# FIELD CONSTRUCTION QUALITY ASSURANCE OF GEOTEXTILE INSTALLATIONS

RICHARD S. THIEL, P.E.
MICHAEL G. STEWART, C.E.T.
EMCON, USA

## ABSTRACT

Construction quality assurance (CQA) monitoring of geotextile installations is an important and often required element for construction projects where certifying that the installation was performed in accordance with the design intent is necessary. Problems typically encountered during construction can often be reduced by properly specifying geotextiles, avoiding "over" specifying, and having the design and specifications reviewed by an experienced CQA monitor. Important elements of a comprehensive CQA program are a project-specific CQA Plan and knowledgeable and experienced CQA monitors. Issues regarding design intent and liability protection are most efficiently resolved when the design engineer is represented on the CQA team. The successful CQA monitor is one who anticipates problems, applies assertive input to problem solving, and ultimately saves projects time and money. CQA programs typically represent between 5 and 10 percent of the construction costs for the elements being monitored.

## INTRODUCTION

This paper is intended to be a guidance document for construction quality assurance (CQA) monitors, and professional engineers who act as CQA officers and certifiers of geotextile installations. It provides a useful discussion of the CQA monitor's role in the construction process, and some installation monitoring details specific to geotextiles. It also provides a summary of important qualifications for a CQA monitor. Although an attempt has been made to discuss geotextiles as they generally relate to all applications, most of the authors' experience is related to the use of geotextiles in separation and filtration applications for waste containment systems.

## PURPOSE OF CONSTRUCTION QUALITY ASSURANCE

In an ideal world CQA for geotextile installations (or any other aspect of construction) would not be needed. A designer would properly design and specify a material, and an informed contractor would install the material in accordance with the design intent, occasionally calling the engineer for a design clarification. Unfortunately, we do not live in an ideal world, but in the world of the "low bid" contractor. Low bid often means smallest profit margin, which potentially leads to attempts to cut corners and thus sacrifice quality.

Enter the CQA monitor, sometimes thought of as the "necessary evil" inspector who is often put into an adversarial role with the contractor. The relationship between the CQA monitor and the contractor does not, however, have to be antagonistic. In a well-designed and coordinated project the CQA monitor becomes a useful, productive part of the construction process.

There are three phases in a project's life during which a CQA monitor can have a beneficial role: design, construction, and certification reporting. This paper describes the CQA monitor's role in each phase.

**CQA MONITOR'S ROLE IN DESIGN**

Design Review. The CQA monitor does not design the project. An experienced CQA monitor can, however, provide a significant role in the design phase by reviewing the design based on how a contractor would consider it. Even though a project's design intent and critical construction requirements may be clear to the designer, they may not be clearly communicated through the contract drawings and specifications. This is common in geotextile applications because geotextiles have many potential design functions. When reviewing construction documents the experienced CQA monitor familiar with these functions should ask himself the following questions:

- What is the function of the material?
- Is the geotextile accurately and clearly shown in relation to other products and is that relationship consistent throughout the documents?
- Are dimensions provided?
- Are material descriptions consistent between different drawings and the specifications?
- Does the specification describe the intent of the geotextile function?
- Are the material requirements clearly and specifically defined and appropriate for the material's function?
- Are the installation requirements for other materials adjacent to the geotextile defined in the specifications and consistent with the drawings?
- Are the conformance testing requirements reasonable and appropriate for the material's specification and function?

The intent of the CQA monitor's final design review is to determine if enough information is provided to understand the material's quality, the product's intent, and the installation requirements. If these objectives are met, a reasonable bid can be expected and construction problems avoided. If these objectives are not met, one can expect many calls from suppliers during bidding and problems during construction. An experienced CQA monitor is a valuable asset in avoiding these problems and can also help greatly in resolving potential problems.

Over Specifying. This discussion generally assumes that the geotextile has been properly designed and specified, and that it is the monitor's responsibility to verify that the specified material is installed in accordance with the design's intent. A common problem is, however, inappropriately "over" specifying geotextiles.

Over specifying generally occurs when an engineer uses all of one manufacturer's published material properties as minimum specifications. This may lead to arbitrary, overly stringent requirements for a geotextile that may not be related to the design function and could add unnecessary cost to a project. The product requirements for a geotextile should be specific to the design function. Using all the published property values to specify geotextiles on a project will cost owners more money and cause suppliers and contractors more distress, while not necessarily improving the quality of the project.

