Anchor System Performance

Case Study – Pullout Testing Comparison

Introduction

Regardless of whether a rolled erosion control product (RECP) is a temporary Erosion Control Blanket (ECB) designed to last for a few months or a Turf Reinforcement Mat (TRM) designed to reinforce vegetation for the life of the project, proper installation is necessary to ensure expected performance.

Proper installation includes soil preparation and the use of the appropriate seed and soil amendments. The installation also includes correct trenching and overlaps where needed. Last, but certainly not least, the selection and placement of the best possible anchoring system must not be overlooked.

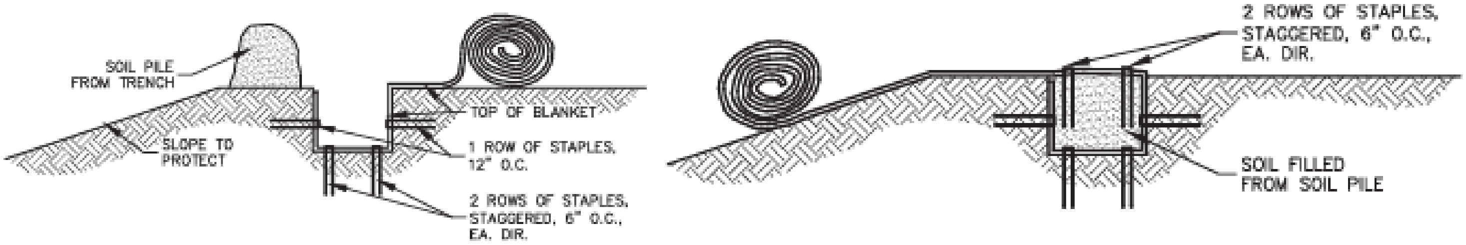

Figure 1: Example Rolled Erosion Control Product (RECP) trench method.

Background – Anchors

There are many different types of anchors on the market, but the most common anchor type used on RECPs is the metal U-staple, often called a sod staple. They vary in length, but the most common are 6” long. These sod staples are relatively inexpensive and can be easily installed by hand, with a hammer or with a variety of manual or pneumatic installation tools. As with all anchors, these sod staples are designed to hold the RECP close to the ground so that vegetation can easily grow through the RECP without tenting, which is what occasionally happens when vegetation under the RECP pushes it upward instead of growing through it. Staples, along with proper trenching where required, protect the RECP from being displaced by wind and help hold the RECP down under flowing water.

Figure 2: U-staple / Sod staple.

Background – Concerns

Assuming all other installation instructions and staple patterns are followed, RECPs installed in relatively flat areas with minimal exposure to water flow and shear stress may not require anything more than common sod staples for anchoring.

However, when ECBs or TRMs are installed on steeper slopes and in channels, the performance capabilities of the anchor system become even more important.

Temporary RECPs, though not designed to handle the same shear stresses as TRMs, are often used in critical areas where an additional layer of safety is needed. In less cohesive soils, sod staples and other anchors often do not have the performance capabilities in the form of pullout resistance levels required to meet jobsite requirements. In tougher soils, common steel wire staples tend to bend, whereas thicker, stronger twist anchors more easily coil their way into the soil and hold the RECP in place.

TRMs are used in critical areas of concern where they experience high flow, high erosion-risk scenarios. The anchors used with these products must a have higher pullout resistance to withstand higher shear forces.

Figure 3: Gripple® twist anchor through Curlex® II FibreNet™.

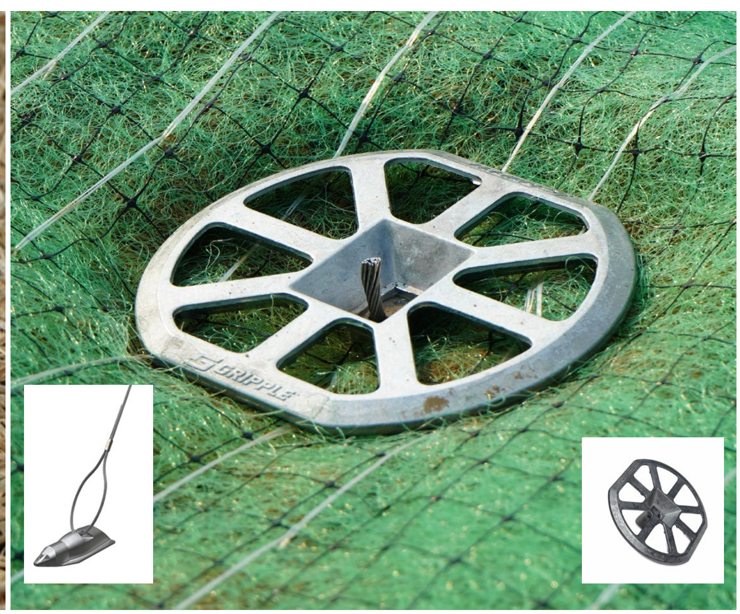

Figure 4: Gripple earth percussion anchor through Recyclex® TRM.

