44.         44.        564.
   5.86          543.       589.          46.         46.        589.
   5.00          543.       735.          57.         57.        735.
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   4.00          543.       906.        71.        71.       906.
   3.60          543.      1093.        75.        75.      1093.
   3.00          543.      1354.        80.        80.      1354.
   2.00          543.      1537.        93.        93.      1537.
   1.00          543.      1791.       108.       108.      1791.
   0.00          543.      2045.       123.       123.      2045.
  -1.00          543.      2301.       138.       138.      2301.
  -2.00          543.      2558.       153.       153.      2558.
  -2.61          543.      2716.       162.       162.      2716.
  -3.00          543.      2815.       168.       168.      2815.
  -4.00          543.      3073.       182.       182.      3073.
  -5.00          543.      3330.       197.       197.      3330.
  -6.00          543.      3587.       212.       212.      3587.
  -7.00          543.      3845.       227.       227.      3845.
  -7.19          543.      4102.       242.       242.      4102.
  -9.00          543.      4359.       257.       257.      4359.
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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 9-JANUARY-2013                                          TIME: 10:09:50

                               ****************
                               *  INPUT DATA  *
                               ****************

    I.--HEADING
    'S72 COFFER DAM WALL DESIGN -UPSTREAM CENTER

    II.--CONTROL
       CANTILEVER WALL DESIGN
       FACTOR OF SAFETY FOR ACTIVE PRESSURES  = 1.00
       FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.00

   III.--WALL DATA
       ELEVATION AT TOP OF WALL    = 26.00 FT.

    IV.--SURFACE POINT DATA

        IV.A.--RIGHTSIDE
           DIST. FROM     ELEVATION
           WALL (FT)        (FT)
               0.00          3.60
              50.00          3.60

        IV.B.--LEFTSIDE
           DIST. FROM     ELEVATION
           WALL (FT)        (FT)
               0.00          3.60
              50.00          3.60

     V.--SOIL LAYER DATA

       V.A.--RIGHTSIDE
           LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
           LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

                ANGLE OF          ANGLE OF                             <-SAFETY->
 SAT.    MOIST  INTERNAL  COH-      WALL     ADH-     <--BOTTOM-->    <-FACTOR->
 WGHT.   WGHT.  FRICTION  ESION  FRICTION   ESION    ELEV.  SLOPE    ACT. PASS.
 (PCF)   (PCF)   (DEG)    (PSF)    (DEG)    (PSF)    (FT)  (FT/FT)
115.00  110.00   31.00     0.00    14.00     0.00   -18.40   0.00     DEF   DEF
110.00  105.00   30.00     0.00    11.00     0.00                     DEF   DEF

       V.B.--LEFTSIDE
           LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
           LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

                ANGLE OF          ANGLE OF                             <-SAFETY->
 SAT.    MOIST  INTERNAL  COH-      WALL     ADH-     <--BOTTOM-->    <-FACTOR->
 WGHT.   WGHT.  FRICTION  ESION  FRICTION   ESION    ELEV.  SLOPE    ACT. PASS.
 (PCF)   (PCF)   (DEG)    (PSF)    (DEG)    (PSF)    (FT)  (FT/FT)
115.00  110.00   31.00     0.00    14.00     0.00   -18.40   0.00     DEF   DEF
110.00  105.00   30.00     0.00    11.00     0.00                     DEF   DEF

    VI.--WATER DATA
       UNIT WEIGHT          = 62.40 (PCF)
       RIGHTSIDE ELEVATION = 21.50 (FT)
       LEFTSIDE ELEVATION   = 3.60 (FT)
       NO SEEPAGE
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VII.--VERTICAL SURCHARGE LOADS
    NONE

VIII.--HORIZONTAL LOADS
    NONE




PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                         BY CLASSICAL METHODS
DATE: 9-JANUARY-2013                                          TIME: 10:09:53

                         **************************
                         *    SOIL PRESSURES FOR  *
                         * CANTILEVER WALL DESIGN *
                         **************************