Over specifying can lead to problems during bidding and construction. During bidding many suppliers want to sell their product and will try to convince the designer that their product meets the design intent. With over specifying, the designer either has to stick with the specification or write an addendum. Addendums can mean delays, which can be costly.

During construction the low bidder may supply a material that meets the critical material properties but does not meet all of the specified material properties. The designer and CQA monitor are then left with two choices, neither of them desirable: Either a change order has to be written or the material has to be rejected. Sometimes contractors and material suppliers try to convince the engineer or CQA monitor that the material is acceptable because it missed the specification only by a small amount and that the conformance test for which it is deficient is not important to the design function. Often they are correct. For example, Mullen Burst is not a critical design index test for a geotextile that will be used as a filter. What the contractor and manufacturer have to realize is that although they may be technically correct, the material can only be accepted if a change order or other formal documentation of a specification change is written. If such a formal change is not made and later something goes wrong with the project, the engineer or CQA monitor responsible for accepting nonconforming material may face a major liability problem, although there is no technical basis for it.

The designer should know that the CQA monitor's role is to defend and protect the design. This can often put the monitor in an adversarial position especially if the geotextile has been over specified. If designing is done by function and an experienced CQA monitor is allowed to review the design and specifications, these issues can generally be avoided.

**CQA MONITOR'S ROLE DURING CONSTRUCTION**

During the construction phase the CQA monitor takes a leadership role representing the engineer and owner. His primary objective is to document that construction complies with the design's intent. The documentation process for geotextiles includes the following specific work:

- Prepare a CQA Plan
- Perform or coordinate material conformance testing
- Observe construction techniques
- Document testing and observations

The CQA program is usually done under the direction of a licensed professional engineer who acts as the CQA officer. The CQA officer signs the final construction certification report.

**CONSTRUCTION QUALITY ASSURANCE PLAN**

The CQA Plan is a written plan prepared before construction. It defines the role of the CQA monitor and designer, establishes reporting protocol, defines specific observation and testing criteria, and provides a plan for providing written documentation of the work. The items specific to geotextiles include monitoring priorities, product conformance testing, and a list of items to verify through observation and testing. The plan also includes standard forms for inventorying products, conducting tests, summarizing test data, and documenting daily construction progress and issues.

The plan should emphasize the following five tenants of good CQA practice for monitors:

- <u>Accuracy</u> - Correctly apply the proper standards; correctly report information; apply care in all activities.
- <u>Traceability</u> - Accurately document submittals, test results, observations, deficiencies and subsequent solutions, and other pertinent information to provide a historical paper trail that allows an independent reviewer to reconstruct the CQA activities and results.
- <u>Neatness</u> - Maintain files in a clean, orderly manner, organized in a way that can be logically understood by others; all data should be legible.
- <u>Completeness</u> - Account for all required and necessary documentation; use a method such as a checklist to verify that all necessary CQA functions have been performed.
- <u>Disposition of Nonconforming Results</u> - Maintain a complete history of nonconformances including their causes, actions taken by various parties to address them, and the status of the resolution; verify that all nonconformances are completely resolved before the project is completed.

## THE CQA PROGRAM FOR GEOTEXTILES

The following paragraphs outline CQA activities that are typically included in a CQA Plan for geotextile installations. A more detailed checklist would be prepared for a specific project. Required CQA activities would be specified to suit the needs of the job as described by Christopher and Holtz (1985) and Giroud and Peggs (1990). These activities can be grouped into four general categories:

- Preconstruction Preparation
- Written Documentation
- Construction Observation
- Material Testing

### Preconstruction Preparation.

1. Review design plans, specifications, contract procedures, and the CQA Plan specific to the project. Understand the design intent for each element of the geotextile and those related to the geotextile. Understand if specification method is based on prescriptive properties, performance, or an approved list. Be wary about dealing with "or equal" statements.

2. Establish filing, organization, tracking, and communications systems. Follow the communications and information-distribution protocol established in the project's CQA Plan. Organize three-ring binders and files in a clear, understandable way that can be audited by another person such as the owner's construction manager, the resident engineer, or the CQA officer. Separate notebooks or files should be kept for submittals, test data, change orders, nonconformances, photographs, correspondence, and field reports. Keep clean master copies of standard forms for reporting and testing. Use extra copies of full-size construction plans for tracking panel layouts and construction progress, if appropriate.