Project Scope

As of October 2023, there are no standardized test methods to determine anchor pullout performance. Standardizing these tests would allow engineers and specifiers to design appropriate anchor systems more effectively to meet expected slope and shear stress scenarios. For example, anchors with a tested pullout strength equal to or greater than the calculated pullout force resulting from the expected flows on a given channel would allow for appropriate specification.

To answer the question of anchor system performance, an experimental full-scale anchor pullout test was developed by TRI Environmental, Inc. The test allows for uniform compaction of a defined soil type in a confined chamber apparatus. *(The testing process referenced herein was developed and performed by TRI Environmental, Inc. on behalf of Gripple, Inc. Test results are wholly owned by Gripple, Inc. and reproduced with their consent.)*

The Plan - Standardized Testing Development

The pullout mechanism used in the test is a pulley system utilizing interchangeable single or double-pulley advantage to accommodate both low and high load applications on individual anchors. One end of the pulley system is attached to a load cell and vessel for gradual water-weight loading. The other end of the system is attached to the anchor.

Figure 5: Water vessel hanging on load cell. Photo provided by TRI Environmental, Inc.

Figure 6: Load cell attached to water vessel and anchor. Photo provided by TRI Environmental, Inc.

The Plan - Standardized Testing Development - Continued

Anchors are installed in accordance with manufacturer instructions or standard industry practice. The pulley mechanism is set atop two steel beams to allow for multiple-replicate testing on any single compaction scenario.

The vessel is gradually filled with water, and the anchor movement is monitored manually using a ruler. Full pullout strength is recorded as the maximum weight recorded on the load cell. The load cell is set to hold the maximum reading.

The system allows for the exertion of the true vertical pullout force without the impacts of the pullout device contacting the soil surface around the anchor.

Anchors tested were chosen to represent a cross section of anchor styles used on construction sites.

Anchor type, size, and embedment depth were recorded for comparison.
Multiple anchor types were evaluated at different sizes and embedment depths.

Figure 7: Anchor installed prior to test.
Photo provided by TRI Environmental, Inc.

Figure 8: Water added to vessel.
Photo provided by TRI Environmental, Inc.

Figure 9: Before pullout test.
Photo provided by TRI Environmental, Inc.

Figure 10: Pullout measured.
Photo provided by TRI Environmental, Inc.

Results

Test results showed quantifiable performance differences between anchor systems of different designs and sizes. The calculated pullout strength of the tested anchors ranged from 10–230 lb. This range represents the large difference in performance between product designs.

Anchor systems are an important part of all RECP installations. ECBs and TRMs may be used in high-risk scenarios that include less cohesive soils, steep slopes or high shear stress. The selection of the best anchor type is especially important when these more challenging scenarios are present on-site.

The chart below illustrates the difference in two common anchors. The 8" staple (sod staple) had pullout resistance results of 56 lb. (loam), 9.2 lb. (sand), 30.4 lb. (clay). The 8" Gripple TL-TA1 twist anchor had pullout resistance results of 171 lb. (loam), 50.4 lb. (sand), 189 lb. (clay). The Gripple twist anchor's pullout resistance improvement over the sod staple was 205% (loam), 447% (sand), 523% (clay). That is an average improvement of 392%.

