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TECHNICAL MEMORANDUM

To: Barefoot Resort Residential Association (BRRA)

From: Ardurra Group, Inc.

Subject: Evaluation of Erosion Prevention & Slope Stabilization Alternatives

Project: (BRRA) Drainage Outfall Canal Erosion Evaluation – Phase 1

Project No.: 2020-0353-00

Date: December 1, 2020

BACKGROUND

The Barefoot Resort Residential Association, (BRRA), located in North Myrtle Beach, South Carolina, has retained the Ardurra Group, Inc. to evaluate a severely eroded drainage outfall canal, located immediately east of the Harbour Cove development, which conveys stormwater through several communities within the Barefoot Resort Development. The Phase 1 scope of this evaluation focuses on a reach of this canal, located southeast of Barefoot Resort Bridge Road, where the erosion was observed to have occurred and continues to occur near the stormwater pond and other localized areas along the canal bank. This on-going erosion of the canal bank has the potential to threat existing improvements within the Harbour Cove Condominium development. No occupied structures within the Harbour Cove development are currently at risk; however, an existing stormwater detention pond could be breached if erosion continues unabated. Refer to the Figure 1 for the location of the subject project area.

The BRRA has also authorized Ardurra to perform another phase (Phase 2) of the drainage canal erosion evaluation. The Phase 2 scope will evaluate erosion issues along the canal reach that is upstream of the Phase 1 study reach and north of Barefoot Resort Bridge Road; (refer to Figure 1). Like the first phase, recommendations to restore and to permanently stabilize the canal banks will be addressed in Phase 2. An amendment to the Phase 1 Technical Memorandum will be issued for the Phase 2 evaluation.

The ultimate purpose of the Phase 1 evaluation is to develop long-term solutions to permanently stabilize the canal slope on the Harbour Cove side of the canal and Harbour Cove's property from future damage. This analysis and discussion will address various alternatives to repair and to permanently stabilize the canal slope.

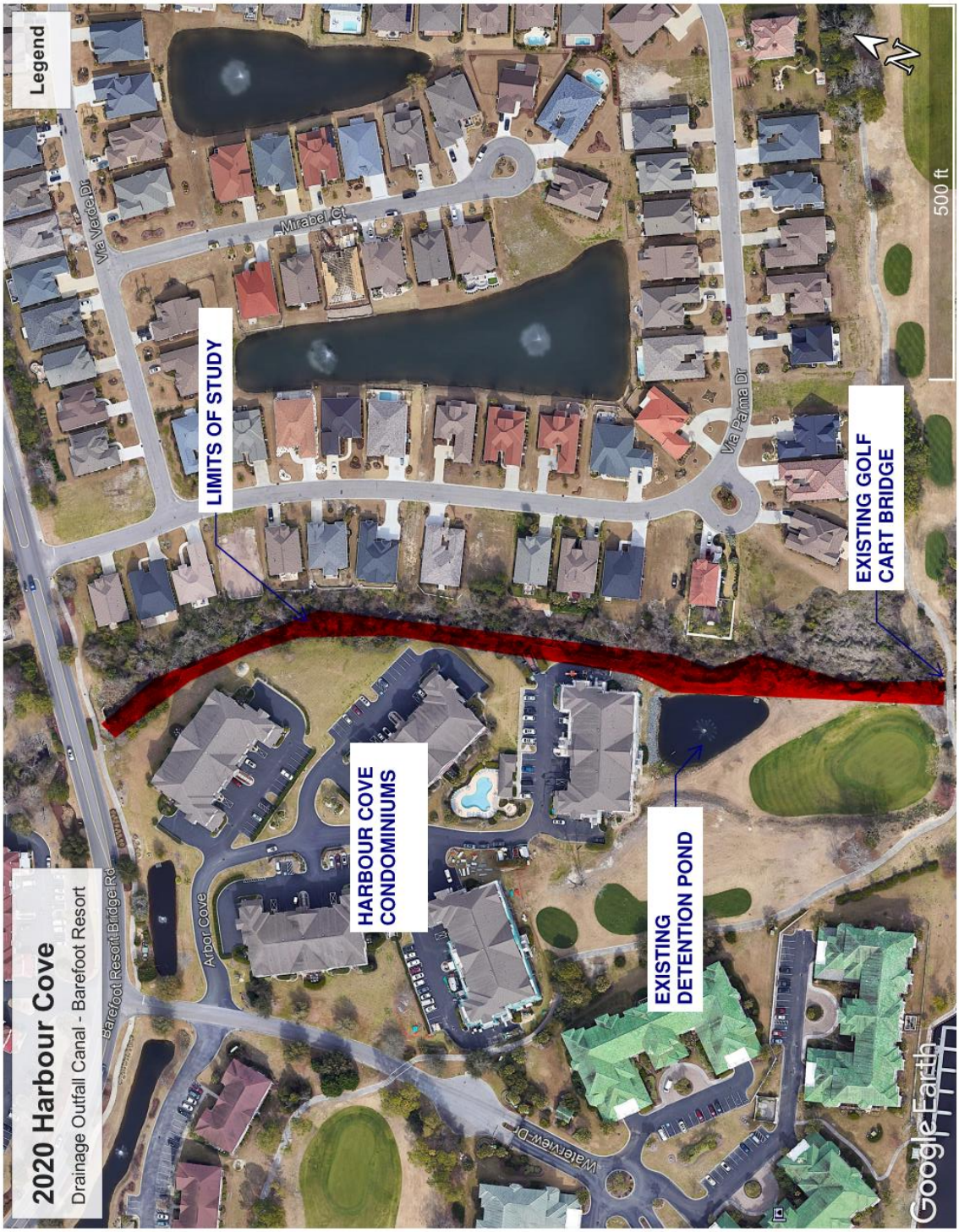

Figure 1 – Aerial Map of the Phase 1 Study Reach

SITE RECONNAISANCE

On July 27th, 2020, representatives of the BRRA and Ardurra met on-site to recon the current condition of the subject canal, discuss the scope of work, and to inspect the erosion along the Harbour Cove side of this canal. The canal is overgrown with vegetation and mature trees, making it difficult to clearly assess the full extent of the damage to its slope. Furthermore, this vegetation and tree density within the canal decreases the hydraulic flow capacity canal. Excessive overgrowth of trees and other vegetation within the canal section increases resistance to flow; thereby, decreasing hydraulic capacity.

On the Harbour Cove side of the canal, erosion of the side slope is moderate to severe; however, no occupied structures are threatened. There are two (2), separate concrete retaining walls along the canal, which provide support to existing parking lots within the Harbour Cove development. These walls are not connected, and the areas beyond the wall limits are not protected other than by vegetative cover. The BRRA representatives expressed concern about the potential for damage to the stormwater detention pond if erosion prevention measures were not implemented at this location.

Figure 2 – Canal Slope Erosion at the Hidden Cove Detention Pond

At the upstream end of this canal, dual 8-ft. by 8-ft. concrete box culverts are installed under Barefoot Resort Bridge Road. The outfall and side slope of the canal are armored with riprap. Some of the riprap appears to have been displaced by high flows. Erosion of the canal bank was observed; however, it is not as severe as areas downstream and the roadway is not at risk.

Record drawings, furnished by the BRRA, show that the Harbour Cove site was constructed on imported fill. During our site visit, we observed that this fill material did not appear to be a cohesive soil and, although it may have been suitable for structural foundations, this fill material is highly susceptible to the erosive forces generated in the drainage canal; (refer to Figure 2).

Finally, we observed that existing bulkhead abutment walls, which provide support for the existing golf cart bridge, appear to reduce the channel cross-section at the cart crossing; (refer to Figure 3). This restriction, in combination with decreased flow capacity in the canal because of dense vegetation and trees, can cause flow to surcharge upstream of the bridge. This surcharging may cause eddy currents to form along the flow boundary. The swirling action of these eddies exacerbate erosion of the canal slope during moderate to high flow events.

Figure 3 – Golf Cart Bridge

Figure 4 – Golf Cart Bridge Canal Constriction

EROSION PREVENTION & SLOPE STABILIZATION ALTERNATIVES

In the following sections, we will present four (4) - alternatives for the permanent stabilization of the drainage canal slope. The main goals for the alternatives considered are to restore the canal slope and to protect property from the erosive forces of the canal by permanently stabilizing the slope. These alternatives include:

- Alternative 1 - Anchored Reinforced Grid Solution (ARGS)
- Alternative 2 - Articulating Concrete Block (ACB) Revetment System
- Alternative 3 - Synthetic Sheet Piling Wall`
- Alternative 4 - Reinforced Concrete Retaining Wall
- Alternative 5 – Concrete Retaining Walls and ARGS

Alternative 1 – Anchored Reinforced Grid Solution (ARGS)

Alternative 1 involves the installation of an anchored reinforced grid solution (ARGS); (refer to Figure 5). The ARGS system consists of high-strength synthetic geogrid mats installed on a prepared surface and anchored in place with percussion driven earth anchors (PDEA). Typically, the geogrid should be installed at least 3-feet beyond the top of the slope onto flat final grade. The geogrid should also be anchored in a trench constructed parallel to the slope and fastened to the bottom of this trench with PDEA's. At the toe of the slope, the geogrid should be installed in an anchor trench, constructed at least 3-feet beyond the toe. Also, the geogrid should be fastened to the bottom of the anchor trench with PDEA's. Surface preparation is critical to the proper installation of the ARGS system. Therefore, all vegetation, including trees, should be cleared, and grubbed from the canal prior to installation. Also, eroded, and irregular portions of the slope should be graded to create a uniform surface to receive fill material. The prepared surface can then be backfilled with suitable soil and be compacted to achieve the specified density for the full depth of the fill. Once the slope reconstruction is complete, the ARGS can then be installed to stabilize and to protect the slope from the erosive forces of the drainage canal. Product information and specifications for the ARGS are

included in Appendix A. Riprap could also be installed at the toe of the slope to provide added protection against storm flows.

Figure 5 – ARGS Installation

Some of the advantages of the ARGS system include:

- Fast and simple installation
- Less environmental impact
- Encourages revegetation
- Low initial capital costs

Alternative 2 – Articulating Concrete Block (ACB) Revetment System

Alternative 2 employs an articulating concrete block (ACB) revetment system to stabilize the canal slope. The ACB revetment system consists of interlocking concrete blocks held together by heavy steel or polyester tendon cables to form a protective mattress; (refer to Figure 6). The slope preparation described in Alternative 1 is applicable to this alternative. Also, a geotextile stabilization/separation fabric underlayment is required to cover the bare slope before installing the ACB revetment system; therefore, all vegetation, including trees, should be cleared, and grubbed from the canal prior to installation. The geotextile prevents the migration of soil through the concrete block, which could undermine and cause the failure of the system. Termination trenches, which typically consist of a two-block toe-in, will be constructed at the top and toe of the canal slope, as well as the flanks of the mats. This design is typical of an ACB system to protect all sides from erosive

forces. Installation of the ACB system will require the mobilization of heavy equipment to place the mats on the canal slopes. If conditions warrant, soil anchors can also be installed to provide additional anchoring as needed. Once the ACB system is in-place, the blocks will be backfilled with topsoil and seeded to promote the growth of vegetative cover.

The ACB revetment system design is selected for the specific site conditions. For this installation, the ACB design is based on the maximum capacity of the canal and on the type of imported fill soil used to restore the slopes. Product data and specifications for the ACB revetment system are provided in Appendix B.

Figure 6 – Articulated Concrete Block (ACB) Revetment System

Some of the advantages of the ACB revetment system include:

- Efficient and relatively fast installation
- Mats come as assembled units, lifted in one-piece sections from flatbed
- Promotes revegetation
- Low environmental impacts
- Highly durable protective barrier

A major disadvantage of the ACB system is the slope reconstruction requirements as compared to ARGS system. The ACB system requires much flatter slopes for proper installation than does the ARGS. Because the area for slope reconstruction is limited the ACB revetment system is a less desirable solution and in the case of the detention pond embankment, it may not be feasible to install the ACB system. Therefore, we do not recommend the ACB revetment system for this application.

Alternative 3 – Synthetic Sheet Piling Wall

Alternative 3 involves the installation of an anchored synthetic sheet pile bulkhead wall to create a protective barrier between the Harbour Cove improvements (e.g., parking lots, buildings, etc.), common areas and the canal; (refer to Figure 7), which can consist of UV-inhibited vinyl or FRP sheet piles. Sheet pilings are designed to interlock with successive sheets to form a continuous and structurally sound wall. Site preparation will include clearing and grubbing all vegetation, including trees, from the canal bank and bottom. The final location of the sheet pile wall will be based on an analysis of the channel flow capacity to determine the required cross-section to carry the design flow. The synthetic sheet pilings are installed with a vibrator hammer, which drives each sheet to a predetermined depth below the ground surface. This depth is determined by geotechnical investigations (soil borings) to identify a soil layer that provides adequate bearing capacity to support the wall and to resistance lateral soil pressure. The sheet pile bulkhead will be required to be anchored using one level or possibly multiple levels of horizontal pressure treated timber walers and ground anchors. The ground anchors would consist of the installation of percussion driven earth anchors or helical ground anchors, which would not require pre-excavation of the backfill slope as required for setting traditional concrete deadman type earth anchors. The ground anchor rods would extend thru the wall and be connected to the timber walers. The sheet pile wall can be capped with a concrete or pressure treated timber cap. Product data and specifications for the synthetic sheet piling wall are included in Appendix C.

After the sheet piling wall is installed, yards and common areas along the upland side of the wall can then be backfilled to restore those areas to their original ground elevations. The canal slope will also be restored along the face of the wall. The restored slope that are exposed to stormwater flow should be stabilized with either riprap or vegetation; (refer to Figure 8). Erosion control blankets can be used to temporarily stabilize the canal slope until vegetative cover is well established. The wall will provide a substantial and permanent barrier between the Harbour Cove properties and the erosive forces of the drainage canal.

Figure 7 - Synthetic Sheet Piling Wall Installation

Some of the advantages of the Synthetic Sheet Piling Wall installation include:

- Sheet piles are corrosion resistant; ideal for marine environment
- Maximizes area behind wall for public/private uses
- Low maintenance
- Ground anchors are driven/screwed into the insitu earth, eliminating the need for further excavation
- Highly durable barrier to erosive forces

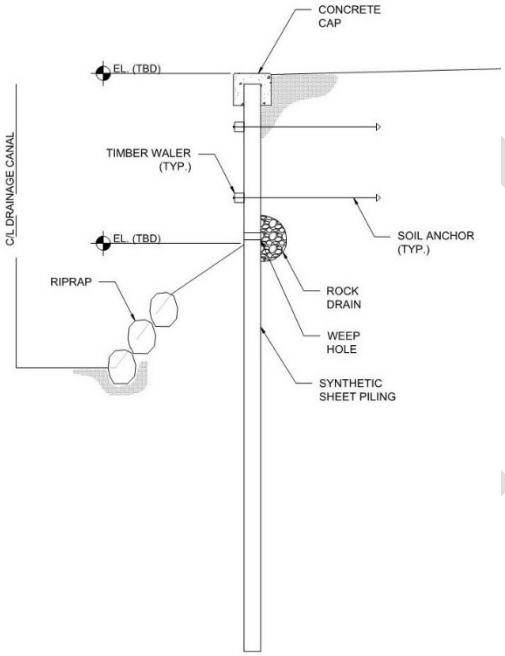

Figure 8 - Sheet Pile Wall Section

Alternative 4 – Reinforced Concrete Retaining Wall

Alternative 4 proposes to extend and to connect the existing reinforced concrete retaining walls along the Harbour Cove side of the canal; (refer to Figure 9). A new concrete retaining wall would be constructed to form a connection between the existing retaining walls as shown on the attached exhibit; (refer to Exhibit 2). The soil boring (B-1) taken between the two existing retaining walls shows a soil layer, approximately 15-feet below grade, that should provide foundational support for the new wall without the need for piling. This connection will provide a permanent and a sound structural barrier between the erosive forces of the canal and existing site improvements and condos within the Harbour Cove development. To protect the detention pond, the existing wall could be extended beyond the limits of the existing pond; (refer to Exhibit 2). However, based on soil boring information, a wall extending south from the existing retaining wall and past the detention pond will likely be piled supported. Soil boring (B-2), as shown on the map in Appendix E, identifies mostly soft clays in this area that will not provide adequate bearing capacity to support the proposed retaining wall. Therefore, this section of the wall should be pile supported. This extension will prevent further erosion of the canal slope and allow restoration of the eroded pond berm. Like the

synthetic sheet piling wall, the concrete retaining wall construction will require that the canal slope be cleared and grubbed of all vegetation, including trees. Immediate slope restoration will not be necessary because the concrete retaining wall would be designed as a cantilever retaining wall and would not rely on tie backs into the soil for support.

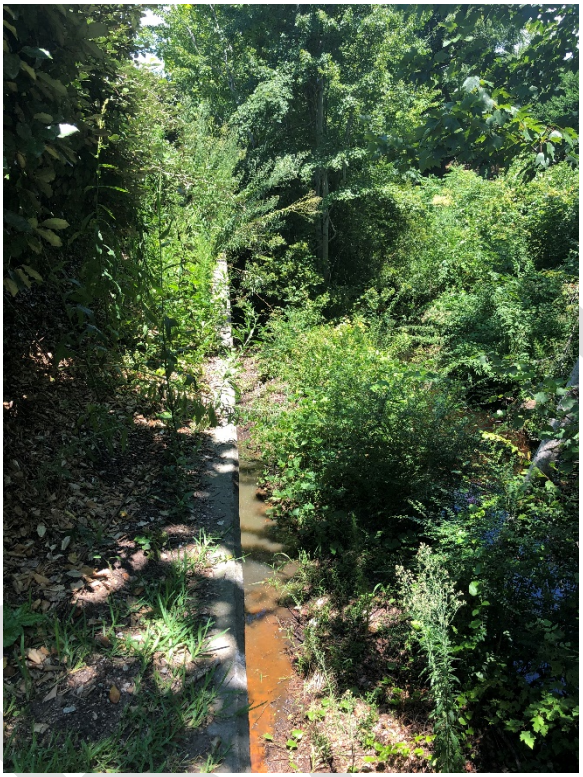

Figure 9 - Existing Harbour Cove Retaining Wall

After the retaining wall is installed, common area along the upland side of the wall can then be backfilled to repair erosion and to restore those areas to their original ground elevations. The canal slope will also be restored along the face of the wall. The restored slope that are exposed to stormwater flow should be stabilized with either riprap or vegetation; (refer to Figure 11). Erosion control blankets can be used to temporarily stabilize the canal slope until vegetative cover is well established. The wall will provide a permanent barrier between the Harbour Cove properties and the erosive forces of the drainage canal.

To provide additional protection at the road culverts, the existing retaining wall could be extended to the concrete headwall; (refer to Figure 10). This extension will provide a substantial protective barrier at the culverts and will allow the canal embankment to be restored.

Some of the advantages of the Reinforced Concrete Retaining Wall alternative include:

- Corrosion resistant (with addition of corrosion inhibitive additive)
- Low maintenance
- Maximizes areas behind wall for public/private uses

- Extends and connects existing concrete walls
- Provides durable barrier to erosive forces

Figure 10 - Existing Culverts under Barefoot Resort Bridge Road

Alternative 5 – Reinforced Concrete Retaining Walls and ARGS

Alternative 5 combines reinforced concrete retaining walls with the anchored reinforced grid solution (ARGS) to address erosion and slope instability issues on the Harbour Cove side of the canal. A new retaining wall would be constructed to connect the two existing concrete walls; (refer to Exhibit 3). A second retaining wall would be extended from the northern wall to the existing headwall of the dual culverts, located at Barefoot Resort Bridge Road. Soil boring B-1, (refer to Appendix E), which was taken between the existing concrete walls, indicates a relatively hard sand layer approximately 15-feet below surface that appears adequate to support the concrete retaining walls. From the end of the south wall to the Intracoastal Waterway, geotechnical data indicates that soil conditions in this area deteriorate significantly. Soil boring B-2, taken near the detention pond, shows mostly soft clays that do not posses the bearing capacity to support a retaining wall. As mentioned in Alternative 4, the wall south of the existing retaining wall will require pile foundations to support this type of construction. Because of the soil conditions, constructing a concrete retaining wall is cost prohibitive; therefore, we recommend that the ARGS be used in lieu of a conventional retaining wall along the canal bank south of the existing wall to the waterway.

As described in Alternative 1, the ARGS system consists of high-strength synthetic geogrid mats

installed on a prepared surface and anchored in place with percussion driven earth anchors (PDEA). Product information and specifications for the ARGS are included in Appendix A. Because the bank between the canal and the detention pond is so narrow, the geogrid mats will extend over this strip of land and into the detention pond. The PDEA's would then be installed through the pond bank and fasten to the geogrid mats on both the canal and pond sides. The ARGS system would be installed from the end of the existing wall, past the detention pond, and terminate at the replacement golf cart bridge; (refer to Exhibit 3). For additional protection of the geogrid, riprap armoring could be installed along the toe of the slope.

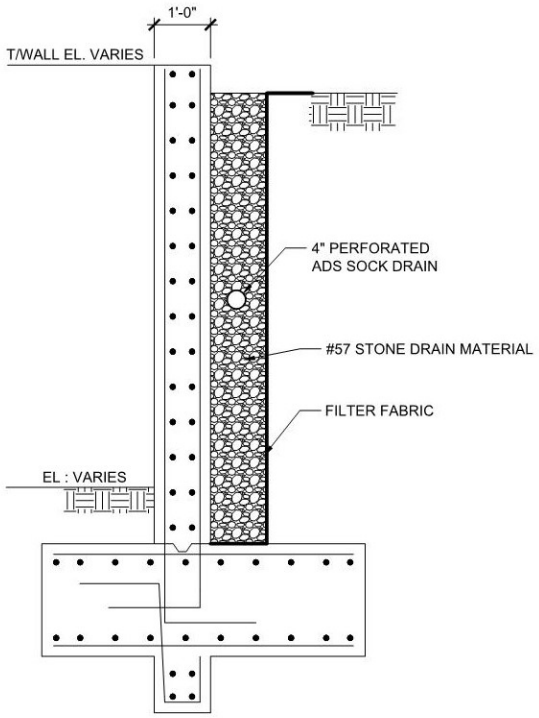

Figure 11 - Reinforced Concrete Retaining Wall Section

REGULATORY COMPLIANCE

Regardless of the alternative selected, the proposed repairs to the subject canal will likely require that permits and approvals be obtained from the following local, State and Federal agencies:

- U.S. Army Corps of Engineers
- S.C. Department of Health & Environmental Control, Office of Ocean & Coastal Resource Management
- S.C. Department of Transportation
- City of North Myrtle Beach, Stormwater Department
- City of North Myrtle Beach, Floodplain Management

The Corps of Engineers permit will likely require review by the U.S. Fish & Wildlife Service as well as the S.C. Department of Natural Resources. All permit applications will require supporting documentation, which may include, but not be limited to, construction drawings, technical specifications, calculations, and easement exhibits (as needed). These agencies may take into consideration the urgency of these repairs and expedite the permitting process to prevent further property damage. If the permitting process is not expedited, it could take 4 to 8 months to obtain all the necessary permits.

PRELIMINARY OPINION OF PROBABLE COSTS

The opinions of cost presented herein are preliminary in nature and do not represent an exact accounting, based on detailed studies and/or documents. They are based on our previous experience with other projects of a similar nature and should be used only for the purposes of determining the project's feasibility and for preliminary budgeting. We offer the following preliminary cost breakdowns for comparing and implementing the recommended alternatives for improvements along the Harbour Cove slope and across the bottom of the drainage canal. **(NOTE: We reserve the right to modify our opinions of cost based on information in the forthcoming geotechnical report that may affect these alternatives.)**

Alternative 1 – Anchored Reinforced Grid Solution (ARGS)

ITEM	DESCRIPTION	ESTIMATED COST
1.	Mobilization	$31,000
2.	Clear & Grub	$30,000
3.	Remove Existing Golf Cart Bridge & Abutments	$30,000
4.	Restore Canal Slope – Sand/Clay Fill	$165,000
5.	Install Riprap	$423,000
6.	Install Anchored Reinforced Grid Solution (ARGS)	$115,000
7.	Place Concrete Bridge Footings, Piles, & Abutments	$79,000
8.	Install New Golf Cart Bridge	$117,000
9.	Dewatering	$30,000
10.	Landscaping Allowance	$35,000
11.	Erosion & Sediment Control Allowance	$10,000

Subtotal =	**$1,065,000**
Contingency (20%) =	$213,000
Engineering Services =	$107,000
Construction Services =	$53,000
Estimated Project Cost	**$1,440,000**

Alternative 2 – Articulated Concrete Block (ACB) Revetment System

ITEM	DESCRIPTION	ESTIMATED COST
1.	Mobilization	$36,000
2.	Clear & Grub	$30,000
3.	Remove Existing Golf Cart Bridge & Abutments	$30,000
4.	Restore Canal Slope – Sand/Clay Fill	$165,000
5.	Install Geotextile Fabric Underlay	$82,000
6.	Install Contech ArmorFlex 50 Mats	$616,000
7.	Place Concrete Bridge Footings, Piles & Abutments	$79,000
8.	Install New Golf Cart Bridge	$117,000
9.	Dewatering	$30,000
10.	Landscaping Allowance	$35,000
11.	Erosion & Sediment Control Allowance	$10,000
	Subtotal =	**$1,230,000**
	Contingency (20%) =	$246,000
	Engineering Services =	$123,000
	Construction Services =	$62,000
	Estimated Project Cost	**$1,660,000**

Alternative 3 – Synthetic Sheet Piling Wall

ITEM	DESCRIPTION	ESTIMATED COST
1.	Mobilization	$50,000
2.	Clear & Grub	$30,000
3.	Remove Existing Golf Cart Bridge & Abutments	$30,000
4.	Restore Canal Slope – Sand/Clay Fill	$165,000
5.	Install Synthetic Sheet Piling	$1,256,000
6.	Place Concrete Bridge Footings, Piles, & Abutments	$23,000
7.	Install New Golf Cart Bridge	$117,000
8.	Landscaping Allowance	$35,000
9.	Erosion & Sediment Control Allowance	$10,000
	Subtotal =	**$1,716,000**
	Contingency (20%) =	$343,000
	Engineering Services =	$172,000
	Construction Services =	$86,000
	Estimated Project Cost	**$2,320,000**

Barefoot Resort Residential Association – Drainage Canal Erosion Evaluation - Alternative 4

ITEM	DESCRIPTION	ESTIMATED COST
1.	Mobilization	$49,000
2.	Clear & Grub	$30,000
3.	Remove Existing Golf Cart Bridge & Abutments	$30,000
4.	Restore Canal Slope – Sand/Clay Fill	$165,000
5.	Construct Concrete Retaining Walls w/out piles	$439,000
6.	Construct Concrete Retaining Walls w/piles	$446,000
7.	Concrete Piling	$319,000
8.	Wall Footing Excavation	$80,000
9.	Place Concrete Bridge Footings, Piles, & Abutments	$23,000
10.	Install New Golf Cart Bridge	$117,000
11.	Dewatering	$94,000
12.	Temporary Cofferdam	$40,000
13.	Landscape Allowance	$35,000
14.	Erosion & Sediment Control Allowance	$10,000

Subtotal	=	**$1,877,000**
Contingency (20%)	=	$375,000
Engineering Services	=	$188,000
Construction Services	=	$94,000
Estimated Project Cost		**$2,530,000**

ITEM	DESCRIPTION	ESTIMATED COST
1.	Mobilization	$31,000
2.	Clear & Grub	$30,000
3.	Remove Existing Golf Cart Bridge & Abutments	$30,000
4.	Restore Canal Slope – Sand/Clay Fill	$165,000
5.	Construct Concrete Retaining Walls w/out piles	$439,000
	Install Geogrid with Soil Anchors (ARGS)	$70,0000
	Install Riprap	$125,000
6.	Wall Footing Excavation	$40,000
7.	Place Concrete Bridge Footings, Piles, & Abutments	$23,000
8.	Install New Golf Cart Bridge	$117,000
9.	Dewatering	$94,000
10.	Temporary Cofferdam	$40,000
11.	Landscape Allowance	$35,000
12.	Erosion & Sediment Control Allowance	$10,000

Subtotal	=	**$1,249,000**
Contingency (20%)	=	$250,000
Engineering Services	=	$125,000
Construction Services	=	$62,000
Estimated Project Cost		**$1,690,000**

RECOMMENDED ALTERNATIVE

From our evaluation of the alternatives considered, it is our recommendation that Alternative 5, which consists of reinforced concrete retaining walls combined with the Anchored Reinforced Grid Solution (ARGS), be utilized to stabilize the existing drainage canal and to prevent further erosion of Harbour Cove property. This alternative is not the low - cost solution but is the best value solution for reducing the potential for erosion and slope instability issues. The proposed solution will provide a permanent and durable barrier to the erosive forces generated in the canal during moderate to high flow conditions. Our recommendation is made without the benefit of the geotechnical slope stability analysis at this time. During our site recon, we did not observe settlement or other structural issues associated with the existing walls; therefore, as long as soil conditions are consistent along the length of this section of the canal, we would anticipate that the new wall would also perform in a similar manner. With respect to the canal slopes in the vicinity of the detention pond and south to the Intracoastal Waterway, the ARGS should provide permanent stabilization of the canal bank. As mentioned previously, soils in this portion of the canal will not support the concrete wall without deep piled foundations; consequently, the ARGS provides the best and most economical solution to address erosion and slope instability issues.

Maintenance of the proposed wall is relatively low for this type of structure. Routine visual inspections should be undertaken on an annual basis to identify damage or other conditions, which may impact the structural integrity of the wall. Properly constructed and maintained, the normal design life of a reinforced concrete retaining wall should range between 30 to 40-years. Also, the ARGS system should be inspected at the same frequency of the new retaining walls. Trees or other vegetation that could damage the geogrid should be removed; however, grass and other ground cover plants should be allowed to grow freely. The ARGS system, properly installed and maintained, should have design life of approximately 75-years.

Another benefit of the concrete retaining wall is the expanded area that will be created behind the wall for community use. The retaining wall will have a significantly smaller footprint and disturb less area than the ARGS (Alternative 1) or the ACB revetment system (Alternative 2). The new wall's connection to the existing retaining walls forms a continuous barrier to the canal.

In addition to the implementation of Alternative 5, we recommend that the existing golf cart bridge be removed and replaced with a new steel truss bridge. The span of the replacement bridge would be increased as compared to the old bridge span, so that flow is no longer restricted through the canal. Replacement of the existing bridge is a common recommendation for all the alternatives evaluated for this project. Product information and specifications for the steel truss bridge are provided in Appendix D.