3. Review contractor installation workplan and schedule, if applicable. The specifications may require special work sequencing, equipment, or both. Be prepared to track contractor performance against the workplan and schedule and alert appropriate parties if significant deviations are found.

### Written Documentation.

1. Prepare daily, weekly, and monthly reports covering information required in the project's CQA Plan. Weekly and monthly reports are typically a good forum for summarizing construction progress, disposition of nonconforming results, general construction issues, and test data not covered daily. The more data summarized along the way, the easier the preparation of the final construction certification report.

2. Review material submittals. This usually includes geotextile test reports and certifications supplied by manufacturers regarding the geotextile's physical properties and compliance with specified requirements. Check that values certified are consistent with the specified test methods and basis of evaluation. The most common basis of evaluation for geotextile testing is the "minimum average roll value", where the average test result from any roll must meet or exceed the specified value. A good description of the minimum average roll value is provided by Koerner (1990). Check that the manufacturer QC tests were performed at the frequency and are of the type specified, if applicable. After review, prepare a written report regarding material acceptance or rejection.

### Construction Observation.

1. Inspect and inventory shipment as it arrives. Check for intact, opaque (some exceptions to opacity may be allowed), waterproof wrappers. All rolls should be identified with roll and lot numbers that correspond to the manufacturer's QC test results. Observe unloading procedures to make sure rolls and wraps are not damaged. Material should be stored where it will not be damaged, contaminated, or exposed to sunlight. The industry standard for observing shipment and handling is summarized in ASTM D4873.

2. Verify that construction elements required before geotextile installation have been performed (e.g., all subdrains and trenches below the geotextile have been completed), and that proper lines, grades, and compaction have been achieved on subgrade soils before the geotextile is deployed.

3. Inspect subgrade preparation. During construction subgrade preparation is often the single most important factor in determining the quality of the geotextile installation. The firmer and smoother the subgrade, the better the installation will be. Soft and uneven subgrades with protruding objects may damage the geotextile. (The project specification should define the limits of acceptability.) Even though the geotextile may act as a cushion on a poor subgrade, every attempt should be made to obtain as firm and smooth a subgrade as practicable. Construction stakes and hubs should be removed before placing the geotextile.

   Excellent tables on survivability are available in the literature (Christopher and Holtz, 1985; Koerner, 1990; AASHTO-AGC-ARTBA Task Force 25; AASHTO Material Spec. M-288) that can help a CQA monitor to evaluate the acceptability of a given subgrade condition for a specific geotextile. As stated by Christopher and Holtz (1985), "the subgrade preparation must correspond to the survivability properties of the fabric."

   If the geotextile is being installed in a trench, check for sloughing and voids in the trench walls. This is essential in filtration applications where intimate contact must be developed between the geotextile and subgrade.

4. Verify that geotextile is properly deployed and not dragged into place. Inspect the geotextile panels for gross manufacturing defects as they are deployed.

5. Observe seaming methods. Check for proper overlap. For sewn seams, check for proper seam geometry, stitch pattern, and thread type. If required, take sewn seam samples for testing in accordance with the specification requirements and project CQA Plan. In some cases, heat bonding may be acceptable (generally only for materials of no less than 8 ounces per square yard). If heat bonding is acceptable, the contractor should demonstrate his ability to properly heat bond, and an extra round of seam inspection is warranted to check for burn holes.

6. Keep track of exposed geotextile. Unless otherwise specified, the industry standard is to cover "immediately" (sometimes defined as within 1 to 5 days). Most geotextile manufacturers recommend a 14-day maximum exposure time. For large projects, working panel-layout drawings with dates can help keep track of when areas need to be covered. If areas are exposed longer than the time allowed in the specifications, samples can be cut and tested for conformance with material specifications.

7. Holes, tears, or other defects should be repaired with patches of the same material. Minimum repair procedures should be outlined in the specifications, depending on the geotextile's design function.

8. Perform a final inspection of the installed geotextile before it is covered to check for defects, burn holes, or other deleterious conditions. Have any excess slack and wrinkles removed before backfilling. If the geotextile is to provide for separation or reinforcement, extra effort should be made to make the geotextile taut before backfilling.

