XR GEOMEMBRANES
By Seaman Corporation

# Tear and Coating Adhesion, How Do They Relate?

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Long term stability of geomembranes is critical to protect the environment from contamination. Premature failure can occur if the geomembrane does not meet the requirements of the application. There are a variety of geomembranes in the marketplace to choose from; when looking strictly at a specification they appear to be similar in physical attributes but have unique performance characteristics. In some cases, the specifications are not similar at all making it more difficult to perform a direct comparison. For example, Figure 1 compares test methods between reinforced and non-reinforced geomembranes. Specific test standards are required based on the type of geomembrane resulting in a difference in: standards, units, sample sizes, test consistency, and mode of failure.

**Figure 1.** Differences between reinforced (Ethylene Interpolymer Alloy - EIA) and non-reinforced (HDPE)

| Test | Reinforced | Non-reinforced | Comments | |
|---|---|---|---|---|
| | | | Reinforced | Non-reinforced |
| Thickness | ASTM D751 | ASTM D5199 | Different foot area & applied pressure | |
| Carbon Black Content | n/a | ASTM D4218 | Provides color to reinforced | Carbon black required for non-reinforced to protect the polymer |
| Tensile Strength - Elongation | ASTM D751 | ASTM D6693 | Elongation based reinforced 1" strip tensile | Elongation based on dumbbell film specimen |
| Tear Resistance | ASTM D4533 | ASTM D1004 | Trap tear of geotextiles; 12 in/min, average of the maximum tear | Tear resistance of plastic film; 2 in/min, average of the mean |
| Puncture Resistance | ASTM D4833 | ASTM D4833 | Same Test Method | |
| Oven Aging | ASTM D751 | ASTM D5885 | High temp oven, test physicals properties of geomembrane | High oxygenation under pressure test, scan material for antioxidant package to determine life expectancy, EIA does not fail by this mechanism |
| UV Resistance | ASTM G155 | GRI GM11 | 12,000+ hrs (UV, moisture, water spray) best simulates weathering; run physicals | 1600 hrs (UV, moisture) then run Oven Aging to determine antioxidant package to determine life expectancy |
| Adhesion | ASTM D751 | n/a | Prefabricated, testing in laboratory setting @ 12"/min, avg 5 highest peaks, pulls to base cloth | Field welding, test 2"/min, visual estimates, report highest peak, average and mode of failure |

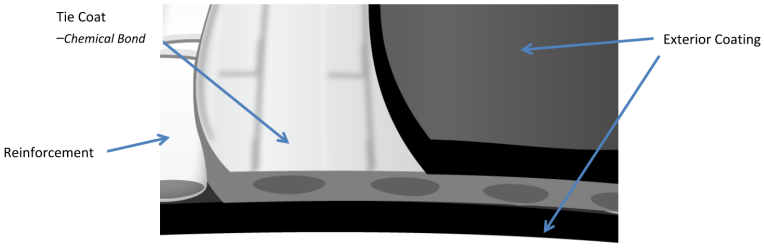
-Detailed information on degradation can be found at http://cdn2.hubspot.net/hubfs/481889/PDFs/Whitepapers/wp_Degradation.pdf?t=1466597960987

Even though it is difficult to perform a direct comparison based on test methods, there are two product properties that influence long term performance on all types of geomembranes, tear and coating adhesion. The tear is a concern if the geomembrane is jeopardized. In reinforced EIA membranes with high adhesion, tear is based on the shearing of the internal reinforcement. Reinforced geomembranes that do not have high adhesion, the reinforcement is allowed to move inside the matrix to bundle and inhibit tear. These are referred to as laminates. The lack of adhesion threatens the integrity of the geomembrane as the film will lift and the area will lack the strength of the reinforcement. Non-reinforced geomembranes tear is based on the film toughness. There is no reinforcement to support the film.

We will further discuss the mechanisms of coating adhesion and tears on reinforced and non-reinforced geomembranes in regards to long-term performance.

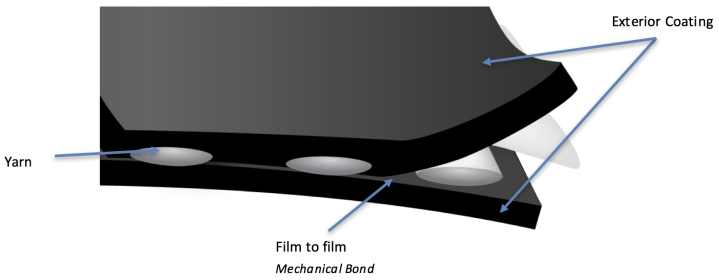
**Product Design** The tear property on EIA reinforced geomembranes can be directly affected by the adhesion of the coating to the internal reinforcement, known as the base cloth. On EIA geomembranes, a tie coat can be applied to saturate the yarns in the base cloth to increase the bond of the exterior coating to the yarn. This creates a molecular chemical bond which results in a high performance composite. The tear and adhesion properties are optimized in these geomembranes to inhibit the film from lifting and resist tear. Figure 2 illustrates a composite of heavily reinforced base cloth with a tie coat bonding the EIA coating matrix together.