Clearing and grubbing the canal banks and portions of the channel bottom are essential to the proper installation and function of the selected alternative. Tree roots should be removed from the slope completely to eliminate the possibility of voids forming under the geogrid mats. These voids often form when tree stumps and other organic matter are left in place to decay rather being removed during the initial clearing activities.

We reserve the right to modify our recommendations and opinions of cost, as necessary, in response to information provided in forthcoming geotechnical report.

JAG/BFM:aba

Attachments: Exhibit 1 – ARGS and ACB Revetment Systems
Exhibit 2 – Sheet Piling and Concrete Retaining Walls
Exhibit 3 – Concrete Retaining Wall and ARGS

Appendices: A – Product Data and Specifications for ARGS
B – Product Data and Specifications for the ACB Revetment System
C – Product Data and Specifications for the Synthetic Sheet Piling Wall
D – Product Data and Specifications for the Steel Truss Bridge
E – Geotechnical Data and Soil Boring Logs

EXHIBIT 1

PROFILE VIEW: CL CANAL
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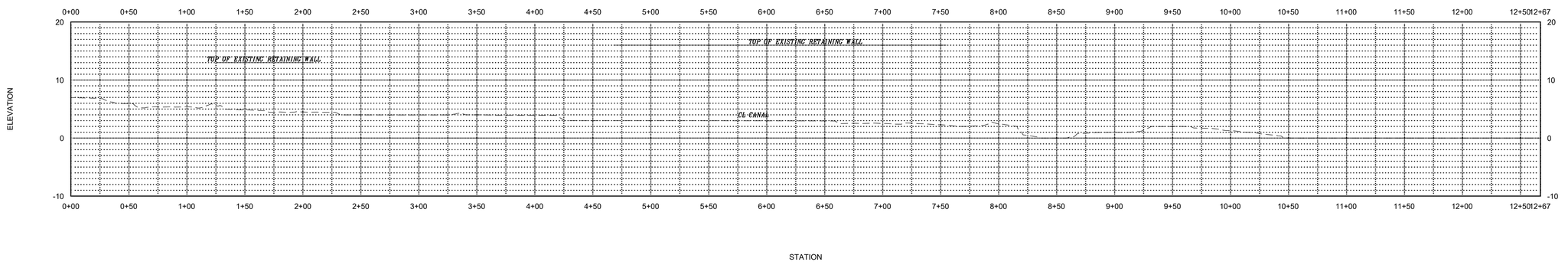
DATUM: -10.00



A1	**PLAN & PROFILE**
SCALE:	**1" = 50'**

NOT - RELEASED FOR CONSTRUCTION

NO.	DESCRIPTION	DATE	BY	CHKD	DRWN
	REVISIONS				

3 LINWA BOULEVARD
ANDERSON, SOUTH CAROLINA 29621
PHONE: (864) 226-61111

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BRRA DRAINAGE CANAL EROSION EVALUATION

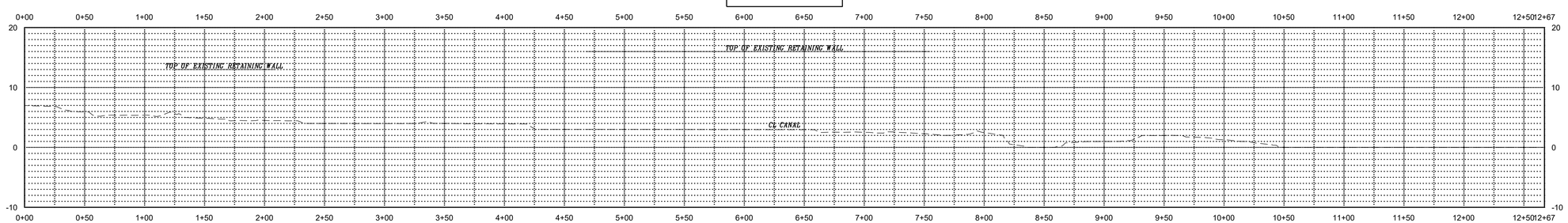
ALTERNATIVES 1 & 2 PLAN

DESIGNED BY	CHECKED BY
BFM	JAG
DRAWN BY	PROJ. NO.
JJG	2033
DATE	FILE NO.
9-30-2020	EXHIBIT 1

SHEET NO.
EXHIBIT 1

EXHIBIT 2

PROFILE VIEW: CL CANAL
SCALE: 10
DATUM: -10.00



PROFILE VIEW: CL EX RETAINING WALL
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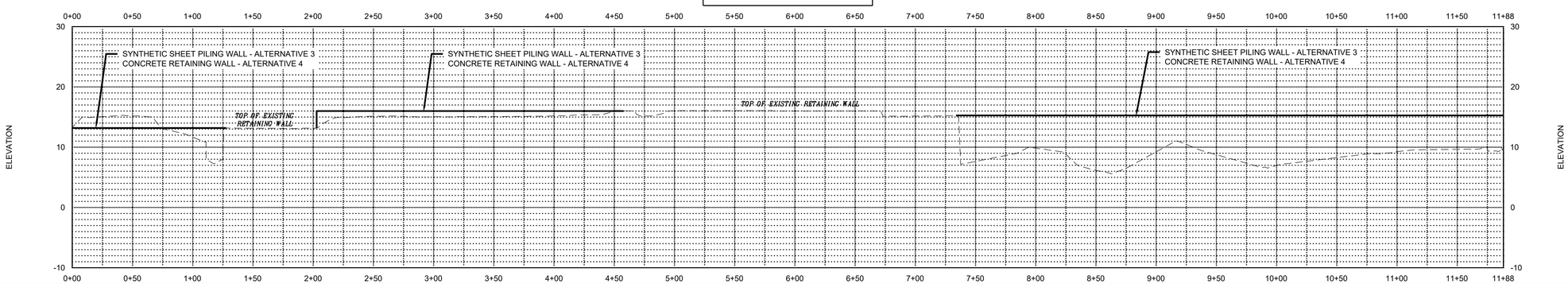
DATUM: -10.00



A1	PLAN & PROFILE
SCALE:	1" = 50'

NOT - RELEASED FOR CONSTRUCTION

NO.	DESCRIPTION	DATE	BY	CHKD	DRWN
	REVISIONS				

3 LINWA BOULEVARD
ANDERSON, SOUTH CAROLINA 29621
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BRRA DRAINAGE CANAL EROSION EVALUATION

ALTERNATIVES 3 & 4 PLAN

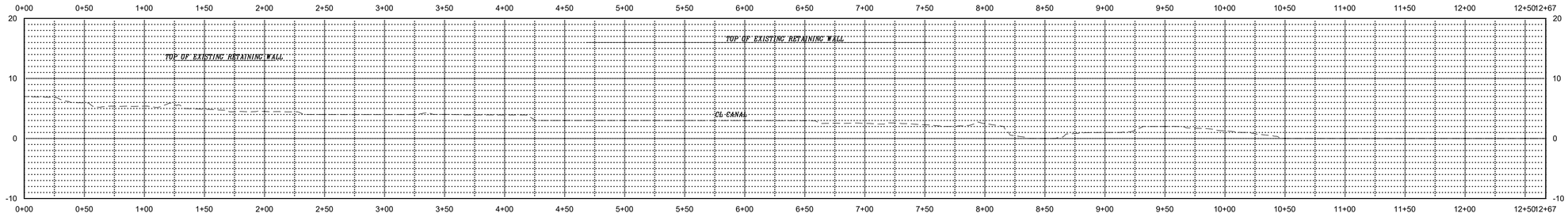
DESIGNED BY	CHECKED BY
BFM	JAG
DRAWN BY	PROJ. NO.
JJG	2033
DATE	FILE NO.
9-30-2020	EXHIBIT 2

SHEET NO.

EXHIBIT 2

EXHIBIT 3

PROFILE VIEW: CL CANAL
SCALE: 10
DATUM: -10.00



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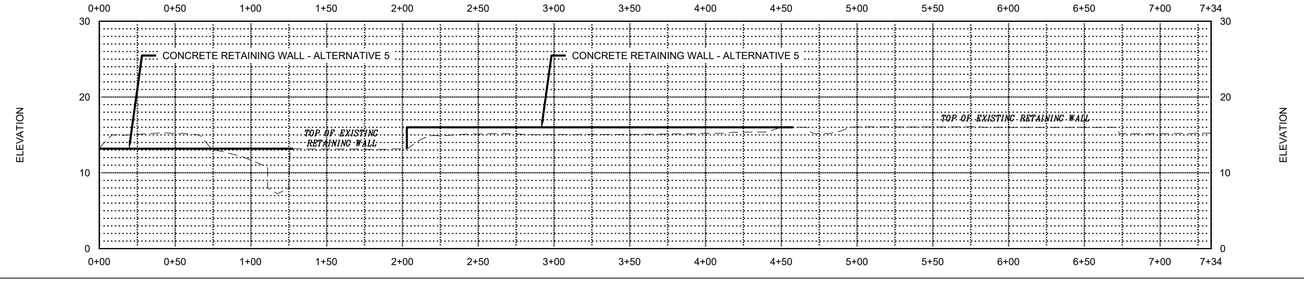
DATUM: 0.00



A1	**PLAN & PROFILE**
SCALE:	**1" = 50'**

NOT - RELEASED FOR CONSTRUCTION

REVISIONS

NO.	DESCRIPTION	DATE	BY	CHKD	DRWN

3 LINWA BOULEVARD
ANDERSON, SOUTH CAROLINA 29621
PHONE: (864) 226-61111

ARDURRA
COLLABORATE. INNOVATE. CREATE.

BRRA DRAINAGE CANAL EROSION EVALUATION

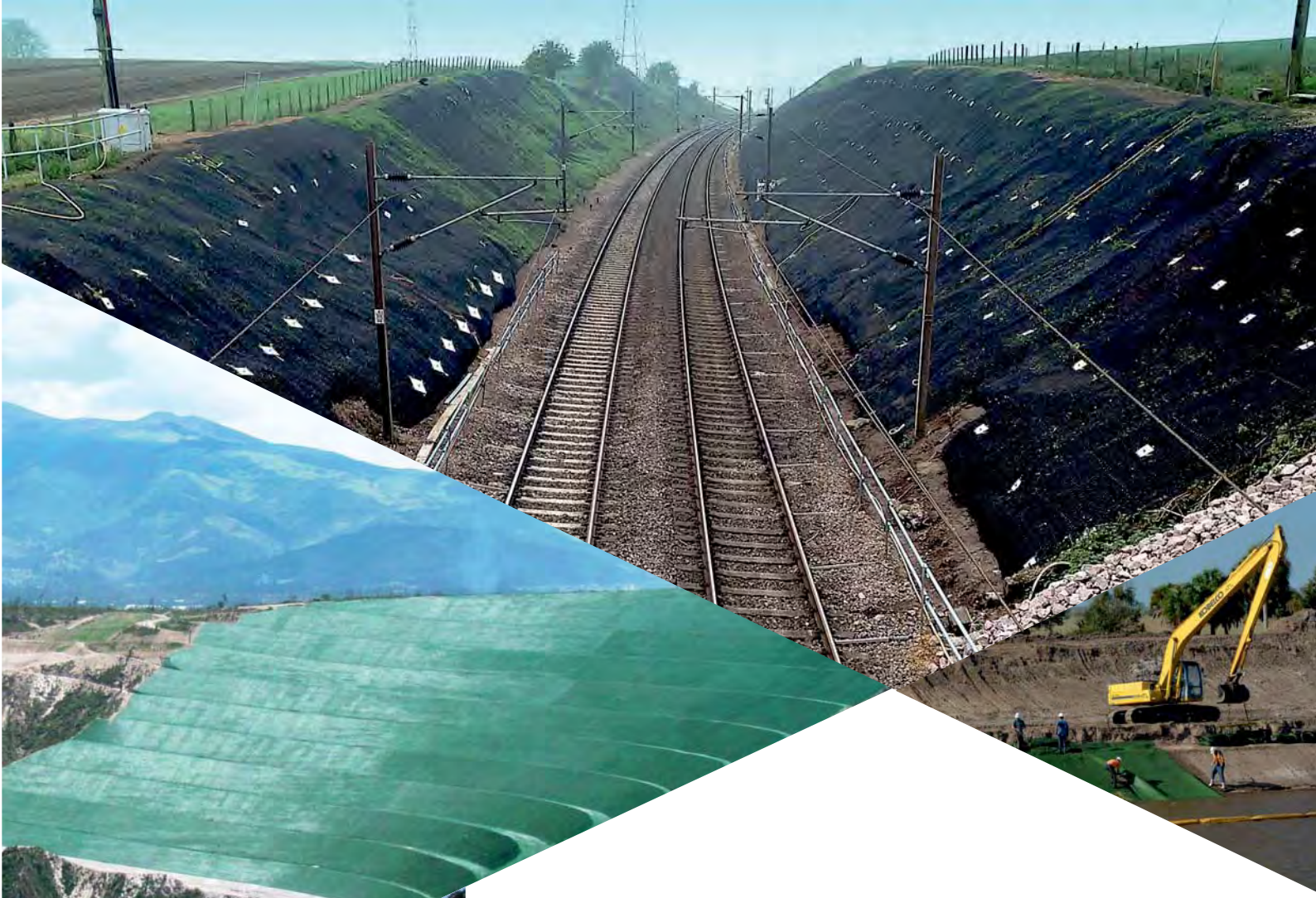
ALTERNATIVE 5

DESIGNED BY	CHECKED BY
BFM	JAG
DRAWN BY	PROJ. NO.
JJG	2033
DATE	FILE NO.
9-30-2020	EXHIBIT 3

SHEET NO.

EXHIBIT 3

APPENDIX A



PLATIPUS
EARTH ANCHORING SYSTEMS

ARGS®

Anchored Reinforced Grid Solutions

Brochure

INTRODUCTION TO ARGS®
Anchored Reinforced Grid Solutions

Stabilizing slopes offers many significant challenges. Platipus® combine Percussion Driven Earth Anchors (PDEA®) with a suitable surface or facing material to make an Anchored Reinforced Grid Solution (ARGS®). The ARGS® System is ideal for stabilizing slopes where over steepening, excess water, poor drainage or lack of deep rooted vegetation have caused erosion or instability.

The ARGS® System offers many advantages over traditional solutions:

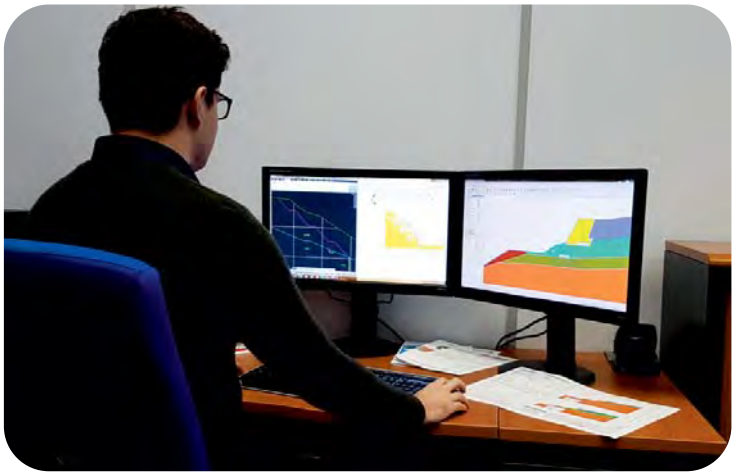
- Simple and cost effective
- Fast and easy installation
- Immediately quantifiable anchor loads
- Low environmental impact
- Encourages re-vegetation
- Can be used with most surface or facing materials
- Incorporating Plati-Drain® can reduce pore water pressure

DESIGN LIFE

Platipus ARGS® Systems are designed to meet the engineers requirements for the project.

TECHNICAL GUIDANCE & SUPPORT

With over 35 years' experience and thousands of successful projects worldwide we offer pre-contract site evaluation and anchor testing together with on-site training and support. In addition, we are able to provide real time technical guidance at all stages of the design and installation process allowing for greater engineering confidence. As part of our commitment to offer a complete package, a System Proposal outlining possible anchoring solutions/specifications, suitable for your project, can be provided at no charge. We understand that each project is unique and suggest that the design of every slope is approved by a qualified engineer.

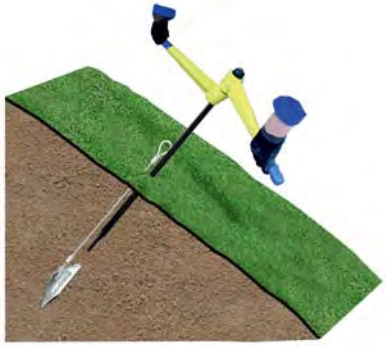


'SIMPLY' HOW A MECHANICAL ANCHOR WORKS

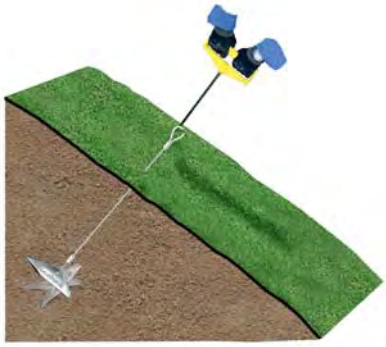
There are three steps to the installation of an anchor system:

1. DRIVE THE ANCHOR

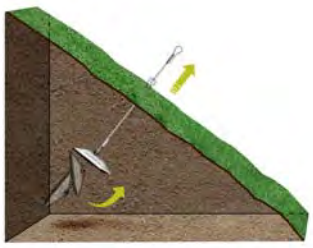
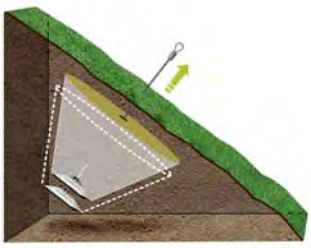
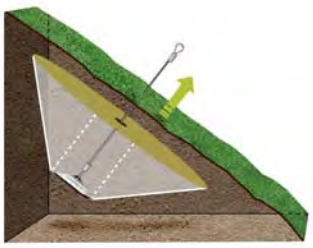
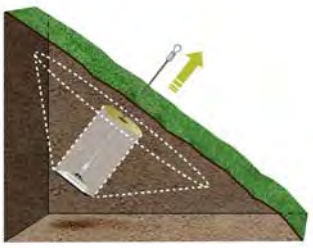
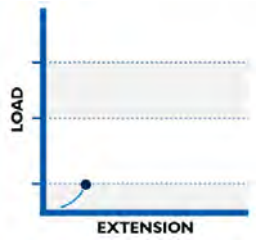
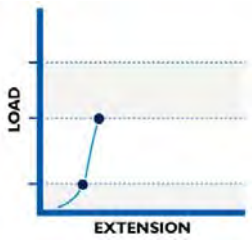
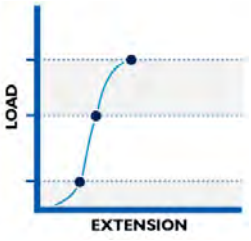
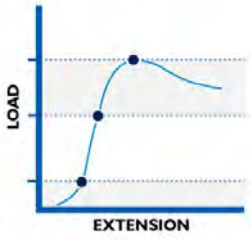
2. REMOVE THE DRIVE ROD



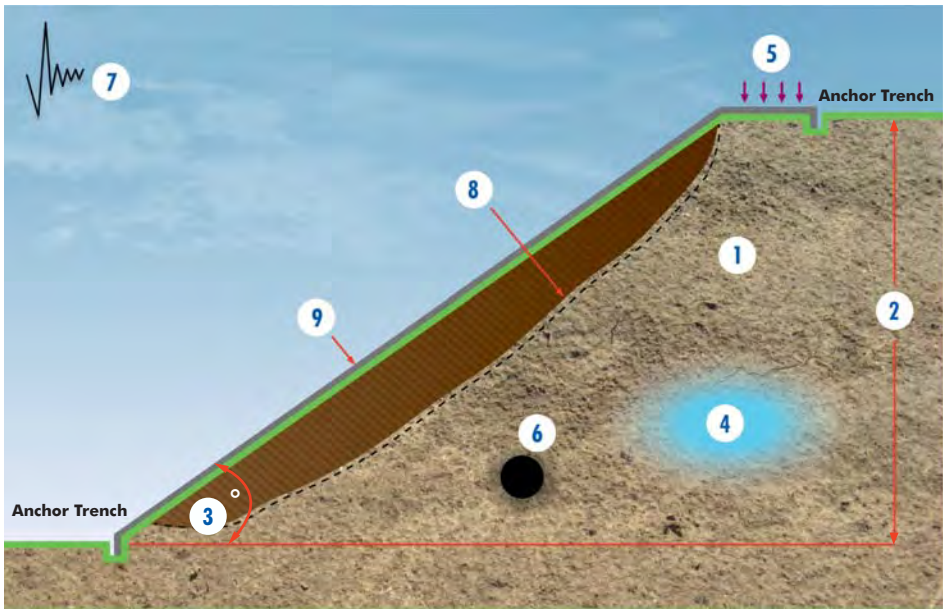
3. LOADLOCK THE ANCHOR



TYPICAL ANCHOR BEHAVIOR

LOADLOCK	COMPACTION AND LOAD	MAXIMUM LOAD RANGE	BEARING CAPACITY FAILURE
			
The first stage is where a load is applied to rotate the anchor into its loadlocked position. Elements of both load and extension are present.	The second stage is where the anchor system is generating a frustum of soil immediately in front of the anchor. At this point load normally increases with minimum extension. The soil type will affect the overall extension.	The third stage is where the anchor produces its ultimate load. As the anchor load approaches the bearing capacity of the soil, the rate of increase in load will reduce until bearing capacity failure of the soil takes place.	Caution: If the mechanical shear strength of the soil is exceeded, the residual load will decrease with continued extension as the anchor shears through the soil.
			

DESIGN CONSIDERATIONS



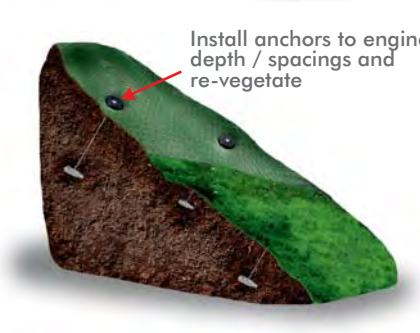
1. What is the soil type / conditions where the anchor will reside?
2. What is the vertical height of the slope?
3. What is the slope angle?
4. Is the slope affected by pore water pressures or does it have an elevated water table?
5. Is there a surcharge affecting the slope?
6. Are there any buried services which may obstruct the anchor?
7. Is the site within a seismically sensitive area?
8. How deep is the critical failure plane and has movement already occured within the slope?
9. What facing material is locally available?
10. What is the desired factor of safety for the slope (usually between 1.2 to 1.5)?
11. What is the design life?

ARGS® - EROSION CONTROL

1 Remove rocks / debris and re-profile the slope

2 Apply erosion control matting

3 Install anchors to engineered depth / spacings and re-vegetate



4

PLATIPUS® S2 GEO / S2 ARGS®

The Platipus® S2 GEO / S2 ARGS® System comes in a variety of configurations. The S2 GEO has a field swaged top component, while the S2 ARGS® anchor includes a self-setting wedge grip. See individual project details for specifications.

S2GEO

S2ARGS

PLATIPUS® S2 ZIP ANCHOR

The S2 Zip Anchor is a reliable low cost solution. It can be installed, in a wide range of soils, using simple hand tools. The system's unique design incorporates Platipus T-Loc technology with a simple 'cable tie style' strap to receive an adjustable self-locking load plate. It's quick to use and offers a much more reliable alternative to traditional pins which can easily pull out.

Surface Materials

S2 ZIP

- Landfill Rain Covers
- Waste Containment
- Erosion Control Blankets

S2 GEO / S2 ARGS®

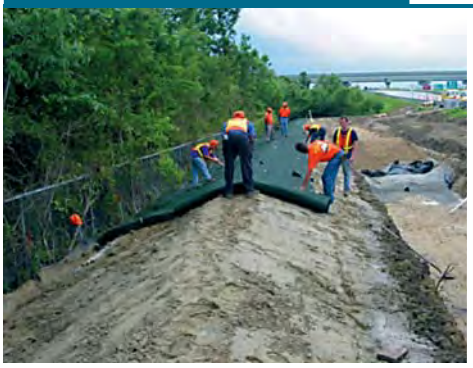
- Turf Reinforcement Matting
- Geotextiles / Geogrids
- HDPE Coverings
- Turf Pavers
- Lightweight Concrete Flexacrete

PROJECT EXAMPLES
Erosion Control

SURFACE EROSION



FLOOD PREVENTION



OVERFLOW RETENTION POND



STORM WATER PROTECTION



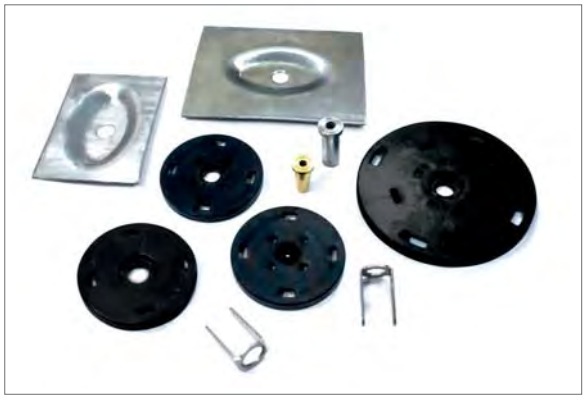
ARGS® - SHALLOW SLIDE PROTECTION

PLATIPUS® S4 & S6 ARGS®

The Platipus® S4 & S6 ARGS® System assembly comes in a variety of configurations and can vary on a project by project basis. See individual project details for specifications.

Surface Materials

- High Performance Turf Reinforcement Matting (HPTRM)
- High Strength Geotextiles & Geogrids
- Wire Mesh
- Articulated Concrete Blocks (ACBs)
- Landfill Liners

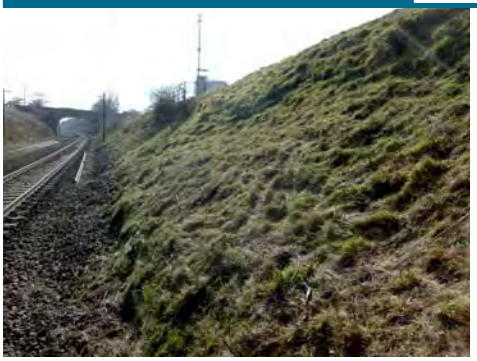


PROJECT EXAMPLES
Shallow Slide Protection

SLIDES



SLOPE REMEDIATION



LANDFILL CAPPING

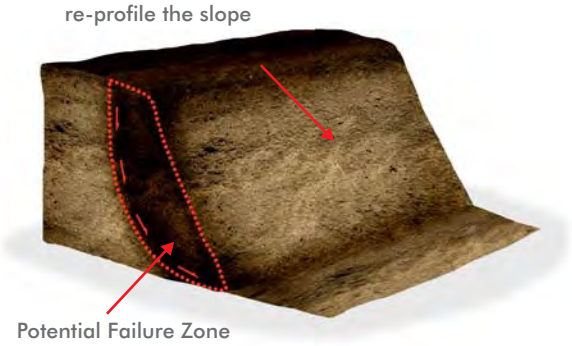


LEVEE PROTECTION & OVERTOPPING



ARGS® - DEEP SEATED FAILURES

1



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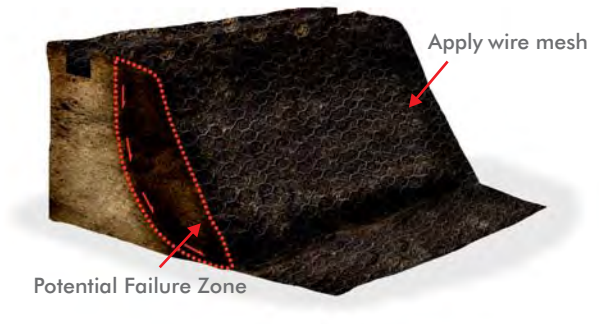

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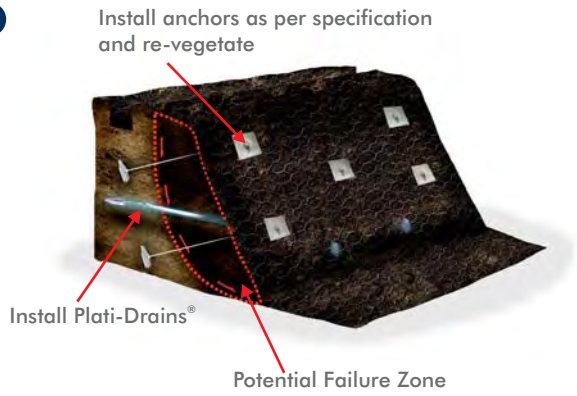


4

PLATIPUS® STEALTH & BAT ANCHOR SOLUTIONS

Deep seated failures can be supported using larger Stealth and Bat anchors along with a solid geotechnical engineered design. In conjunction with our online Anchor Load Indicator guideline software an Engineer can design a low impact economical solution. Typically this begins with a review of the soils report and installation of a test anchor to prove the holding requirements are met.

Surface Materials

- High Strength Geotextiles
- Shot Crete
- Wire Mesh
- Rockfall protection netting

PROJECT EXAMPLES
Deep Seated Failures

TEMPORARY STABILIZATION



PERMANENT SLOPE REINFORCEMENT



PERMANENT SLOPE REMEDIATION

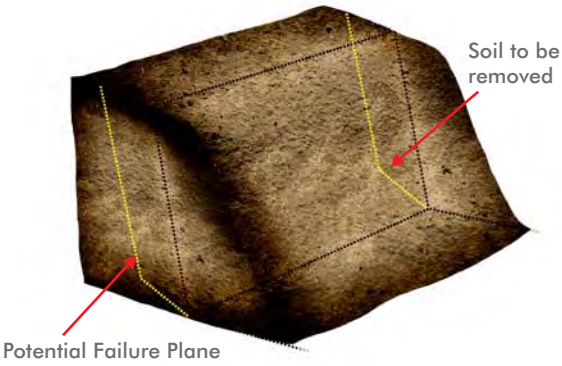


DIFFICULT ACCESS



ARGS® - CUT FACE SLOPES

1



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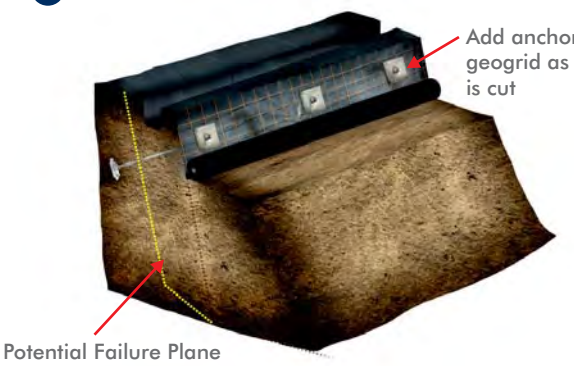

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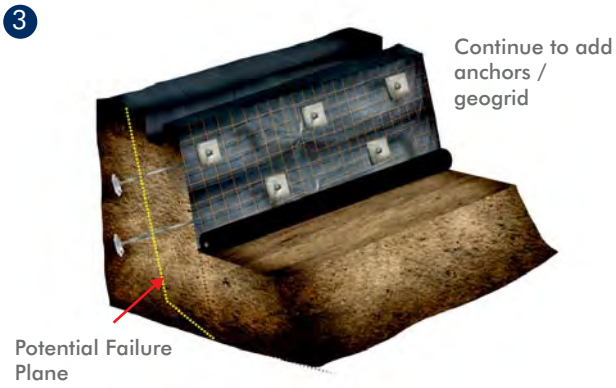


PLATIPUS® STEALTH AND BAT ANCHOR SOLUTIONS

Cut face slopes can be supported using larger Stealth and Bat anchors along with a solid geotechnical engineered design. In conjunction with our online Anchor Load Indicator guideline software an Engineer can design a low impact economical solution. Typically this begins with a review of the soils report and installation of a test anchor to prove the holding requirements are met.