  I.--HEADING
   'S72 COFFER DAM WALL DESIGN -UPSTREAM CENTER

 II.--SOIL PRESSURES

      RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

      LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

                                        <------NET------>
          NET     <---LEFTSIDE--->      (SOIL + WATER)      <--RIGHTSIDE--->
ELEV.    WATER    PASSIVE   ACTIVE     ACTIVE   PASSIVE     ACTIVE  PASSIVE
(FT)     (PSF)     (PSF)    (PSF)      (PSF)     (PSF)      (PSF)    (PSF)
 26.0      0.0       0.0      0.0        0.0       0.0        0.0      0.0
 25.0      0.0       0.0      0.0        0.0       0.0        0.0      0.0
 24.0      0.0       0.0      0.0        0.0       0.0        0.0      0.0
 23.0      0.0       0.0      0.0        0.0       0.0        0.0      0.0
 22.0      0.0       0.0      0.0        0.0       0.0        0.0      0.0
 21.5      0.0       0.0      0.0        0.0       0.0        0.0      0.0
 21.0     31.2       0.0      0.0       31.2      31.2        0.0      0.0
 20.0     93.6       0.0      0.0       93.6      93.6        0.0      0.0
 19.0    156.0       0.0      0.0      156.0     156.0        0.0      0.0
 18.0    218.4       0.0      0.0      218.4     218.4        0.0      0.0
 17.0    280.8       0.0      0.0      280.8     280.8        0.0      0.0
 16.0    343.2       0.0      0.0      343.2     343.2        0.0      0.0
 15.0    405.6       0.0      0.0      405.6     405.6        0.0      0.0
 14.0    468.0       0.0      0.0      468.0     468.0        0.0      0.0
 13.0    530.4       0.0      0.0      530.4     530.4        0.0      0.0
 12.0    592.8       0.0      0.0      592.8     592.8        0.0      0.0
 11.0    655.2       0.0      0.0      655.2     655.2        0.0      0.0
 10.0    717.6       0.0      0.0      717.6     717.6        0.0      0.0
  9.0    780.0       0.0      0.0      780.0     780.0        0.0      0.0
  8.0    842.4       0.0      0.0      842.4     842.4        0.0      0.0
  7.0    904.8       0.0      0.0      904.8     904.8        0.0      0.0
  6.0    967.2       0.0      0.0      967.2     967.2        0.0      0.0
  5.0   1029.6       0.0      0.0     1029.6    1029.6        0.0      0.0
  4.0   1092.0       0.0      0.0     1092.0    1092.0        0.0      0.0
  3.6   1117.0       0.0      0.0     1117.0    1117.0        0.0      0.0
  3.0   1117.0     154.6      8.9      971.3    1262.6        8.9    154.6
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   2.6  1117.0    257.6   14.9    874.2   1359.7   14.9    257.6
   2.0  1117.0    412.1   23.8    728.6   1505.3   23.8    412.1
   1.0  1117.0    669.7   38.6    485.8   1748.1   38.6    669.7
   0.0  1117.0    927.3   53.5    243.1   1990.8   53.5    927.3
  -1.0  1117.0   1184.9   68.3      0.4   2233.6   68.3   1184.9
  -1.0  1117.0   1185.3   68.4      0.0   2233.9   68.4   1185.3
  -2.0  1117.0   1442.5   83.2   -242.4   2476.3   83.2   1442.5
  -3.0  1117.0   1700.1   98.0   -485.1   2719.0   98.0   1700.1
  -4.0  1117.0   1957.7  112.9   -727.8   2961.8  112.9   1957.7
  -5.0  1117.0   2215.3  127.7   -970.6   3204.5  127.7   2215.3
  -6.0  1117.0   2472.9  142.6  -1213.3   3447.2  142.6   2472.9
  -7.0  1117.0   2730.5  157.5  -1456.1   3690.0  157.5   2730.5
  -8.0  1117.0   2988.1  172.3  -1698.8   3932.7  172.3   2988.1
  -9.0  1117.0   3245.7  187.2  -1941.5   4175.5  187.2   3245.7
 -10.0  1117.0   3503.2  202.0  -2184.3   4418.2  202.0   3503.2
 -11.0  1117.0   3760.8  216.9  -2427.0   4660.9  216.9   3760.8
 -12.0  1117.0   4018.4  231.7  -2669.7   4903.7  231.7   4018.4
 -13.0  1117.0   4276.0  246.6  -2912.5   5146.4  246.6   4276.0
 -14.0  1117.0   4533.6  261.4  -3155.2   5389.1  261.4   4533.6
 -15.0  1117.0   4791.2  276.3  -3398.0   5631.9  276.3   4791.2
 -16.0  1117.0   5048.8  291.1  -3640.7   5874.6  291.1   5048.8
 -17.0  1117.0   5306.4  306.0  -3883.4   6117.3  306.0   5306.4
 -18.0  1117.0   5564.0  320.8  -4126.2   6360.1  320.8   5564.0
 -18.4  1117.0   4759.9  322.0  -3321.0   5554.9  322.0   4759.9
 -19.0  1117.0   4169.0  334.4  -2717.6   4951.5  334.4   4169.0
 -20.0  1117.0   5423.5  366.8  -3939.7   6173.6  366.8   5423.5
 -21.0  1117.0   5624.4  381.2  -4126.2   6360.2  381.2   5624.4
 -22.0  1117.0   5825.4  395.6  -4312.9   6546.8  395.6   5825.4
 -23.0  1117.0   6026.4  409.9  -4499.5   6733.5  409.9   6026.4
 -24.0  1117.0   6227.5  424.3  -4686.3   6920.2  424.3   6227.5
 -25.0  1117.0   6428.7  438.7  -4873.0   7107.0  438.7   6428.7
 -26.0  1117.0   6629.8  453.0  -5059.9   7293.8  453.0   6629.8
 -27.0  1117.0   6831.1  467.4  -5246.7   7480.7  467.4   6831.1
 -28.0  1117.0   7032.3  481.7  -5433.6   7667.5  481.7   7032.3
 -29.0  1117.0   7233.6  496.1  -5620.5   7854.5  496.1   7233.6
 -30.0  1117.0   7434.8  510.4  -5807.5   8041.4  510.4   7434.8
 -31.0  1117.0   7636.1  524.8  -5994.4   8228.4  524.8   7636.1
 -32.0  1117.0   7837.5  539.1  -6181.4   8415.3  539.1   7837.5
 -33.0  1117.0   8038.8  553.4  -6368.4   8602.3  553.4   8038.8
 -34.0  1117.0   8240.2  567.8  -6555.4   8789.3  567.8   8240.2
 -35.0  1117.0   8441.5  582.1  -6742.4   8976.4  582.1   8441.5
 -36.0  1117.0   8642.9  596.5  -6929.5   9163.4  596.5   8642.9
 -37.0  1117.0   8844.3  610.8  -7116.5   9350.4  610.8   8844.3
 -38.0  1117.0   9045.7  625.1  -7303.6   9537.5  625.1   9045.7
 -39.0  1117.0   9247.1  639.5  -7490.6   9724.5  639.5   9247.1
 -40.0  1117.0   9448.5  653.8  -7677.7   9911.6  653.8   9448.5
 -41.0  1117.0   9641.4  668.2  -7856.3  10090.2  668.2   9641.4
 -42.0  1117.0   9829.0  682.5  -8029.6  10263.5  682.5   9829.0
 -43.0  1117.0  10024.7  696.8  -8210.9  10444.8  696.8  10024.7
 -44.0  1117.0  10225.1  711.2  -8397.0  10630.9  711.2  10225.1
 -45.0  1117.0  10425.6  725.5  -8583.1  10817.1  725.5  10425.6
 -46.0  1117.0  10626.1  739.8  -8769.3  11003.2  739.8  10626.1
 -47.0  1117.0  10826.6  754.2  -8955.4  11189.4  754.2  10826.6
 -48.0  1117.0  11027.1  768.5  -9141.6  11375.5  768.5  11027.1
 -49.0  1117.0  11227.6  782.9  -9327.8  11561.7  782.9  11227.6
 -50.0  1117.0  11428.1  797.2  -9513.9  11747.8  797.2  11428.1
 -51.0  1117.0  11628.6  811.5  -9700.1  11934.0  811.5  11628.6
 -52.0  1117.0  11829.1  825.9  -9886.3  12120.2  825.9  11829.1
 -53.0  1117.0  12029.6  840.2 -10072.4  12306.3  840.2  12029.6
 -54.0  1117.0  12230.1  854.5 -10258.6  12492.5  854.5  12230.1
 -55.0  1117.0  12430.6  868.9 -10444.8  12678.7  868.9  12430.6
 -56.0  1117.0  12631.1  883.2 -10631.0  12864.9  883.2  12631.1
 -57.0  1117.0  12831.6  897.5 -10817.1  13051.1  897.5  12831.6
```

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-58.0  1117.0    13032.1     911.9  -11003.3   13237.2      911.9   13032.1
-59.0  1117.0    13232.6     926.2  -11189.5   13423.4      926.2   13232.6
-60.0  1117.0    13433.2     940.5  -11375.7   13609.6      940.5   13433.2
-61.0  1117.0    13633.7     954.9  -11561.9   13795.8      954.9   13633.7
-62.0  1117.0    13834.2     969.2  -11748.0   13982.0      969.2   13834.2
-63.0  1117.0    14034.7     983.5  -11934.2   14168.2      983.5   14034.7
-64.0  1117.0    14235.2     997.9  -12120.4   14354.3      997.9   14235.2
```

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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 9-JANUARY-2013                                         TIME: 10:09:54

                      ****************************
                      *   SUMMARY OF RESULTS FOR  *
                      *   CANTILEVER WALL DESIGN  *
                      ****************************

    I.--HEADING
     'S72 COFFER DAM WALL DESIGN -UPSTREAM CENTER

    II.--SUMMARY

        RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

        LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

      WALL BOTTOM ELEV. (FT)     :       -25.85
            PENETRATION (FT)     :        29.45

      MAX. BEND. MOMENT (LB-FT)  :   1.9876E+05
            AT ELEVATION (FT)    :       -11.18

      MAX. SCALED DEFL. (LB-IN^3):   2.3699E+11
            AT ELEVATION (FT)    :        26.00

                NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                       ELASTICITY IN PSI TIMES PILE MOMENT
                       OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                       IN INCHES.
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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 9-JANUARY-2013                                         TIME: 10:09:54

                      ****************************
                      * COMPLETE OF RESULTS FOR   *
                      *  CANTILEVER WALL DESIGN   *
                      ****************************

     I.--HEADING
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```
'S72 COFFER DAM WALL DESIGN -UPSTREAM CENTER

II.--RESULTSO. (LB))

