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EVALUATING CHANNEL CHECK DAMS

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Biography

C. Joel Sprague, Sr. Engineer - Mr. Sprague is a Senior Engineer for TRI/Environmental, Inc., Austin, TX. Mr. Sprague is based in Greenville, South Carolina where he also consults for Sprague & Sprague Consulting Engineers. He is a registered professional engineer in North and South Carolina, Georgia, and Texas. He has authored numerous articles and technical papers on the development, testing, and application of erosion and sediment control materials.

Benton Ruzowicz, Technical Specialist – Mr. Ruzowicz provides technical assistance to land disturbers, local governments, and erosion and sediment control professionals around the State on erosion and sedimentation control issues and the appropriate use of urban BMP's. He also provides technical plan reviews on behalf of the Districts in the Metro Atlanta area as well as technical support to all plan reviewers throughout the State. Ben also helps oversee the State's education and certification program for people involved in land disturbing activities in which there have been over 75.000 people certified.

Jay Sprague, Lab Director – Mr. Sprague supervises a staff of technicians, directs all site operations and testing, and is responsible for implementation of TRI's Quality Systems throughout all lab operations. Mr. Sprague's background includes developing markets and technologies associated with agricultural and erosion and sediment control products.

Abstract

In 2010, the Georgia Soil and Water Conservation Commission (GSWCC) received funding to revise the Manual for Erosion and Sediment Control in Georgia. One of the parameters was to incorporate new BMP's into the Manual. This was done by characterizing full-scale, installed performance of commonly used best management practices (BMPs) for sediment control. Some of the specific BMPs tested included what the GSWCC refers to as check structures or check dams. Check dams have traditionally been constructed of straw bales, riprap mounds, and occasionally silt fence structures. More recently "wattles", "socks" and other alternatives have been used. These check dams slow, or "check", concentrated flows to make them less erosive until the associated channel can vegetate sufficiently to resist flow erosion. Critical elements of this protection are the ability of the temporary check structure to: (a.) slow and/or pond runoff to encourage sedimentation, thereby reducing soil particle transport downstream, (b.) trap soil particles upstream of a structure, and (c.) decrease soil erosion.

Since there is relatively little performance data available for most BMPs, including check dams, and the limited data that is available has generally been developed using widely differing protocols, the testing protocol chosen should, as much as possible, conform to an existing standardized procedure so that future check structure BMPs could be subjected to the same protocols and easily and reliably be compared to the results of this program.

Recognizing that the actual performance of many check structure BMPs is system or installation dependent, the GSWCC determined that a large-scale test that could incorporate full-scale “as installed” conditions would be the best evaluation procedure. To this end, the GSWCC selected a large-scale standard test method - ASTM D 7208 – for the evaluations. ASTM D 7208, “Determination of Temporary Ditch Check Performance in Protecting Earthen Channels from Stormwater-Induced Erosion” has been developed to simulate this condition. It uses full-scale channel flow in a trapezoidal channel with check structure(s) installed. The test protocol included one replicate each at increasing flow levels of 0.5, 1.0, and 2.0 cubic feet per second. The testing evaluated compost socks, straw bales, and 2”-10” rock checks, as well as, a silt fence check. The test soil was classified as a Sandy Clay as shown on the USDA soil triangle.

Soil loss and the associated flow depth and velocity measurements were made at numerous locations along the channel during the testing. This data was used to calculate soil accretion and loss volumes using cut/fill calculations based on the Simpson Rule. From this data a Soil Accretion Index (SAI) and a Clopper Soil Loss Index (CSLI) were determined.

In general, as a check dam gets taller it may be able to increasingly reduce channel soil loss by creating greater ponding and, thus, greater slowing of water. Yet, in the process, the check dam must provide greater structural integrity and adjacent scour resistance. The original single row straw bale system and the silt fence system both offered taller damming, but even at the lowest flow level they provide insufficient structural integrity and scour resistance to function effectively. Conversely, the compost sock, rock check, and the enhanced, i.e. double row + deep trench, (NRCS) straw bale systems provided the necessary balance between damming and scour resistance to perform effectively under all flow levels.

Keywords: check dam, BMP, channel testing, GSWCC, ASTM D 7208

1 Background

The Georgia Soil and Water Conservation Commission (GSWCC) testing program described herein was intended to characterize full-scale, installed performance of commonly used best management practices (BMPs) for sediment control. These BMPs are commonly referred to as sediment retention devices, or SRDs. The SRDs tested include what the GSWCC refers to as check structures or check dams and were exposed to conditions relevant to typical installations. This testing served as a “baseline” for qualification of future check dams. Additionally, the “index properties” of the tested materials were verified and documented to go along with their associated performance properties. Together the index and performance data facilitates the correlation of performance to certain easily measured properties of the check dam components, and it “bench-marks” the performance of a given product to specific index properties.