Facing Materials

- Segmental Concrete Blocks
- Poured in Place Concrete Wall
- Vegetated Wire Baskets
- Rock Filled Gabion Baskets
- Sheet Piling
- Timbers
- Shot Crete

PROJECT EXAMPLES
Cut Face Slopes

HYBRID WALLS


TEMPORARY WORKS


DEEP EXCAVATION

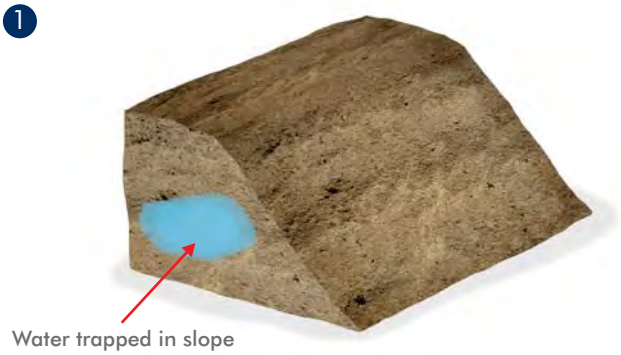


GABION SUPPORT



DRAINAGE SOLUTIONS

1

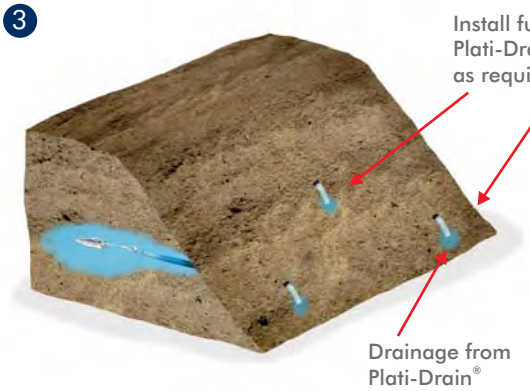


Water trapped in slope

2

Drive Plati-Drain® into optimum position

3



Install further Plati-Drains® as required

Drainage from Plati-Drain®

4

PLATI-DRAIN®

Water saturation, due to heavy rainfall and insufficient drainage, leads to the softening of clay soils within slopes and increases hydraulic forces behind earth retaining structures.

Plati-Drain® is a unique patented solution that reduces pore water pressure within clay slopes. It can provide deep penetration in excess of 10m / 33' and can also prevent shallow or deep seated slope failures.

Available as a 'Passive' or 'Active' solution. The 'Passive' system uses a sacrificial anchor head to drive the Plati-Drain® into its optimum position providing an immediate channel for water to drain. The 'Active' system has an additional wire tendon attached to the anchor which allows it to be loadlocked, providing simultaneous draining and restraining capability.

PROJECT EXAMPLES
Drainage Solutions

DEEP SLOPE PENETRATION



EMERGENCY DRAINAGE



INCREASE SLOPE STABILITY



PASSIVE PLATI-DRAINS



CASE STUDY

Mariscal Sucre International Airport Access, Quito - Ecuador

Project Specification

Steep cuts along the newly constructed access road to the airport required surface protection against deep erosion and shallow surface sliding. Traditional shotcrete methods were used on much of the easy access areas. The extremely high slopes posed difficulties for traditional methods so Platipus introduced the Anchor Reinforced Grid Solution (ARGS®) to protect the surface. The solution was employed and recently withstood a 5.1 earthquake on August 12th 2014 while other unprotected areas experienced some failures.

Solution

The cut slopes were first protected with 2 layers of erosion control materials. The first provided the erosion protection and kept the surface soil from sliding down the slope. The top layer provided the strength to handle the load generated by the Percussion Driven Earth Anchor (PDEA®) as well as UV protection.

CASE STUDY
M4 Motorway Widening, Sydney - Australia

Project Specification

An 11m high steep slope supporting the M4 Motorway required stabilizing as part of the WestConnex infrastructure project which aims to reduce the journey time between Sydney Airport and Parramatta. 7.5km (4.6 miles) of the M4 Motorway is being expanded to 4 lanes and a temporary works embankment was used to enable the construction of a permanent concrete panelled wall.

Solution

The Platipus Percussive Driven Earth Anchor (PDEA®) stabilized the temporary embankment using B6 and B8 anchors driven to 8m (26.2ft). Cirtex Australia provided both design and installation support. The Platipus anchors were installed using locally available equipment and were loadlocked and set with immediately quantifiable loads offering significant cost savings to the contractor and client over alternative methods.

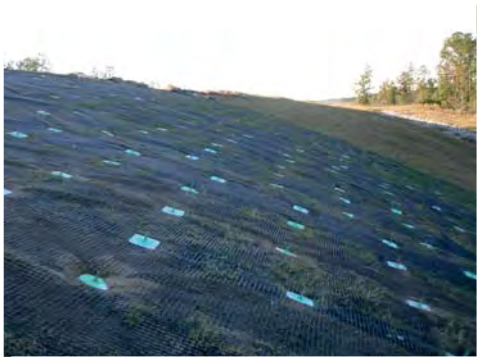
CASE STUDY
US Highway 98, Mobile Alabama - USA

Project Specification

The Alabama Dept. of Transportation's Geotechnical Engineering units tasked TTL Inc to perform a temporary shallow plane failure repair while engineering a permanent embankment stability solution. This site was suffering from shallow plane failures, rill erosion, regressive failures and tension cracks. Through solid engineering practices and on site preliminary anchor testing provided by Platipus it was determined that TTL could provide a solution that would solve the immediate concerns as well as providing the long term 50 year design with the use of Platipus anchors and a permanent surface protection material.

Solution

The slope was re-graded and Platipus Anchors / Plati-Drains® were installed by Bridge Creek Construction, a certified Platipus installer, to a depth of 20' (6m) with a working load of 4,000 lbs (18kN) and a proof load of 6,000 lbs (27kN). The surface of the slope was then covered with a permanent UV stabilized geogrid and re-vegetated. The Anchored Reinforced Grid Solution (ARGS®) provided the opportunity for the Engineer to model the failure and determine the necessary anchor capacity and spacing. In process load testing verified the design through the entire process. The site was then able to be vegetated and put back to an aesthetically pleasing environmentally sound state.



CASE STUDY
Savièse Slope Stabilisation - Switzerland

Project Specification

Soon after this 14m (46ft) high slope had been excavated for a new building, a section of the slope failed due to unforeseen ground conditions leading to the immediate closure of the site. Before construction could continue an urgent solution was required to permanently secure the entire slope. Platipus Percussion Driven Earth Anchors (PDEA®) were proposed through their partner, Anteq SA, and were selected due to a number of key factors: suitable granular material, easy installation in extremely limited space & immediate availability of products.

Solution

This 500m² (5381sq ft) slope was safely secured in two main anchoring stages: Firstly the lower half, which consisted of 4 rows of B4 anchors driven to a depth of 9m (29.5ft), installed using a 'spider' excavator and proof tested to 90kN (20233lbs) each. Secondly the top half, where 5 rows of the smaller S6 anchor were installed using a handheld pneumatic hammer from a mobile platform to a depth of 4m, each proof tested to 30kN (6745lbs). The 55° re-profiled slope was completed using a Maccaferri geomat providing a secure and smart finish to the project.

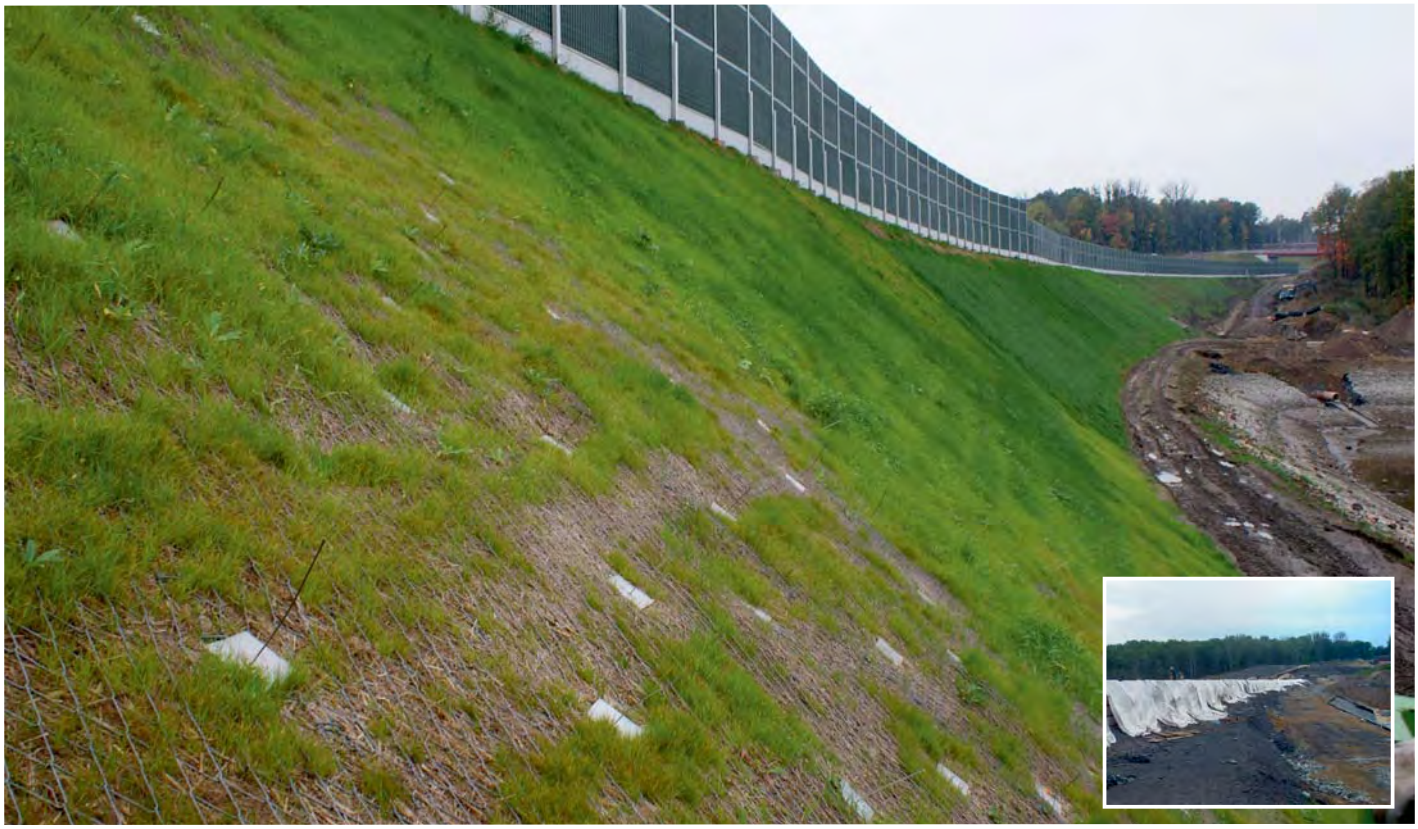
CASE STUDY
A1 Autostrada, Majiejow, Piekary - Poland

Project Specification

The A1 Autostrada is a north-south motorway that runs 568km (353 miles) through central Poland from Gdansk, on the Baltic Sea, through Lódz, to the Polish border in Gorzyczki where it connects to the Czech D1 motorway. As part of an upgrade a new section of motorway was constructed between Piekary and Maciejów which required an anchoring solution to secure all of the facing materials to three large new slopes.

Solution

Early site testing revealed that the compacted granular fill was ideal for the Platipus mechanical anchor confirming that the small S6 anchor would easily achieve the 10kN (2249lbs) ultimate load required by the Designer. Once construction of the motorway section was complete, soil was imported to create a new slope profile.
A hydroseed mix was then sprayed over the freshly imported soil and a combination of coir mat and Geobrugg Tecco Mesh was secured tightly in place, by the Platipus S6 ARGS® anchor system, to encourage immediate vegetation of the slope. Due to the height and gradient of the slope a hydraulic work platform was used to allow quick installation of the anchor system; using simple hand held equipment. On average a total of 130 anchor systems were installed each day which was much more than initially expected.



CASE STUDY
A57 Land Slip - Slope Reinforcement - UK

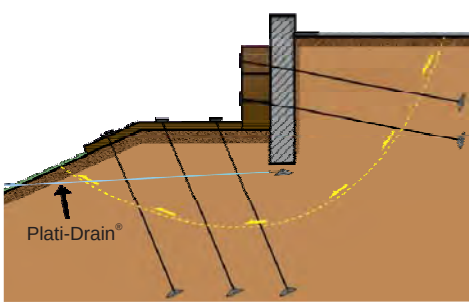
Project Specification

A landslip along a 100m (328ft) stretch of the A57 Manchester Road just outside Sheffield resulted in a partial road closure whilst remedial solutions were considered.

Solution

Platipus Anchors were approached by Amey Consulting to work with them developing an anchored solution for remediation of what the Engineer deemed to be a deep seated failure. Starting with a simple conceptual cross-sectional sketch and a Ground Investigation report, Platipus carried out extensive site testing to prove the performance and 'drivability' of a range of anchor systems.

Amey were responsible for the global design while Platipus Geotechnical Engineers designed and indemnified the Anchor specification to meet the Engineer's requirements. A row of Plati-Drains® were introduced towards the toe of the slope to reduce pore water pressure.



CASE STUDY

Winston Salem State University, North Entry Parking - NC, USA

Project Specification

To provide much needed access to two remote parking lots at Winston Salem State University, a bridge was built that will cross over an existing rail line and connect the lots to the main campus. The owner of the railroad, Norfolk Southern, would not allow the newly built bridge to be accessed until an adjacent abutment that had begun to slough was reinforced. The railroad felt there was a risk that the vibrations caused by passing trains could lead to a shallow plane failure.

Solution

The Platipus ARGS® (Anchor Reinforced Grid Solutions) system was specified by a local Geotechnical Engineer who was very experienced in the local geology of the Piedmont region. Summit Design and Engineering performed a global stability analysis and concluded that the depth of failure was approximately between 5 –10 feet deep. The design included a grid patterned of 2 TN anchors being driven to a minimum depth of 15' and pre-tensioned to 2,000 lbs. After all the anchors were tensioned, the slope was covered in a 4" thick reinforced concrete face including a 4"x4" welded wire mesh. The load plates and wedge grips were post tensioned to the concrete face once the concrete facing had cured.

CASE STUDY
Midshore I Landfill - Easton, MD - USA

Project Specification

Maryland Environmental Service (MES) owns and maintains the Midshore Regional Solid Waste System in a region that serves 140,000 residents on the eastern shore of Maryland's Chesapeake Bay. The 175 acre (708,200m^2) Midshore I closed in 2010 after operating successfully for 20 years. MES chose to cover the landfill with an Exposed Geomembrane Cover (EGC.) Designed to protect the environment and minimize the need for ongoing maintenance, the EGC also allows for future use of the landfill.

Solution

The EGC design specified an HDPE 60mil (1.5mm) geomembrane liner secured with Platipus Percussive Driven Earth Anchors (PDEA®) as a cost effective and easily installed alternative to traditional vertical trenching. The Platipus anchor assembly was manufactured with components to meet the holding capacity and 20-year design life required by Geosyntec Consultants/MES in this highly corrosive environment. The anchor was driven through the liner and into 4-5 feet (1.2 – 1.5m) of compacted waste. The pull out resistance was then field tested to meet the engineered wind and LFG uplift requirements of 1,800 lbs (8kN). Once the anchor assembly was fully installed and tested, a HDPE patch was placed over to create an impermeable system.

CASE STUDY
Orford Levee Improvement - UK

Project Specification

The Orford Estuary Defence Levee protects the town of Orford and surrounding farmland. It also carries a public footpath along its crest. The defences, which have dried and cracked, have also, during the last sixty years, settled into the soft silts below by more than 0.5m (1.6ft). Following on from its application in Louisiana, for the US Army Corps of Engineers during the post Hurricane Katrina flood defence improvement, the Orford levee provided another opportunity to trial this innovative method to increase flood resistance. The landward slope is particularly important for the resilience of levees. Experience has shown that prolonged over-topping of the crest will initiate a breach in the defence.

Solution

The solution was to apply double twist rockfall netting to the back and crest of the defence, which was folded back on itself and infilled with engineered clay taken from the adjacent farmland to heighten the defence. The landward side of the defence was protected by continuing the double twist rockfall netting towards the toe of the slope and securing it with two horizontally offset rows of Platipus S6 ARGS anchor assemblies. These were installed on 2m (6.6ft) horizontal centres and driven to a depth of 1.2m (3.9ft). Combining Platipus anchors with double twist rockfall netting in this way significantly increases the duration of overtopping that can be withstood without damage to the turf. In addition to turf reinforcement, a substantial improvement to the factor of safety against rotational slips has been achieved by the use of the anchors. The whole of the defence was seeded using a native grass mix, which grows through the anchored rock fall netting. Since its successful installation, the system has been used as a model for costing defence strengthening for the remainder of the estuary.

INSTALLATION TOOLS

Over many years we have developed a wide range of bespoke equipment to provide customers with well engineered, high quality, durable and practical installation tools designed for sustained use.

LIGHT INSTALLATION



Our range of stealth anchors up to and including the S6 can be installed using simple hand tools. The S2, S4 and S6 variants need only a Drive Rod, RR1 Rod Removers (optional), Plati-Hook (PH1), Plati-Klein (PHK), SJ5 or Setting Plate / Bobbin.

The anchors can be installed using a sledgehammer or postrammer which can be sourced locally. In multiple anchor installations electric, light air or hydraulic hammers make higher production rates fast and easily achievable.

The Manual Stressing Jack (SJ1) will provide up to 10kN of uplift to loadlock and proof test the anchors.



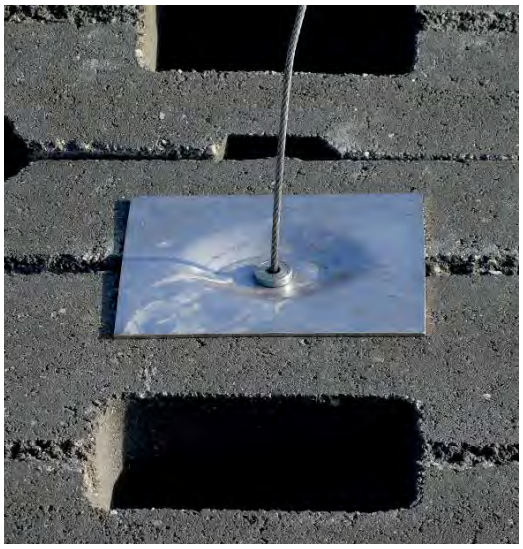
The Stressing Jack (SJ3) is an extremely compact solution for loadlocking / stressing multiple anchor installations particularly on steep slopes up to 10kN.

MEDIUM / HEAVY INSTALLATION



The installation of the S8 and B4 anchors typically require larger installation tools. Manual or Hydraulic Stressing equipment and Rod Removers are useful accessories. For multiple installations the use of hand or powered Hydraulic Stressing equipment is advised.

The B6, B8 and B10 Bat anchors will normally be used in either Deep Seated Failures or Cut Face Slopes. Installation equipment will vary from portable Hydraulic to Machine Mounted Hammers, Drive Rods, Rod Removers and Hydraulic Stressing equipment. In all cases let us advise you of our recommendations for equipment choice based upon your project's criteria.



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Installation Guide for Rolled Erosion Control Products (RECPs) Including Mulch Control Nettings (MCNs), Open Weave Textiles (OWTs), Erosion Control Blankets (ECBs), and Turf Reinforcement Mats (TRMs)

This document is intended to provide general guidelines for the installation of RECPs and does not supersede manufacture's guidelines. The following sections summarize the general, accepted procedures for installation of RECPs and provide basic guidance for slope and channel installations. Detailed design/installation information should be obtained from the manufacturer.

General Procedure.

Prepare a stable and firm soil surface free of rocks and other obstructions. Apply soil amendments as necessary to prepare seedbed. Place fertilizer, water, and seed in accordance with manufacturer, local/state regulations, or engineer/specifiers requirements. Typically, RECPs are unrolled parallel to the primary direction of flow. Ensure the product maintains intimate contact with the soil surface over the entirety of the installation. Do not stretch or allow material to bridge over surface inconsistencies. Staple/stake RECPs to soil such that each staple/stake is flush with underlying soil. Install anchor trenches, seams and terminal ends as specified.

Install RECPs after application of seed, fertilizer, mulches (if necessary) and other necessary soil amendments, unless soil in-filling of the TRM is required. For TRMs if soil in-filling, install TRM, apply seed, and other soil amendments lightly brush or rake 0.3 to 0.7 in. (8 to 18 mm) of topsoil into TRM matrix to fill the product thickness. If in-filling with a hydraulically-applied matrix or medium is required; install TRM, then install hydraulically-applied matrix or medium at the manufacturer's suggested application rate.

Apply MCNs (Materials Type 1.A., 2.A., 3.A.) immediately after dry mulch application.

Anchor Trenches, Seams and Terminal Ends

(A) Upslope Anchor – utilize one of the methods detailed below for initial anchoring of RECPs

(1) Staples. Install the RECPs 3 ft. (900 mm) beyond the shoulder of the slope onto flat final grade. Secure roll end with a single row of stakes/staples on 1 ft. (300-mm) centers.

(2) Anchor trench. Excavate a 6 in. by 6 in. (150 mm by 150 mm) anchor trench. Extend the upslope terminal end of the RECPs 3 ft. (900 mm) past the anchor trench. Use stakes or staples to fasten the product into the bottom of the anchor trench on 1 ft. (300 mm) centers. Backfill the trench and compact the soil into the anchor trench. Apply seed and any necessary soil amendments to the compacted soil

and cover with remaining 1 ft. (300 mm) terminal end of the RECPs. Fold product over compacted soil in anchor trench to overlap downslope material. Secure terminal end of RECPs with a single row of stakes or staples on 1 ft. (300 mm) centers.

(3) Staple check. Construct a stake/staple check slot along the top edge of the RECPs by installing two rows of staggered stakes/staples 4 in. (100 mm) apart on 4 in. (100 mm) centers.

(4) Single net product anchor trench. Excavate a 6 in. by 6 in. (150 mm by 150 mm) anchor trench. Position roll such that the leading end of the roll is downslope and upside down. Apply seed and necessary soil amendments. Extend product 1 ft. downslope of anchor trench and place material in anchor trench (upside down). Secure terminal end and material in anchor trench with staples at 1 ft. intervals. Fill anchor trench with soil and compact. Apply seed and necessary soil amendments to fill placed in anchor trench. Move remaining roll over and downslope of anchor trench and proceed unrolling RECP downslope (since roll was initially reversed, folding material over anchor trench will result in the net side up, and rolling correctly downslope over the anchor trench).

(B) Seams – utilize one of the methods detailed below for seaming of RECPs

(1) Adjacent seams. Overlap edges of adjacent RECPs by 2 to 4 in. (50 to 100 mm) or by abutting products as defined by manufacturer. Use a sufficient number of stakes or staples to prevent seam or abutted rolls from separating.

(2) Consecutive rolls. Shingle and overlap consecutive rolls 2 to 6 in. (50 to 150 mm) in the direction of flow. Secure staples through seam at 1 ft. (300 mm) intervals.

(3) Check seam. Construct a stake/staple check seam along the top edge of RECPs for slope application and at specified intervals in a channel by installing two staggered rows of stakes/staples 4 in. (100 mm) apart on 4 in. (100 mm) centers.

(4) Slope interruption check slot. Excavate a trench measuring 6 in. wide by 6 in. deep (150 x 150 mm). Secure product to the bottom of the trench. Fold product over upslope material and fill and compact the trench on the downslope side of check slot and seed fill. Continue rolling material downslope over trench.

(C) Terminal Ends – utilize one of the methods detailed below for all terminal ends of RECPs

(1) Staples. Install the RECPs 3 ft. (900 mm) beyond the end of the channel and secure end with a single row of stakes/staples on 1 ft. (300-mm) centers. Stakes/staples for securing RECPS to the soil are typically 6 in. (150 mm) long.

(2) Anchor trench. Excavate a 6 in. by 6 in. (150 mm by 150 mm) anchor trench. Extend the terminal end of the RECPs 3 ft. (900 mm) past the anchor trench. Use stakes or staples to fasten the product into the bottom of the anchor trench on 1 ft. (300 mm) centers. Backfill the trench and compact the soil into the anchor trench. Apply seed and any necessary soil amendments to the compacted soil and cover with remaining 1 ft. (300 mm) terminal end of the RECPs. Secure terminal end of RECPs with a single row of stakes or staples on 1 ft. (300 mm) centers.

(3) Check slot. Construct a stake/staple check slot along the terminal end of the RECPs by installing two rows of staggered stakes/staples 4 in. (100 mm) apart on 4 in. (100 mm) centers.

Slope Installations.

At the top of slope, anchor the RECPs according to one of the method detailed in Section (A) above. Securely fasten all RECPs to the soil by installing stakes/staples at a minimum rate of 1.3/yd^2 (1.5/m^2) within the body of the blanket. For the most effective RECP installation use stake/staple patterns and densities as recommended by the manufacturer. For adjacent and consecutive rolls of RECPs follow seaming instructions detailed in Section (B) above. The terminal end of the RECPs installation must be anchored using one of the methods detailed in Section (C) above.

Channel Installations.

Construct an anchor trench at the beginning of the channel across its entire width according to Section (A) (2) above. Follow the manufacturer's installation guidelines in constructing additional anchor trenches or stake/staple check slots at intervals along the channel reach and at the terminal end of the channel, according to paragraph (A) above respectively. Unroll RECPs down the center of the channel in the primary water flow direction. Securely fasten all RECPs to the soil by installing stakes/staples at a minimum rate of 1.7/yd^2 (1.5/m^2). Significantly higher anchor rates and longer stakes/staples may be necessary in sandy, loose, or wet soils and in severe applications. For adjacent and consecutive rolls of RECPs follow seaming instructions detailed in Section (B) above. All terminal ends of the RECPs must be anchored using one of the methods detailed in Section (C) above.

With any RECP installation, ensure sufficient staples to resist uplift from hydraulics, wind, mowers, and foot traffic. For the most effective installation of RECPs, the ECTC recommends using stake/staple patterns and densities as recommended by the manufacturer.

Repair any damaged areas immediately by restoring soil to finished grade, re-applying soil amendments and seed, and replacing the RECPs.

Shoreline Installations.

When required, lower the waterline as necessary and construct an anchor trench at the top of slope as described in Section (A) (2). Unroll the product down the slope and follow the manufacturer's installation guidelines in constructing additional anchor trenches or stake/staple check slots at intervals along the shoreline. Construct an anchor trench just below the mean water line at the terminal end of the shoreline, according to paragraph (C) (2) above. Securely fasten all RECPs along the shoreline to the soil by installing stakes/staples at a minimum rate of 1.7/yd^2 (1.5/m^2) through the body of the rolled erosion control product. Significantly higher anchor rates and longer stakes/staples may be necessary in sandy, loose, or wet soils, below the waterline and in severe applications. For adjacent and consecutive rolls of RECPs follow seaming instructions detailed in Section (B) above.

ECTC Standard Specification For Temporary Rolled Erosion Control Products

For use where natural vegetation alone will provide sufficient permanent erosion protection.