              BENDING                              SCALED        NET
ELEVATION     MOMENT          SHEAR            DEFLECTION     PRESSURE
  (FT)        (LB-FT)          (LB)            (LB-IN^3)        (PSF)
  26.00     0.0000E+00            0.           2.3699E+11        0.00
  25.00    -8.1025E-08            0.           2.3014E+11        0.00
  24.00     8.3819E-09            0.           2.2330E+11        0.00
  23.00     8.3819E-09            0.           2.1645E+11        0.00
  22.00     8.3819E-09            0.           2.0960E+11        0.00
  21.50    -1.6205E-07            0.           2.0618E+11        0.00
  21.00     1.3000E+00            8.           2.0276E+11       31.20
  20.00     3.5100E+01           70.           1.9591E+11       93.60
  19.00     1.6250E+02          195.           1.8906E+11      156.00
  18.00     4.4590E+02          382.           1.8222E+11      218.40
  17.00     9.4770E+02          632.           1.7537E+11      280.80
  16.00     1.7303E+03          944.           1.6853E+11      343.20
  15.00     2.8561E+03         1318.           1.6169E+11      405.60
  14.00     4.3875E+03         1755.           1.5485E+11      468.00
  13.00     6.3869E+03         2254.           1.4802E+11      530.40
  12.00     8.9167E+03         2816.           1.4121E+11      592.80
  11.00     1.2039E+04         3440.           1.3441E+11      655.20
  10.00     1.5817E+04         4126.           1.2762E+11      717.60
   9.00     2.0313E+04         4875.           1.2087E+11      780.00
   8.00     2.5588E+04         5686.           1.1415E+11      842.40
   7.00     3.1706E+04         6560.           1.0748E+11      904.80
   6.00     3.8728E+04         7496.           1.0086E+11      967.20
   5.00     4.6718E+04         8494.           9.4311E+10     1029.60
   4.00     5.5737E+04         9555.           8.7840E+10     1092.00
   3.60     5.9648E+04         9997.           8.5278E+10     1116.96
   3.00     6.5838E+04        10623.           8.1466E+10      971.32
   2.60     7.0162E+04        10992.           7.8947E+10      874.22
   2.00     7.6906E+04        11473.           7.5206E+10      728.58
   1.00     8.8703E+04        12080.           6.9078E+10      485.84
   0.00     1.0099E+05        12445.           6.3104E+10      243.11
  -1.00     1.1351E+05        12567.           5.7305E+10        0.37
  -1.00     1.1351E+05        12570.           5.7305E+10        0.37
  -1.00     1.1353E+05        12570.           5.7296E+10        0.00
  -1.00     1.1353E+05        12565.           5.7296E+10        0.00
  -2.00     1.2604E+05        12444.           5.1702E+10     -242.37
  -3.00     1.3832E+05        12080.           4.6316E+10     -485.11
  -4.00     1.5012E+05        11474.           4.1170E+10     -727.84
  -5.00     1.6119E+05        10624.           3.6283E+10     -970.58
  -6.00     1.7128E+05         9532.           3.1674E+10    -1213.32
  -7.00     1.8017E+05         8198.           2.7361E+10    -1456.06
  -8.00     1.8760E+05         6620.           2.3359E+10    -1698.79
  -9.00     1.9333E+05         4800.           1.9681E+10    -1941.53
 -10.00     1.9712E+05         2737.           1.6337E+10    -2184.27
 -11.00     1.9872E+05          432.           1.3333E+10    -2427.00
 -12.00     1.9790E+05        -2117.           1.0672E+10    -2669.74
 -13.00     1.9441E+05        -4908.           8.3528E+09    -2912.48
 -14.00     1.8800E+05        -7942.           6.3691E+09    -3155.22
 -15.00     1.7844E+05       -11218.           4.7098E+09    -3397.95
 -16.00     1.6549E+05       -14738.           3.3583E+09    -3640.69
 -16.47     1.5814E+05       -16478.           2.8228E+09    -3754.91
 -17.00     1.4892E+05       -18301.           2.2923E+09    -3133.06
 -18.00     1.2925E+05       -20847.           1.4832E+09    -1958.52
 -18.40     1.2077E+05       -21536.           1.2240E+09    -1488.70
 -19.00     1.0762E+05       -22218.           8.9713E+08     -783.97
 -20.00     8.5206E+04       -22415.           4.9692E+08      390.58
 -21.00     6.3182E+04       -21437.           2.4401E+08     1565.13
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  -22.00      4.2723E+04         -19285.         1.0049E+08        2739.67
  -23.00      2.5004E+04         -15958.         3.1200E+07        3914.22
  -24.00      1.1200E+04         -11456.         5.6778E+06        5088.77
  -25.00      2.4837E+03          -5780.         2.4174E+05        6263.32
  -25.85      0.0000E+00              0.         0.0000E+00        7266.54

              NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                     ELASTICITY IN PSI TIMES PILE MOMENT
                     OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                     IN INCHES.

 III.--WATER AND SOIL PRESSURES

                               <-------------SOIL PRESSURES-------------->
                 WATER         <----LEFTSIDE----->       <---RIGHTSIDE---->
ELEVATION      PRESSURE        PASSIVE       ACTIVE       ACTIVE     PASSIVE
  (FT)           (PSF)          (PSF)         (PSF)        (PSF)       (PSF)
  26.00             0.             0.            0.           0.          0.
  25.00             0.             0.            0.           0.          0.
  24.00             0.             0.            0.           0.          0.
  23.00             0.             0.            0.           0.          0.
  22.00             0.             0.            0.           0.          0.
  21.50             0.             0.            0.           0.          0.
  21.00            31.             0.            0.           0.          0.
  20.00            94.             0.            0.           0.          0.
  19.00           156.             0.            0.           0.          0.
  18.00           218.             0.            0.           0.          0.
  17.00           281.             0.            0.           0.          0.
  16.00           343.             0.            0.           0.          0.
  15.00           406.             0.            0.           0.          0.
  14.00           468.             0.            0.           0.          0.
  13.00           530.             0.            0.           0.          0.
  12.00           593.             0.            0.           0.          0.
  11.00           655.             0.            0.           0.          0.
  10.00           718.             0.            0.           0.          0.
   9.00           780.             0.            0.           0.          0.
   8.00           842.             0.            0.           0.          0.
   7.00           905.             0.            0.           0.          0.
   6.00           967.             0.            0.           0.          0.
   5.00          1030.             0.            0.           0.          0.
   4.00          1092.             0.            0.           0.          0.
   3.60          1117.             0.            0.           0.          0.
   3.00          1117.           155.            9.           9.        155.
   2.60          1117.           258.           15.          15.        258.
   2.00          1117.           412.           24.          24.        412.
   1.00          1117.           670.           39.          39.        670.
   0.00          1117.           927.           53.          53.        927.
  -1.00          1117.          1185.           68.          68.       1185.
  -1.00          1117.          1185.           68.          68.       1185.
  -2.00          1117.          1443.           83.          83.       1443.
  -3.00          1117.          1700.           98.          98.       1700.
  -4.00          1117.          1958.          113.         113.       1958.
  -5.00          1117.          2215.          128.         128.       2215.
  -6.00          1117.          2473.          143.         143.       2473.
  -7.00          1117.          2730.          157.         157.       2730.
  -8.00          1117.          2988.          172.         172.       2988.
  -9.00          1117.          3246.          187.         187.       3246.
 -10.00          1117.          3503.          202.         202.       3503.
 -11.00          1117.          3761.          217.         217.       3761.
 -12.00          1117.          4018.          232.         232.       4018.
 -13.00          1117.          4276.          247.         247.       4276.
 -14.00          1117.          4534.          261.         261.       4534.
 -15.00          1117.          4791.          276.         276.       4791.
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 -16.00        1117.       5049.       291.        291.       5049.
 -16.47        1117.       5170.       298.        298.       5170.
 -17.00        1117.       5306.       306.        306.       5306.
 -18.00        1117.       5564.       321.        321.       5564.
 -18.40        1117.       4760.       322.        322.       4760.
 -19.00        1117.       4169.       334.        334.       4169.
 -20.00        1117.       5424.       367.        367.       5424.
 -21.00        1117.       5624.       381.        381.       5624.
 -22.00        1117.       5825.       396.        396.       5825.
 -23.00        1117.       6026.       410.        410.       6026.
 -24.00        1117.       6228.       424.        424.       6228.
 -25.00        1117.       6429.       439.        439.       6429.
 -25.85        1117.       6630.       453.        453.       6630.
 -27.00        1117.       6831.       467.        467.       6831.
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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 9-JANUARY-2013                                         TIME: 10:13:59

                              ****************
                              *  INPUT DATA  *
                              ****************

   I.--HEADING
   'S72 COFFER DAM WALL DESIGN -UPSTREAM MIDDLE

   II.--CONTROL
      CANTILEVER WALL DESIGN
      FACTOR OF SAFETY FOR ACTIVE PRESSURES  = 1.00
      FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.00

  III.--WALL DATA
      ELEVATION AT TOP OF WALL    = 26.00 FT.