9. Observe the first lift of soil fill to be placed over the geotextile. Soil material should be initially dumped and spread with low ground pressure track equipment. Verify that the initial lift thickness, soil gradation, equipment type, maximum rutting depth, and soil spreading are in accordance with the specifications. A minimum 12-inch lift should typically be maintained above geotextiles (some specifications may allow as little as 6 inches). Soil should be spread in direction of seam overlaps, and in a manner that does not pull, stress, separate, or puncture the geotextile. Equipment should not be allowed to make sudden stops or sharp turns when spreading soil fill.

10. If the geotextile is being installed in a trench, check for intimate soil contact, conformance with specified backfilling procedures, contamination of backfill from sidecast trench spoils, and proper geotextile overlap at the top of the trench.

Material Testing.

1. Select samples for conformance testing in accordance with ASTM D4354 and ASTM D4759, or other specified sampling method. If some conformance tests fail, use ASTM D4759 as guidance for resampling, acceptance, and rejection procedures. For very large or complex projects, source inspection at the manufacturing plant may be preferable.

2. Cut samples from selected rolls. Samples should be 3 feet long, across the entire roll width, and exclude the exposed portion of the roll. Clearly label the sample with a sample number and log the sample number with the roll and lot number in a book. Send the sample to a testing laboratory to perform the appropriate conformance tests. Table 1 lists standard conformance tests depending on the function of the geotextile. Additional index or performance tests may be required by the engineer, depending on the design conditions.

   Note that conformance testing is on the critical path for material acceptance and should be performed as soon as the material is available. One of the worst things that can happen is to have the material installed and then find out that it does not pass the conformance tests.

   If the conformance testing or contractor submittals require direct shear or filtration testing, on-site soils may need to be collected and sent with the geotextile sample to special laboratories for testing. Testing must be performed with parameters representative of the design conditions (e.g., appropriate normal stress range for direct shear testing).

**DESIGN PRINCIPLES TO AID THE CQA MONITOR**

Even with poorly written specifications, a knowledgeable CQA monitor can improve the quality of the final product if the contractor is willing to work in the spirit of the design's intent. A good overview of the design's intent for geotextile systems is presented in a design primer published by the Industrial Fabrics Association International (1992). By applying the following basic design principals the monitor and the contractor can produce a better long-term installation.

1. Conscientious installation. Attention to subgrade preparation, termination and penetration details, backfill drop height, and initial lift thickness and spreading operations will greatly assist in providing a sound geotextile installation.

2. Extra care for geotextiles lighter than 8 ounces per square yard. Studies have shown these lower weight geotextiles have a much higher tendency to be punctured during installation than the 8 ounce per square yard and heavier geotextiles (Koerner and Koerner, 1988).

3. Holes are probably the most significant construction defect impacting design function (especially when geotextiles are used for filtration/separation where water will flow). Most holes can be prevented by conscientious construction and thorough CQA. Major causes of holes in geotextiles are summarized below:

   - Poor subgrade (soft, uneven, containing protruding and sharp objects)
   - Drop height of backfill material too great
   - Initial backfill lift too thin
   - Backfill too coarse, sharp, or contaminated with deleterious materials
   - Burn-through holes due to improper heat welding of seams
   - Insufficient overlap along seams and incorrect backfilling across overlapped seams
   - Rough handling during loading, transport, and deployment
   - Geotextile mass per unit area too light for application (i.e., insufficient survivability rating)

4. All geotextiles will degrade with exposure to ultraviolet radiation and need to be covered as soon as practicable. The degradation rates for different materials vary widely depending on the type of polymer and antidegradation additives. The allowable exposure time should be defined in the specifications or CQA plan.

5. Intimate contact with soil materials is needed to prevent failure in filtration applications. This is an issue especially when an excavation where geotextile is placed has vertical walls. Good compaction of the soil materials adjacent to the geotextile is required.

6. In reinforcement applications geotextiles should be placed as taut as possible, even staked before backfilling, if needed (check with engineer to evaluate possible damage concerns due to staking or pinning). This will reduce the amount of strain deformation the soil needs to undergo before mobilizing the geotextile's strength.

7. When an adequate subgrade cannot be achieved per the specifications, a geotextile is sometimes used as a cushion over the poor subgrade as an alternative measure. When directing the contractor to install extra geotextile for use as a cushion, a weight of at least 8 ounces per square yard (preferably heavier) should be requested. Nonwoven geotextiles are better suited for this purpose.