**Figure 2.** Cross-section of an EIA composite



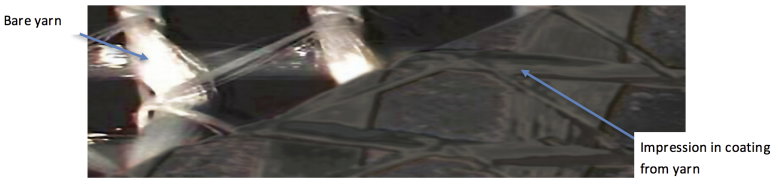

The reinforced laminate geomembranes rely strictly on the adhesion of the exterior coating to itself and to the yarn for stability. These geomembranes rely strictly on a mechanical bond for long-term performance. Mechanical bond is a result of the film being pressed onto the yarn and through the openings between the yarns. Figure 3 shows the laminate geomembrane which does not have a tie coat to ensure a high performance bond of the yarn to the exterior coating.

**Figure 3.** Cross section of a laminate




Initial peel adhesion may seem high on laminates as produced but with low film adhesion to the yarn along with movement of the yarn, adhesion can be jeopardized over time. This can result in inter-ply separation as shown in Figure 4. This laminate has no tie coat, bare yarns between 2 black films. Note the impressions from the yarn on the black film in the lower right half of the picture.

**Figure 4.** Laminate geomembrane with poor mechanical adhesion



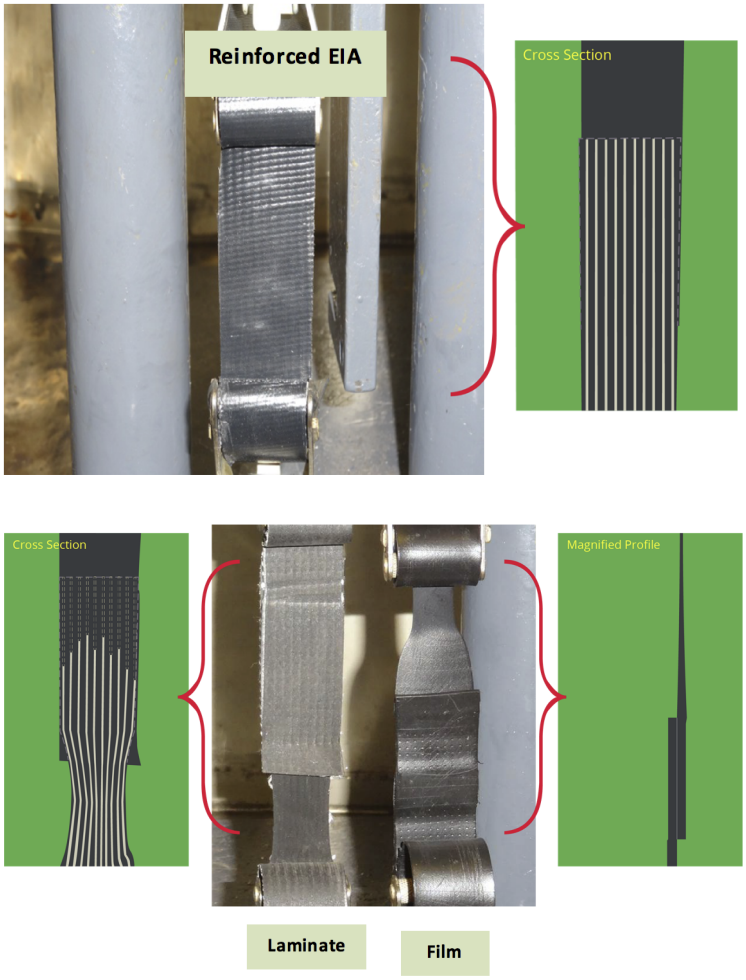

The non-reinforced geomembrane is made of extruded polymeric film(s). There is no yarn reinforcement found in these sheets. Since there is no internal reinforcement to provide strength and durability, the non-reinforced membrane relies on the integrity of the film. The tear resistance is based shear resistance of the film. Coating adhesion is based on proper processing conditions. Variation in the process conditions could result in inter-ply separation of the layered films shown in Figure 5.