The testing protocols were either existing standard test methods or fully documented for potential standardization, so that future check dams can be subjected to the same protocols and be easily and reliably compared to the results of this program.

2 Objectives

The program sought to accomplish the following objectives:

- Document easily measureable (index/QC) properties of check dams for “bench-marking”, or relating, the performance results to the component materials used in the check dams tested.
- Document the actual performance of check dams under application-specific simulations to provide “baseline” information to develop specifications and to assess relative performance products.
- Use test experience and results to recommend preferred test protocols for both QC and performance testing of check dams used in sediment barrier applications.

3 Overview of Standard Test Procedures for check dams

3.1 Why Standardize Test Procedures?

There is relatively little performance data available for most check dams and the limited data that is available has generally been developed using widely differing protocols. Thus, it is rarely possible to accurately compare check dam performance data developed on different check dams at different testing organizations. The solution to this is to define common, or standard, protocols that can be used by all testing organizations.

Additionally, most check dams are comprised of components that may be easily changed by the manufacturer without understanding the affect the change may have on product performance. At very least, the manufacturer must perform regular quality control (QC) tests on the components used in check dam manufacturing, and these QC tests must be consistently run and reported. These QC test results are often used as the basis for listing on state DOT Qualified Product Lists (QPL) and must, therefore, be independently verifiable. Thus, it is important that a common, or standard, protocol be used by manufacturer and regulator alike.

3.2 Basic Index Tests for QC and "Bench-marking" of Tested Products

All product manufacturers must perform a few tests on a very frequent basis so that they can prove that they are keeping their manufacturing processes within preset limits and thereby producing a consistent product.

3.2.1 Basic Index Properties for 2-Dimensional (Geotextile-based) check dams

In the manufacturing of check dams with geotextile components, a few basic mechanical and hydraulic properties are routinely measured in the manufacturer's own QC lab. These include:

- Mass per Unit Area via ASTM D 5261, "Standard Test Method for Measuring Mass per Unit Area of Geosynthetics."
- Thickness via ASTM D 5199, "Standard Test Method for Measuring Thickness of Geosynthetics."
- Tensile Strength via ASTM D 4632, "Standard Test Method for Grab Breaking Load and Elongation of Geosynthetics."
- Permittivity – Permittivity relates to the vertical water flow capacity of the material. It is often reported as gallons per minute per square foot of material and uses clear water and is measured via ASTM D 4491, "Standard Test Methods for Water Permeability of Geotextiles by Permittivity".
- Apparent Opening Size (AOS) – The approximate largest (O_{95}) size opening in the fabric is called the apparent opening size (AOS). The standard test method is ASTM D 4751, "Standard Test Method for Measuring the Apparent Opening Size of Geosynthetics".
- Percent Open Area (POA) – While the AOS is a good indicator of a geotextile's ability to retain sediments when the geotextile has lots of varying sized openings – such as with a nonwoven geotextile – a woven geotextile can have a few larger openings and a lot of very small ones making it prone to clogging even though the AOS test may indicate that it has relatively large openings. To make sure it has enough openings, the overall percent of open area can be determined using light projection. Though the test is not standardized, a commonly used protocol is available.

3.2.2 Basic Index Properties for 3-Dimensional check dams

Many check dams are 3-dimensional products (i.e. wattles, bales, etc.), thus non-standard procedures are currently used to measure such material properties as density (or unit weight per length) and circumference.

3.3 Full-scale Performance Testing of Check Dam Systems

As noted earlier, the actual performance of many check dams is system or installation dependent. Therefore a large-scale test that can incorporate full-scale "as installed" conditions is the ideal evaluation procedure. Check dams have been used to slow, or "check", concentrated flows to make them less erosive until the associated channel can vegetate sufficiently to resist soil loss during concentrated flow events. Critical elements of this protection are the ability of the temporary check structure to: (a.) slow and/or pond runoff to encourage sedimentation, thereby reducing soil particle transport downstream, (b.) trap soil particles upstream of a structure, and (c.) decrease soil erosion. ASTM D 7208, "*Determination of Temporary Ditch Check Performance in Protecting Earthen Channels from Stormwater-Induced Erosion"* has been developed to simulate this condition. It uses full-scale channel flow (up to 3 cubic feet per second) in a trapezoidal channel with check structure(s) installed.