ULTRA SHORT-TERM - Typical 3 month functional longevity.			**C Factor[b]**	**Shear Stress[c]**	**MD Material Tensile Strength**	**TD Material Tensile Strength**	**Material Thickness**	**Ground Coverage**	**Material Mass**	**Installed Slope Steepness[d]**
			Performance Test	**Performance Test**	**Typical**	**Typical**	**Typical**	**Typical**	**Typical**	**Maximum**
Type	**Product Description**	**Material Composition**			**ASTM D6818**	**ASTM D6818**	**ASTM D6525**	**ASTM D6567**	**ASTM D6475**	
1.A[a]	**Netting / Open Weave Textile**	*A photodegradable synthetic mesh or woven biodegradable natural fiber netting.*	≤ 0.10	≥ 1.0 lbs/ft^2 (48 Pa)	≥ 125 lbs/ft (1.8 kN/m)	≥ 10 lbs/ft (0.1 kN/m)	≥ 0.03 in (0.76 mm)	≥ 3 %	≥ 0.2 oz/yd^2 (7 g/m^2)	5:1 (H:V)
1.B	**Netless Rolled Erosion Control Blankets**	*Natural and/or polymer fibers mechanically interlocked and/or chemically adhered together to form an RECP.*	≤ 0.10	≥ 1.0 lbs/ft^2 (48 Pa)	≥ 125 lbs/ft (1.8 kN/m)	≥ 10 lbs/ft (0.1 kN/m)	≥ 0.30 in (≥ 7.6 mm)	≥ 50% - ≤ 90 %	≥ 10.0 oz/yd^2 (339 g/m^2)	3:1 (H:V)
1.C	**Single-net Erosion Control Blankets**	*Processed degradable natural and/or polymer fibers mechanically bound together by a single rapidly degrading, synthetic or natural fiber netting.*	≤ 0.10	≥ 1.5 lbs/ft^2 (72 Pa)	≥ 60 lbs/ft (0.9 kN/m)	≥ 20 lbs/ft (0.3 kN/m)	≥ 0.25 - ≤ 0.50 in (≥ 6.4 - ≤ 12.7 mm)	≥ 50% - ≤ 90 %	≥ 8.0 oz/yd^2 (271 g/m^2)	3:1 (H:V)
1.D	**Double-net Erosion Control Blankets**	*Processed degradable natural and/or polymer fibers mechanically bound together between two rapidly degrading, synthetic or natural fiber nettings.*	≤ 0.10	≥ 1.75 lbs/ft^2 (84 Pa)	≥ 75 lbs/ft (1.1 kN/m)	≥ 40 lbs/ft (0.6 kN/m)	≥ 0.25 - ≤ 0.50 in (≥ 6.4 - ≤ 12.7 mm)	≥ 50% - ≤ 90 %	≥ 8.0 oz/yd^2 (271 g/m^2)	2:1 (H:V)

SHORT-TERM - **Typical 12 month functional longevity.**			**C Factor[b]**	**Shear Stress[c]**	**MD Material Tensile Strength**	**TD Material Tensile Strength**	**Material Thickness**	**Ground Coverage**	**Material Mass**	**Installed Slope Steepness[d]**
Type	**Product Description**	**Material Composition**	**Performance Test**	**Performance Test**	**Typical**	**Typical**	**Typical**	**Typical**	**Typical**	**Maximum**
					ASTM D6818	**ASTM D6818**	**ASTM D6525**	**ASTM D6567**	**ASTM D6475**	
2.A[a]	**Netting / Open Weave Textile**	*A photodegradable synthetic mesh or woven biodegradable natural fiber netting.*	≤ 0.10	≥ 1.0 lbs/ft^2 (48 Pa)	≥ 125 lbs/ft (1.8 kN/m)	≥ 10 lbs/ft (0.1 kN/m)	≥ 0.03 in (≥ 0.76 mm)	≥ 3 %	≥ 0.2 oz/yd^2 (7 g/m^2)	5:1 (H:V)
2.B	**Netless Rolled Erosion Control Blankets**	*Natural and/or polymer fibers mechanically interlocked and/or chemically adhered together to form an RECP.*	≤ 0.10	≥ 1.0 lbs/ft^2 (48 Pa)	≥ 125 lbs/ft (1.8 kN/m)	≥ 10 lbs/ft (0.1 kN/m)	≥ 0.30 in (≥ 7.6 mm)	≥ 50% - ≤ 90 %	≥ 10.0 oz/yd^2 (339 g/m^2)	3:1 (H:V)
2.C	**Single-net Erosion Control Blankets**	*Processed degradable natural and/or polymer fibers mechanically bound together by a single degrading, synthetic or natural fiber netting.*	≤ 0.10	≥ 1.5 lbs/ft^2 (72 Pa)	≥ 60 lbs/ft (0.9 kN/m)	≥ 20 lbs/ft (0.3 kN/m)	≥ 0.25 - ≤ 0.50 in (≥ 6.4 - ≤ 12.7 mm)	≥ 50% - ≤ 90 %	≥ 8.0 oz/yd^2 (271 g/m^2)	3:1 (H:V)
2.D	**Double-net Erosion Control Blankets**	*Processed degradable natural and/or polymer fibers mechanically bound together between two degradable, synthetic or natural fiber nettings.*	≤ 0.10	≥ 1.75 lbs/ft^2 (84 Pa)	≥ 75 lbs/ft (1.1 kN/m)	≥ 40 lbs/ft (0.6 kN/m)	≥ 0.25 - ≤ 0.50 in (≥ 6.4 - ≤ 12.7 mm)	≥ 50% - ≤ 90 %	≥ 8.0 oz/yd^2 (271 g/m2)	2:1 (H:V)

EXTENDED-TERM - **Typical 24 month functional longevity.**			**C Factor**[b]	**Shear Stress**[c]	**MD Material Tensile Strength**	**TD Material Tensile Strength**	**Material Thickness**	**Ground Coverage**	**Material Mass**	**Installed Slope Steepness**[d]
Type	**Product Description**	**Material Composition**	**Performance Test**	**Performance Test**	**Typical** **ASTM D6818**	**Typical** **ASTM D6818**	**Typical** **ASTM D6525**	**Typical** **ASTM D6567**	**Typical** **ASTM D6475**	**Maximum**
3.A	**Open Weave Textiles**	*An open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix.*	≤ 0.05	≥ 2.0 lbs/ft^2 (96 Pa)	≥ 100 lbs/ft (1.5 kN/m)	≥ 40 lbs/ft (0.6 kN/m)	≥ 0.20 - ≤ 0.40 in (≥ 5.1 - ≤ 10.1 mm)	≥ 40 %	≥ 11.0 oz/yd^2 (373 g/m^2)	2:1 (H:V)
3.B	**Erosion Control Blankets**	*An erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically bound together between two slow degrading synthetic or natural fiber nettings to form a continuous matrix.*	≤ 0.05	≥ 2.0 lbs/ft^2 (96 Pa)	≥ 100 lbs/ft (1.5 kN/m)	≥ 40 lbs/ft (0.6 kN/m)	≥ 0.25 - ≤ 0.50 in (≥6.4 - ≤ 12.7 mm)	≥ 50% - ≤ 95 %	≥ 8.0 oz/yd^2 (271 g/m^2)	1.5:1 (H:V)

LONG-TERM - Typical 36 month functional longevity.			**C Factor[b]**	**Shear Stress[c]**	**MD Material Tensile Strength**	**TD Material Tensile Strength**	**Material Thickness**	**Ground Coverage**	**Material Mass**	**Installed Slope Steepness[d]**
			Performance Test	**Performance Test**	**Typical**	**Typical**	**Typical**	**Typical**	**Typical**	**Maximum**
Type	**Product Description**	**Material Composition**			**ASTM D6818**	**ASTM D6818**	**ASTM D6525**	**ASTM D6567**	**ASTM D6475**	
4.A	**Open Weave Textiles**	*An open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix.*	≤ 0.05	≥ 2.25 lbs/ft^2 (108 Pa)	≥ 100 lbs/ft (1.5 kN/m)	≥ 40 lbs/ft (0.6 kN/m)	≥ 0.20 - ≤ 0.40 in (≥ 5.1 - ≤ 10.1 mm)	≥ 50 %	≥ 20.0 oz/yd^2 (678 g/m^2)	1:1 (H:V)
4.B	**Erosion Control Blankets**	*An erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically bound together between two slow degrading synthetic or natural fiber nettings to form a continuous matrix.*	≤ 0.05	≥ 2.25 lbs/ft^2 (108 Pa)	≥ 100 lbs/ft (1.5 kN/m)	≥ 40 lbs/ft (0.6 kN/m)	≥ 0.20 - ≤ 0.50 in (≥ 5.1 - ≤ 12.7 mm)	≥ 50% - ≤ 95 %	≥ 8.0 oz/yd^2 (271 g/m^2)	1:1 (H:V)

a. C Factor and permissible shear stress for Types 1.A. and 2.A. mulch control nettings must be obtained with netting used in conjunction with pre-applied mulch material.

b. This value should be the maximum C Factor from standardized large-scale rainfall performance testing, ASTM D6459 or equivalent deemed acceptable by the engineer.

c. Required minimum shear stress RECP (unvegetated) can sustain without physical damage or excess erosion (> 12.7 mm (0.5 in) soil loss) during a 30-minute flow event in large-scale performance testing, ASTM D6460 or equivalent deemed acceptable by the engineer.

d. This value should represent the maximum gradient the product should be recommended for rainfall/slope application.

Table 2. ECTC Standard Specification For Turf Reinforcement Mats (TRMs)

For applications where vegetation alone will not sustain expected flow conditions and/or provide sufficient long-term erosion protection.

							Index Value at Time of Manufacture				
Type	**Product Description**	**Material Composition**	**Slope Application Maximum Gradient**	**Performance Test Unvegetated Shear Stress [b, c, d] Typical ASTM D6460**	**Performance Test Vegetated Shear Stress [c, d, e, f] Typical ASTM D6460**	**Seedling Emergence [d] Typical ASTM D7322**	**Tensile Strength MD [d, f] Typical ASTM D6818**	**Tensile Strength TD [d, f] Typical ASTM D6818**	**Material Mass / Unit Area [d] Typical ASTM D6566**	**Thickness [d] Typical ASTM D6525**	**UV Stability [d, f] Typical ASTM D4355**
5.A	**Turf Reinforcement Mat**	*A product composed of UV-stabilized non-degradable synthetic fibers, filaments, nets, wire mesh and/or other elements, processed into a permanent, three-dimensional matrix which may be supplemented with degradable components.*	1:1 (H:V)	≥ 2.0 lb/ft² (≥ 96 Pa)	≥ 6.0 lb/ft² (≥ 287 Pa)	≥ 250%	≥ 150 lbs/ft (≥ 2.2 kN/m)	≥ 150 lbs/ft (≥ 2.2 kN/m)	≥ 8.0 oz/yd² (≥ 271 g/m2)	≥ 0.25 in (≥ 6.35 mm)	≥ 80% @ 500 hrs
5.B	**Turf Reinforcement Mat**		1:1 (H:V)	≥ 2.0 lb/ft² (≥ 96 Pa)	≥ 8.0 lb/ft² (≥ 383 Pa)	≥ 250%	≥ 175 lbs/ft (≥ 2.6 kN/m)	≥ 175 lbs/ft (≥ 2.6 kN/m)	≥ 8.0 oz/yd² (≥ 271 g/m2)	≥ 0.25 in (≥ 6.35 mm)	≥ 80% @ 500 hrs
5.C	**Turf Reinforcement Mat**		0.5:1 (H:V)	≥ 2.0 lb/ft² (≥ 96 Pa)	≥ 10.0 lb/ft² (≥ 479 Pa)	≥ 250%	≥ 200 lbs/ft (≥ 2.9 kN/m)	≥ 200 lbs/ft (≥ 2.9 kN/m)	≥ 8.0 oz/yd² (≥ 271 g/m2)	≥ 0.25 in (≥ 6.35 mm)	≥ 80% @ 1,000 hrs
5.D	**Turf Reinforcement Mat**		0.5:1 (H:V)	≥ 2.0 lb/ft² (≥ 96 Pa)	≥ 12.0 lb/ft² (≥ 575 Pa)	≥ 250%	≥ 325 lbs/ft (≥ 4.8 kN/m)	≥ 225 lbs/ft (≥ 3.3 kN/m)	≥ 8.0 oz/yd² (≥ 271 g/m2)	≥ 0.25 in (≥ 6.35 mm)	≥ 80% @ 1,000 hrs
5.E [a]	**Turf Reinforcement Mat**		0.5:1 (H:V)	≥ 2.0 lb/ft² (≥ 96 Pa)	≥ 12.0 lb/ft² (≥ 575 Pa)	≥ 250%	≥ 1,500 lbs/ft (≥ 21.9 kN/m)	≥ 1,500 lbs/ft (≥ 21.9 kN/m)	≥ 8.0 oz/yd² (≥ 271 g/m2)	≥ 0.25 in (≥ 6.35 mm)	≥ 90% @ 1,000 hrs
5.F [a]	**High Performance Turf Reinforcement Mat**	*A product composed of UV-stabilized, non-degradable, synthetic fibers, filaments, nets, wire mesh and/or other elements, processed into a permanent, three-dimensional matrix.*	0.5:1 (H:V)	≥ 2.0 lb/ft² (≥ 96 Pa)	≥ 14.0 lb/ft² (≥ 670 Pa)	≥ 250%	≥ 3,000 lbs/ft (≥ 43.8 kN/m)	≥ 3,000 lbs/ft (≥ 43.8 kN/m)	≥ 8.0 oz/yd² (≥ 271 g/m2)	≥ 0.25 in (≥ 6.35 mm)	≥ 80% @ 3,000 hrs

[a] *For material Types 5.E and 5.F, property values tested per ASTM D6818 and D6525 are reported as minimum average roll values (MARVs). MARVs are calculated as the typical minus two standard deviations. Statistically, it yields a 97.7% degree of confidence that any samples taken from quality assurance testing will exceed the value reported.*

[b] *Required minimum shear stress TRM (unvegetated) can sustain without physical damage or excess erosion (> 12.7 mm (0.5 in.) soil loss) during successive, minimum 30 minute flow events in large scale testing.*

[c] *Acceptable large-scale testing protocol may include ASTM D6460, or other independent testing deemed acceptable by the engineer. Large scale performance testing typically involves limited soil types and vegetative stands, therefore it is recommended that an appropriate factor of safety be used in design and product selection (see Guidance Document for further information).*

[d] *Typical values are calculated as the average value. Statistically, it yields a 50% degree of confidence that any samples taken from quality assurance testing will exceed the value reported.*

[e] *Required minimum shear stress TRM (fully vegetated) can sustain without physical damage or excess erosion (> 12.7 mm (0.5 in.) soil loss) during successive, minimum 30 minute flow events in large scale testing.*

[f] *For TRMs containing degradable components, property values must be obtained on the non-degradable portion of the matting alone.*

NOTE: TRMs are typically used in hydraulic applications, such as high flow ditches and channels, steep slopes, stream banks, and shorelines, where erosive forces may exceed the limits of natura, unreinforced vegetation or in areas where limited vegetation establishment is anticipated.

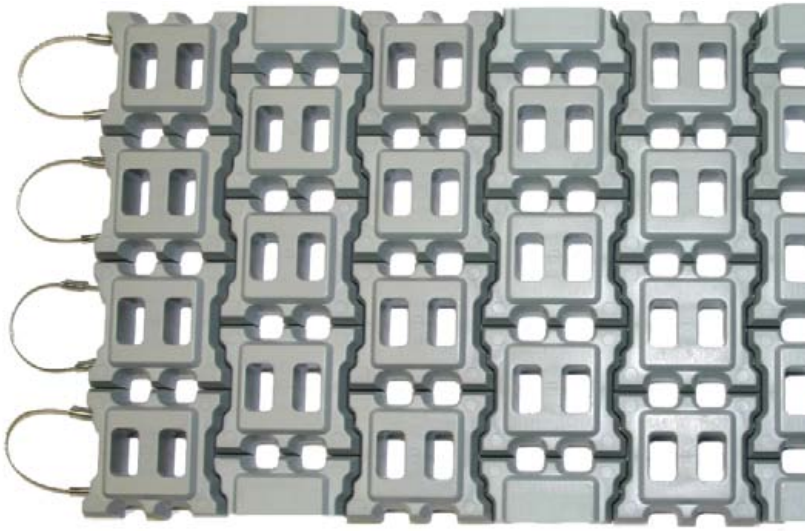
APPENDIX B

CONTECH®
ENGINEERED SOLUTIONS

ArmorFlex® Installation Guide

ARMORTEC®
Erosion Control Solutions

ArmorFlex® Installation Guide



The purpose of the ArmorFlex Installation Guide is to provide recommendations for the proper installation of Articulating Concrete Block (ACB) revetment systems. While this guide offers a set of instructions for performing those operations that are critical for the proper functioning of ACB revetment systems, final preparation and installation is the responsibility of the end user. Additional information is contained in ASTM D6884 Standard Practice for Installation of Articulating Concrete Block (ACB) Revetment Systems.

The proper installation of ACB revetment systems is important to achieving the intended hydraulic performance and maintaining stability against the erosive forces of flowing water. An ACB revetment system consists of a suitably prepared and compacted subgrade, a suitable site-specific filter fabric and properly sized ACB block mattresses placed in "intimate contact" with the filter fabric and subgrade. Each individual site will vary so it is important to follow the engineering project drawings as designed and sealed by a registered Professional Engineer; particularly as they relate to standard termination details. All illustrations and photographs used in this guide are examples of typical situations.

It is the Contractor's responsibility to maintain safe work practices consistent with OSHA (Occupational Safety and Health Administration) regulations and other prevailing safe work practices. This guide is intended to be used in conjunction with all applicable safety regulations and safe work practices and is in no way a replacement thereof.

Site Planning & Preparation

Foundation Preparation

Areas on which filter fabric and ACB units are to be placed shall be constructed to the lines and grades shown on the contract drawings to the tolerances specified in the contract documents and approved by the engineer. All areas to receive the ACB shall be compacted and graded smooth to facilitate the installation of the articulated concrete block system and ensure that intimate contact (between the slope face, the filter fabric and the entire bottom surface of the ACB units) is maintained throughout the system.

Unsatisfactory soils (soils having excessive in-place moisture content, soils containing clods, roots, or other organic material that impair the local slope face) must be removed, replaced with approved material and compacted to a minimum 90% of Standard Proctor density (Test Method D698).

Holes, "pockmarks", slope board teeth marks, footprints or other voids greater than 1 inch in depth normal to the local slope face shall not be permitted. No grooves or depressions greater than 0.5 inches in depth normal to the local slope face with a dimension exceeding 1 foot in any direction shall be permitted. Where such areas are evident, they shall be brought to grade by placing compacted homogeneous material. The slope and slope face shall be uniformly compacted, and the Engineer shall determine the depth of layers, homogeneity of soil, and amount of compaction required. If differing block heights are used — the slope is to be prepared so that the tops of the blocks are flush.

Care shall be exercised so as not to excavate below the grades shown on the Engineer's Contract Drawings, unless directed by the Engineer to remove unsatisfactory materials. Excavation of subgrade shall not be more than 2 inches (50 mm) below specified grade. In such areas, placing and compacting approved material, in order to get up to specified grade, in layers not exceeding 6 inches (150 mm) is required. In such areas where subgrade is above specified grade, they shall be brought to grade by removing material or reworking existing material and compacting.

Proper excavation, grading and compaction is critical to the performance of the ACB system.

Fabric shall have the proper overlap and be free of any holes or tears.

When working in an underwater application, it is the contractor's responsibility to assess the jobsite conditions and the means of achieving proper subgrade preparation, per the Engineer's Contract drawings, specifications, and tolerances.

Placement of Filter Fabric

The subgrade shall be inspected immediately prior to filter fabric and ACB placement for proper preparation. The filter fabric shall be placed directly on the prepared subgrade, in intimate contact with the subgrade and free of folds, wrinkles or excess tension. The filter fabric shall not be walked on or disturbed in a manner resulting in the loss of intimate contact between the filter frabric, the ArmorFlex block and subgrade soils.

The filter fabric shall be placed so that upstream sections overlap downstream sections and so that upslope sections overlap downslope sections ("shingle effect"). Overlaps shall be in the direction of flow wherever possible. The longitudinal and transverse joints shall be overlapped at least 3 feet (91 cm) for below-water installations and at least 2 feet (60 cm) for dry installations. The filter fabric shall extend at least 1 foot beyond the top, bottom, and flanking revetment termination points.

Product Delivery and Handling

Deliveries are typically scheduled to accommodate the overall installation sequence requested though the stacking of mats on an individual load is limited to larger mats towards the bottom and smaller mats toward the top of the trailer.

Deliveries are typically made on 48' flat beds with over-the-road tractors, so adequate truck access and turnaround room at the jobsite must be provided by the Contractor. The trucks and drivers are typically contract carriers (not CONTECH trucks).

The drivers are not expected to have any special certifications, jobsite training or equipment. In the case special requirements are needed, the terms and conditions will need to be negotiated and established at the time of the order. Drivers will untie their loads but are not qualified to help with any rigging, unloading or installation.

CONTECH requires at least a full 4 day notice to schedule trucks (Example: notification on Monday for Friday delivery).

For staging mats (offloading for installation later) allow approximately 30-45 minutes to offload each truck. Staging of mats on-site is highly recommended, especially if your company has never installed ArmorFlex in the past.

Timing is everything. Be prepared to unload the mats when the trucks arrive. If applicable, the first load will have the Spreader Bar and filter fabric, along with the first sequence of mats. For installation off the truck, allow 45-60 minutes for direct installation off the truck. Additional time between loads should be considered for inexperienced crews.

CONTECH loads typically allow 2 hours for unloading time. Detention may apply after this 2 hour period and will be charged to the contractor. Loads are typically pre-loaded the day before in order to arrive first thing in the morning.

Each load will have a Bill of Lading (BOL) that has the load number with unloading dates and times.

All mats will be marked on the side of each mat with one of the following descriptions:

1. Rectangle mats will be marked with the size (Example: 8' W x 20' L).
2. Angle/Pie shape mats will be marked with the mat number per the Mat Layout Spreadsheet.

CONTECH requires notification of any changes or cancellation of scheduled deliveries during normal business hours the day prior to loading in order to avoid any cancellation charges.

The use of a crane is optimal for fast and safe unloading and installation of the mats.

Spreader Bar Overview

This instruction content is for informational purposes and should not be considered to be used in lieu of consultation with a professional rigger. Distribute this guide as a procedure for rigging and handling CONTECH supplied Spreader Bars (See Detail A). Notwithstanding the instructions contained in this guide, it is the responsibility of the customer or customer's agent to handle CONTECH products in a safe and efficient manner. For additional information, refer to safety standard ASME B30.20, *Below-the-Hook Lifting Devices*.

Inspection

The operator or other designated personnel should visually inspect the unit before every lift, as well as during operation in the event that damage occurs during a lift. Connector Links, Eye Hooks with Snap Lock and Screw Pin Shackles should engage properly and be free of damage (see Detail B).

The unit shall be free of structural deformation, cracks or excessive wear of any part of the Main Lifting Beam and the Hook Tube Assemblies. The operator should check for loose or missing fasteners, including Connector Links (12), Eye Hooks with Snap Lock (12) and Screw Pin Shackles (2). Welds should also be inspected for signs of obvious cracking.

Maintenance

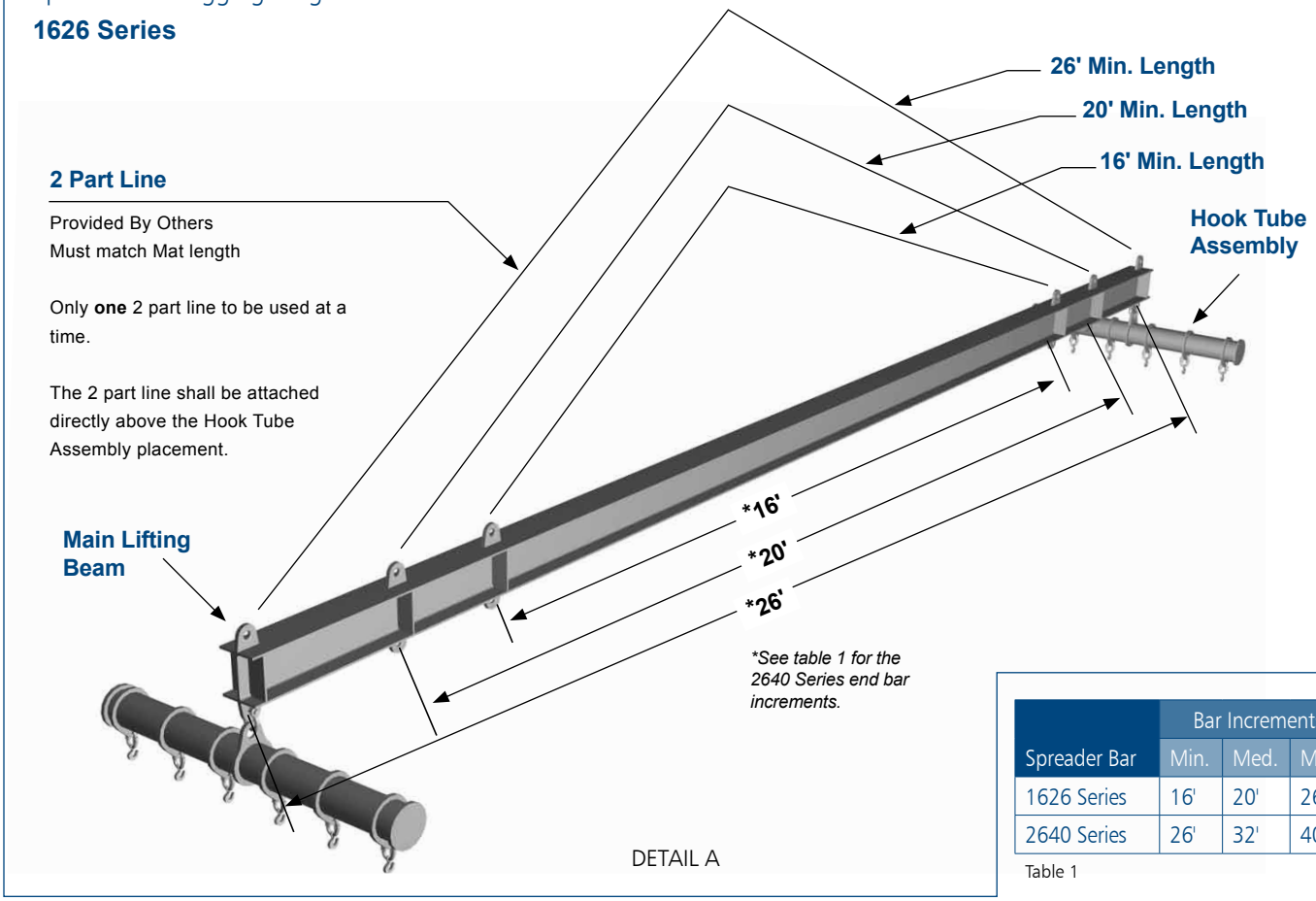
Any observed damage to the Connector Links, Eye Hooks with Snap Lock and Screw Pin Shackles or hazardous conditions found during an inspection shall be corrected before the Spreader Bar is put back into service. Adjustments and repairs shall only be done by a qualified person, and the following process shall be followed by the contractor or their designee:

1. Contact a CONTECH Project Manager before any repair work is performed.
2. The Spreader Bar shall be tagged "OUT OF SERVICE."
3. Replacement parts shall be equal and/or exceed the original manufacturer's specifications (see "Spreader Bar Parts List").
4. Personnel working on the device must be qualified to make the given repair.

When structural damage of the unit is noted or repairs are needed (except for Connector Link, Eye Hooks with Snap Lock, Screw Pin Shackle), the contractor shall halt use of the Spreader Bar, tag the bar "OUT OF SERVICE" and contact the CONTECH Project Manager for further instruction. No welding whatsoever shall be performed on the Spreader Bar unit.

Spreader Bar Rigging Diagram

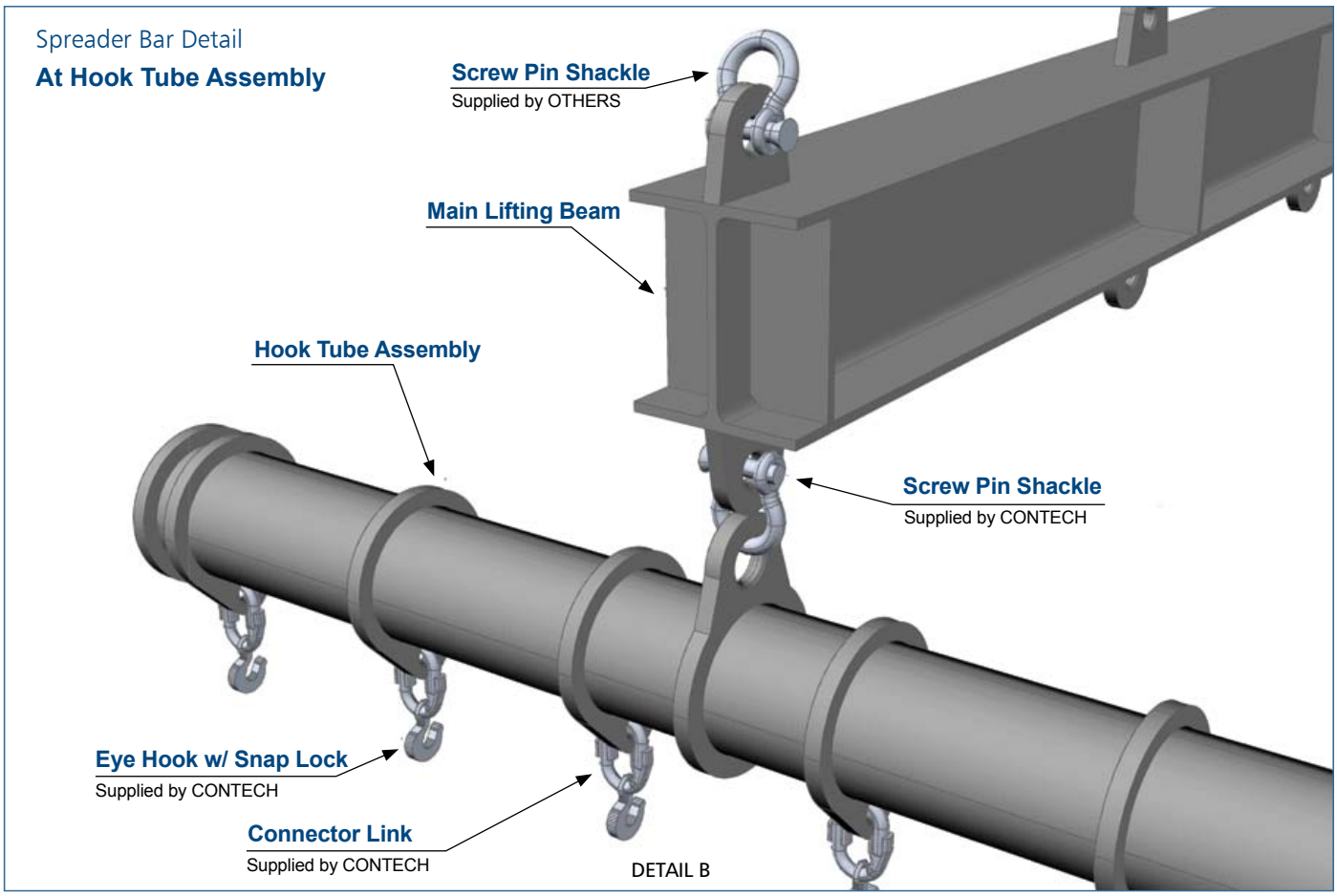
1626 Series



DETAIL A

Spreader Bar	Bar Increments		
	Min.	Med.	Max.
1626 Series	16'	20'	26'
2640 Series	26'	32'	40'

Table 1



SPREADER BAR PARTS LIST	
Qty.	Description
1	Main Lifting Beam
2	Hook Tube Assembly
12	Connector Link, Lok-A-Loy 6-5/8", 16,500 lb Crosby #1014459
12	Eye Hook w/ Snap Lock - 2 ton S-320C Crosby #1022233
2	1" Screw Pin Shcackle 20,000 lb Columbus McKinnon #600-02515
	Replacement Latch Kit - Crosby #1096468

Equipment Needs

Prior to delivery, review the heaviest lift and highest pick in order to properly size the equipment used for the offload and the installation of the mats.

Total pick weight will include the weight of each mat AND Spreader Bar. Estimated Spreader Bar weight is 2,600 lbs for 26’ bars and 3,500 lbs for 40’ bars.

Total vertical lift height typically ranges between 30’ - 65’ and is determined by the following variables:

Setting Mats with a Crane or Excavator

1. “Walking” mats with an excavator or using more than one piece of equipment to pick is not recommended and can result in unsafe working conditions and/or damage to the ACB mattresses.
2. Proper lifting with the Spreader Bar ensures the 5:1 working load factor of the cable is preserved.
3. Single end picks (picking up the mat from one end) are not allowed.
4. Identify and avoid obstructions that may hinder reach height (Example: Power lines).