   IV.--SURFACE POINT DATA

        IV.A.--RIGHTSIDE
           DIST. FROM     ELEVATION
           WALL (FT)        (FT)
               0.00         8.60
              50.00         8.60

        IV.B.--LEFTSIDE
           DIST. FROM     ELEVATION
           WALL (FT)        (FT)
               0.00         8.60
              50.00         8.60

    V.--SOIL LAYER DATA

       V.A.--RIGHTSIDE
           LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
           LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

                  ANGLE OF           ANGLE OF                            <-SAFETY->
  SAT.    MOIST   INTERNAL   COH-      WALL     ADH-     <--BOTTOM-->    <-FACTOR->
 WGHT.    WGHT.   FRICTION   ESION   FRICTION   ESION    ELEV.   SLOPE   ACT. PASS.
 (PCF)    (PCF)    (DEG)     (PSF)    (DEG)     (PSF)    (FT)   (FT/FT)
105.00   100.00    29.00      0.00    11.00      0.00     3.60    0.00    DEF   DEF
115.00   110.00    31.00      0.00    14.00      0.00   -18.40    0.00    DEF   DEF
110.00   105.00    30.00      0.00    11.00      0.00                     DEF   DEF

       V.B.--LEFTSIDE
           LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
           LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

                  ANGLE OF           ANGLE OF                            <-SAFETY->
  SAT.    MOIST   INTERNAL   COH-      WALL     ADH-     <--BOTTOM-->    <-FACTOR->
 WGHT.    WGHT.   FRICTION   ESION   FRICTION   ESION    ELEV.   SLOPE   ACT. PASS.
 (PCF)    (PCF)    (DEG)     (PSF)    (DEG)     (PSF)    (FT)   (FT/FT)
105.00   100.00    29.00      0.00    11.00      0.00     3.60    0.00    DEF   DEF
115.00   110.00    31.00      0.00    14.00      0.00   -18.40    0.00    DEF   DEF
110.00   105.00    30.00      0.00    11.00      0.00                     DEF   DEF

   VI.--WATER DATA
      UNIT WEIGHT          = 62.40 (PCF)
      RIGHTSIDE ELEVATION = 21.50 (FT)
      LEFTSIDE ELEVATION  = 8.60 (FT)
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      NO SEEPAGE

    VII.--VERTICAL SURCHARGE LOADS
          NONE

   VIII.--HORIZONTAL LOADS
          NONE




PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                              BY CLASSICAL METHODS
DATE: 9-JANUARY-2013                                            TIME: 10:14:03

                                  **************************
                                  *    SOIL PRESSURES FOR   *
                                  * CANTILEVER WALL DESIGN *
                                  **************************

    I.--HEADING
      'S72 COFFER DAM WALL DESIGN -UPSTREAM MIDDLE

   II.--SOIL PRESSURES

         RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

         LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

                                         <------NET------>
          NET      <---LEFTSIDE--->      (SOIL + WATER)     <--RIGHTSIDE--->
ELEV.    WATER     PASSIVE   ACTIVE     ACTIVE   PASSIVE     ACTIVE  PASSIVE
(FT)     (PSF)      (PSF)    (PSF)      (PSF)     (PSF)      (PSF)    (PSF)
 26.0      0.0        0.0      0.0        0.0       0.0        0.0      0.0
 25.0      0.0        0.0      0.0        0.0       0.0        0.0      0.0
 24.0      0.0        0.0      0.0        0.0       0.0        0.0      0.0
 23.0      0.0        0.0      0.0        0.0       0.0        0.0      0.0
 22.0      0.0        0.0      0.0        0.0       0.0        0.0      0.0
 21.5      0.0        0.0      0.0        0.0       0.0        0.0      0.0
 21.0     31.2        0.0      0.0       31.2      31.2        0.0      0.0
 20.0     93.6        0.0      0.0       93.6      93.6        0.0      0.0
 19.0    156.0        0.0      0.0      156.0     156.0        0.0      0.0
 18.0    218.4        0.0      0.0      218.4     218.4        0.0      0.0
 17.0    280.8        0.0      0.0      280.8     280.8        0.0      0.0
 16.0    343.2        0.0      0.0      343.2     343.2        0.0      0.0
 15.0    405.6        0.0      0.0      405.6     405.6        0.0      0.0
 14.0    468.0        0.0      0.0      468.0     468.0        0.0      0.0
 13.0    530.4        0.0      0.0      530.4     530.4        0.0      0.0
 12.0    592.8        0.0      0.0      592.8     592.8        0.0      0.0
 11.0    655.2        0.0      0.0      655.2     655.2        0.0      0.0
 10.0    717.6        0.0      0.0      717.6     717.6        0.0      0.0
  9.0    780.0        0.0      0.0      780.0     780.0        0.0      0.0
  8.6    805.0        0.0      0.0      805.0     805.0        0.0      0.0
  8.0    805.0      102.6      8.0      710.4     899.6        8.0    102.6
  7.6    805.0      171.0     13.3      647.3     962.6       13.3    171.0
  7.0    805.0      273.6     21.3      552.7    1057.2       21.3    273.6
  6.0    805.0      444.6     34.7      395.0    1214.9       34.7    444.6
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   5.0    805.0     615.6    48.0     237.4    1372.6     48.0     615.6
   4.0    805.0     786.6    61.3      79.7    1530.2     61.3     786.6
   3.8    805.0     868.3    63.3       0.0    1609.9     63.3     868.3
   3.6    805.0     954.7    65.4     -84.4    1694.3     65.4     954.7
   3.0    805.0    1198.5    71.1    -322.4    1932.3     71.1    1198.5
   2.0    805.0    1398.0    84.7    -508.4    2118.3     84.7    1398.0
   1.0    805.0    1652.4    99.6    -747.9    2357.8     99.6    1652.4
   0.0    805.0    1907.0   114.4    -987.6    2597.5    114.4    1907.0
  -1.0    805.0    2163.9   129.3   -1229.6    2839.5    129.3    2163.9
  -2.0    805.0    2420.9   144.2   -1471.8    3081.7    144.2    2420.9
  -3.0    805.0    2678.1   159.0   -1714.1    3324.0    159.0    2678.1
  -4.0    805.0    2935.3   173.9   -1956.5    3566.4    173.9    2935.3
  -5.0    805.0    3192.7   188.8   -2199.0    3808.9    188.8    3192.7
  -6.0    805.0    3450.1   203.6   -2441.5    4051.4    203.6    3450.1
  -7.0    805.0    3707.5   218.5   -2684.1    4294.0    218.5    3707.5
  -8.0    805.0    3964.9   233.3   -2926.6    4536.6    233.3    3964.9
  -9.0    805.0    4222.4   248.2   -3169.3    4779.2    248.2    4222.4
 -10.0    805.0    4479.9   263.0   -3411.9    5021.8    263.0    4479.9
 -11.0    805.0    4737.4   277.9   -3654.5    5264.5    277.9    4737.4
 -12.0    805.0    4994.9   292.8   -3897.2    5507.1    292.8    4994.9
 -13.0    805.0    5252.5   307.6   -4139.9    5749.8    307.6    5252.5
 -14.0    805.0    5510.0   322.5   -4382.6    5992.5    322.5    5510.0
 -15.0    805.0    5767.5   337.3   -4625.2    6235.2    337.3    5767.5
 -16.0    805.0    6025.1   352.2   -4867.9    6477.9    352.2    6025.1
 -17.0    805.0    6282.6   367.0   -5110.6    6720.6    367.0    6282.6
 -18.0    805.0    6540.2   381.9   -5353.3    6963.3    381.9    6540.2
 -18.4    805.0    5505.1   380.0   -4320.1    5930.0    380.0    5505.1
 -19.0    805.0    4757.2   391.9   -3560.3    5170.2    391.9    4757.2
 -20.0    805.0    6327.4   431.0   -5091.5    6701.4    431.0    6327.4
 -21.0    805.0    6528.3   445.4   -5278.0    6887.9    445.4    6528.3
 -22.0    805.0    6729.2   459.7   -5464.5    7074.4    459.7    6729.2
 -23.0    805.0    6930.2   474.1   -5651.1    7261.1    474.1    6930.2
 -24.0    805.0    7131.2   488.4   -5837.8    7447.7    488.4    7131.2
 -25.0    805.0    7332.3   502.8   -6024.5    7634.4    502.8    7332.3
 -26.0    805.0    7533.4   517.1   -6211.3    7821.2    517.1    7533.4
 -27.0    805.0    7734.5   531.5   -6398.1    8008.0    531.5    7734.5
 -28.0    805.0    7935.7   545.8   -6584.9    8194.8    545.8    7935.7
 -29.0    805.0    8136.9   560.2   -6771.7    8381.7    560.2    8136.9
 -30.0    805.0    8338.1   574.5   -6958.6    8568.5    574.5    8338.1
 -31.0    805.0    8539.4   588.9   -7145.5    8755.4    588.9    8539.4
 -32.0    805.0    8740.6   603.2   -7332.4    8942.4    603.2    8740.6
 -33.0    805.0    8941.9   617.6   -7519.4    9129.3    617.6    8941.9
 -34.0    805.0    9143.2   631.9   -7706.3    9316.3    631.9    9143.2
 -35.0    805.0    9344.5   646.2   -7893.3    9503.2    646.2    9344.5
 -36.0    805.0    9544.8   660.6   -8079.2    9689.1    660.6    9544.8
 -37.0    805.0    9732.6   674.9   -8252.8    9862.7    674.9    9732.6
 -38.0    805.0    9921.1   689.3   -8426.9   10036.8    689.3    9921.1
 -39.0    805.0   10121.5   703.6   -8613.0   10222.9    703.6   10121.5
 -40.0    805.0   10321.9   717.9   -8799.0   10409.0    717.9   10321.9
 -41.0    805.0   10522.3   732.3   -8985.1   10595.0    732.3   10522.3
 -42.0    805.0   10722.8   746.6   -9171.2   10781.1    746.6   10722.8
 -43.0    805.0   10923.2   760.9   -9357.3   10967.2    760.9   10923.2
 -44.0    805.0   11123.6   775.3   -9543.4   11153.3    775.3   11123.6
```