4 Products/Systems Tested and Associated Index Properties

Table 1 presents a list of product/system types used in the testing and their more common descriptions.

check dam Description	Installation	Measured Properties
Compost Sock	Manufacturer's Recommendation	(~12-inch diameter, 25 lbs/ft; approx. 9" high x 16" wide installed
Straw Bales	GSWCC (1 row, std trench)	42"L x 18"H x 14"W @ 26.5 lbs = 4.3 lbs/ft^3
Straw Bales	NRCS (2 rows, deep trench)	42"L x 18"H x 14"W @ 26.5 lbs = 4.3 lbs/ft^3
Stone Check Dam	GSWCC (15-in High)	Graded size 2-10 inch stone
GADOT Type C Silt Fence	GADOT ("W" + wire backing)	Qualified Product List 36

Table 1. Test Matrix

5 Check Dam Testing in accordance with ASTM D7208

5.1 Testing Overview

Check Dams were tested in accordance with ASTM D 7208-06, except the test was run with one replicate each at 0.5, 1.0, and 2.0 cfs instead of 3 replicates at 3 cfs. Systems tested included compost socks, straw bales, 2"-10" rock checks, and a Type C silt fence check. The Type C Silt Fence check was installed in a special configuration to control energy dissipation per the GaDOT detail Cd-F specifications. The test soil was classified as a Sandy Clay as shown on the USDA soil triangle. Index tests were run as follows:

- Index tests on 2-dimensional (woven geotextile-type) products include:
    - mass/area
    - thickness
    - tensile strength
    - permittivity (flow)
    - Apparent Opening Size
    - Percent Open Area

- Index tests on 3-dimensional (wattle-type) products include:
    - mass/volume
    - circumference/perimeter
    - relevant component properties like netting tensile strength.

5.1.1 Test Setup

The large-scale check dam testing reported herein was performed in accordance with ASTM D7208 modified as described above. The testing is performed in a trapezoidal shaped flume with a 2 ft wide bottom and 2:1 side slopes and a 5% bed slope as shown in Figure 1. The concentrated flow is produced by opening a valve to allow gravity flow from an adjacent pond. Each test is run at a single predetermined flow rate for 30 minutes. The test channel is 60 ft long and includes a 40 ft test section along with a 10ft upstream and a 10 ft downstream transition section. Flow is metered into the channel via a calibrated sharp-crested weir as shown in Figure 2. Nine (9) evenly spaced cross-sections are delineated within the test section and nine (9) evenly spaced measurement points are located at each cross-section. These measurement points enable before and after measurements of the soil surface. Tables and graphs of cross-sectional soil loss are generated from the accumulated data.

Figure 1. Flume Setup (typical control)

Figure 2. Flow into Channel at Weir

5.1.2 Test Soil

The test soil used in the test plots had the following characteristics.

Soil Characteristic	Test Method	Value
% Gravel	ASTM D 422	0
% Sand		49.2
% Silt		12.6
% Clay		38.2
Soil Classification	USDA	Sandy Clay

Table 2. TRI Sandy-Clay Characteristics

5.1.3 Preparation of the Test Channels

The initial channel soil veneer (12-inch thick minimum) is placed and compacted. Compaction is verified to be 90% (± 3%) of Proctor Standard density using ASTM D2937 (drive cylinder method). The test channels undergo a “standard” preparation procedure prior to each test. First, any rills or depressions resulting from previous testing are filled in with test soil. The soil surface is replaced to a depth of 1 inch and groomed to create a channel bottom that is level side-to-side with smooth, compacted 2:1 side slopes and at a smooth 5% bed slope. Finally, a trapezoidal form with a vibrating plate compactor is run over the renewed channel surface. The submitted check dam system is then installed as directed by the client.

5.1.4 Installation of Check Dams in the Test Channels

As noted, each check dam was installed as directed by the client. For the tests reported herein, the check dam installations were in accordance with the GSWCC’s Manual for Erosion and Sediment Control in Georgia (“the Green Book”), except that the silt fence check structure was installed in accordance with GADOT detail Cd-F. The basis for each system installation is shown in Table 1.