EQUIPMENT	*PICK HEIGHT IMPACT*
Flatbed Trailer	5'
Sag of Mat	5'-20'
2-Part Line	15'-35'
Height of Spreader Bar	4'
Total Vertical Lift Range	**30'-65'**

Is the reach of your crane or excavator sufficient to set the mats?

CAUTION: Consult the load chart for the machine to verify its load rating is not exceeded.

WARNING NOTES & SAFETY INSTRUCTIONS

Only trained and authorized equipment operators are to be permitted to use CONTECH supplied Spreader Bars. Failure to follow these instructions can result in serious injury or death and/or damage to the product.

DO NOT: Exceed the rated load or lift loads not specified in this guide.

DO NOT: Operate a damaged or malfunctioning unit or a unit with missing parts.

DO NOT: Lift people.

DO NOT: Leave suspended loads unattended.

DO NOT: Remove or obscure warning labels.

DO NOT: Operate without having read and understood the operating guide.

DO NOT: Stand under or near suspended load.

DO NOT: Lift loads higher than necessary.

DO NOT: Make alterations or modifications to a Spreader Bar.

Installation Instructions

Placement of ArmorFlex Units

Care shall be taken while installing the system in order to avoid damage to the filter fabric or the underlying subgrade. The ArmorFlex units shall be placed on the filter fabric in such a manner as to produce a smooth plane surface in intimate contact with the filter fabric.

The preferred method is to start installation of the ACB system at the downstream end and proceed upstream, taking care to protect the leading edge against erosive forces. These erosive forces could potentially undermine the system if proper installation procedures are not followed.

No individual unit within the plane of the system shall exceed a 0.5 inch protrusion or greater protrusion than is specified in the contract drawings. The units shall be placed side by side so that the blocks abut. Termination trenches typically consist of a 2-block toe-in, including the top of slope, the toe of slope and flanks unless otherwise directed by the EOR. This design is typical of an ACB system to protect all sides from erosive factors.

Subgrade preparation, placement of filter fabric, placement of the ArmorFlex concrete units and the final completed project shall be inspected and approved by the Contractor and EOR.

To assist in aligning the unit being placed, use of a pry bar may be necessary.

Earth Anchors (if required):

1. Anchors shall be installed per the manufacturer's instructions.
2. Anchor penetrations through the filter fabric shall be grouted with approved material to prevent migration of subsoil through the penetration point.

FINISHING

Grouting

4,000 psi non-shrinking grout or 4,000 psi concrete shall be placed where the loop ends of the mats meet, or wherever there is greater than a 2-inch gap between adjacent mats or structures. Grout to the top of the block or slightly lower (not above). Grouting of seams is meant to provide a hydraulic connection, not necessarily a structural connection between mats.

Backfill

Backfill of the block shall be specified by the Engineer of Record (EOR). Typical backfill is either suitable soil for revegatation or .375 to .750 inch (10 to 20 mm) diameter crushed stone. Backfilling should occur as early as possible to protect the filter fabric from UV damage. The exposed edges shall be backfilled until flush, ensuring the integrity of a soil backfill is maintained.

Termination trenches shall be backfilled as shown on the approved contract drawings. This backfill material shall be approved by the EOR. It is the recommendation by Armortec® that this non-erodible backfill be 4,000 psi non-shrinking grout or concrete.

Repair of Damaged Units

In the event that a damaged concrete unit exists prior to the placement or after the mat has been installed, the concrete unit can be repaired in one of the following acceptable manners; unit to be completely removed and then backfilled with 4,000 psi grout/concrete or, replaced with a new block unit.

Depending on the size of the crack or chip, the perimeter and void areas of the block can be filled with grout up to or just below the top grade of the block.

Chipping resulting in a weight loss exceeding 10% of the average weight of a concrete unit shall be repaired. Surface chipping (i.e. weight loss of less than 10%) resulting from customary handling methods generally do not require repair.

Grout to the top of the block or slightly lower — not above.

Backfilling should occur as early as possible to protect the filter fabric from UV damage.

Tool and Material Checklist	
Two-part line for attachment to the Spreader Bar's Main Lifting Beam. Each leg of the two-part line needs to be equal to or greater than the longest mat to be picked to achieve an angle no less than 60 degrees between the bar and line. (See Detail A).	**Supplied by others**
Chokers or Straps for ease of Spreader Bar adjustment, recommend: 6 chokers each 2', 5', 8' or 1-2 nylon straps each 2', 5', 8'.	**Supplied by others**
Swivel Clevis for picking point of equipment	**Supplied by others**
Three heavy duty rock bar or pry bars (5 feet length is optimal).	**Supplied by others**
Upside down marking paint (for alignment markings on the mats or ground during installation).	**Supplied by others**
100' measuring tape.	**Supplied by others**
Amortec's Mat Layout Plan Drawings and Mat Layout Spreadsheet with mat numbers and sizes. Have these documents on-site at ALL times for reference.	**Supplied by CONTECH**

Notes:

Support

If you need guidance please, call your local sales representative or our corporate headquarters at 1.800.338.1122 and ask for a representative.

- Drawings and specifications are available at www.ContechES.com.
- Site-specific design support is available from Contech representatives.

Contech Engineered Solutions LLC provides site solutions for the civil engineering industry. Contech's portfolio includes bridges, drainage, sanitary sewer, stormwater and earth stabilization products.

Nothing in this catalog should be construed as an expressed warranty or an implied warranty of merchantability or fitness for any particular purpose. See the Contech standard quotation or acknowledgement for applicable warranties and other terms and conditions of sale.

For information on other Contech offerings,
visit www.ContechES.com or call 800.338.1122

CONTECH® ENGINEERED SOLUTIONS

ARMORTEC® Erosion Control Solutions

ARTICULATING CONCRETE BLOCK (ACB) SYSTEM SPECIFICATIONS

NOTE TO SPECIFIERS:

THE PURPOSE OF THIS GUIDE SPECIFICATION IS TO ASSIST THE SPECIFIER IN DEVELOPING A PROJECT SPECIFICATION FOR THE USE OF ARTICULATING CONCRETE BLOCK SYSTEMS. THIS GUIDE DOCUMENT IS INTENDED TO BE PART OF A COMPLETE PROJECT MANUAL; IT IS NOT INTENDED TO BE A "STAND ALONE" DOCUMENT.

THIS GUIDE SPECIFICATION WILL NEED TO BE CAREFULLY REVIEWED FOR APPROPRIATENESS FOR THE GIVEN PROJECT AND EDITED ACCORDINGLY TO COMPLY WITH PROJECT-SPECIFIC REQUIREMENTS. PLEASE CONTACT AN ARMORTEC REPRESENTATIVE WITHIN CONTECH FOR ASSISTANCE IN EDITING THIS DOCUMENT.

DELETE THE FOREGOING TEXT PRIOR TO PUBLISHING IN A PROJECT DESIGN MANUAL.

PART 1 GENERAL

1.1 SCOPE OF WORK

A. The contractor shall furnish all labor, materials, equipment, and incidentals required for, and perform all operations in connection with, the installation of the ArmorFlex® Articulating Concrete Block (ACB) system in accordance with the lines, grades, design and dimensions shown on the Contract Drawings and as specified herein.

1.2 RELATED SECTIONS

A. Section 03 61 00 – Cementitious Grouting

B. Section 31 22 00 – Grading

C. Section 31 35 19.16 – Geotextile Slope Protection

1.3 SUBMITTALS

A. Submit under provisions of Section 01 30 00 - Administrative Requirements.

B. Product Data: Manufacturer's data sheets on each product to be used, including:

1. Certification of successful completion of full-scale laboratory testing in accordance with the current version of ASTM D 7277, *Standard Test Method for Performance Testing of Articulating Concrete Block (ACB) Revetment Systems for Hydraulic Stability in Open Channel Flow*. This certification shall comprise a final test report from the testing facility, or a summary test report from the testing facility providing the test procedure and the obtained Critical Shear Stress parameters of the tested block. Third-party testimonies of compliance shall not be sufficient to satisfy this requirement.
2. Certified analysis and interpretation of the test data shall conform to the guidance contained in the current version of ASTM D 7276, *Standard Guide for Analysis and Interpretation of Test Data for Articulating Concrete Block (ACB) Revetment Systems in Open Channel Flow*.
3. The following information obtained from the above testing, analysis, and interpretation:
    a. Tested bed slope
    b. Maximum discharge attained prior to failure
    c. Measured water surface elevation
    d. Calculated energy grade line (EGL)
    e. Plot of the applied shear and velocity by station
    f. An illustration of the selected control volume on a profile of the test slope
    g. Calculated design Manning's n
    h. Calculated block system coefficient of Lift
    i. Characteristic block properties including weight and moment arms
    j. Extrapolation of tested values to thicker block (if required)

C. Factor of Safety (FoS) calculations in support of the proposed ACB system

1. In accordance with the Factor-of-Safety design methodology as described in *"Moment Stability Analysis Method for Determining Safety Factors for Articulated Concrete Blocks"*, by Amanda L. Cox, 2010.
2. Stamped and signed by a Professional Engineer licensed to practice in the state where the project is located.
3. The following project specific hydraulic requirements are to be utilized:

Property	Value
Channel Bottom Width (ft)	
Channel Side Slopes (_H:1V)	
Channel Bed Slope (ft/ft)	
Design Volumetric Flow Rate (cfs)	

4. The analysis shall be performed based upon the stability of the ACBs due to gravity alone, conservatively neglecting any stabilizing forces potentially provided by cabling, mechanical anchorage, contact with adjacent blocks, or other restraints not attributable to gravity alone.
5. **All design calculations submitted must be based upon the smallest block utilized in the mats. Partial "half blocks" must be analyzed separately**.
6. The analysis must account for a 0.5-inch block projection, in accordance with *ASTM D 6884, Standard Practice for Installation of Articulating Concrete Block (ACB) Revetment Systems,* Section 6.3.3. Site grading requirements may not be used to omit this requirement for standard (non-tapered) block. For block that is tapered (i.e., the block thickness is greater on the downstream edge than on the upstream edge, by at least 0.5"), this block projection value may be 0 inches for analysis purposes.

D. An appropriate geotextile, selected for the site being protected on the basis of the gradation and permeability of the surface soils.

E. Manufacturer's certificates of compliance for ACB/mats, revetment cable, geotextile, and any revetment cable fittings and connectors in accordance with the current version of ASTM D 6884, *Standard Practice for Installation of Articulating Concrete Block (ACB) Revetment Systems*.

F. Shop Drawings for the layout of the mats, installation, and safety instructions, and any recommendations, if applicable, that are specifically related to the project.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Suppliers must own and operate their own manufacturing facility.
2. Suppliers shall directly employ a minimum of five (5) registered Professional Engineers.
3. A list of five (5) comparable projects, in terms of size and applications, in the United States, where the satisfactory performance of the specific ACB system can be verified after a minimum of five (5) years of service life.
4. The names and contact information (phone numbers and e-mail addresses, at a minimum) for the suppliers' representatives, for technical, production or logistics questions, at least one of whom must reside in the state where the project is located.

B. Installer Qualifications: Minimum 2 year experience installing similar products.

1.5 PRE-INSTALLATION MEETINGS

A. Supplier's representative shall be available for pre-installation meeting a minimum two weeks prior to starting work of this section.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Materials delivered to the site shall be inspected for damage, unloaded and stored with the minimum of handling. Material shall be kept free of dirt and debris.

B. Storage shall be in accordance with manufacturer's requirements.

C. Handling: Materials shall be handled in such a manner as to ensure delivery to the site in sound, undamaged condition.

PART 2 PRODUCTS

2.1 MATERIALS

A. Articulating Concrete Blocks
1. Manufacturing shall conform to the current version of ASTM D-6684, *Standard Specification for Materials and Manufacture of Articulating Concrete Block (ACB) Revetment Systems*.
2. Cementitious Materials - Materials shall conform to the following applicable ASTM specifications:
   a. Portland Cements - Specification C 150, for Portland Cement.
   b. Blended Cements - Specification C 595, for Blended Hydraulic Cements.
   c. Hydrated Lime Types - Specification C 207, for Hydrated Lime Types.
   d. Pozzolans - Specification C 618, for Fly Ash and Raw or Calcined Natural Pozzolans for use in Portland Cement Concrete.
   e. Aggregates – Specification C 33, for Concrete Aggregates, except that grading requirements shall not necessarily apply.
3. Casting: The ACB units shall be produced using a dry cast method only. Dry cast units obtain strength more quickly than wet cast blocks, and will also achieve a greater uniformity of quality and greater durability.
4. Cables must be independent of blocks.
5. Physical Requirements: At the time of delivery to the work site, the ACB units shall conform to the physical requirements prescribed in Table listed below.

PHYSICAL REQUIREMENTS

Compressive Strength Net Area Min. p.s.i (mPa)		Water Absorption Max. lb/ft^3 (kg/m^3)	
Avg. of 3 units	Individual Unit	Avg. of 3 units	Individual Unit
4,000 (27.6)	3,500 (24.1)	9.1 (160)	11.7 (192)

6. Visual Inspection
   a. All units shall be sound and free of defects which would interfere with the proper placement of the unit, or which would impair the performance of the system. Surface cracks incidental to the usual methods of manufacture, or surface chipping resulting from customary methods of handling in shipment and delivery, shall not be deemed grounds for rejection.
   b. Cracks exceeding 0.25 inches (.635 cm) in width and/or 1.0 inch (2.54 cm) in depth shall be deemed grounds for rejection. Chipping resulting in a weight loss exceeding 10% of the average weight of a concrete unit shall be deemed grounds for rejection.
   c. Blocks rejected prior to delivery from the point of manufacture shall be replaced at the manufacturer's expense. Blocks rejected at the job site shall be repaired with structural grout or replaced upon request at the expense of the contractor.
7. Sampling and Testing
   a. The purchaser (or their authorized representative) shall be afforded access to

the relevant manufacturing facility or facilities, if desired, in order to inspect and/or sample the ACB units from lots ready for delivery prior to release for delivery to the job site. Such inspections are at the sole expense of the requesting entity.

b. Purchaser may request additional testing other than that provided by the manufacturer as needed. Such requested testing will extend any stated lead times for manufacturing and delivery, if the results of such testing are a prerequisite to approval (i.e., approval for release to manufacturing). Costs associated with such testing shall be borne by the purchaser.

B. Revetment Cables and Fittings

1. Option 1. Polyester Revetment Cable and Fittings
   a. Revetment cable shall be constructed of high tenacity, low elongating, and continuous filament polyester fibers. Cable shall consist of a core construction comprised of parallel fibers contained within an outer jacket or cover.
   b. The size of the revetment cable shall be selected such that the minimum acceptable strength is at least five (5) times that required for lifting of the mats, in accordance with ASTM D-6684 paragraph 5.5.2. This design shall include a reduction factor for splicing of 60%, unless a larger factor can be substantiated by laboratory testing.
   c. The revetment cable shall exhibit resistance to most concentrated acids, alkalis and solvents. Cable shall be impervious to rot, mildew and degradation associated with marine organisms. The materials used in the construction of the cable shall not be affected by continuous immersion in fresh or salt water.
   d. Selection of cable and fittings shall be made in a manner that ensures a safe design factor for mats being lifted from both ends, thereby forming a catenary. Consideration shall be taken for the bending of the cables around hooks or pins during lifting. Fittings such as sleeves and stops shall be aluminum and washers shall be plastic unless otherwise shown on the Contract Drawings.
2. Option 2. Galvanized Steel Revetment Cable and Fittings
   a. Revetment cable shall be constructed of preformed galvanized aircraft cable (GAC). The cables shall be made from individual wires and strands that have been formed during the manufacture into the shape they have in finished cable.
   b. Cable shall consist of a core construction comprised of seven (7) wires wrapped within seven (7) or nineteen (19) wire strands.
   c. The size of the revetment cable shall be selected such that the minimum acceptable strength is at least five (5) times that required for lifting of the mats, in accordance with ASTM D-6684 paragraph 5.5.2. This design shall include a reduction factor for splicing of 75%, unless a larger factor can be substantiated by laboratory testing.
   d. The revetment cable shall exhibit resistance to mild concentrations of acids, alkalis, and solvents. Fittings such as sleeves and stops shall be aluminum, and the washers shall be galvanized steel or plastic. Furthermore, depending on material availability, the cable type (7x7 or 7x19) can be interchanged while always ensuring the required factor of safety for the cable.
   e. Selection of cable and fittings shall be made in a manner that insures a safe design factor for mats being lifted from both ends, thereby forming a catenary. Consideration shall be taken for the bending of the cables around hooks or pins during lifting. Fittings such as sleeves and stops shall be aluminum and washers shall be plastic unless otherwise shown on the Contract Drawings.

C. Filter Fabric

1. The standard for sizing geotextile for these applications is AASHTO M-288, Permanent Erosion Control, Class 2. Either woven monofilament or non-woven geotextile are acceptable; woven slit-film geotextiles are not acceptable.
2. Geotextile shall be sized for the soil subgrade permeability per Section 31 35 19.16 –

Geotextile Slope Protection.

3. Under no circumstances shall the filter fabric be permanently affixed or otherwise adhered to the blocks or mats; i.e., the filter fabric shall be independent of the block system.
4. During all periods of shipment and storage, the filter fabric shall be protected from direct sunlight, UV radiation, and temperatures greater than 140°F. To the extent possible, the fabric shall be maintained wrapped in its protective covering. Geotextile exposure to sunlight or UV radiation shall be minimized to the greatest extent possible until the installation process begins.

PART 3 EXECUTION

3.1 SUBGRADE PREPARATION

A. All subgrade preparation shall be performed in accordance with the current version of ASTM D 6884, *Standard Practice for Installation of Articulating Concrete Block (ACB) Revetment Systems*.

B. The slope shall be graded to a smooth plane surface to ensure that intimate contact is achieved between the slope face and the geotextile (filter fabric), and between the geotextile and the entire bottom surface of the individual ACBs. All slope deformities, roots, grade stakes, and stones which project normal to the local slope face must be re-graded or removed. No holes, "pockmarks", slope board teeth marks, footprints, or other voids greater than 0.5 inch in depth normal to the local slope face shall be permitted. No grooves or depressions greater than 0.5 inches in depth normal to the local slope face with a dimension exceeding 1.0 foot in any direction shall be permitted. Where such areas are evident, they shall be brought to grade by placing compacted homogeneous material. The slope and slope face shall be uniformly compacted, and the depth of layers, homogeneity of soil, and amount of compaction shall be as required by the EOR.

C. Excavation and preparation for all termination trenches or aprons shall be done in accordance to the lines, grades and dimensions shown in the Contract Drawings. The termination trench hinge-point at the top of the slope shall be uniformly graded so that no dips or bumps greater than 0.5 inches over or under the local grade occur. The width of the termination trench hinge-point shall also be graded uniformly to assure intimate contact between all ACBs and the underlying grade at the hinge-point.

D. Immediately prior to placing the filter fabric and ACB mats, the prepared subgrade shall be inspected by the EOR as well as the owner's representative. No fabric or blocks shall be placed thereon until that area has been approved by each of these parties.

3.2 PLACEMENT OF GEOTEXTILE FILTER FABRIC

A. All placement and preparation should be performed in accordance with the current version of ASTM D 6884, *Standard Practice for Installation of Articulating Concrete Block (ACB) Revetment Systems*. Filter Fabric, or filtration geotextile, as specified elsewhere, will be placed within the limits of ACBs shown on the Contract Drawings.

B. The filtration geotextile will be placed directly on the prepared area, in intimate contact with the subgrade, and free of folds or wrinkles. The geotextile will not be walked on or disturbed when the result is a loss of intimate contact between the ACB and the geotextile or between the geotextile and the subgrade. The geotextile filter fabric will be placed so that the upstream strip of fabric overlaps the downstream strip. The longitudinal and transverse joints will be overlapped at least one and a half (1.5) feet for dry installations and at least three (3) feet for below-water installations. The geotextile will extend at least one (1) foot beyond the top and bottom revetment termination points, or as required by the EOR. If ACBs are assembled and placed as large mattresses, the top lap edge of the geotextile should not

occur in the same location as a space between ACB mats unless the space is concrete filled.

3.3 PLACEMENT OF THE ACBs/MATS

A. ACB placement and preparation should be performed in accordance with the current version of ASTM D 6884, *Standard Practice for Installation of Articulating Concrete Block (ACB) Revetment Systems*. ACB block/mats, as specified in Part 2:A of these Specifications, will be constructed within the specified lines and grades shown on the Contract Drawings.

B. Field installation shall be consistent with the way the system was installed in preparation for hydraulic testing pursuant to the current version of ASTM D 7277, *Standard Test Method for Performance Testing of Articulating Concrete Block (ACB) Revetment Systems for Hydraulic Stability in Open Channel Flow*. Any external restraints, anchors, or other ancillary components (such as synthetic drainage mediums) shall be employed as they were during testing; e.g., if the hydraulic testing installation utilized a drainage layer, then the field installation must also utilize a drainage layer. This does not preclude the use of other section components for other purposes, e.g., a geogrid for strengthening the subgrade for vehicular loading, or an intermediate filter layer of sand to protect very fine-grained native soils.

C. The subgrade shall be prepared in such a manner as to produce a smooth plane surface prior to placement of the ACBs or mats. No individual block within the plane of placed ACBs will protrude more than 0.5 inches or as otherwise specified by the EOR. ACBs should be flush and develop intimate contact with the subgrade section, as approved by the EOR. Proposed hand placing is only to be used in limited areas, specifically identified by the EOR or manufacturers' mat layout drawings, as approved by the EOR.

D. If assembled and placed as large mattresses, the ACB mats will be attached to a spreader bar or other approved device to aid in the lifting and placing of the mats in their proper position by the use of a crane or other approved equipment. The equipment used should have adequate capacity to place the mats without bumping, dragging, tearing or otherwise damaging the underlying fabric. The mats will be placed side-by-side, so that the mats abut each other, and/or end-to-end. Mat seams or openings between mats greater than two (2) inches will be backfilled with 4000 p.s.i. non-shrink grout, concrete or other material approved by the EOR. Whether placed by hand or in large mattresses, distinct changes in grade that results in a discontinuous revetment surface in the direction of flow will require backfill at the grade change location so as to produce a continuous surface.

E. Termination trenches will be backfilled and compacted flush with the top of the blocks. The integrity of the trench backfill must be maintained so as to ensure a surface that is flush with the top surface of the ACBs for its entire service life. Termination trenches will be backfilled as shown on the Contract Drawings. Backfilling and compaction of trenches will be completed in a timely fashion. No more than 500 linear feet of placed ACBs with non-completed termination trenches will be permitted at any time.

F. The cells or openings in the ACBs will be backfilled and compacted with suitable material, as specified by the EOR. Backfilling and compaction will be completed in a timely manner so that no more than 500 feet of exposed mats exist at any time. Finishing requirements are explicitly at the discretion of the EOR.

G. The manufacturer of the ACBs/mats shall provide design and construction advice during the design and initial installation phases of the project when required or as necessary, at the discretion of the EOR. The ACB supplier shall provide, at a minimum, one full day or two half-days of on-site project support upon request.

END OF SECTION

APPENDIX C

Are you looking for a cost-effective, non-corrosive product that is environmentally friendly?

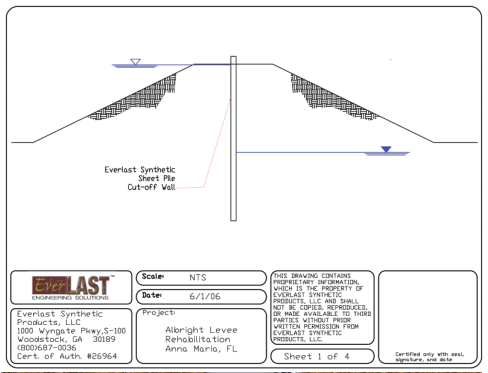
EverLAST™
ENGINEERING SOLUTIONS

The Global Leader In Innovative Geotechnical Applications Using Synthetic Sheet Piling

LEVEE/DIKE STABILIZATION

Levees and dikes fail because of the saturation of inherently poor soils due to the piping effect of water during flood events. The piping of water becomes a flow which creates "boils" through the levee. The flow soon increases in velocity, resulting in a breech which ultimately compromises the entire levee.

Our vinyl and composite sheeting provides underground hydraulic cut-off that effectively stops the piping. This is an immediate and long-term solution for levee repair and stabilization at a fraction of the cost of re-doing the thousands of miles of levees with either steel or clay.



FOUNDATION PROTECTION

Vinyl sheeting provides an excellent erosion barrier against flooding to coastal homes such as this.

RETAINING WALLS

Our composite sheeting is able to withstand the toughest geotechnical and civil applications and conditions.

WEIR WALLS

The advantage of vinyl is the longevity it provides to structures that are always in the water and whose purpose it is to manage the flow of water.

DETENTION PONDS

Synthetic sheet piling has become the material of choice for the construction of detention ponds. Our site-friendly product, at an attractive price point, is replacing traditional materials such as concrete, wood, and block. Additionally, our sheets can easily adapt to accommodate outflow pipes and culverts.

FLOOD WALLS

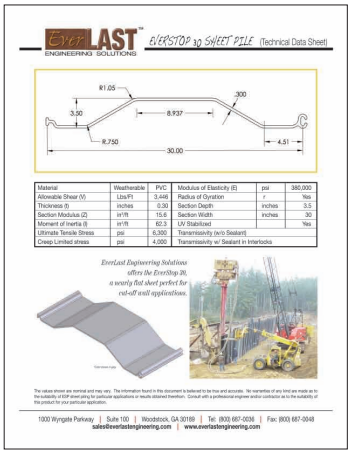
Flood walls can be constructed using vinyl or composite sheet piling to temporarily contain waters which may rise to unusual levels during seasonal or extreme weather events. Vinyl and Composite sheeting is both lightweight and long-lasting, providing for rapid constructability and long service life.

WAVE BREAKS

Composite sheet piling is ideal in this application since the water and organisms have no effect on the material and thus provides longevity in a marine environment at an economical cost. Moreover, the corregation of the sheeting provides additional wave attenuation.

CUT-OFF WALLS

The EverStop 30 is the first synthetic sheet piling designed specifically for cut-off wall and Superfund site applications. When you require a chemically resistant solution at a low cost, choose the 30" wide EverStop cut-off wall panel that can be driven faster–with fewer interlocks!


EverLAST ENGINEERING SOLUTIONS

EVERSTOP 30 SHEET PILE (Technical Data Sheet)

Material	Weatherable	PVC	Modulus of Elasticity (E)	psi	380,000
Allowable Shear (V)	Lbs/Ft	3,446	Radius of Gyration	r	Yes
Thickness (t)	inches	0.30	Section Depth	inches	3.5
Section Modulus (Z)	in^ft	15.6	Section Width	inches	30
Moment of Inertia (I)	in^ft	62.3	UV Stabilized		Yes
Ultimate Tensile Stress	psi	6,380	Transmissivity (w/o Sealant)		
Creep Limited stress	psi	4,000	Transmissivity w/ Sealant in Interlocks		

EverLast Engineering Solutions offers the EverStop 30, a nearly flat sheet perfect for cut-off wall applications.

1900 Wyngate Parkway | Suite 100 | Woodstock, GA 30189 | Tel: (800) 687-0036 | Fax: (800) 687-0048
sales@everlastengineering.com | www.everlastengineering.com

Call today for a copy of the EverStop 30 spec sheet.

BRIDGE ABUTMENTS

Synthetic sheet piles are used around bridges and end bents as well as other pile supported piers for scour protection.

CHANNEL LININGS

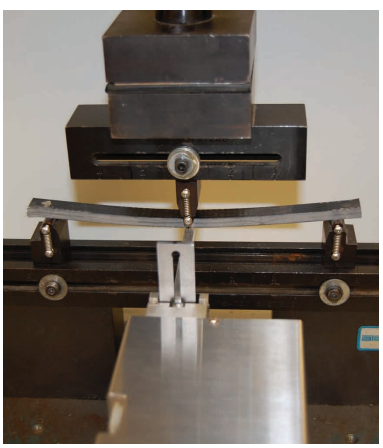
Vinyl sheets provide for the retaining structure and tie into pond liners at the wall's base.

COMPLEX SITE GEOMETRY

The versatile and lightweight features of our synthetic sheet piling makes difficult site development a breeze. No costly concrete footers or leveling pads are required.

We use UV Inspection Lamp Testing for consistency and quality.

The Drop Dart Test ensures impact resistance ductility.



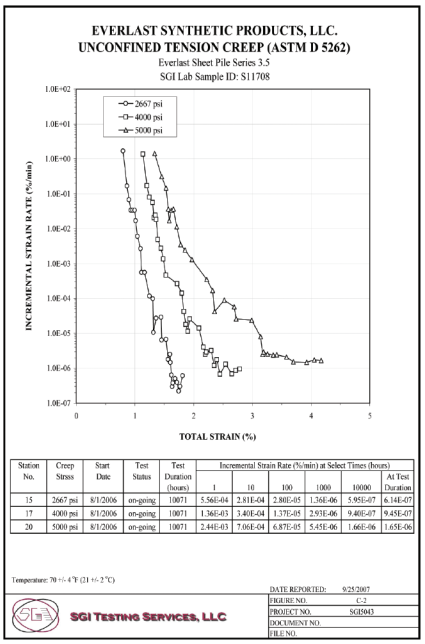
Tensile & Modulus Test performed by an independent ISO 9001 certified testing laboratory.

Calipers measure this Ever-Last vinyl's thickness to ensure it meets or exceeds specifications.

We Set Testing & Engineering Standards!

Licensed engineering team capable of signing & sealing designs & drawings.

Creep testing is one of the most important because it measures the maximum stress at which a material is able to be loaded and not experience failure in the future.