**Figure 5.** Inter-ply separation of unreinforced film

image courtesy of: *The First Pan American Geosynthetics Conference & Exhibition*

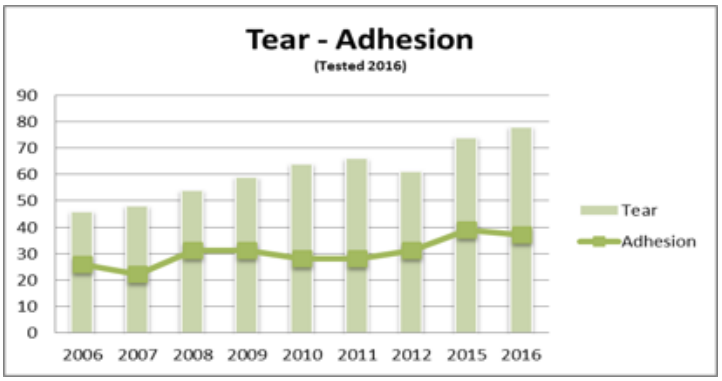
**Load Bearing Properties** Adhesion will affect the seam carrying capability of the geomembranes. Geomembranes with a tie coat holds the base cloth coating matrix in place under shear loads. The mechanically adhered laminate geomembrane slides out of the coating matrix. On non-reinforced the film stretches; under continuous load the film will eventually tear. Examples in Figure 6 show the results of these three scenarios when tested in accordance with ASTM D751 Standard Test Methods for Coated Fabrics, Dead Load Seam Strength. This gives concern to seams put into shear loads on the laminate geomembranes as the reinforcement pulls out of the seam area and unreinforced the film(s) thins.

**Figure 6.** Seamed samples under sustained shear



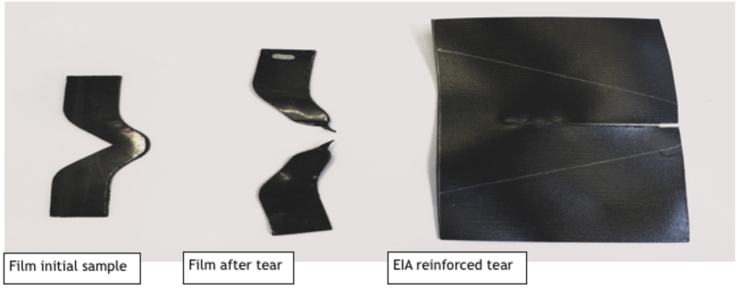

**Tear Performance** Tear resistance is a performance property that can be affected by the adhesion and the base cloth construction. On geomembranes with a tie coat an increase in adhesion may embrittle the yarn, resulting in a lower tear. A balance is made between the tear and coating adhesion to the base cloth on tie coated reinforced geomembrane to optimize physical properties for durability in stringent environments. The EIA geomembrane is formulated to terminate the crosslinking of the molecular chemical bond over time. The yarns are locked within the geomembrane matrix hence acting as a composite in the true sense. The reinforced tie coated geomembrane shows excellent retention of tear properties, see Figure 7. It is critical to get the correct balance in physical properties to ensure the geomembrane will perform in the intended application.

**Figure 7.** Reinforced geomembrane with a tie coat tear properties




The laminate geomembrane base cloth is open and relies on the shearing, elongation, and movements of the uncoated yarn for tear performance. The yarns will slide within the coating matrix to inhibit tear. Movement of the yarns will jeopardize the strength of the geomembranes in the material adjacent to the damaged areas as there is no reinforcement left to support the integrity of the membrane. On non-reinforced film, the tear propagation is based on the toughness of the film. Once the film is compromised, the tear will continue to propagate. Figure 8 shows the film physical sample before and after tear. There is no reinforcement to resist the tear propagation as seen on the reinforced EIA tear sample.

**Figure 8.** Tear propagation of non-reinforced geomembrane vs EIA reinforced




**Conclusion** The adhesion of the coating will affect the tear and overall performance of the geomembrane. Tear and coating adhesion can be affected by:

- Cohesiveness between the layers in geomembranes
- Stability and strength of the reinforcement
- Toughness of the film

A proven formulation with balanced properties between adhesion and tear result in a geomembrane composite that can withstand the loads and inhibit tear. The EIA geomembranes with a tie coat to increase adhesion maintain tear and performs like a composite.

The laminate geomembrane allows the yarns to move and elongate jeopardizing load carrying characteristics and tear in adjacent areas. Non reinforced film shows low tear propagation once the material has been jeopardized. Thinning of the film occurs under load. Tear and coating adhesion should be taken into consideration when specifying geomembranes for long-term high performance applications.