5.1.5 Specific Test Procedure

Immediately prior to testing, the initial soil surface elevation readings are made at predetermined cross-sections. The channel is then exposed to the predetermined flow rate for 30 minutes. During the testing, flow depth and corresponding flow velocity measurements are taken at the predetermined cross-section locations. At the end of 30 minutes, the flow is stopped and soil surface elevation measurements are made to facilitate calculation of soil loss. Pictures of channel preparation are shown in Figures 3 and 4. Pictures of typical channel flows are shown in Figures 5 thru 8.


Figure 3. Compaction of Veneer


Figure 4. Channel Forming (typical)


Figure 5. Compost Sock Check Structure


Figure 6. Straw Bale (NRCS) Check Structure


Figure 7. Rock Check Structure


Figure 8. Silt Fence Check Structure

5.2 Test Results

Soil loss and the associated flow depth and velocity measurements made during the testing are the principle data used to determine the performance of the product tested. This data is entered into a spreadsheet that transforms the soil gain/loss measurements into related soil accretion and loss volumes using cut/fill calculations based on the Simpson Rule. From this data a Soil Accretion Index (SAI) and a

Clopper Soil Loss Index (CSLI) are determined. Data and calculations are summarized for each test in Table 3.

Tested System (0.5 cfs)	Total Soil Gain, ft^3	Total Soil Loss, ft^3	Total Wetted Area, ft^2	SAI	CSLI	Net	Net % of Unchecked	Obser-vations	Approx. Installation Time, min.
Control (Unchecked Channel)	0.00	-2.53	95.22	0.00	-2.65	-2.65	100		0
Straw Bales (14" High / GSWCC)	2.99	-9.68	134.15	2.23	-7.22	-4.99	188	Blowout	30
Straw Bales (14" High / GSWCC)	3.74	-6.24	127.94	2.93	-4.88	-1.96	74	Blowout	30
Straw Bales (14" High / NRCS)	2.33	-2.34	152.30	1.53	-1.54	-0.01	0		60
Compost Sock (9" High)	0.28	-1.21	118.20	0.24	-1.02	-0.79	30		10
Rock + Geotextile (15" High)	0.97	-1.55	118.92	0.82	-1.31	-0.49	18		60
Type C Silt Fence (21" High / GSWCC)	0.77	-4.14	116.02	0.67	-3.57	-2.90	109	Blowout	240
Type C Silt Fence (21" High / Retest)	2.90	-4.78	128.42	2.26	-3.73	-1.46	55	Blowout	240

Tested System (1.0 cfs)	Total Soil Gain, ft^3	Total Soil Loss, ft^3	Total Wetted Area, ft^2	SAI	CSLI	Net	Net % of Unchecked	Obser-vations	Approx. Installation Time, min.
Control	0.00	-4.07	102.27	0.00	-3.98	-3.98	100		0
Straw Bales (14" High / NRCS)	2.93	-2.54	172.44	1.70	-1.47	0.22	-6		60
Compost Sock (9" High)	0.62	-1.55	121.93	0.51	-1.27	-0.76	19		10
Rock + Geotextile (15" High)	2.87	-2.94	134.62	2.13	-2.18	-0.05	1		60

Tested System (2.0 cfs)	Total Soil Gain, ft^3	Total Soil Loss, ft^3	Total Wetted Area, ft^2	SAI	CSLI	Net	Net % of Unchecked	Obser-vations	Approx. Installation Time, min.
Control	0.00	-6.79	112.43	0.00	-6.04	-6.03	100		0
Straw Bales (14" High / NRCS)	2.91	-5.13	196.46	1.48	-2.61	-1.13	19		60
Compost Sock (9" High)	2.19	-3.90	126.12	1.73	-3.09	-1.36	23		10
Rock + Geotextile (15" High)	2.22	-3.66	143.53	1.54	-2.55	-1.01	17		60

Table 3. Summary Data Table – ASTM D7208 Channel Tests
(values in shaded boxes revised Aug. 21, 2014)

5.3 Discussion

When the data in Table 3 is presented graphically, as shown in Figures 9 and 10, some relationships between check dam types and installed system performance measurements are suggested. In general, as a check dam gets taller it may be able to increasingly reduce channel soil loss by creating greater ponding and, thus, greater slowing of water. Yet, in the process, the check dam must provide greater structural integrity and adjacent scour resistance. The original straw bale system and the silt fence system both offered taller damming, but even at the lowest flow level they provide insufficient structural integrity and scour resistance to function effectively. Conversely, the compost sock, rock check, and the enhanced (NRCS) straw bale systems provided the necessary balance between damming and scour resistance to perform effectively under all flow levels.