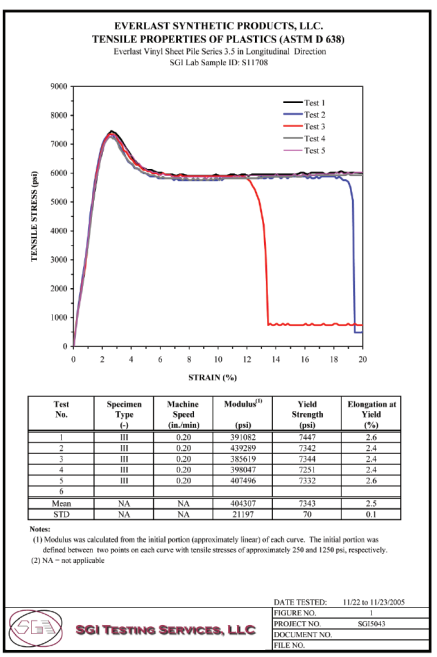
Station No.	Creep Strsss	Start Date	Test Status	Test Duration (hours)	Incremental Strain Rate (%/min) at Select Times (hours)					
					1	10	100	1000	10000	At Test Duration
15	2667 psi	8/1/2006	on-going	10071	5.56E-04	2.81E-04	2.80E-05	1.36E-06	5.95E-07	6.14E-07
17	4000 psi	8/1/2006	on-going	10071	1.36E-03	3.40E-04	1.37E-05	2.93E-06	9.40E-07	9.45E-07
20	5000 psi	8/1/2006	on-going	10071	2.44E-03	7.06E-04	6.87E-05	5.45E-06	1.66E-06	1.65E-06

Temperature: 70 +/- 4°F (21 +/- 2°C)

SGI Testing Services, LLC

DATE REPORTED:	9/25/2007
FIGURE NO.	C-2
PROJECT NO.	SGI5043
DOCUMENT NO.	
FILE NO.	

Stress/strain curve illustrates the material's yield stress and Modulus of Elasticity

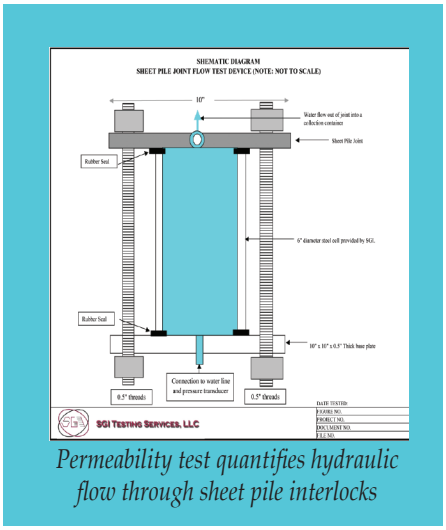


Test No.	Specimen Type (-)	Machine Speed (in./min)	Modulus[1] (psi)	Yield Strength (psi)	Elongation at Yield (%)
1	III	0.20	391082	7447	2.6
2	III	0.20	439289	7342	2.4
3	III	0.20	385619	7344	2.4
4	III	0.20	398047	7251	2.4
5	III	0.20	407496	7332	2.6
6					
Mean	NA	NA	404307	7343	2.5
STD	NA	NA	21197	70	0.1

Notes:
(1) Modulus was calculated from the initial portion (approximately linear) of each curve. The initial portion was defined between two points on each curve with tensile stresses of approximately 250 and 1250 psi, respectively.
(2) NA = not applicable

SGI Testing Services, LLC

DATE TESTED:	11/22 to 11/23/2005
FIGURE NO.	1
PROJECT NO.	SGI5043
DOCUMENT NO.	
FILE NO.	



Permeability test quantifies hydraulic flow through sheet pile interlocks

EverLAST™
ENGINEERING SOLUTIONS

EES offers the industry's leading expertise in product knowledge, testing and design, and Value Engineering for Civil and Geotechnical applications utilizing synthetic sheet piling. Our vinyl and composite sheet pilings, featuring the revolutionary **EverStop 30** cut-off wall profile, are optimum solutions to provide your project with the right answers at the right price.

Value Engineering

Is your project above budget? Let us help you reduce project costs with VE support. Our complete line of synthetic sheet piling, coupled with our engineering expertise, can help you design using non-traditional materials. This can save money, while providing a longer term solution.

Experience

Let us show you how over 20 years of experience in the business has equipped us to be a knowledgeable VE source when it comes to what product to use in what specific condition. Each project has its unique set of design parameters. Whether a lighter gauge vinyl will suffice, or the need for a heavy composite sheet pile is necessary, let us help you arrive at the best solution at the best price.

Testing

EES spends tens of thousands of dollars annually to make sure that our product line of synthetic sheet piles is the most thoroughly tested product in the market. Sheet piles need to have high impact strengths for installation and durability. **Drop Dart** impact (ASTM D256-00) testing and Izod impact testing (ASTM D256) is an excellent indicator of the material's ability to withstand the stresses endured during installation and impact loading for the service life of the structure.

Creep Testing is extremely important for vinyl manufacturers as it measures the deformation of the material under a constant load. EES has completed over 10,000 hours of creep testing utilizing ASTM D 5262 and is proud to report that at 4000 psi total strains of less than 3% are realized. **Tensile tests**, or pull tests, are performed to calculate the Modulus (E) and where the material "yields." These numbers are vital in determining the deflection of a particular structure which is the single-most important criterion to consider when designing with vinyl. Independent certified labs, equipped with the latest equipment and techniques, ensure that the parts perform as designed.

Design

EES can help you in just about any facet of design. Feel confident in our conservative published numbers, AutoCAD designs, and utilization of the latest structural and geotechnical software available, all backed by Finite Element Modeling (FEM). Whether you need signed and sealed engineering service or simply prompt, professional advice, rest assured that you will be getting the best engineering available in the synthetic sheet piling industry.

EverStop 30 Cut-Off

Our EverStop 30 vinyl cut-off wall part is the first vinyl sheet piling part designed specifically for cut-off wall applications. This 30" wide panel is the perfect width to get the job done quickly, while still having as few interlocks as possible. With the help of a mandrel, depths of up to 60 feet can be achieved. Vinyl and composite sheet piling make excellent cut-off walls because of their inert qualities & excellent impermeable values.

Our manufacturing facility

Our state-of-the-art manufacturing plant operates three shifts seven days a week to keep up with the ongoing demand for the industry's most technically advanced, thoroughly tested product line.

We utilize the latest extrusion and pultrusion technology in the manufacturing of our synthetic sheet piling.

With an enviable QA/QC track record, EverLast™ inventories thousands of linear feet of our profiles, which allows us to deliver product to your job when you need it!

EverLAST™
ENGINEERING SOLUTIONS

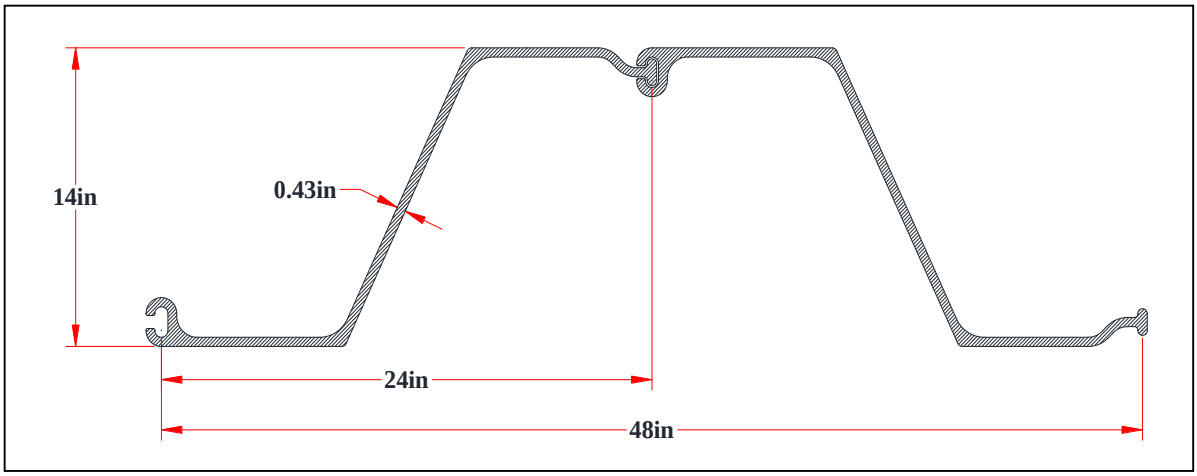
1000 Wyngate Parkway, Suite 100
Woodstock, GA 30189
Toll-Free: 1-(800) 687-0036
sales@everlastengineering.com
www.everlastengineering.com

EverComp 80.5 ™ FRP Sheet Pile

Technical Data Sheet

AL - Along length of sheet pile AWS - Along width of sheet pile

Property	Symbol	Units	Results	ASTM Test Method
Flexural Stress:				
Ultimate (AL)	$\sigma_{ult\ AL}$	psi	68,800	D 790-03
Recommended Allowable Stress(AL)	$\sigma_{all\ AL}$	psi	20,000	-------
Modulus of Elasticity (AL)*	E_{AL}	psi	3,890,000	D 790-03
Ultimate (AWS)	$\sigma_{ult\ AWS}$	psi	20,000	D 790-03
Modulus of Elasticity (AWS)	E_{AWS}	psi	1,660,000	D 790-03
Tensile Stress:				
Ultimate (AL)	$\sigma_{ult\ AL}$	psi	62,500	D 638-03
Recommended Allowable Stress(AL)	$\sigma_{all\ AL}$	psi	20,000	-------
Modulus of Elasticity (AL)	E_{AL}	psi	5,200,000	D 638-03
Ultimate (AWS)	$\sigma_{ult\ AWS}$	psi	6,800	D 638-03
Modulus of Elasticity (AWS)	E_{AWS}	psi	1,150,000	D 638-03
Shear Stress:				
Ultimate (AL)	$\tau_{ult\ AL}$	psi	32,600	D 2344-00
Recommended Allowable Stress(AL)	$\tau_{all\ AL}$	psi	6,000	-------
Ultimate (AWS)	$\sigma_{ult\ AWS}$	psi	18,800	D 2344-00



Properties of Sheet Pile:				
Width	W	in	24.0	-------
Depth	D	in	14.0	-------
Thickness	t	in	0.43	-------
Section Modulus	Z	in^3/ft	38	-------
Moment of Inertia*	I	in^4/ft	268	-------
Radius of Gyration (pair)	r	in	5.65	-------
Area of Web	A_W	in^2	6.5	-------

*Note: Deflection should be limited and usually controls the design. Maximum deflection to be determined by the project's engineer. ESP recommends that max. deflection shoud be less than 2% of the span e.g. distance from lowest wale support to ground line.

The values shown are averages and may vary. No warranties of any kind are made as to the suitability of ESP sheet piling for particular applications

Everlast Synthetic Products, LLC
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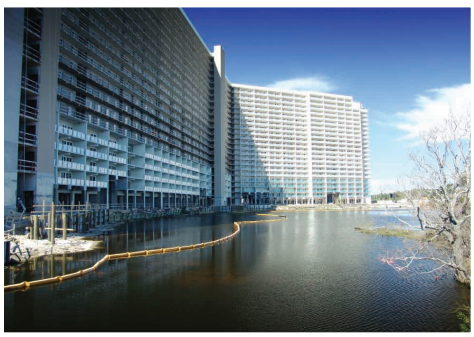
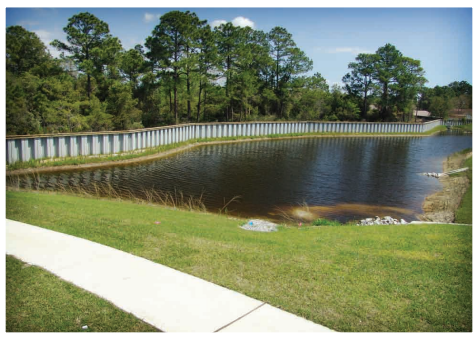
www.everlastseawalls.com

EverLast®
SYNTHETIC PRODUCTS, LLC





Whether working with waterfront homeowners, contractors, commercial builders or developers, we are committed to the same meticulous attention to design and detail. Our premier vinyl and composite sheet piling is second to none, and our engineering staff and product testing are industry leading. Let us prove this to you on your seawall project.

Every Seawall Job is Job #1! ESP™

EverLast®
SYNTHETIC PRODUCTS, LLC

PREFERRED BY HOMEOWNERS

If asked why we are preferred by homeowners over other seawall and bulkhead manufacturers, we would say it's probably because we work extra hard to prove that EverLast is as meticulous about your home's seawall as a job ten times as big.

We are solution driven. With over 2500 seawall designs over the last decade, and 50 years experience in the industry, we are committed to engineer the seawall solution that offers the best shoreline protection for your home.

We offer the industry's leading product warranty guaranteeing against UV damage, corrosion, rot, rust and marine borer damage.

We are a turnkey, results-oriented company. That means if you want to save money by building or contracting your own seawall construction yourself, we are here to assist you. Our engineers can design the most effective and cost-efficient seawall for your needs, provide technical assistance along the way, or refer you to one of our preferred marine construction partners.

Let us help you protect your most important investment against the many storms of life.

SEAWALL 101

The frequency of storms and hurricanes has forced homeowners and commercial developers to look for new ways to protect their properties. The challenges of being in a salt-water climate are many: storm surges that cause erosion, UV damage to traditional materials, corrosion of aluminum and steel, and deterioration caused by marine borers that thrive on pressure-treated lumber. The latest vinyl sheet piling technology from EverLast Synthetic Products offers the industry's leading warranty.

A water jet is often used to drive the vinyl piling into granular soil. In the above photo, you see a drive guide is used which provides a firm surface to drive the sheets plumb and straight.

The stability of any seawall is dependant upon variables such as wall height, sheet pile length and strength, wale system, backfill & foundation soil, and tide.

On the left, the vinyl sheets are sandwiched between front & back wales, anchored into non-active soil and connected to the seawall with tie rods. Our engineers are available to advise you on the optimum tie rod spacing, dead man size and type, and the best backfill to utilize. We take the guesswork out of what your wall really needs to protect your most valuable investment.

A seawall, also known as a bulkhead or retaining wall, keeps the water from eroding the soil back into the water. Each seawall project has its own set of unique requirements.

This deep-water port on the South Carolina coast required superior strength and low life cycle cost, provided by our popular EverComp 26.1, the composite sheet piling designed, tested and perfected by our EverLast engineers for most of the last decade.

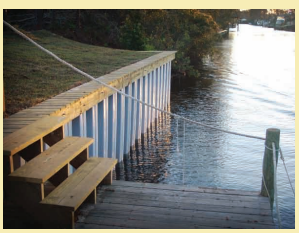
Confirmed by ISO 9001 certified laboratories, EverComp 26.1 can withstand the rigors of the harshest environments, and the attractive graphite grey color blends perfectly with many marine applications. Best of all, EverComp 26.1 can be driven with traditional pile driving equipment as shown on the left.

CAP STYLES

(Left) This canal front Florida homeowner selected the EverLast Vinyl 4.1 Series with a concrete cap.

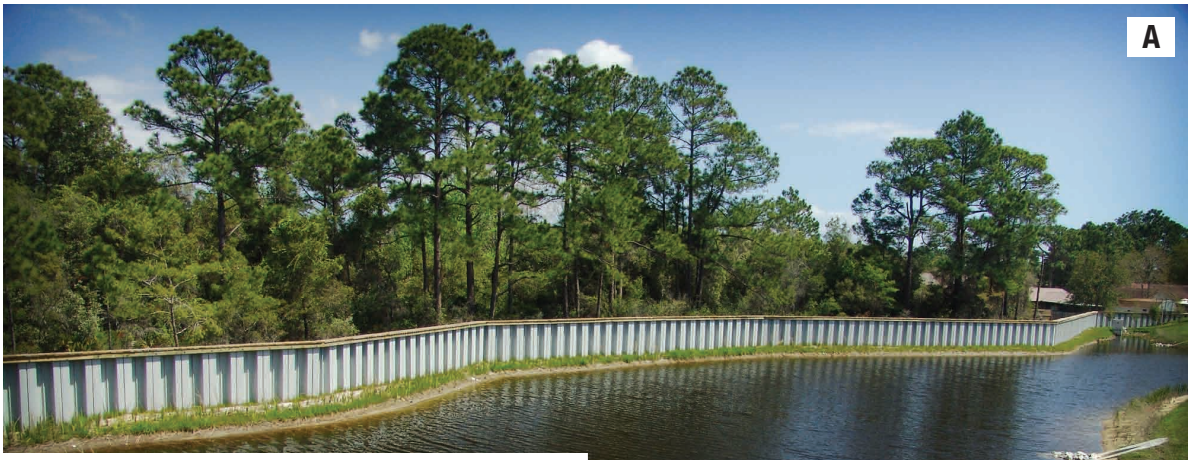
(Right) This homeowner chose the EverLast 3.5 Series vinyl with the customized alloy EverCap system.

(Right) Pressure treated wood caps remain popular due to their low cost and the strength that they provide.



EverLast® SYNTHETIC PRODUCTS, LLC

TRUSTED BY CONTRACTORS & DEVELOPERS



A: *The EverLast 8.5 Series was chosen to protect this Florida panhandle project.*

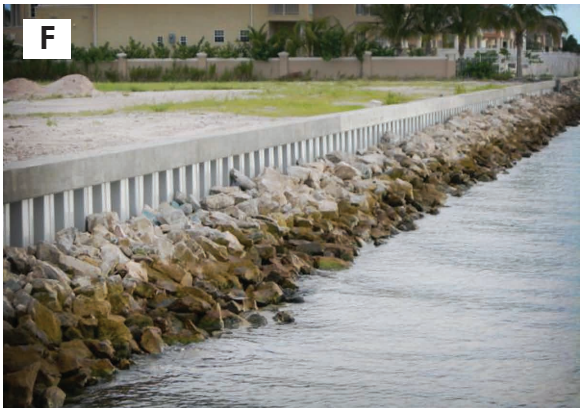
B: *This New Jersey marine contractor installs an EverLast vinyl seawall with pilings driven behind the wall for a clean wood-free appearance.*

C: *This Alabama development features a Navy-style bulkhead construction using the EverLast 4.1 Series.*

D: *EverLast vinyl is now being used for retention ponds rather than reinforced concrete. Typically, this can save some 30% off the budget.*

E: *The EverLast 3.5 Series with the EverCap System engineered in a Navy-style design protects this North Carolina waterfront golf development designed by Arnold Palmer.*

F: *After the old concrete wall was destroyed by Hurricane Frances, the Tampa Bay contractor constructed the new seawall using the EverLast 8.5 Series with a reinforced concrete cap.*



EverLast® SYNTHETIC PRODUCTS, LLC

SETS ENGINEERING & TESTING STANDARDS

Our engineering support team stands ready to consult with homeowners, engineers, contractors and governmental agencies to insure proper design and application. We employ licensed engineers capable of signing and sealing seawall designs in most Atlantic and Gulf states.

Our licensed engineers are available to sign & seal seawall designs and drawings.

Our level of service can include any or all of the following:

- Basic phone discussions regarding your project;
- Conceptual drawings capable of being e-mailed and faxed in AutoCAD or PDF format;
- Preliminary designs involving detailed information based on soil conditions and exposed wall heights that you provide;
- Ability to work "hand-in-hand" with your Professional Engineer or contractor;
- Full-fledged design capability including signed and sealed drawings at a competitive price;
- Value-engineering services to homeowners, developers and contractors alike, that provide superior designs as well as significant monetary and time savings.

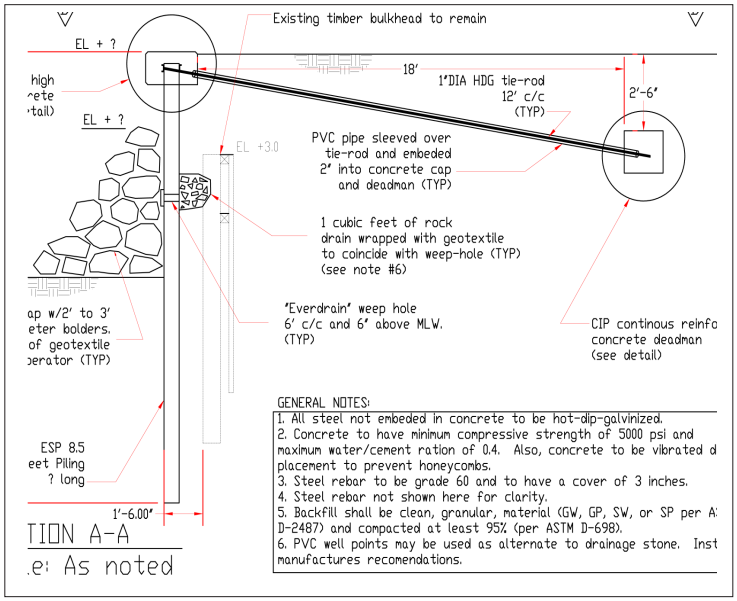
We Pass Every Test!

We use UV Inspection Lamp testing for consistency and quality.

Tensile & Modulus Test performed by an independent ISO 9001 certified testing laboratory.

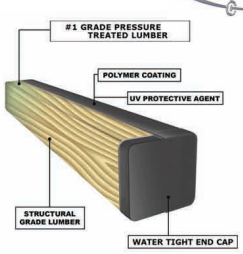
The Drop Dart Test ensures impact resistance ductility.

EverLast Synthetic Products offers the industry's most technically advanced, engineered, and thoroughly tested product line. Our state-of-the-art co-extruded sheet piling offers an industry-leading 2000 hours of QUV test data to give you confidence when choosing our products.



OUR SUPERIOR & INNOVATIVE PRODUCT LINE

EverWood® polymer encapsulated wood



EverWood Pilings & Timbers

EverWood features a marine-grade formulated polymer that is wrapped in tension to create a water-tight encasement around wood. This environmentally "Green" technology is both attractive and eco-system friendly. Our virgin copolymer polyethylene has superior UV stabilization properties and will not yellow, split, chip, crack, peel, or blister in any climate.

EverSeal Marine Adhesive

Used exclusively for EverWood products

EverComp® 26.1

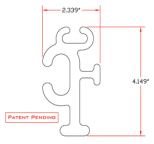
Unprecedented composite sheet piling manufactured to withstand the rigors of the harshest environments.

EverCap®

A structural cap and wale system of a customized alloy designed specifically for harsh marine environments

EverCorner®

Patent-pending, revolutionary design that connects lighter and mid-duty vinyl to a heavier one.



EverDrain®

Sturdy weep holes used in seawall construction.

Owners Brad Lund, Carl Hazenberg, and Jason Nelms, along with their staff, have over 50 years experience in the seawall manufacturing, design and construction industry.

Our manufacturing facility

Our state-of-the-art manufacturing plant operates 3 shifts seven days a week to keep up with the ongoing demand for the industry's most technically advanced, thoroughly tested product line.

We utilize the latest co-extrusion process to ensure color consistency in your wall while adding a 100% weatherable cap stock for additional UV protection.

With an enviable QC/QA track record, EverLast™ inventories thousands of linear feet of all of our profiles, which allows us to deliver product to your job when you need it!

EverLast®
SYNTHETIC PRODUCTS, LLC

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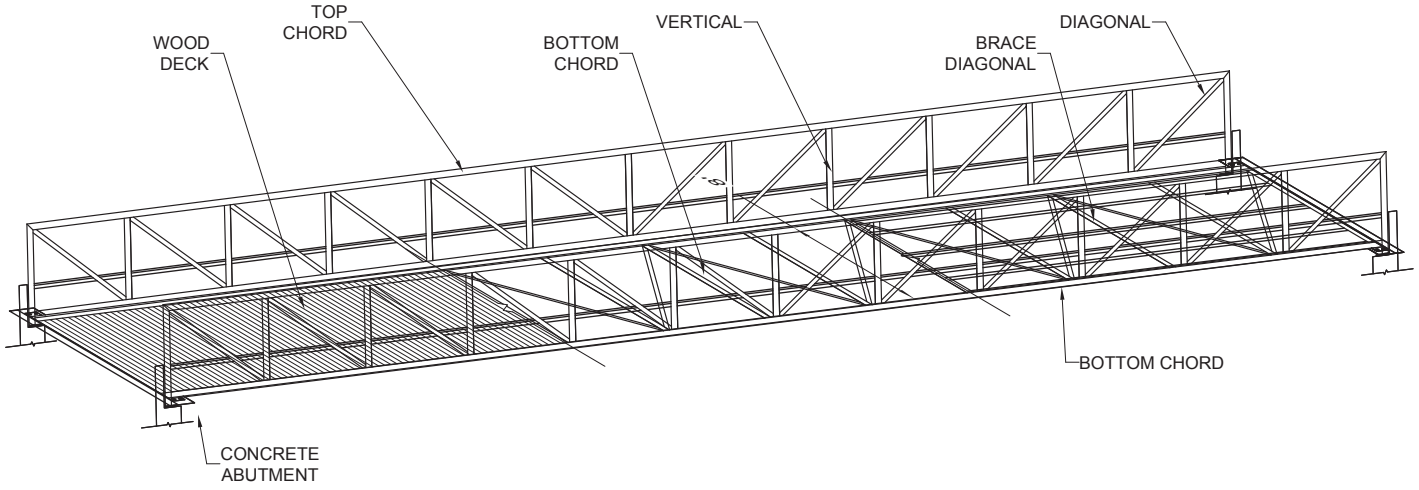
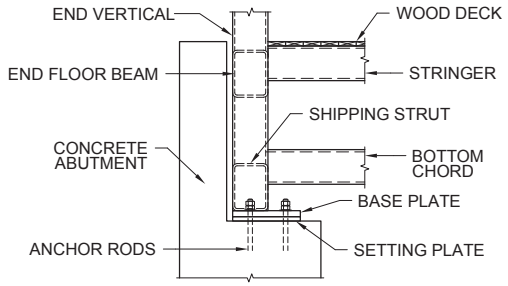
ESP™

APPENDIX D

CONTECH®
ENGINEERED SOLUTIONS

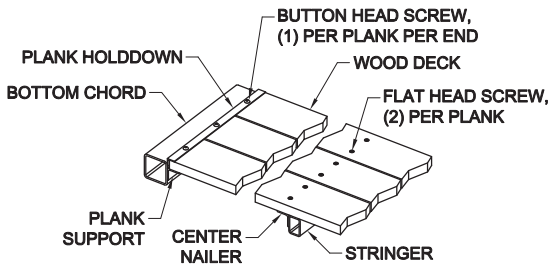
Pedestrian Truss Bridge Details



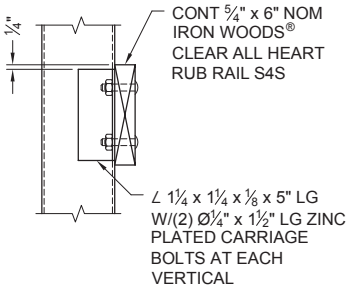


BEARING SIDE VIEW

INFORMATION PROVIDED FOR REPRESENTATION ONLY.
ACTUAL BEARING DIAGRAMS TO BE BASED ON FINAL DESIGN.