8. Geotextile continuity (complete coverage, proper overlaps, competent seams) is essential for all design functions.

**CONSTRUCTION CERTIFICATION REPORT**

The project's documentation should be organized and summarized as the project progresses for inclusion in a construction certification report. The presentation of the information may vary depending on the type of project, and the function and relative importance of geotextiles in the final constructed project. The following generic list of information is typically included in a certification report:

- general description of the project
- organization of the CQA program and working relationship with the Owner, Designer, and Contractor
- general description of the construction methods
- descriptions of design or materials modifications, unusual conditions (e.g. unexpected subgrade conditions, bad weather) encountered, and how they were managed
- summary of contractor submittals and CQA evaluation results
- summary of conformance testing program and results, including any deviations from original plan
- summary of construction observations
- summary of construction testing (e.g., destructive seam testing)
- record drawings, as appropriate

Depending on the project, it may be more appropriate to reference detailed test data, photographs, daily field reports, and so on in the report and file these items at some specific location for review upon request, rather than publishing all this information in appendices.

Finally, the goal is to state that the construction was performed in accordance with the design's intent. This statement should appear in the summary and conclusions of the certification report. The information presented in the report should be sufficient to support this statement.

**WHO SHOULD PERFORM CQA?**

<u>Affiliation.</u> The question often arises about whether the person or organization that conducts the CQA program should be a representative of the engineer (third party) or a fourth (independent) party. The authors' firm belief that all parties (owner, contractor, designer, and regulatory agencies) are best served if a representative of

the design engineer performs the CQA, because of liability issues and the need for understanding the design intent.

To minimize their liability, engineers prefer to monitor the project's construction to verify its conformance with the design's intent. If future problems occur, fewer parties are involved and problem resolution is usually much less complex.

The design engineer is in the best position to evaluate construction materials and methods because the engineer understands the "big picture" and knows how the design elements are interconnected. Even though design questions could be resolved by a fourth party and the engineer, such arrangements are usually less efficient.

Fourth party CQA monitoring is sometimes advocated because it can provide peer review, impartial evaluation, and potentially reduced costs. Each of these points is discussed below.

If peer review is desired it should be incorporated in the design process and not tacked on during the construction phase. The most effective peer review is done at the beginning of the design phase.

Although fourth party involvement may provide impartial evaluation, the engineer has no incentive to cut corners or allow substandard construction to be performed; on the contrary, no one is potentially more liable for failures than the design engineer.

Although up-front costs may be reduced by putting a CQA contract out to bid, the overall project savings are usually negligible. Substantially more money can be saved with a peer review and value engineering process when the project starts. Ultimately the qualifications of the CQA team should be more thoroughly considered than costs.

<u>Qualifications.</u> Qualifications for a geotextile CQA monitor are not formalized as an industry standard. The National Institute for the Certification of Engineering Technologies (NICET) is currently preparing certifications for geosynthetics CQA monitors. Test formats have been developed and some testing has been initiated with an emphasis on geomembranes. The NICET certifications may become a tool for specifying minimum requirements for CQA monitors.

As a practical matter, geotextile CQA monitors should have the following general qualifications:

- familiarity with construction procedures and contract issues
- experience reviewing test results, quality control data, and contractor submittals
- familiarity with the design issues regarding the type of construction project being monitored
- ability to effectively communicate and prepare supporting documentation
- geotextile monitoring experience gained under the supervision of more experienced individuals
- experience reporting, communicating, and resolving deficiencies and performing remediation activities

The CQA monitor has to have certain qualities to effectively perform his job. The most important quality is probably assertiveness. When the monitor observes a problem, he has to act quickly, clearly identify the problem, recommend corrective action, verify that corrective action is taken, and document the issue. The monitor does this knowing that the contractor's schedule and progress will be affected. If the monitor is working alone on a remote site this assertiveness is essential for success and can require courage.

CQA monitors who routinely monitor projects with geotextiles should visit a geotextile manufacturing plant and a laboratory where geotextile tests are performed to gain a better understanding of the materials.

## COST

The geotextile CQA cost is difficult to separate from the CQA costs for the total project. For landfill projects, we have found that CQA costs range between 5 and 10 percent of the construction costs for the elements that are being monitored. Factors that influence the cost of a CQA program are the project's duration, size, complexity, and work scope (ranging from complete construction management to performing CQA only for the geosynthetic elements).