```
MAX. BEND. MOMENT (LB-FT)  :  2.3461E+04
      AT ELEVATION (FT)    :        4.60

MAX. SCALED DEFL. (LB-IN^3):  8.4777E+09
      AT ELEVATION (FT)    :       26.00

          NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                 ELASTICITY IN PSI TIMES PILE MOMENT
                 OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                 IN INCHES.



PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 9-JANUARY-2013                                          TIME: 10:16:02

                        ****************************
                        * COMPLETE OF RESULTS FOR  *
                        *  CANTILEVER WALL DESIGN  *
                        ****************************

   I.--HEADING
   'S72 COFFER DAM WALL DESIGN -UPSTREAM UPPER

  II.--RESULTS0. (LB))

               BENDING                             SCALED          NET
 ELEVATION     MOMENT           SHEAR           DEFLECTION      PRESSURE
   (FT)        (LB-FT)           (LB)           (LB-IN^3)         (PSF)
   26.00     0.0000E+00            0.           8.4777E+09         0.00
   25.00     2.2701E-09            0.           8.0502E+09         0.00
   24.00     2.2701E-09            0.           7.6227E+09         0.00
   23.00    -5.2387E-10            0.           7.1952E+09         0.00
   22.00    -5.2387E-10            0.           6.7677E+09         0.00
   21.50     4.5402E-09            0.           6.5540E+09         0.00
   21.00     1.3000E+00            8.           6.3402E+09        31.20
   20.00     3.5100E+01           70.           5.9127E+09        93.60
   19.00     1.6250E+02          195.           5.4853E+09       156.00
   18.00     4.4590E+02          382.           5.0582E+09       218.40
   17.00     9.4770E+02          632.           4.6319E+09       280.80
   16.00     1.7303E+03          944.           4.2072E+09       343.20
   15.00     2.8561E+03         1318.           3.7856E+09       405.60
   14.00     4.3875E+03         1755.           3.3690E+09       468.00
   13.60     5.1276E+03         1947.           3.2044E+09       492.96
   13.00     6.3790E+03         2215.           2.9601E+09       398.36
   12.60     7.2950E+03         2361.           2.7994E+09       335.29
   12.00     8.7665E+03         2534.           2.5622E+09       240.69
   11.00     1.1395E+04         2696.           2.1795E+09        83.03
   10.47     1.2822E+04         2718.           1.9856E+09         0.00
   10.00     1.4106E+04         2700.           1.8165E+09       -74.64
    9.00     1.6742E+04         2547.           1.4779E+09      -232.30
    8.00     1.9147E+04         2236.           1.1682E+09      -389.97
    7.00     2.1161E+04         1767.           8.9149E+08      -547.63
    6.00     2.2628E+04         1140.           6.5128E+08      -705.30
    5.00     2.3389E+04          356.           4.5007E+08      -862.97
    4.00     2.3287E+04         -586.           2.8916E+08     -1020.63
    3.60     2.2963E+04        -1059.           2.3608E+08     -1346.93
    3.00     2.2062E+04        -1982.           1.6832E+08     -1727.95
    2.00     1.9213E+04        -3719.           8.5372E+07     -1747.01
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   1.67        1.7888E+04          -4310.          6.5534E+07        -1827.04
   1.00        1.4659E+04          -5236.          3.5370E+07         -940.99
   0.00        9.1725E+03          -5516.          1.0564E+07          382.28
  -1.00        4.0686E+03          -4472.          1.6625E+06         1705.54
  -2.00        6.7019E+02          -2105.          3.7334E+04         3028.81
  -2.61        0.0000E+00             0.           0.0000E+00         3839.71

              NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                     ELASTICITY IN PSI TIMES PILE MOMENT
                     OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                     IN INCHES.