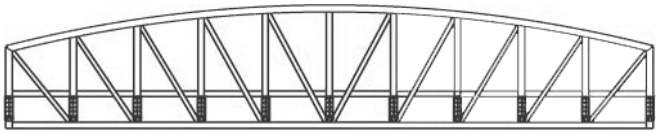


WOOD DECK DETAIL

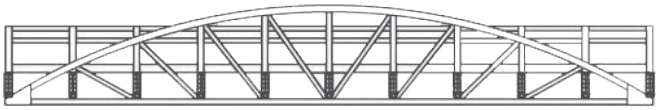


CONTINENTAL BRIDGE®

Typical Truss Styles

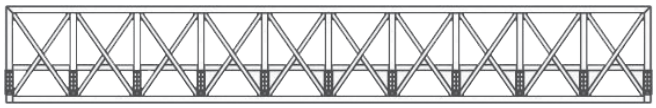


Capstone® Modified Bow Truss



Keystone® Bow Truss

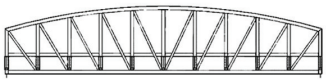
Connector® Standard Truss



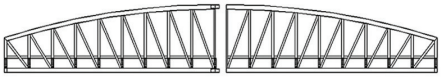
Link® X-Brace Truss

Archway® Underhung Truss

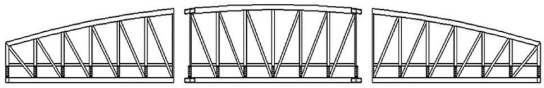
Typical Shipping Splices



Up to 70 feet

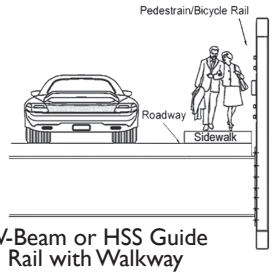


70 feet to 135 feet

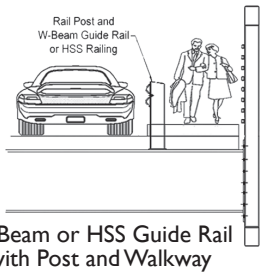


135 feet to 160 feet

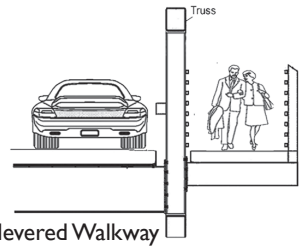
Typical Sidewalk and Railing Arrangements



W-Beam or HSS Guide Rail with Walkway

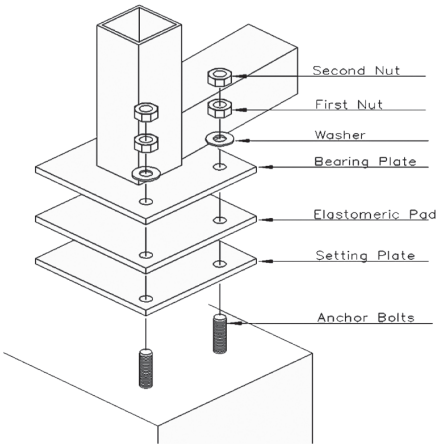


W-Beam or HSS Guide Rail with Post and Walkway

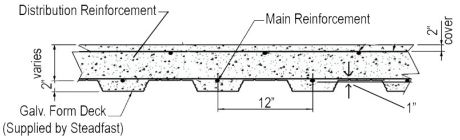


Cantilevered Walkway

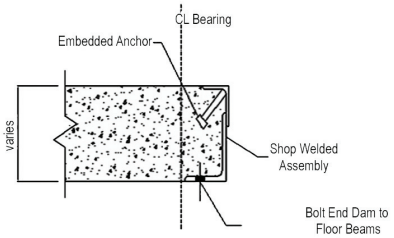
Bearing Details



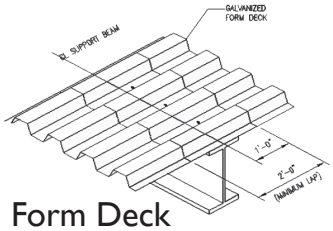
Concrete Floor Connections



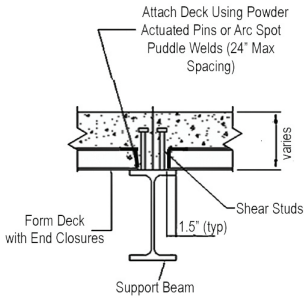
Concrete Deck Reinforcing



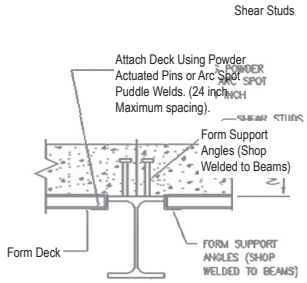
End Dam Detail



Form Deck

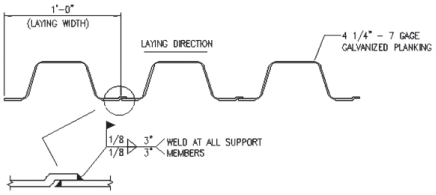


Section View
Option #1

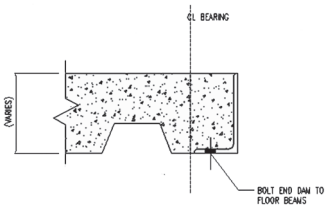


Section View
Option #2

Asphalt Floor Connections

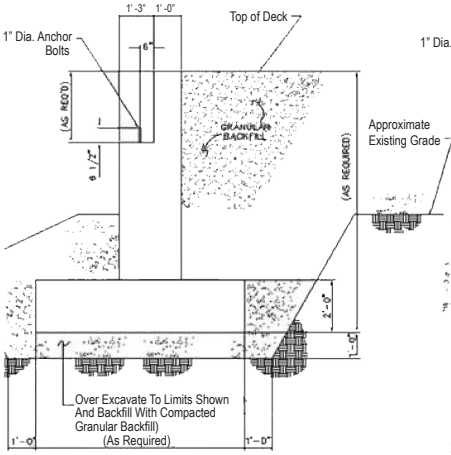


Concrete Deck Reinforcing

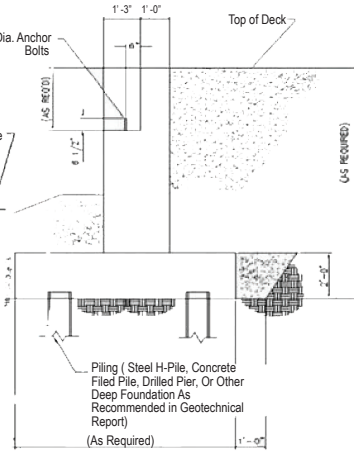


End Dam Detail

Foundations

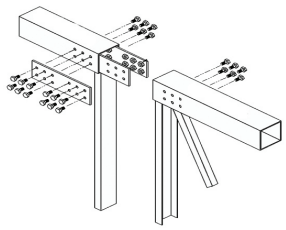


Soil Supported

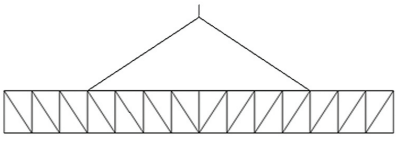


Pile Supported

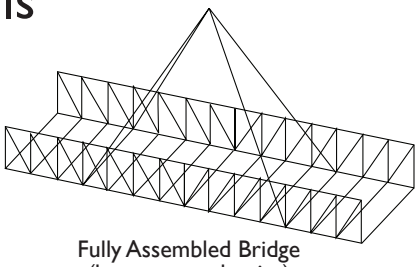
Typical Installation Details



Bolted Splice/Connection Detail



Fully Assembled Truss Only
(top chord lift)

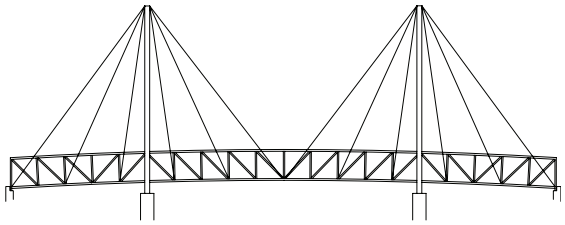


Fully Assembled Bridge
(bottom panel point)

Additional Pedestrian Truss Styles

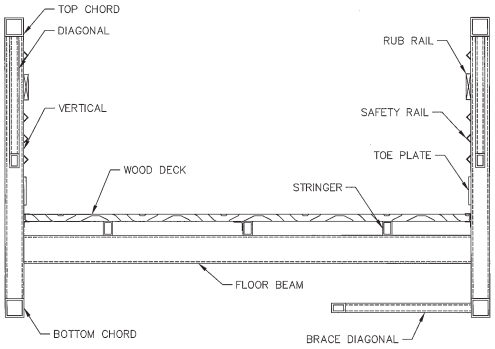
Gateway®

Expressway®

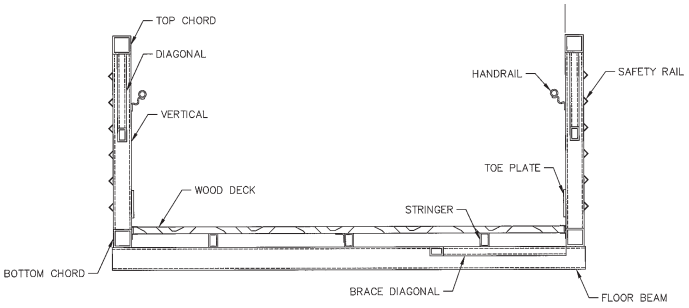


Cable Stayed

Section Views

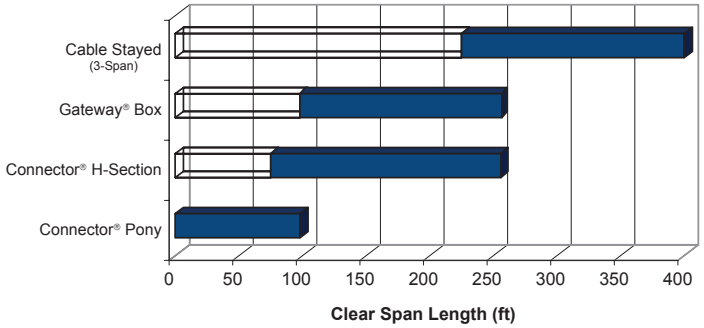


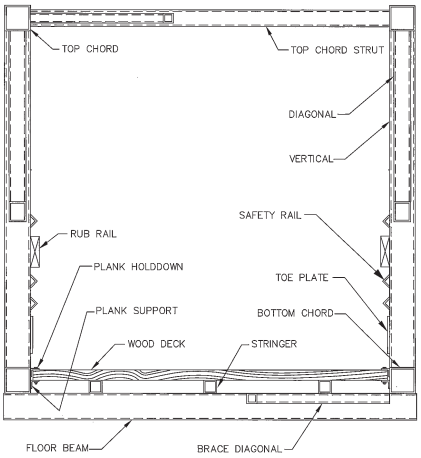
Connector® - H-Section



Connector® - Underhung Floor

Optimum Pedestrian Bridge System Types





Gateway® - Through Box

For Pedestrian Truss Bridges

Material & Finishes:

Steel Types Used (50 ksi material):

- A588 Weathering or A847 (Pedestrian Only)
- A500 Painted (Pedestrian Only)
- A572 Painted (2 Coat and 3 Coat (Zinc Rich Primer) – Any Color)
- A572 Galvanized (35-year Limited Warranty)
- A325 Galvanized or Type 3 Weathering (Bolts Provided)
- A307 Galvanized Anchor Bolts are Specified (By Contractor)

Design Specifications:

- AISC
- AASHTO Standard Specifications for Highway Bridges
- AASHTO Guide Specifications for Pedestrian Bridges
- AWS D1.1, D1.5

Manufacturing/Installation Specifications:

- AISC Shop Certification
  - Fracture Critical Endorsement
  - Sophisticated Paint Endorsement
- AWS

CONTINENTAL BRIDGE

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Continental® Pedestrian Bridges

INTRODUCTION

This Specification is to be used as a guide in developing appropriate final specifications suited to the purchaser's particular needs. The two primary objectives of these Special Specifications are:

- To provide assurance that the submittals and structures provided in response to the award of performance-specified, prefabricated, steel bridges will completely conform to the desires and expectations of the Specifier and Owner without surprises.
- To limit the liability of Specifiers and Owners through following a comprehensive specification process utilizing a well researched published source backed up with an authoritative, technical, specification commentary documenting a full design example. Public safety is thereby assured.

The most critical guarantees for both objectives above are the comprehensive, non-proprietary format of the specifications and the specification checklist. When the entire specification is published, proposals received and compliance enforced at the time of award and submittal approval, Specifiers and Owners will get what they expect and reduce their liability for the bridge and other structures.

DISCLAIMER TO SPECIFICATIONS

This recommended Special Specifications for Prefabricated Bridges has been prepared by Contech Engineered Solutions LLC as a service to bridge Specifiers and Owners. It is offered in good faith and is based on information believed to be accurate and reliable, but is offered without warranty of any kind, either expressed or implied. Contech Engineered Solutions LLC and its employees accept no responsibility for any harm resulting from reliance on this document. Compliance with all applicable government regulations or codes remains the full responsibility of the parties to whom the regulation or code applies.

1.0 GENERAL

SPECIAL SPECIFICATIONS FOR PREFABRICATED BRIDGE

1.1 Scope

These specifications are for a fully engineered clear span bridge of steel construction and shall be regarded as minimum standards for design and construction. These specifications are based on products designed and manufactured by Contech Engineered Solutions LLC, 9025 Centre Pointe Dr. West Chester, Ohio 45069
Phone: 1-513-645-7000 or 1-800-338-1122 Fax: 1-513-645-7993
E-mail: info@conteches.com

1.2 Qualified Suppliers

Each bidder is required to identify their intended bridge supplier as part of the bid submittal. Qualified suppliers must have at least 5 years experience fabricating these type structures.

Pre-approved Manufacturers:

Contech Engineered Solutions LLC
8301 State Highway 29 North
Alexandria, Minnesota 56308
1-800-328-2047

Contech Engineered Solutions LLC
4021 Gault Avenue South
Fort Payne, Alabama 35967
1-800-749-7515

Suppliers other than those listed above may be used provided the engineer or owner's agent evaluates the proposed supplier and approves the supplier 5 days prior to bid.

The contractor must provide the following documentation, for any proposed supplier who is not pre-approved, at least 10 days prior to bid:

* Product Literature

* All documentation to insure the proposed substitution will be in compliance with these specifications. This shall include:

  - Representative design calculations
  - Representative drawings
  - Splicing and erection procedures
  - Warranty information
  - Inspection and Maintenance procedures
  - AISC Shop Certification
  - Welder Qualifications

* Proposed suppliers must have at least five (5) years' experience designing and fabricating these type structures and a minimum of five (5) successful bridge projects, of similar construction, each of which has been in service at least three (3) years. List the location, bridge size, owner, and a contact for reference for each project.

  The engineer will evaluate and verify the accuracy of the submittal prior to bid. If the engineer determines that the qualifying criteria have not been met, the contractor's proposed supplier shall be rejected. The engineer's ruling shall be final.

2.0 GENERAL FEATURES OF DESIGN

2.1 Span

Bridge span shall be xxx'-xx" (straight line dimension) and shall be as measured from each end of the bridge structure.

2.2 Width

Bridge width shall be xx'-xx" and shall be as measured from the inside face of structural elements at deck level.

2.3 Bridge System Type

Bridge(s) shall be designed as a Continental® Half-Through Pony System, Model Number P1-SQ (or equal), that has one (1) diagonal per panel and plumb end vertical members. Interior vertical members may be either plumb or perpendicular to the chord faces.

2.3.1 Bridge(s) shall be designed utilizing an underhung floor beam (top of floor beam welded to the bottom of the bottom chord) or be designed utilizing an H-Section configuration where the floor beams are placed up inside the trusses and attached to the truss verticals.

2.3.2 The bridge manufacturer shall determine the distance from the top of the deck to the top and bottom truss members based upon structural and/or shipping requirements.

2.3.3 The top of the top chord shall not be less than 54 inches above the deck (measured from the high point of the riding surface) on bike path structures.

2.4 Member Components

All members of the vertical trusses (top and bottom chords, verticals, and diagonals) shall be fabricated from square and/or rectangular structural steel tubing. Other structural members and bracing shall be fabricated from structural steel shapes or square and rectangular structural steel tubing.

Unless the floor and fastenings are specifically designed to provide adequate lateral support to the top flange of open shape stringers (w-shapes or channels), a minimum of one stiffener shall be provided in each stringer at every floor beam location.

2.5 Attachments

2.5.1 Safety Rails

Vertical safety rails or pickets shall be placed on the structure to a minimum height of x'-xx" above the deck surface. The pickets shall be spaced so as to prevent a 4" sphere from passing through the truss. Pickets may be placed on the inside or outside of the structure at the bridge fabricators option. The top of the vertical pickets shall have a continuous cap angle or some other means to prevent bridge users from cutting or scraping their hands.

The picket safety system shall be designed for an infill loading of 200 pounds, applied horizontally at right angles, to a one square foot area at any point in the system.

2.6 Camber

The bridge shall have a vertical camber dimension at midspan equal to 100% of the full dead load deflection plus 1% of the full length of the bridge.

2.7 Elevation Difference

The bridge abutments shall be constructed at the same elevation on both ends of the bridge.

3.0. ENGINEERING

Structural design of the bridge structure(s) shall be performed by or under the direct supervision ofa Licensed Professional Engineer and done in accordance with recognized engineering practices and principles.

3.1 Design Loads

In considering design and fabrication issues, this structure shall be assumed to be statically loaded. No dynamic analysis shall be required nor shall fabrication issues typically considered for dynamically loaded structures be considered for this bridge.

3.1.1 Dead Load

The bridge structure shall be designed considering its own dead load (superstructure and original decking) only. No additional dead loading need be considered.

3.1.2 Uniform Live Load

3.1.2.1 Pedestrian Live Load

Main Members: Main supporting members, including girders, trusses and arches shall be designed for a pedestrian live load of 85 pounds per square foot of bridge walkway area. The pedestrian live load shall be applied to those areas of the walkway so as to produce maximum stress in the member being designed. If the bridge walkway area to which the pedestrian live load is applied (deck influence area) exceeds 400 square feet,
the pedestrian live load may be reduced by the following equation:

$$w = 85\,[0.25 + \frac{15}{\sqrt{A_I}})]$$

Where w is the design pedestrian load (psf) and A_I is the deck influence area in square feet.

The reduced design live load shall not be less than 65 pounds per square foot of bridge walkway area.

Secondary Members: Bridge decks and supporting floor systems, including secondary stringers, floor beams and their connections to main supporting members shall be designed for a live load of 85 pounds per square foot, with no reduction allowed.

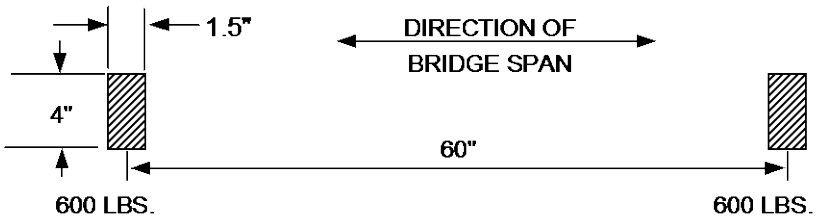
3.1.3 Concentrated Loads

The bridge superstructure, floor system and decking shall be designed for each of

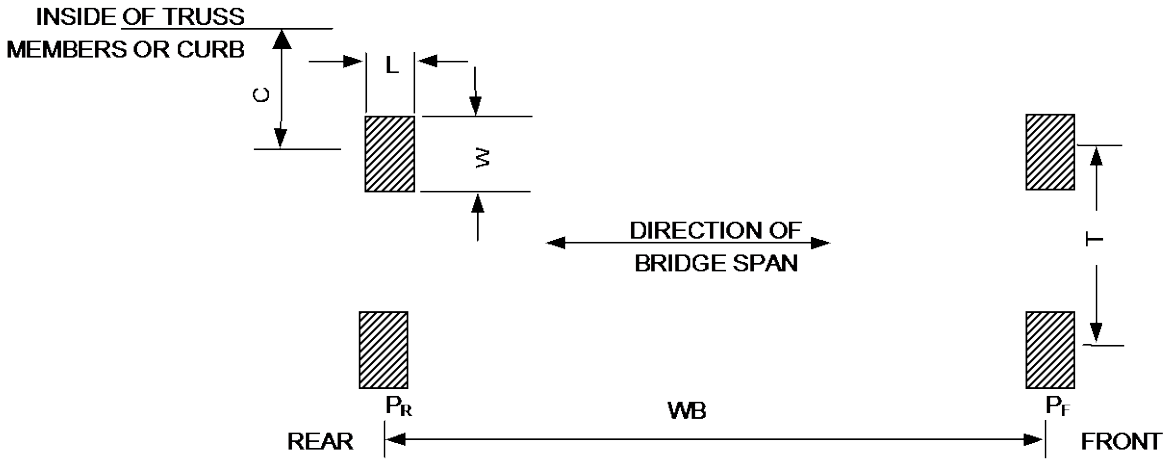
the following point load conditions:

3.1.3.1 A concentrated load of 1000 pounds placed on any area 2.5 ft x 2.5 ft square.

3.1.3.2 A 1200 pound two wheel vehicle with a wheelbase and tire print area as shown in the following diagram:



3.1.3.3 A xxxx pound four wheeled vehicle with the appropriate wheelbase, tire track and tire print area as shown in the following diagram: (See Table I for the values corresponding to the selected vehicle.)



Vehicle	Axle and Wheel Spacings		Front Wheels			Rear Wheels			
Weight	WB	T	P_F	L	W	P_R	L	W	C*
4,000#	48"	32"	1,000#	2.0"	5.0"	1,000#	2.0"	5.0"	9"
6,000#	66"	48"	1,500#	2.5"	6.0"	1,500#	2.5"	6.0"	12"
8,000#	102"	60"	1,600#	3.0"	8.0"	2,400#	3.0"	8.0"	15"
10,000#	120"	72"	2,000#	3.5"	8.5"	3,000#	3.5"	8.5"	18"

(*C is the minimum dimension from center of wheel to the inside face of truss or curb.)

TABLE I

All of the concentrated or wheel loads shall be placed so as to produce the maximum stress in each member being analyzed. Critical stresses need be calculated assuming there is only one vehicle on the bridge at any given time. Assumptions that vehicles only travel down the center of the bridge or that the vehicle load is a uniform line load will not be allowed.

Each four wheeled vehicle load listed in Table I, up to and including the maximum weight vehicle selected, must be used in determining critical deck stresses. The wheel distribution for deck design shall be as specified in Section 4.3.1. Stringers shall be designed for the applied wheel loads assuming no lateral load distribution to adjacent stringers.

A vehicle impact allowance is not required.

3.1.4 Wind Load

3.1.4.1 Horizontal Forces

The bridge(s) shall be designed for a wind load of 25 pounds per square foot on the full vertical projected area of the bridge as if enclosed. The wind load shall be applied horizontally at right angles to the longitudinal axis of the structure.

The wind loading shall be considered both in the design of the lateral load bracing system and in the design of the truss vertical members, floor beams and their connections.

3.1.4.2 Overturning Forces

The effect of forces tending to overturn structures shall be calculated assuming that the wind direction is at right angles to the longitudinal axis of the structure. In addition, an upward force shall be applied at the windward quarter point of the transverse superstructure width. This force shall be 20 pounds per square foot of deck.

3.1.5 Top Chord/Railing Loads

The top chord, truss verticals, and floor beams shall be designed for lateral wind loads (per section 3.1.4.1) and for any loads required to provide top chord stability as outlined in Section 3.3.6; however, in no case shall the load be less than 50 pounds per lineal foot or a 200 pound point load, whichever produces greater stresses, applied in any direction at any point along the top chord or at the top of the safety system (42" or 54" above deck level), if higher than the top chord.

3.1.6 Load Combinations

The loads listed herein shall be considered to act in the following combinations, whichever produce the most unfavorable effects on the bridge superstructure or structural member concerned.
[DL=Dead Load; LL = Live Load; WL = Wind Load; VEH = Vehicle Load]
DL + LL
DL + VEH

DL+WL
DL+LL+WL
DL+VEH+.3WL

NOTE: Allowable stresses may be increased 1/3 above the values otherwise provided when produced by wind loading, acting alone or in combination with the design dead and live loads.

It shall be the responsibility of the foundation engineer to determine any additional loads (i.e. earth pressure, stream force on abutments, wind loads other than those applied perpendicular to the long axis of the bridge, etc.) and load combinations required for design of the abutments.

3.2 Design Limitations

3.2.1 Deflection

3.2.1.1 Vertical Deflection

The vertical deflection of the main trusses due to service pedestrian live load shall not exceed 1/400 of the span.

The vertical deflection of cantilever spans of the structure due to service pedestrian live load shall not exceed 1/300 of the cantilever arm length.

The deflection of the floor system members (floor beams and stringers) due to service pedestrian live load shall not exceed 1/360 of their respective spans.

The service pedestrian live load shall be 85 PSF, reduced in accordance with Section 3.1.2.1, but should in no case be less than 65 PSF for deflection checks.

Deflection limits due to occasional vehicular traffic shall not be considered.

3.2.1.3 Horizontal Deflection

The horizontal deflection of the structure due to lateral wind loads shall not exceed 1/500 of the span under an 85 MPH (25 PSF) wind load.

3.2.2 Minimum Thickness of Metal

The minimum thickness of all structural steel members shall be 3/16" nominal and be in accordance with the AISC Manual of Steel Constructions' "Standard Mill Practice Guidelines". For ASTM A500 and ASTM A847 tubing, the section properties used for design shall be per the Steel Tube Institute of North America's Hollow Structural Sections "Dimensions and Section Properties".

3.3 Governing Design Codes / References

Structural members shall be designed in accordance with recognized engineering practices and principles as follows:

3.3.1 Structural Steel Allowable Stresses

American Institute of Steel Construction (AISC).

Structural steel design shall be in accordance with those sections of the "Manual of Steel Construction: Allowable Stress Design" related to design requirements and allowable stresses.

3.3.2 Welded Tubular Connections

American National Standards Institute / American Welding Society (ANSI/AWS) and the Canadian Institute of Steel Construction (CISC).

All welded tubular connections shall be checked, when within applicable limits, for the limiting failure modes outlined in the ANSI/AWS D1.1 Structural Welding Code or in accordance with the "Design Guide for Hollow Structural Section Connections" as published by the Canadian Institute of Steel Construction (CISC).

When outside the “validity range” defined in these design guidelines, the following limit states or failure modes must be checked:

* Chord face plastification
* Punching shear (through main member face)
* Material failure
    - Tension failure of the web member
    - Local buckling of a compression web member
* Weld failure
    - Allowable stress based on “effective lengths”
    - “Ultimate” capacity
* Local buckling of a main member face
* Main member failure:
    - Web or sidewall yielding
    - Web or sidewall crippling
    - Web or sidewall buckling
    - Overall shear failure

All tubular joints shall be plain unstiffened joints (made without the use of reinforcing plates) except as follows:

* Floor beams hung beneath the lower chord of the structure may be constructed with or without stiffener (or gusset) plates, as required by design.

* Floor beams which frame directly into the truss verticals (H-Section bridges) may be designed with or without end stiffening plates as required by design.
* Where chords, end floor beams and in high profiles the top end struts weld to the end verticals, the end verticals (or connections) may require stiffening to transfer the forces from these members into the end vertical.

* Truss vertical to chord connections.

NOTE: The effects of fabrication tolerances shall be accounted for in the design of the structure. Special attention shall be given to the actual fit-up gap at welded truss joints.

3.3.3 Wood

American Institute of Timber Construction (AITC), the U.S. Forest Products Laboratory, and the American Forest & Paper Association (AF&PA)
Sawn lumber shall be designed in accordance with the ANSI/AF&PA NDS, "National Design Standard for Wood Construction", as published by the American Forest & Paper Association or
the "Timber Construction Manual" as published by the American Institute of Timber Construction (AITC). Design properties for naturally durable hardwoods shall be in accordance with "Tropical Timbers of the World", as published by the U.S. Forest Products Laboratory.

3.3.4 Concrete

Reinforced concrete shall be designed in accordance with the "Building Code Requirements for Structural Concrete" (ACI 318)

3.3.5 Top Chord Stability

Structural Stability Research Council (SSRC), formerly Column Research Council.

The top chord shall be considered as a column with elastic lateral supports at the panel points. The critical buckling force of the column, so determined, shall exceed the maximum force from dead load and live load (uniform or vehicular) in any panel of the top chord by not less than 50 percent for parallel chord truss bridges or 100 percent for bowstring bridges. The design approach to prevent top chord buckling shall be as outlined by E.C. Holt's research work in conjunction with the Column Research Council on the stability of the top chord of a half-through truss. See Appendix A for the calculation of the spring constant C and the determination of an appropriate K factor for out-of-plane buckling.

In addition, for the dead load plus vehicle load combination, the spring constant "C" furnished by the transverse "U-Frames" shall not be less than "C" required as defined by:

$$C\ required = \frac{1.46\ P_c}{L}$$

where P_c is the maximum top chord compression due to dead load plus the vehicle load times the appropriate safety factor (1.5 for parallel chord truss bridges or 2.0 for bowstring bridges) and L is the length in inches of one truss panel or bay.

For uniformly loaded bridges, the vertical truss members, the floor beams and their connections (transverse frames) shall be proportioned to resist a lateral force of not less than 1/100k times the top chord compressive load, but not less than .004 times that top chord load, applied at the top chord panel points of each truss. The top chord load is determined by using the larger top chord axial force in the members on either side of the "U-frame" being analyzed. For end frames, the same concept applies except the transverse force is 1% of the axial load in the end post member.

For bridges with vehicle loads, the lateral force applied at the top chord elevation for design of the transverse frames shall not be less than 1% of the top chord compression due to dead load plus any vehicle loading.

The bending forces in the transverse frames, as determined above, act in conjunction with all forces produced by the actual bridge loads as determined by an appropriate analysis which assumes that the floor beams are "fixed" to the trusses at each end.

NOTE: The effects of three dimensional loading (including "U-frame" requirements) shall be considered in the design of the structure. The "U-frame" forces shall be added to the forces derived from a three dimensional analysis of the bridge.

4.0 MATERIALS

4.1 Steel

4.1.1 Unpainted Weathering Steel

Bridges which are not to be painted shall be fabricated from high strength, low alloy, atmospheric corrosion resistant ASTM A847 cold-formed welded square and rectangular tubing and/or ASTM A588, or ASTM A242, ASTM A606 plate and structural steel shapes (Fy = 50,000 psi). The minimum corrosion index of atmospheric corrosion resistant steel, as determined in accordance with ASTM G101, shall be 6.0.

4.2 Decking

4.2.1 Hardwood Decking

All decking shall be full thickness planks unless approved otherwise.

4.2.1.1. Wood decking shall be naturally durable hardwood Ipe (Tabebuia Spp Lapacho Group). All planks shall be partially air dried to a moisture content of 20% or higher, and shall be supplied S4S (surfaced four sides), E4E (eased four edges), with the edges eased to a radius of 1/8". Measured at 25% moisture content, the width and thickness shall not vary from specified dimensions by more than ± 0.125" and ±0.0625", respectively. All planks shall be supplied with the end sealed with "Anchorseal" Mobil CER-M or an equal aquious wax log sealer.

All planks shall be graded as FEQ (First Export Quality -) grading rules, defined as follows:

* Lumber shall be graded both faces and both edges.
* Lumber shall be straight grained, maximum slope of grain to be 1:10.

4.2.1.1.1 FEQ (first one face and better)

Grading Face, Back Face and Edges

- Include - Mixed Appearance Characteristics
- Include - Mixed Physical Characteristics that can be removed using normal installation methods, tools, or sanding.
- Include - Sound Defects
- Exclude - Milling Defects

Back Face and Edges:

- Include – Unsound Defects
- Include – Milling Defects

SPECIAL SPECIFICATIONS FOR PREFABRICATED BRIDGE

Appearance Characteristics

1) Color variation
2) Mixed grain
3) Drying checks
4) Reverse/roey grain
5) Birdseye
6) Pin knots
7) Maculas
8) Water stain
9) Discoloration
10) Sticker marks
11) Molder knife marks

Milling Defects

1) Skip
2) Torn grain
3) Chipped grain
4) Non compliant profiling

Physical Characteristics

1) Bow
2) Crook
3) Cup
4) Twist
5) Raised grain

Sound Defects

1) Pin holes
2) Sound knots

Unsound Defects

1) Large borer holes
2) Splits
3) Unsound knots
4) Shake
5) Sapwood

All planks shall meet or exceed the following mechanical properties (based on the 2" standard) as defined by the U.S. Forest Products Laboratory publications and testing data:

MC%	Bending Strength	Modulus of Elasticity	Max. Crush Strength
AD	22,475 psi	3,145,000 psi	13,140 psi

Janka side hardness is 3595lbs. at 12% moisture content
Average air-dry density is 56.7 to 59.3 pcf.
Basic specific gravity is 0.85 - 0.97.

All planks shall be naturally fire resistant without the use of any fire resistant preservatives to meet NFPA Class A and UBC Class I.

Planks shall be supplied that meet or exceed the Static Coefficient of Friction for both Neolite and leather shoes in accordance with ASTM Test Method C1028-89.

	FORCE IN POUNDS
SHOE MATERIAL	WET
Neolite	0.69
Leather	0.79

For transverse wood decking, wheel loads shall be assumed to act on one plank only. The wheel loads shown in Section 3.1.3 shall be distributed on the plank along a length equal to the tire print width (W). The plank shall be designed for shear and bending in accordance with the support conditions and spacing. For design, the following unfactored allowable values shall be used:

Allowable Bending = 3,700 psi

Allowable Shear = 320 psi
Modulus of Elasticity = 3,000,000 psi

4.2.1.2 Wood Decking Attachment

* At time of installation, planks are to be placed tight together with no gaps.

* Every plank must be attached with at least one fastener at each end.

All fasteners to be zinc plated. Self-tapping screws or hex-head bolts, with a steel plank hold down, are to be used at the ends of planks. Self-tapping screws or carriage bolts are to be used as interior connection fasteners when required. Power actuated fasteners will not be allowed.

* Planks are to be drilled prior to installation of bolts and/or screws.

* In addition to at least one fastener at each end of every plank (typical for all installations), planks for bridges with widths of 72" to 143" shall be attached with a minimum of two fasteners at a location approximately near the center of the bridge width. Bridges wider than 143" are to have two fasteners located at a minimum of two interior stringer locations, approximately at the third points of the bridge width.

NOTE: Attachments at the ends of the planks may be modified as required when obstructions, such as interior safety system elements, prevent installation of the specified hold down system.

4.2.2 Concrete Deck

The bridge shall be furnished with a stay-in place galvanized steel form deck suitable for pouring a reinforced concrete slab. The form deck shall be designed to carry the dead load of the wet concrete, weight of form decking, plus a construction load of 20 psf or a 150 pound concentrated load on a 1'-0" wide section of deck. When edge supports are used, deflection is limited to 1/180 of the span or ¾", whichever is less. Without edge supports, deflection shall be limited to 1/180 of the span or 3/8". whichever is less.