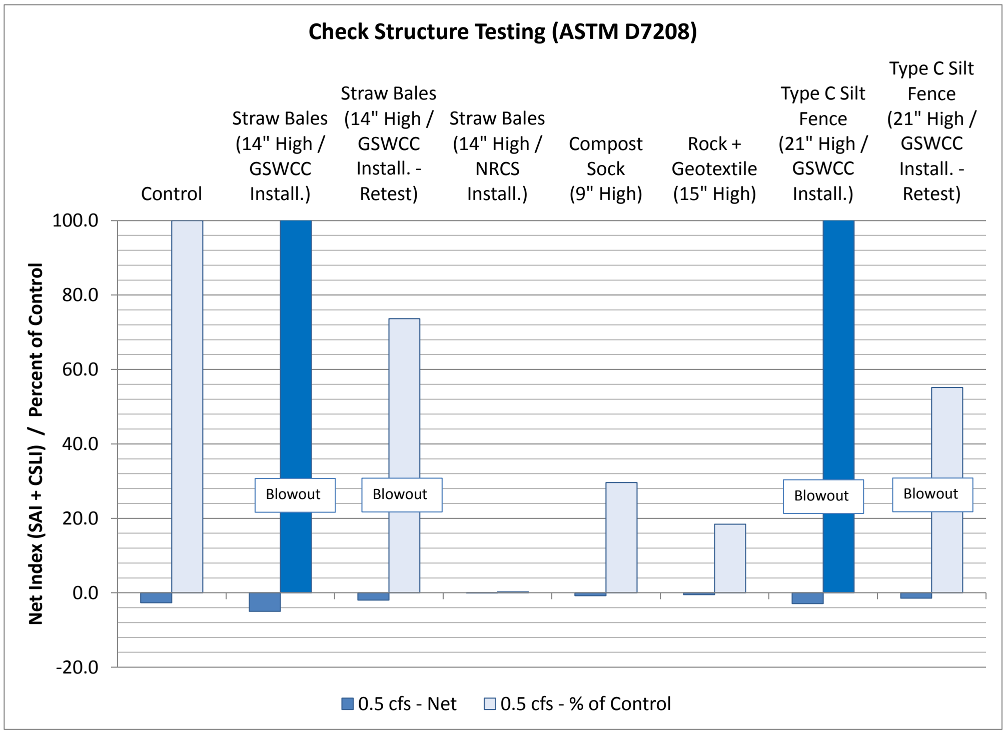

Figure 9. Summary of All 0.5cfs Tests (Revised 8/21/14)

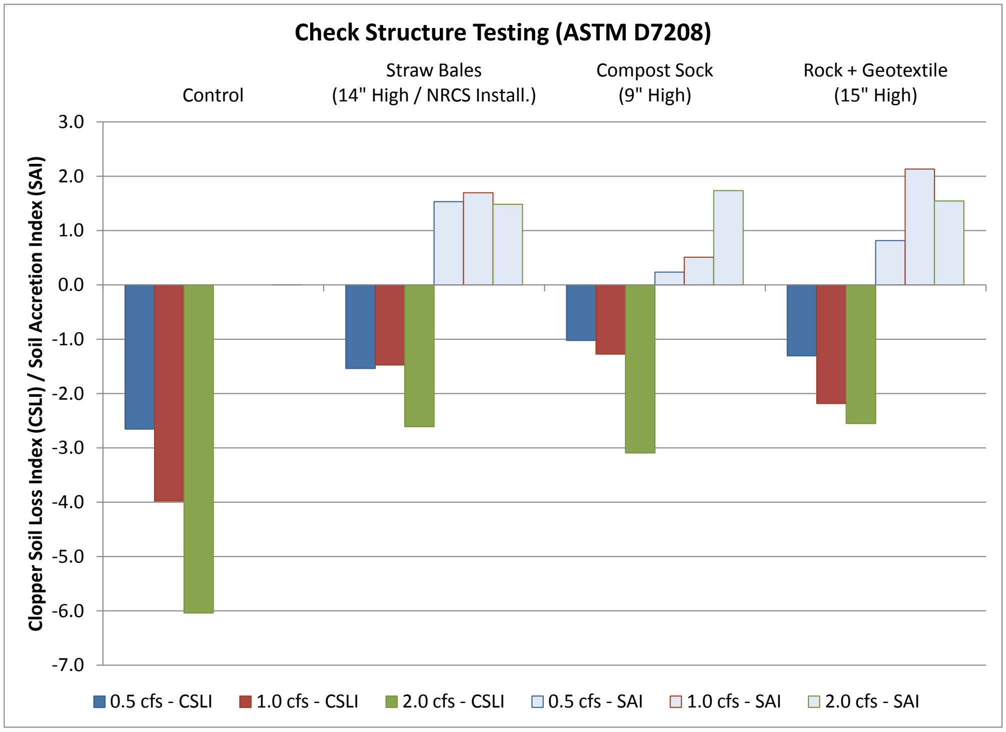

Figure 10. Net Soil Loss/Accretion & Percent of Control (Revised 8/21/14)