 III.--WATER AND SOIL PRESSURES

                                <-------------SOIL PRESSURES-------------->
                   WATER        <----LEFTSIDE----->      <---RIGHTSIDE---->
 ELEVATION       PRESSURE       PASSIVE      ACTIVE      ACTIVE     PASSIVE
   (FT)            (PSF)        (PSF)        (PSF)       (PSF)       (PSF)
  26.00               0.            0.           0.          0.          0.
  25.00               0.            0.           0.          0.          0.
  24.00               0.            0.           0.          0.          0.
  23.00               0.            0.           0.          0.          0.
  22.00               0.            0.           0.          0.          0.
  21.50               0.            0.           0.          0.          0.
  21.00              31.            0.           0.          0.          0.
  20.00              94.            0.           0.          0.          0.
  19.00             156.            0.           0.          0.          0.
  18.00             218.            0.           0.          0.          0.
  17.00             281.            0.           0.          0.          0.
  16.00             343.            0.           0.          0.          0.
  15.00             406.            0.           0.          0.          0.
  14.00             468.            0.           0.          0.          0.
  13.60             493.            0.           0.          0.          0.
  13.00             493.          103.           8.          8.        103.
  12.60             493.          171.          13.         13.        171.
  12.00             493.          274.          21.         21.        274.
  11.00             493.          445.          35.         35.        445.
  10.47             493.          535.          42.         42.        535.
  10.00             493.          616.          48.         48.        616.
   9.00             493.          787.          61.         61.        787.
   8.00             493.          958.          75.         75.        958.
   7.00             493.         1129.          88.         88.       1129.
   6.00             493.         1300.         101.        101.       1300.
   5.00             493.         1471.         115.        115.       1471.
   4.00             493.         1642.         128.        128.       1642.
   3.60             493.         1972.         132.        132.       1972.
   3.00             493.         2357.         136.        136.       2357.
   2.00             493.         2385.         146.        146.       2385.
   1.67             493.         2470.         150.        150.       2470.
   1.00             493.         2643.         160.        160.       2643.
   0.00             493.         2900.         175.        175.       2900.
  -1.00             493.         3153.         190.        190.       3153.
  -2.00             493.         3404.         205.        205.       3404.
  -2.61             493.         3660.         220.        220.       3660.
  -4.00             493.         3917.         235.        235.       3917.
```

Attachment 5

Detailed Cost Estimate

Cost Estimate for S-82 Concrete Repair and Gates Replacement of a Spillway Concrete Structure

Description				Total
Civil Work Direct Cost				$788,429
Structural Work Direct Cost				$731,229
Total Direct Cost				**$1,519,658**
Mobilization	8%			$121,573
Field and Office Overhead	6%			$91,179
Subtotal Cost With Overhead				**$1,732,410**
Sales Tax 6.5% of 20% total Cost	6.5%			$22,521
Profit	10%			$173,241
Construction Cost				**$1,928,172**
Bonds	1.5%			$28,923
Contingency	5%			$96,409
Total Project Construction Cost				**$2,053,503**
	Low Range -5%			**$1,950,828**
	High Range +5%			**$2,156,178**

Estimator: Jack Ismalon

7/17/2013

Cost Estimate for S-82 Concrete Repair and Gates Replacement of a Spillway Concrete Structure

CIVIL WORK				
Description	**Qty**	**Unit**	**Unit Cost**	**Total**
Erosion control, silt fence, adverse conditions, 3' high	900	L.F.	$2.54	$2,286
Floating turbidity barriers @ 20 ' depth	330.0	L.F.	$37.80	$12,474
Additional cost for standby barge	6.0	Month	$8,975.00	$53,850
Attached Sheet Pile Connections to the existing concrete abetments, using chemical anchored, includes. Layout, drilling, threaded rod & epoxy cartridge	4.0	Ea.	$6,500.00	$26,000
Sheet piling, (HZ 1180 MD @ 97.82 lb./sf, using 55' long, drive, extract and salvage, (Two Phase Installation)	10,230	S.F.	$26.00	$265,980
Hydrophilic Grout on the upper and lower streams of he structure	7,560	LB	$20.00	$151,200
Maintain structure dewatering, Includes fuel and discharge pipes	6	Month	$18,000	$108,000
Install Staff gauge (Concrete Pile - Mounted)	2	Ea.	$4,735	$9,470
Replace existing Stilling Wells with (Platform-Mounted)(F&I)	1	Ea.	$35,000	$35,000
Replace guardrail (Roadway)	124	L.F.	$110	$13,640
Sodding, placed and staked	3,867	S.Y.	$3.92	$15,159
Install fall protection	4	L.F.	$2,620	$10,480
Concrete (Approach Slab)	7	C.Y.	$320	$2,240
Platform (Grating) to approach the stilling well	75	S.F.	$102	$7,650
Rubble Riprap (Incl. Bedding Stone & Fabric)	1000	Ton	$75	$75,000
	Construction Direct Cost:			**$788,429**

Cost Estimate for S-82 Concrete Repair and Gates Replacement of a Spillway Concrete Structure

STRUCTURE WORK				
Description	**Qty**	**Unit**	**Unit Cost**	**Total**
Cutout and remove (3 in) depth from the existing reinforced concrete walls, slabs, and weir	4,197	S.F.	$24.71	$103,707.87
Sandblast concrete, walls, slabs, and weir	4,197	S.F.	$4.42	$18,550.74
Attaching welded-wire mesh to the existing concrete walls	4,197	S.F.	$4.12	$17,291.64
Wall Formwork for self-consolidating concrete	2,076	S.F.	$35.78	$74,279.28
Self-consolidating concrete on wall, slab, and weir	39	C.Y.	$400.00	$15,600.00
Stainless Steel plates along the weir (1/8" thick, includes gasket and bolts	997	S.F.	$18.00	$17,946.00
Needle Beam Groove Lower and Upper Detail Stainless Steel needle sill plate, includes gasket and bolts	2,100	Lb.	$12.00	$25,200.00