## CONCLUSIONS

The CQA monitor's job is to understand the overall design objectives, the design drawings, and the specifications, and to perform the appropriate review, testing, and observation to document that the installed geotextile meets the design intent. A project will benefit from

- a proper function-based design with clear, complete, and correct plans and specifications
- a comprehensive CQA program with a detailed project CQA Plan
- an experienced CQA monitor who is
  - familiar with the subtleties of contract procedures
  - familiar with the state of practice for construction with geotextiles
  - knowledgeable about design issues and the interrelationships of all geosynthetic elements
  - aware of the limitations of available geotextile products
  - able to effectively and quickly assess problems, and assertively communicate issues with the installer and designer to effect corrective action

Issues relating to design intent and liability protection are most efficiently resolved when a representative of the design engineer is part of the CQA team.

CQA typically costs between 5 and 10 percent of the construction costs of the elements being monitored.

## REFERENCES

Christopher, B.R., and R.D. Holtz. 1985. Geotextile Engineering Manual. Prepared for Federal Highway Administration, FHWA Contract No. DTFH61-83-C-00150.

Giroud, J.P., and I.D. Peggs. 1990. "Geomembrane Construction Quality Assurance." Waste Containment Systems: Construction, Regulation, and Performance. Geotechnical Special Publication No. 26. American Society of Civil Engineers. New York, NY.

Industrial Fabrics Association International. 1992. A Design Primer: Geotextiles and Related Materials. IFAI, St. Paul, MN.

Koerner, R.M. 1990. Designing with Geosynthetics. Second Edition. Prentice Hall, New Jersey.

Koerner, R.M., and G.R. Koerner. 1988. A Quantification and Assessment of Installation Damage to Geotextiles. Geosynthetic Research Institute, GRI Report #2, Drexel University, Philadelphia, PA.

TABLE 1 - TYPICAL CONFORMANCE TESTS FOR GEOTEXTILE APPLICATIONS

| ASTM TEST METHOD (1) | MASS/ AREA D3776 (2) | GRAB TENSILE AND ELONGATION D4632 | WIDE WIDTH TENSILE D4595 | BURST D3786 (3) | PUNCTURE D4833 | TRAP. TEAR D4533 | PERMITTIVITY D4491 | AOS D4751 | SEWN-SEAM TENSILE D4884 (5) | UV DEGRA-DATION D4355 (6) |
|---|---|---|---|---|---|---|---|---|---|---|
| FUNCTION | | | | | | | | | | |
| SEPARATION | | X | | X | X | X | X | X | | |
| FILTRATION | | X | | X | X | X | X | X | | |
| DRAINAGE | | X | | X | X | X | X | X | | |
| REINFORCEMENT | | | X | X | X | X | | | X | |
| CUSHION | X | X | | | X | X | | | | |
| BARRIER/OVERLAY (4) | | X | | | | | | | | |
| SILT FENCE | | | X | | | | X | X | | X |
| EROSION CONTROL | | X | | X | X | X | X | X | | X |

Notes:

1. Except for wide-width tensile and sewn-seam strength tests, the tests listed in this table are index tests rather than performance tests. For project-specific applications the engineer may require additional performance tests, such as direct shear testing, gradient ratio testing, chemical and biological resistance testing, creep testing, or abrasion resistance testing to be done at the beginning of the construction phase.

2. Although mass/area is only marked for the cushion application, it is a standard index test usually performed for most applications. It is only marked for the cushion application to emphasize its relative importance for this application.

3. The appropriateness of the burst test (often referred to as Mullen Burst) is often questioned by manufacturers and designers because of the small sample size. For example, Task Force 25 has intentionally omitted burst index testing in its recommended specification for separation applications, yet retained it for drainage applications. A larger scale performance-type test developed by the Geosynthetic Research Institute (method GRI-GM4) may be more appropriate for applications where localized differential strains may occur.

4. Pavement overlay applications may require additional specialized tests such as asphalt retention and melting point.

5. The sewn-seam strength test may be appropriate for applications other than reinforcement, depending on the seaming method preferred by the designer.

6. Requirements for resistance to UV degradation can vary depending on the application and allowable exposure time. This column is marked for the erosion control and silt fence applications because these applications have a greater likelihood of long-term exposure.