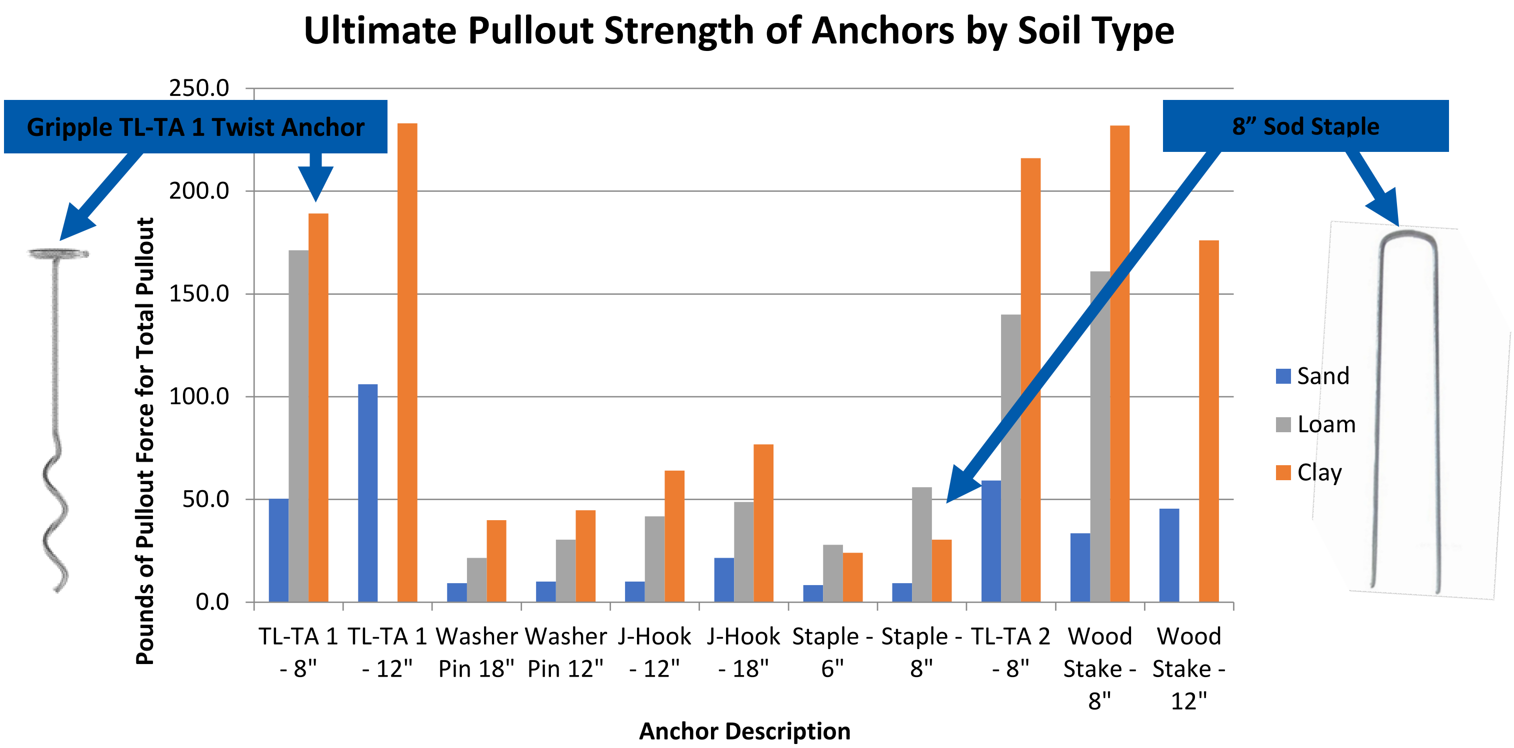

Figure 11: Pullout test results of various anchors in sand, loam and clay soils.

Next Steps

The results of this research clearly demonstrate significant differences in anchor pullout resistance. The testing equipment and methods are straightforward and offer everything required to create a useful industry standard. To further improve the erosion industry, it is recommended that the researchers submit the draft test method to ASTM so that pullout resistance per square yard by RECP may be specified in the future.

Figure 12: Pullout test of pin with washer in loam soil.

Figure 13: Anchors used in pullout testing.

Figure 14: Pullout test of "J" hook in loam soil.

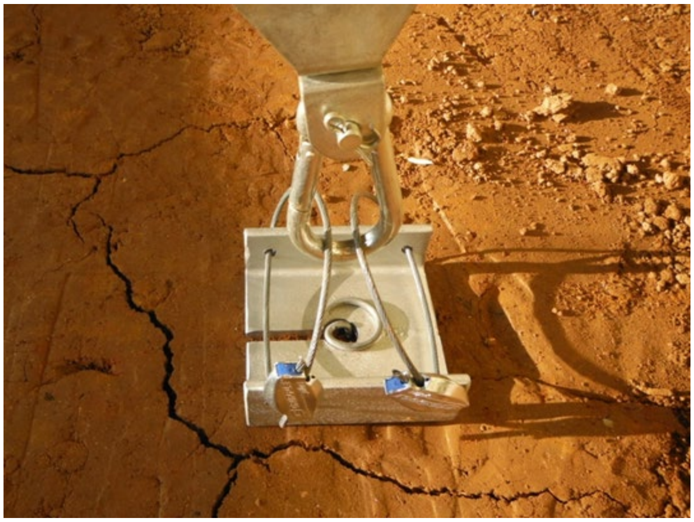

Figure 15: Pullout test of twist style pin in loam soil.