Gate Groove Detail	6540	Lb.	$8.50	$55,590.00
F&I Stainless Steel Railing,	6,120	Lb.	$8.50	$52,020.00
Fabricate and Deliver two (2) Roller Gate (Stainless Steel) (Two 23'-7" x 7'-3")	24,560	Lb..	$7.94	$195,006.40
Additional cost for Brass Hex Nuts	1	L.S.	$1,075.00	$1,075.00
Install Two Stainless Steel (304) Gates	2	Ea.	$20,000.00	$40,000.00
Dewatering Beam Recess (Repair)	8	EA	$2,500.00	$20,000.00
Concrete Repairs (Service Bridge and Platforms)	1	LS	$15,000.00	$15,000.00
Anchor Bolts(Platform)(Remove & Replace)(3/4"Øx10"SST Bolts)	30	EA	$28.00	$840.00
Structure Railing (42"High)(Galvanized)(F&I)	280	LF	$84.00	$23,520.00
Structure (Recoat)	4,254	SF	$4.25	$18,079.50
Steel Sheet Piles Cap (Remove & Replace)	90	LF	$124.00	$11,160.00
Pile Caps	4	EA	$2,500.00	$10,000.00
Recoating sheet piles	1,870	S.F.	$8.75	$16,362.50
	Construction Direct Cost:			**$731,229**

7/17/2013 Estimator: Jack Ismalon

Cost Estimate for S-75 Concrete Repair and Gate Replacement of a Spillway Concrete Structure

Description				Total
Civil Work Direct Cost				$550,185
Structural Work Direct Cost				$466,774
Total Direct Cost				**$1,016,959**
Mobilization	8%			$81,357
Field and Office Overhead	6%			$61,018
Subtotal Cost With Overhead				**$1,159,333**
Sales Tax 6.5% of 20% total Cost	6.5%			$15,071
Profit	10%			$115,933
Construction Cost				**$1,290,338**
Bonds	1.5%			$19,355
Contingency	5%			$64,517
Total Project Construction Cost				**$1,374,210**
	Low Range -5%			**$1,305,499**
	High Range +5%			**$1,442,920**

Estimator: Jack Ismalon

7/17/2013

S-75 Structure Concrete Repairs and Gate Replacement

CIVIL WORK				
Description	**Qty**	**Unit**	**Unit Cost**	**Total**
Erosion control, silt fence, adverse conditions, 3' high	825	L.F.	$2.54	$2,096
Floating turbidity barriers @ 20 ' depth	315	L.F.	$37.80	$11,907
Sheet piling, @ 40' long, drive, extract and salvage, includes wales, (Two Phase Installation)	10,305	S.F.	$22.00	$226,710
Maintain structure dewatering, Includes fuel and discharge pipes	6	Month	$18,000	$108,000
Install Staff gauge (Concrete Pile - Mounted)	2	Ea.	$4,735	$9,470
Replace existing Stilling Wells with (Platform-Mounted)(F&I)	2	Ea.	$35,000	$70,000
Sodding, placed and staked	1,875	S.Y.	$3.92	$7,350
Replace (Roadway) guardrail	120	L.F.	$110	$13,200
Install fall protection	2	L.F.	$2,620	$5,240
Concrete (Approach Slab)(F&I)	7	C.Y.	$320	$2,240
Platform (Grating) to approach the stilling well	186	S.F.	$102	$18,972
Rubble Riprap (F&I)(Incl. Bedding Stone & Fabric)	1000	TN	$75	$75,000
	Construction Direct Cost:			**$550,185**

S-75 Structure Concrete Repairs and Gate Replacement

STRUCTURE WORK				
Description	**Qty**	**Unit**	**Unit Cost**	**Total**
Cutout and remove (3 in) depth from the existing reinforced concrete walls, slabs, and weir	2,595	S.F.	$24.71	$64,122.45
Sandblast concrete, walls, slabs, and weir	2,595	S.F.	$4.42	$11,469.90
Attaching welded-wire mesh to the existing concrete walls	2,595	S.F.	$4.12	$10,691.40
Wall Formwork for self-consolidating concrete	1,842	S.F.	$35.78	$65,906.76
Self-consolidating concrete on wall, slab, and weir	20	C.Y.	$400.00	$8,080.00
Stainless Steel plates along the weir (1/8" thick, includes gasket and bolts	711	S.F.	$18.00	$12,798.00
Needle Beam Groove Lower and Upper Detail Stainless Steel needle sill plate, includes gasket and bolts	1,050	Lb.	$12.00	$12,600.00
F&I Stainless Steel Railing,	3,100	Lb.	$8.50	$26,350.00
Fabricate and Deliver Roller Gate (Stainless Steel) (One 28'-91/4" x 10'-0")	18,480	Lb.	$7.94	$146,731.20
Additional cost for Brass Hex Nuts	1	L.S.	$500.00	$500.00
Install one Stainless Steel (304) Gates	1	Ea.	$20,000.00	$20,000.00
Dewatering Beam Recess (Repair)	4	EA	$2,500.00	$10,000.00
Concrete Repairs (Service Bridge and Platforms)	1	LS	$8,000.00	$8,000.00
Anchor Bolts(Platform)(Remove & Replace)(3/4"Øx10"SST Bolts)	30	EA	$28.00	$840.00
Structure Railing (Remove)	143	LF	$8.50	$1,215.50
Structure Railing (42"High)(Galvanized)(F&I)	273	LF	$84.00	$22,932.00
Structure (Recoat)	1,036	SF	$4.25	$4,404.46
Steel Sheet Piles Cap (Remove & Replace)	111	LF	$124.00	$13,770.13
Pile Caps	4	Ea.	$2,500.00	$10,000.00
Recoating sheet piles	1,870	S.F.	$8.75	$16,362.50
	Construction Direct Cost:			**$466,774**

7/17/2013

Estimator: Jack Ismalon

Cost Estimate for S-72 Concrete Repair and Gates Replacement of a Spillway Concrete Structure

Description				Total
Civil Work Direct Cost				$1,039,884
Structural Work Direct Cost				$1,047,628
Total Direct Cost				**$2,087,513**
Mobilization	8%			$167,001
Field and Office Overhead	6%			$125,251
Subtotal Cost With Overhead				**$2,379,764**
Sales Tax 6.5% of 20% total Cost	6.5%			$30,937
Profit	10%			$237,976
Construction Cost				**$2,648,678**
Bonds	1.5%			$39,730
Contingency	5%			$132,434
Total Project Construction Cost				**$2,820,842**
	Low Range -5%			**$2,679,800**
	High Range +5%			**$2,961,884**

Estimator: Jack Ismalon

7/17/2013

S-72 Structure Concrete Repairs and Gates Replacement

CIVIL WORK				
Description	**Qty**	**Unit**	**Unit Cost**	**Total**
Erosion control, silt fence, adverse conditions, 3' high	380	L.F.	$2.54	$965
Floating turbidity barriers @ 20 ' depth	379.5	L.F.	$37.80	$14,345
Additional cost for standby barge	6.0	Month	$8,975.00	$53,850
Attached Sheet Pile Connections to the existing concrete abetments, Using Chemical anchor, 1-3/4" Dia. x 15" L, incl. layout, drilling, threaded rod & epoxy cartridge	4	Ea.	$6,500.00	$26,000
Sheet piling, (HZ 1180 MD @ 97.82 lb./sf, using 55' long, drive, extract and salvage, (Two Phase Installation)	18,495	S.F.	$26.00	$480,870
Hydrophilic Grout on the upper and lower streams of the structure	7,560	LB	$20.00	$151,200
Maintain structure dewatering, Includes fuel and discharge pipes	6	Month	$18,000	$108,000
Install Staff gauge (Concrete Pile - Mounted)	2	Ea.	$4,735	$9,470
Replace existing Stilling Wells with (Platform-Mounted)(F&I)	2	Ea.	$35,000	$70,000
Sodding, placed and staked	1,350	S.Y.	$3.92	$5,292
Replace (Roadway) guardrail	120	L.F.	$110	$13,200
Install fall protection	4	L.F.	$2,620	$10,480