6 Conclusions and Recommendations

Figure 11 summarizes the results of check dam testing associated with systems that did not experience some type of failure during testing. Both the original, non NCRS, single-row straw bale and “zig-zag” silt fence, installed per the GaDOT detail Cd-F specifications, experienced significant undermining under the lowest flow events, and thus are considered undesirable alternatives. Figure 11 presents the “net” of soil accretion and soil loss in the test section and the percent of the control soil loss that this represents. Superimposed on Figure 11 is the suggested performance level (30% of control) for acceptable check dam systems. Table 4 shows how this performance limit could be incorporated into the existing GSWCC specifications for check dams. Generally, the test results agree with the GADOT and GSWCC goals of specifying check structure systems that provide the structural capacity to resist concentrated flows, ease of installation, and resistance to downstream scour.

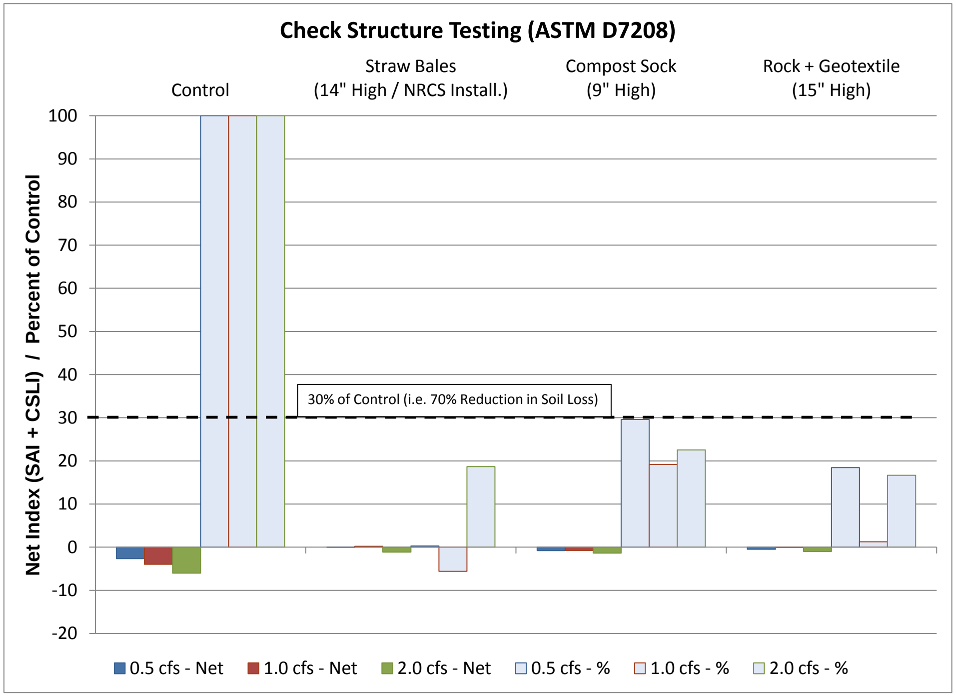

Figure 11. Net Soil Loss/Accretion & Percent of Control (Corrected 8/21/14)

Property	Units	Spec	ASTM Test	Straw Bales (NRCS Installation)	Compost Socks	Rock over Geotextile
Material	-	-	-	Straw	Compost	2 – 10 inch
Density	pcf	min	-	4.3 lb/ft^3	25 lb/ft	1.4 tons/yd^3
Installed Height	in	max	-	14	9	15
Staking / Underlayment	-	min	-	2”x2” wood at 12” c-c	2”x2” wood at 12” c-c	8 oz/sy nonwoven geotextile
Performance	%	max	D7208	30	30	30

Table 4. Recommended Revised Specifications (Corrected 8/21/14)

7 Reference

ASTM D 7208, “*Standard Test Method for Determination of Temporary Ditch Check Performance in Protecting Earthen Channels from Stormwater-Induced Erosion*”. ASTM, Conshohocken, PA.

8 Acknowledgement

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