The form deck shall be either smooth or composite. Composite decking shall not be used as reinforcing when designing for concentrated loads (wheel loads). The decking shall be galvanized in accordance with ASTM A525 (G60)

Concrete deck design shall be performed by the Bridge manufacturer. Concrete decks shall be designed for concentrated load as specified in Section 3.1.3. The wheel loads used for deck design shall be distributed per the Structural Engineering Handbook by Gaylord and Gaylord. The load distribution width is equal to the tire width plus 0.6 times the slab span but in no case will it be greater than the smallest of the following values:

1. ½ the deck width
2. 75% of the wheel track spacing, or
3. 4' + 0.06S, per AASHTO, where S = slab span in feet

5.0 WELDING

5.1 Welding

Welding and weld procedure qualification tests shall conform to the provisions of ANSI/AWS D1.1 “Structural Welding Code”, 1996 Edition. Filler metal shall be in accordance with the applicable AWS Filler Metal Specification (i.e. AWS A 5.28 for the GMAW Process). For exposed, bare, unpainted applications of corrosion resistant steels (i.e. ASTM A588 and A847), the filler metal shall be in accordance with AWS D1.1, Section 3.7.3.

5.2 Welders

Welders shall be properly accredited operators, each of whom shall submit certification of satisfactorily passing AWS standard qualification tests for all positions with unlimited thickness of base metal, have a minimum of 6 months experience in welding tubular structures and have demonstrated the ability to make uniform sound welds of the type required.

6.0 SUBMITTALS

6.1 Submittal Drawings

Schematic drawings and diagrams shall be submitted to the customer for their review after receipt of order. Submittal drawings shall be unique drawings, prepared to illustrate the specific portion of the work to be done. All relative design information such as member sizes, bridge reactions, and general notes shall be clearly specified on the drawings. Drawings shall have cross referenced details and sheet numbers. All drawings shall be signed and sealed by a Professional Engineer who is licensed in accordance with Section 3.0.

6.2 Structural Calculations

Structural calculations for the bridge superstructure shall be submitted by the bridge manufacturer and reviewed by the approving engineer. All calculations shall be signed and sealed by a Professional Engineer who is licensed in accordance with Section 3.0. The calculations shall include all design information necessary to determine the structural adequacy of the bridge. The calculations shall include the following:

* All AISC allowable stress checks for axial, bending and shear forces in the critical member of each truss member type (i.e. top chord, bottom chord, floor beam, vertical, etc.).

* Checks for the critical connection failure modes for each truss member type (i.e. vertical, diagonal, floor beam, etc.). Special attention shall be given to all welded tube on tube connections (see section 3.3.2 for design check requirements).

* All bolted splice connections.

* Main truss deflection checks.

* U-Frame stiffness checks (used to determine K factors for out-of-plane buckling of the top

chord) for all half through or "pony" truss bridges.

* Deck design.

NOTE: The analysis and design of triangulated truss bridges shall account for moments induced in members due to joint fixity where applicable. Moments due to both truss deflection and joint eccentricity must be considered.

6.3 Welder certifications in compliance with AWS standard qualification tests.

6.4 Welding procedures in compliance with Section 5.1.

7.0 FABRICATION

7.1 General Requirements

7.1.1 Drain Holes

When the collection of water inside a structural tube is a possibility, either during construction or during service, the tube shall be provided with a drain hole at its lowest point to let water out.

7.1.2 Welds

Special attention shall be given to developing sufficient weld throats on tubular members. Fillet weld details shall be in accordance with AWS D1.1, Section 3.9 (See AWS Figure 3.2). Unless determined otherwise by testing, the loss factor “Z” for heel welds shall be in accordance with AWS Table 2.8. Fillet welds which run onto the radius of a tube shall be built up to obtain the full throat thickness (See Figure 7.1). The maximum root openings of fillet welds shall not exceed 3/16” in conformance with AWS D1.1, Section 5.22. Weld size or effective throat dimensions shall be increased in accordance with this same section when applicable (i.e. fit-up gaps> 1/16”).

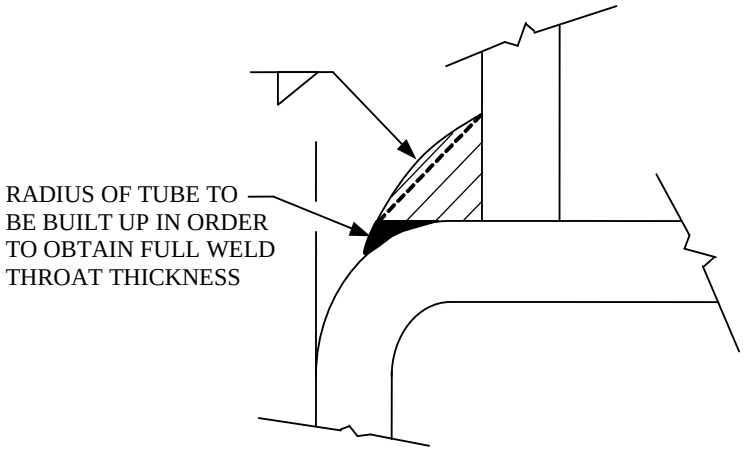


FIGURE 7.1
BUILD UP RADIUS WELD

The fabricator shall have verified that the throat thickness of partial joint penetration groove welds (primarily matched edge welds or the flare-bevel-groove welds on underhung floor beams) shall be obtainable with their fit-up and weld procedures. Matched edge welds shall be "flushed" out when required to obtain the full throat or branch member wall thickness.

For full penetration butt welds of tubular members, the backing material shall be fabricated prior to installation in the tube so as to be continuous around the full tube perimeter, including corners.

Backing may be of four types:

* A "box" welded up from four (4) plates.
* Two "channel" sections, bent to fit the inside radius of the tube, welded together with full penetration welds.
* A smaller tube section which slides inside the spliced tube.
* A solid plate cut to fit the inside radius of the tube.

Corners of the "box" backing, made from four plates, shall be welded and ground to match the inside corner radii of the chords. The solid plate option shall require a weep hole either in the chord wall above the "high side" of the plate or in the plate itself. In all types of backing, the minimum fit-up tolerances for backing must be maintained at the corners of the tubes as well as across the "flats".

7.2 Quality Certification

Bridge(s) shall be fabricated by a fabricator who is currently certified by the American Institute of Steel Construction to have the personnel, organization, experience, capability, and commitment to produce fabricated structural steel for the category "Major Steel Bridges" as set forth in the AISC Certification Program. Quality control shall be in accordance with

procedures outlined for AISC certification. For painted structures, the fabricator must hold a "Sophisticated Paint Endorsement" as set forth in the AISC certification program. Furthermore, the bridge(s) shall be fabricated in a facility owned and/or leased by the corporate owner of the manufacturer, and fully dedicated to bridge manufacturing.

8.0 FINISHING

8.1 Blast Cleaning

8.1.1 Bare applications of enhanced corrosion resistant steels.

All Blast Cleaning shall be done in a dedicated OSHA approved indoor facility owned and operated by the bridge fabricator. Blast operations shall use Best Management Practices and exercise environmentally friendly blast media recovery systems.

To aid in providing a uniformly “weathered” appearance, all exposed surfaces of steel shall be blast cleaned in accordance with Steel Structures Painting Council Surface Preparation Specifications No. 7 Brush-Off Blast Cleaning, SSPC-SP7 latest edition.

Exposed surfaces of steel shall be defined as those surfaces seen from the deck and from outside of the structure. Stringers, floor beams, lower brace diagonals and the inside face of the truss below deck and bottom face of the bottom chord shall not be blasted.

9.0 DELIVERY AND ERECTION

Delivery is made to a location nearest the site which is easily accessible to normal over-the-road tractor/trailer equipment. All trucks delivering bridge materials will need to be unloaded at the time of arrival.

The manufacturer will provide detailed, written instruction in the proper lifting procedures and splicing procedures (if required). The method and sequence of erection shall be the responsibility of others.

The bridge manufacturer shall provide written inspection and maintenance procedures to be followed by the bridge owner.

10.0 BEARINGS

10.1 Bearing Devices

Bridge bearings shall consist of a steel setting or slide plate placed on the abutment or grout pad. The bridge bearing plate which is welded to the bridge structure shall bear on this setting plate. One end of the bridge will be fixed by fully tightening the nuts on the anchor bolts at that end. The opposite end will have finger tight only nuts to allow movement under thermal expansion or contraction.

The bridge bearings shall sit in a recessed pocket on the concrete abutment. Minimum 28-day strength for the abutment concrete shall be 3,000 PSI. The bearing seat shall be a

minimum of 16" wide. The step height (from bottom of bearing to top-of-deck) shall be determined by the bridge manufacturer.

Bridges in excess of 100 feet in length or bridges with dead load reactions of 15,000 pounds or more (at each bearing location) shall have teflon on teflon or stainless steel on teflon slide bearings placed between the bridge bearing plate and the setting plate. The top slide plate shall be large enough to cover the lower teflon slide surface at both temperature extremes.

11.0 FOUNDATIONS

Unless specified otherwise, the bridge manufacturer shall determine the number, diameter, minimum grade and finish of all anchor bolts. The anchor bolts shall be designed to resist all horizontal and uplift forces to be transferred by the superstructure to the supporting foundations. Engineering design of the bridge supporting foundations (abutment, pier, bracket and/or footings), including design of anchor bolt embedments, shall be the responsibility of the foundation engineer. The contractor shall provide all materials for (including anchor bolts) and construction of the bridge supporting foundations. The contractor shall install the anchor bolts in accordance with the manufacturer's anchor bolt spacing dimensions.

Information as to bridge support reactions and anchor bolt locations will be furnished by the bridge manufacturer after receipt of order and after the bridge design is complete.

12.0 PAYMENT

A partial payment or "deposit" for the prefabricated bridge shall be made upon order and storage as required by the terms of the manufacturer.

13.0 WARRANTY

The bridge manufacturer shall warrant their steel structure(s) to be free of design, material and workmanship defects for a period of ten years from the date of delivery. Naturally durable hardwood decking and hardwood attachments shall carry a ten-year warranty against rot, termite damage, or fungal decay. Other types of wood are excepted under this warranty.

This warranty shall not cover defects in the bridge caused by abuse, misuse, overloading, accident, improper maintenance, alteration or any other cause not the result of defective materials or workmanship.

This warranty shall be void unless owner’s records can be supplied which shall indicate compliance with the minimum guidelines specified in the inspection and maintenance procedures.

Repair or replacement shall be the exclusive remedy for defects under this warranty. The bridge manufacturer shall not be liable for any consequential or incidental damages for breach of any express or implied warranty on their structures.

14.0 APPROVAL CHECKLIST

The following checklist will be used in the evaluation of all submittals to assure compliance with the Special Specifications for Prefabricated Bridge. This checklist is considered the minimum acceptable requirements for compliance with these specifications. Any deviations from this checklist shall be considered grounds for rejection of the submittal. Any costs associated with delays caused by the rejection of the submittal, due to non-compliance with this checklist, shall be fully borne by the contractor and bridge supplier.

SUBMITTAL DRAWINGS
Data Required to be Shown:

Bridge Elevation
Bridge Cross Section
All Member Sizes
All Vertical Truss Members are Square or Rectangular Tubing
Bridge Reactions
General Notes Indicating AASHTO or AISC Stress Conformance
Material Specifications to be Followed
Design Live Load
Design Vehicle Load (If Applicable)
Design Wind Load
Other Specified Design Loads
Welding Process
Blast Cleaning
Paint System to be Used (If Applicable)
Paint Color Chart (If Applicable)
Detailed Bolted Splices (If Applicable)
Bolted Splice Location (If Applicable)
Signature and Seal of Professional Engineer, licensed in Accordance with Section 3.0

DESIGN CALCULATIONS (Cont.)
Data Required to be Shown

Weld Failure Checks (Ultimate)
Local Buckling of the Main Member Face Checks
Main Member Yielding Failure Checks
Main Member Crippling Failure Checks
Main Member Buckling Failure Checks
Main Member Shear Failure Checks
All Bolted Splice Checks (if applicable)
Main Truss Deflection Checks
Decking Material Checks
“U-Frame” Stiffness Checks (if applicable)
Interior and End Portal Design Checks (if applicable)
Determination of Top Chord K Factor Based on “U-Frame” Stiffness (if applicable)
Consideration of Individual Member Moments Due to Truss Deflection, Joint Fixity and Joint Eccentricity

DESIGN CALCULATIONS
Data Required to be Shown

Data Input for 3-D Analysis of Bridge
Joint Coordinates & Member Incidences
Joint and Member Loads
Member Properties
Load Combinations
AISC Member Stress Checks for Each Member Type
Critical Connection Failure Mode Checks For Each Member Type
Chord Face Plastification Checks
Punching Shear Checks
Material Failure Checks (Truss Webs)
Weld Failure Checks (Effective Length)

FABRICATION SUBMITTALS
Data Required to be Shown

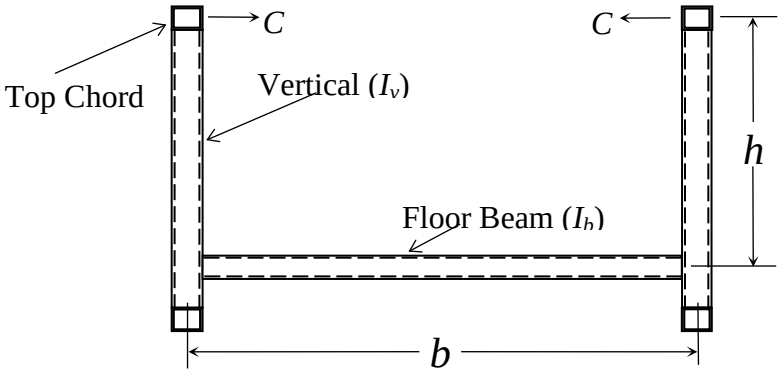
**Written Installation Instructions
**Written Splicing Instructions
**Written Maintenance & Inspection Instructions
**Welder Certifications
**Welding Procedures
Material Certifications (if applicable)
Structural Steel (if applicable)
Decking (if applicable)
Structural Bolts (if applicable)
**Quality Control Section of AISC Certification Manual (if applicable)
**Painter Certifications (if applicable)
Weld Testing Reports (if applicable)

** NOTE: These items are required to be submitted along with Submittal Drawings and Design Calculations. Those Fabrication Submittal Items not marked are be submitted prior to shipment of the bridge.

Appendix A

1/K FOR VARIOUS VALUES OF CL/P_c and n

	n						
1/K	4	6	8	10	12	14	16
1.000	3.686	3.616	3.660	3.714	3.754	3.785	3.809
0.980		3.284	2.944	2.806	2.787	2.771	2.774
0.960		3.000	2.665	2.542	2.456	2.454	2.479
0.950			2.595				
0.940		2.754		2.303	2.252	2.254	2.282
0.920		2.643		2.146	2.094	2.101	2.121
0.900	3.352	2.593	2.263	2.045	1.951	1.968	1.981
0.850		2.460	2.013	1.794	1.709	1.681	1.694
0.800	2.961	2.313	1.889	1.629	1.480	1.456	1.465
0.750		2.147	1.750	1.501	1.344	1.273	1.262
0.700	2.448	1.955	1.595	1.359	1.200	1.111	1.088
0.650		1.739	1.442	1.236	1.087	0.988	0.940
0.600	2.035	1.639	1.338	1.133	0.985	0.878	0.808
0.550		1.517	1.211	1.007	0.860	0.768	0.708
0.500	1.750	1.362	1.047	0.847	0.750	0.668	0.600
0.450		1.158	0.829	0.714	0.624	0.537	0.500
0.400	1.232	0.886	0.627	0.555	0.454	0.428	0.383



" U - Frame"

Where: $C = \dfrac{E}{h^2\,[h/3I_v + b/2I_b]}$

$L = Length\ in\ inches\ of\ one\ truss\ panel$

$P_c = Buckling\ Load\ (= Top\ Chord\ Compression\ x\ F.S.)$

$n = Number\ of\ Panels$

Reference: Galambos, T.V. (1988) "Guide to Stability Design Criteria for Metal Structures", 4th Ed., PP 515-529.

APPENDIX E

Laboratory Testing Summary

Sample Source	Sample Number	Depth (feet)	MC (%)	Soil Type	Atterberg Limits			Percent Passing No. 200 Sieve	Moisture - Density		CBR (%)		Organic Content (%)
					LL	PL	PI		Maximum Density (pcf)	Optimum Moisture (%)	0.1 in.	0.2 in.	
B-1	S-3	6-7.5	19.1	SP-SM				7.6					
B-1	S-7	23.5-25	31.4	SP-SM				9.5					
B-1	S-8	28.5-30	70.9		70	22	48						
B-2	S-3	6-7.5	26	SP-SM				6					
B-2	S-4	8.5-10	102.4		80	26	54						
B-2	S-5	13.5-15	42.9		44	17	27						
B-2	S-6	18.5-20	45.5	SM				43.7					
B-2	S-7	23.5-25	80		73	25	48						

Notes: See test reports for test method, *ASTM D2488

Definitions: MC: Moisture Content, Soil Type: USCS (Unified Soil Classification System), LL: Liquid Limit, PL: Plastic Limit, PI: Plasticity Index, CBR: California Bearing Ratio, OC: Organic Content

Project: Barefoot Resort Residential - Erosion Investigation
Client: Ardurra Group
Project No.: 22:29596
Date Reported: 11/5/2020

Office / Lab	Address	Office Number / Fax
ECS Southeast LLP - Wilmington	6714 Netherlands Drive Wilmington, NC 28405	(910)686-9114 (910)686-9666

Tested by	Checked by	Approved by	Date Received
kwatson	kleimer	kleimer	10/30/2020

Site Location Diagram
BAREFOOT RESORT RESIDENTIAL - EROSION INVESTIGATION

VIA PALMA DRIVE, NORTH MYRTLE BEACH, SOUTH CAROLINA

ARDURRA GROUP

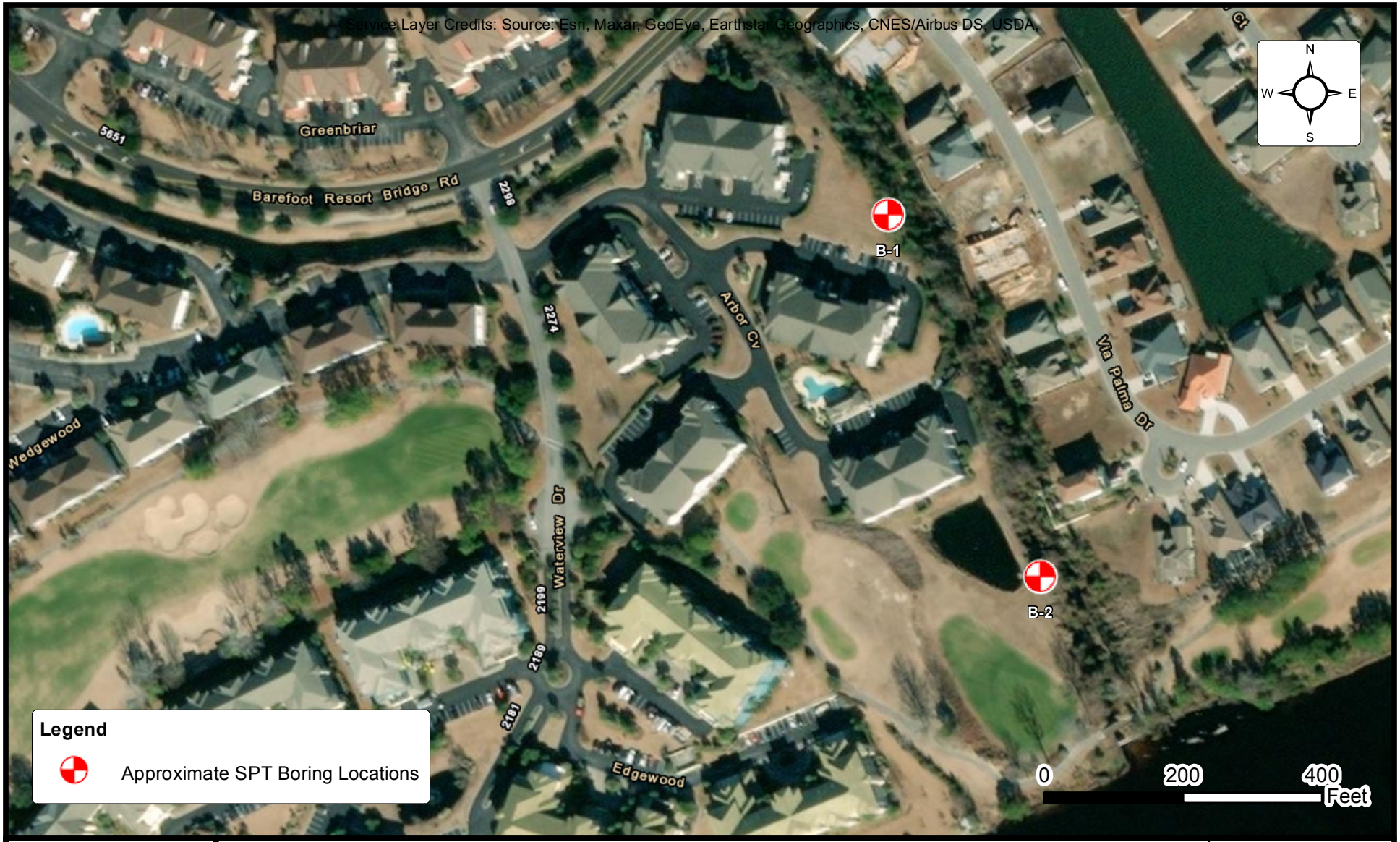
ENGINEER	WEG
SCALE	AS NOTED
PROJECT NO.	22:29596
SHEET	1 OF 2
DATE	11/12/2020

Site Location Diagram
BAREFOOT RESORT RESIDENTIAL - EROSION INVESTIGATION

VIA PALMA DRIVE, NORTH MYRTLE BEACH, SOUTH CAROLINA

ARDURRA GROUP

ENGINEER	WEG
SCALE	AS NOTED
PROJECT NO.	22:29596
SHEET	1 OF 2
DATE	11/12/2020



Boring Location Diagram
BAREFOOT RESORT RESIDENTIAL - EROSION INVESTIGATION

VIA PALMA DRIVE, NORTH MYRTLE BEACH, SOUTH CAROLINA

ARDURRA GROUP

ENGINEER	WEG
SCALE	AS NOTED
PROJECT NO.	22:29596
SHEET	2 OF 2
DATE	11/12/2020

CLIENT:	PROJECT NO.:	BORING NO.:	SHEET:
Ardurra Group	**22:29596**	**B-1**	**1 of 1**

PROJECT NAME:	DRILLER/CONTRACTOR:
Barefoot Resort Residential - Erosion Investigation	**Mid Atlantic Drilling, Inc.**

SITE LOCATION: **Via Palma Drive, North Myrtle Beach, South Carolina 29582**

LOSS OF CIRCULATION

NORTHING:	EASTING:	STATION:	SURFACE ELEVATION:

BOTTOM OF CASING

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6"
					Topsoil Thickness[3.00"]			
	S-1	SS	18	18	(SP-SM) FINE SAND with silt, tan, moist to saturated, loose			2-2-3 (5)
	S-2	SS	18	18				3-3-4 (7)
5							-5	
	S-3	SS	18	18		▼		3-2-3 (5)
	S-4	SS	18	0	[NO RECOVERY] - metal and wooden debris encountered			2-1-1 (2)
10					(SP-SM) FINE TO MEDIUM SAND with silt, gray, saturated, medium dense to loose, with shell fragments and cemented layers		-10	
	S-5	SS	18	18				7-10-14 (24)
15							-15	
	S-6	SS	18	18				3-3-4 (7)
20							-20	
	S-7	SS	18	18				7-6-7 (13)
25							-25	
					(CH) SANDY FAT CLAY, gray, saturated, soft			
	S-8	SS	18	18				1-1-2 (3)
30					**END OF DRILLING AT 30.0 FT**		-30	

Plastic Limit Water Content Liquid Limit

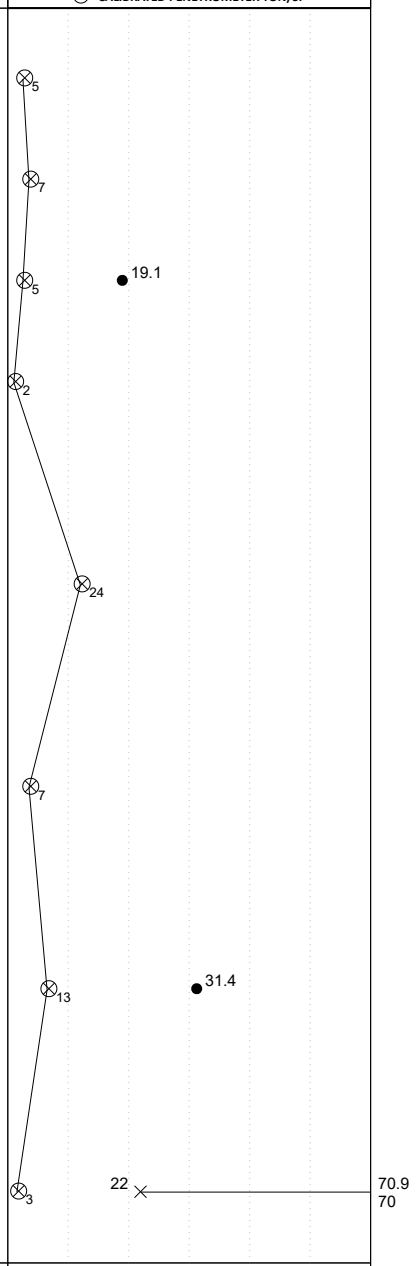
⊗ STANDARD PENETRATION BLOWS/FT

ROCK QUALITY DESIGNATION & RECOVERY

RQD

REC

○ CALIBRATED PENETROMETER TON/SF



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

▽ WL (First Encountered)	BORING STARTED: **Oct 28 2020**		CAVE IN DEPTH:
▼ WL (Completion) **7.33**	BORING COMPLETED: **Oct 28 2020**		HAMMER TYPE: **Auto**
▼ WL (Seasonal High Water)	EQUIPMENT: **Truck**	LOGGED BY: **MPD1**	DRILLING METHOD: **Mud rotary**
▽ WL (Stabilized)			

GEOTECHNICAL BOREHOLE LOG

CLIENT:	PROJECT NO.:	BORING NO.:	SHEET:
Ardurra Group	**22:29596**	**B-2**	**1 of 1**

PROJECT NAME:	DRILLER/CONTRACTOR:
Barefoot Resort Residential - Erosion Investigation	**Mid Atlantic Drilling, Inc.**

SITE LOCATION: **Via Palma Drive, North Myrtle Beach, South Carolina 29582**

LOSS OF CIRCULATION

NORTHING:	EASTING:	STATION:	SURFACE ELEVATION:

BOTTOM OF CASING

DEPTH (FT)	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DIST. (IN)	RECOVERY (IN)	DESCRIPTION OF MATERIAL	WATER LEVELS	ELEVATION (FT)	BLOWS/6"
0					Topsoil Thickness[8.00"]		0	
	S-1	SS	18	18	(SP-SM) SILTY FINE SAND, brown, moist to saturated, loose	▼		2-2-3 (5)
	S-2	SS	18	18				3-3-4 (7)
5	S-3	SS	18	18			-5	5-4-3 (7)
	S-4	SS	18	18	(CH) FAT CLAY, gray, saturated, very soft			WOH-WOH-WOH (0)
10							-10	
	S-5	SS	18	18	(CL) SANDY LEAN CLAY, gray, saturated, very soft			1-1-1 (2)
15							-15	
	S-6	SS	18	18	(CH) SANDY FAT CLAY, gray, saturated, firm to very soft, with shell fragments			4-4-3 (7)
20							-20	
	S-7	SS	18	18				1-1-1 (2)
25							-25	
	S-8	SS	18	18				WOH-WOH-2 (2)
30					**END OF DRILLING AT 30.0 FT**		-30	

Plastic Limit Water Content Liquid Limit

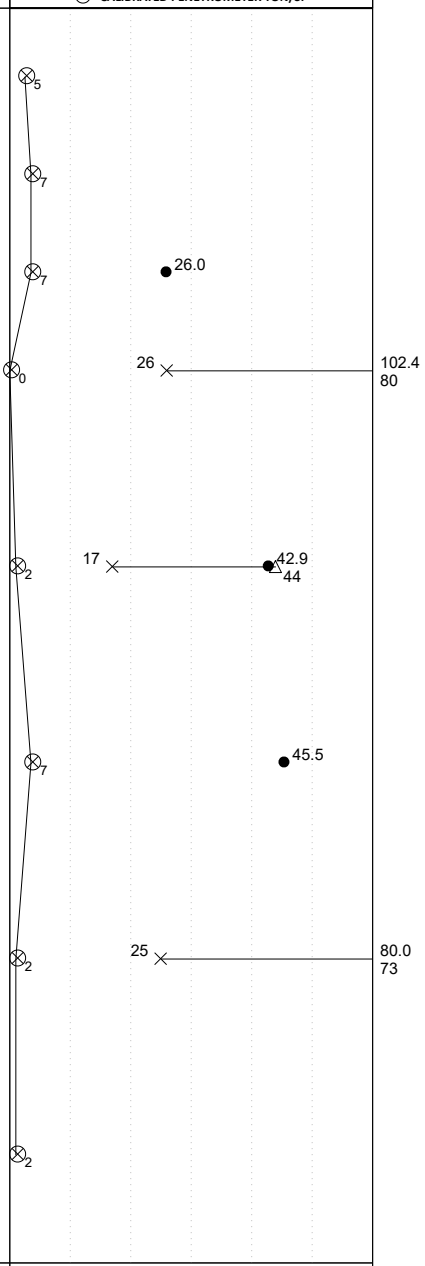
STANDARD PENETRATION BLOWS/FT

ROCK QUALITY DESIGNATION & RECOVERY

RQD

REC

CALIBRATED PENETROMETER TON/SF



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL TYPES. IN-SITU THE TRANSITION MAY BE GRADUAL

▽ WL (First Encountered)	BORING STARTED: **Oct 28 2020**		CAVE IN DEPTH:
▼ WL (Completion) **2.25**	BORING COMPLETED: **Oct 28 2020**		HAMMER TYPE: **Auto**
▼ WL (Seasonal High Water)	EQUIPMENT: **Truck**	LOGGED BY: **MPD1**	DRILLING METHOD: **Mud rotary**
▽ WL (Stabilized)			

GEOTECHNICAL BOREHOLE LOG