Concrete (Approach Slab)	7	C.Y.	$320	$2,240
Platform (Grating) to approach the stilling well	186	S.F.	$102	$18,972
Rubble Riprap (Incl. Bedding Stone & Fabric)	1000	Ton	$75	$75,000
	Construction Direct Cost:			**$1,039,884**

S-72 Structure Concrete Repairs and Gates Replacement

STRUCTURE WORK				
Description	**Qty**	**Unit**	**Unit Cost**	**Total**
Cutout and remove (3 in) depth from the existing reinforced concrete walls, slabs, and weir	6,108	S.F.	$24.71	$150,928.68
Sandblast concrete, walls, slabs, and weir	6,108	S.F.	$4.42	$26,997.36
Attaching welded-wire mesh to the existing concrete walls	6,108	S.F.	$4.12	$25,164.96
Wall Formwork for self-consolidating concrete	4,272	S.F.	$35.78	$152,852.16
Self-consolidating concrete on wall, slab, and weir	57	C.Y.	$400.00	$22,800.00
Stainless Steel plates along the weir (1/8" thick, includes gasket and bolts	998	S.F.	$18.00	$17,964.00
Needle Beam Groove Lower and Upper Detail Stainless Steel needle sill plate, includes gasket and bolts	1,050	L.b	$12.00	$12,600.00
Gate Groove Detail	6540	L.b	$8.50	$55,590.00
F&I Stainless Steel Railing,	6,120	L.b	$8.50	$52,020.00
Fabricate and Deliver two (2) Roller Gate (Stainless Steel) (Two 27'-91/4" x 12'-3/4")	46,480	L.b.	$7.94	$369,051.20
Additional cost for Brass Hex Nut	1	L.S	$2,500.00	$2,500.00
Install Two Stainless Steel (304) Gates	2	Ea.	$20,000.00	$40,000.00
Dewatering Beam Recess (Repair)	8	EA	$2,500.00	$20,000.00
Concrete Repairs (Service Bridge and Platforms)	1	LS	$15,000.00	$15,000.00
Anchor Bolts(Platform)(Remove & Replace)(3/4"Øx10"SST Bolts)	30	EA	$28.00	$840.00
Structure Railing (Remove)	260	LF	$8.50	$2,211.42
Structure Railing (42"High)(Galvanized)(F&I)	390	LF	$84.00	$32,774.00
Structure (Recoat)	2,544	SF	$4.25	$10,812.00
Steel Sheet Piles Cap (Remove & Replace)	90	LF	$124.00	$11,160.00
Pile Caps	4	Ea.	$2,500.00	$10,000.00
Recoating sheet piles	1,870	S.F.	$8.75	$16,362.50
			Construction Direct	**$1,047,628**

7/17/2013

Estimator: Jack Ismalon

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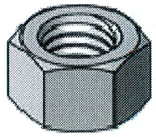
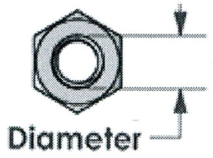
Stainless steel 18-8



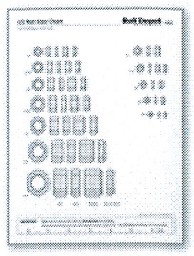
Nut size (A.K.A. diameter) is the size bolt that the nut is used with. The same is true of the thread count. Thus a 1/4"-20 nut fits a 1/4"-20 bolt.



Resources

US Nut sizes

US Nut dimention table



« Hide Bulk | Add All Entered

Product #	Diameter and Thread count	Buy Each	Buy Box	Box Qty	Buy Bulk	Bulk Qty
					Coarse (standard) thread	
2563	1/4"-20	$0.08 Add	$4.97 Add	100	$42.50 Add	1000
2564	5/16"-18	$0.10 Add	$6.45 Add	100	$55.00 Add	1000
2565	3/8"-16	$0.15 Add	$10.50 Add	100	$89.40 Add	1000
5574	7/16"-14	$0.33 Add	$11.59 Add	50	$99.50 Add	500
2566	1/2"-13	$0.35 Add	$11.99 Add	50	$103.00 Add	500
2567	5/8"-11	$0.64 Add	$12.39 Add	25	$106.00 Add	250
2568	3/4"-10	$0.90 Add	$14.97 Add	20	$129.00 Add	200
4068	7/8"-9	$2.08 Add	$33.85 Add	20	$289.00 Add	200
4069	1"-8	$2.59 Add	$43.17 Add	20	$380.00 Add	200
					Fine thread	
5260	1/4"-28	$0.12 Add	$6.50 Add	100	$56.50 Add	1000
5261	5/16"-24	$0.14 Add	$9.34 Add	100	$80.60 Add	1000
5262	3/8"-24	$0.20 Add	$12.22 Add	100	$106.00 Add	1000
5263	7/16"-20	$0.37 Add	$13.14 Add	50	$114.00 Add	500
5264	1/2"-20	$0.41 Add	$15.54 Add	50	$135.00 Add	500
5265	5/8"-18	$1.10 Add	$21.12 Add	25	$190.00 Add	250
5266	3/4"-16	$1.43 Add	$25.28 Add	20	$228.00 Add	200

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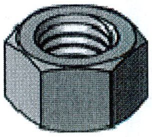
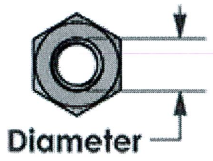
Brass



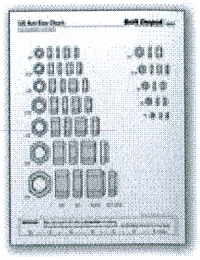
Nut size (A.K.A. diameter) is the size bolt that the nut is used with. The same is true of the thread count. Thus a 1/4"-20 nut fits a 1/4"-20 bolt.



Resources

US Nut sizes

US Nut dimention table



« Hide Bulk | Add All Entered

Product #	Diameter and Thread count	Buy Each			Buy Box			Box Qty	Buy Bulk			Bulk Qty
									Coarse (standard) thread			
4152	1/4"-20	$0.21		Add	$13.63		Add	100	$122.00		Add	1000
4153	5/16"-18	$0.36		Add	$21.94		Add	100	$197.00		Add	1000
4154	3/8"-16	$0.54		Add	$33.55		Add	100	$302.00		Add	1000
4155	7/16"-14	$1.04		Add	$38.09		Add	50	$343.00		Add	500
4158	1/2"-13	$1.07		Add	$38.68		Add	50	$348.00		Add	500
4159	5/8"-11	$1.86		Add	$34.42		Add	25	$310.00		Add	250
4160	3/4"-10	$2.84		Add	$44.81		Add	20	$403.00		Add	200
4161	7/8"-9	$6.97		Add	$76.44		Add	15	$688.00		Add	150
4162	1"-8	$10.04		Add	$80.04		Add	10	$720.00		Add	100
									Fine thread			
10520	1/4"-28	$0.38		Add	$23.09		Add	100	$208.00		Add	1000
10521	5/16"-24	$0.50		Add	$32.08		Add	100	$289.00		Add	1000
10522	3/8"-24	$0.72		Add	$45.06		Add	100	$405.00		Add	1000
10523	7/16"-20	$1.40		Add	$49.72		Add	50	$447.00		Add	500
10524	1/2"-20	$1.45		Add	$50.67		Add	50	$456.00		Add	500
10525	5/8"-18	$3.00		Add	$53.64		Add	25	$483.00		Add	250
10526	3/4"-16	$4.43		Add	$65.02		Add	20	$585.00		Add	200

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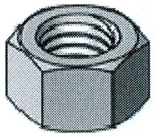
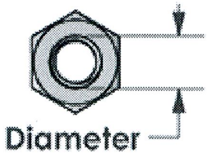
Silicon bronze



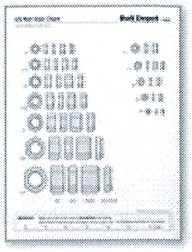
Nut size (A.K.A. diameter) is the size bolt that the nut is used with. The same is true of the thread count. Thus a 1/4"-20 nut fits a 1/4"-20 bolt.



Resources

US Nut sizes

US Nut dimention table



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Product #	Diameter and Thread count	Buy Each	Buy Box	Box Qty	Buy Bulk	Bulk Qty
						Coarse (standard) thread
3481	1/4"-20	$0.27 Add	$18.35 Add	100	$170.00 Add	1000
3482	5/16"-18	$0.46 Add	$31.81 Add	100	$288.00 Add	1000
3483	3/8"-16	$0.59 Add	$39.96 Add	100	$368.00 Add	1000
3484	7/16"-14	$1.26 Add	$51.66 Add	50	$480.00 Add	500
3485	1/2"-13	$1.46 Add	$59.07 Add	50	$543.00 Add	500
3486	5/8"-11	$3.75 Add	$73.51 Add	25	$683.00 Add	250
3487	3/4"-10	$7.95 Add	$119.75 Add	20	$1,113.00 Add	200

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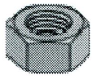
See also



Metric hex nuts
A standard six sided nut.

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