

Long Term Performance Requirements for HDPE Drainboards

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ABSTRACT

Drainboards are gaining more and more interest in residential and commercial construction, as well as in the civil engineering industry for their ability to control ground water and protect foundation walls against moisture, reduce/eliminate hydrostatic water pressure on tunnel linings, provide a waterproof membrane as well as either an air gap and/or an open drainage channel on buried structures such as foundation walls. The main objective of these products is to eliminate infiltration of water into the construction, to avoid fungus growth in basements, and to control the humidity of the protected structure's materials in order to decrease their rates of degradation.

In order to provide adequate performance and protection for the construction, the product must maintain its full integrity over the entire design life of the structure. However, it appears that current product specifications completely avoid any reference to durability and long-term performance properties of these products, although many HDPE drainboards available on the market are manufactured with recycled polyethylene, either in part or in whole.

The first section of this paper describes essential advantages and possible concerns associated with the usage and design with dimple sheets and drainboards. In the second section, the common degradation mechanisms associated to HDPE sheets are described. The third section presents two years of laboratory investigations conducted on HDPE dimple sheets, focusing on the aging mechanisms identified in the second section. Details associated with the test procedures that have been developed to reflect the specific geometrical properties of dimpled sheets are presented as well as the results obtained.

Finally, a summary table presenting recommended product specifications needed to confine the aging properties of drainboards and to design a system that performs adequately throughout the entire lifetime of the structure is provided.

1. INTRODUCTION

Damage to sub-grade building structures ranks high in the damage statistics of buildings (Abel et al., 1991). To a large extent, the – often far-reaching – damages caused by moisture penetration in basements occur due to wrongly assessed underground moisture conditions and water pressure, resulting in the selection of unsuitable protection measures. Having reached the ground in the form of precipitation, water finds its own way as it follows the forces of gravity. If it infiltrates the soil swiftly and without delay, a building will not be exposed to water pressure from surface water. If precipitating water seeps away at a slow rate, however, water pressure will act on a building as long as precipitation continues. An equivalent situation occurs whenever underground water infiltrates permeable subsoil layers and migrates laterally until it reaches a building.

Exposure of a building to hydrostatic pressure increases when the adjacent subsoil layers are impermeable. In clay soils, for instance, water may accumulate in the top layers of soil, causing it to swell and block flow to a footing drain (Rose, 2005). In this case, building walls may be permanently exposed to water pressure. For proper planning of an effective waterproofing, drainage, and protection system, it is important to identify which of these water exposure conditions are present. A careful investigation of the soil-structure, as well as all other relevant factors such as the characteristics of the landscape, is therefore vitally important.

Efficient drainage greatly improves and warrants the reliability of the waterproofing layer by relieving the hydrostatic pressure caused by dammed-up seepage water. A drainboard can also provide effective protection for the waterproofing system against potential damage from mechanical impacts (i.e. from sharp-edged rocks during backfilling) and consequential moisture intrusion.

This paper reflects on the essential advantages of using HDPE dimple sheets and drainboards and on their performance criteria, as well as the possible concerns associated with the usage and design with such products. Furthermore, a general description of potential degradation mechanisms and aging processes of HDPE membranes is given and laboratory investigations conducted on HDPE dimple sheets, focusing on the aging mechanisms are being discussed. Finally, details associated to the test procedures that have been developed to reflect the specific geometrical properties of dimpled sheets are presented, as well as the results that were obtained. A summary table presenting recommended

exhaustive product specifications needed to describe and confine the performance properties of dimple sheets and drainboards and to design a system that performs adequately throughout the lifetime of the structure is provided.

1.1 Essential Advantages of Dimple Sheets and Drainboards

Dimple sheets and drainboards have been gaining increasing interest over the last number of years, and are commonly used in residential and commercial constructions, as well as in the civil engineering industry for their ability to protect foundation walls against moisture, control ground water, and reduce or eliminate hydrostatic water pressure. Dimple sheets are also used in tunnel lining applications to intercept artesian, fissure, and seepage water.

Below grade, the most effective moisture transport mechanism is liquid flow of water. Gravity forces can cause hydrostatic pressure build-up on the outside of sub-grade structures. Even in the absence of hydrostatic pressure moisture can migrate through foundation walls due to capillary conduction. Especially affected by capillary wicking is concrete that shows evidence of voids (i.e. honeycombing).

In addition, fissures and cracks in concrete walls allow adjacent water to migrate through the concrete, either by being pushed through the structure due to hydrostatic pressure build-up on the outside, or by capillary forces occurring within the concrete structure. To eliminate capillary conduction, a capillary breaking layer is required. A 3-dimensional dimple sheet provides a full capillary break with inherent redundancy: the plastic membrane (High Density Polyethylene is commonly used by manufacturers for this type of product) in itself is a capillary break. Additionally, the air-gap, which is being generated between the membrane and the structure also serves as a capillary break.

The main objective of drainboards is to reduce or eliminate hydrostatic pressure against the foundation or below grade structure by providing an effective drainage layer, and to prevent infiltration of water into the construction. Drainboards, generally comprised of a rigid polymer core (dimple sheet) with a geotextile (filter fabric) bonded to the dimpled surface (see Figure 1), make an excellent drain on the backfilled side of retaining walls, basement walls, and plaza decks (Koerner, 1997).

The drainage path for the water is provided by the air gap between the studded polymer core and the geotextile. Figure 1 illustrates how soil-water adjacent to a below-grade structure passes through the geotextile and is safely drained to the footer drain. Hence, the potential for building up hydrostatic pressure against the structure is eliminated.

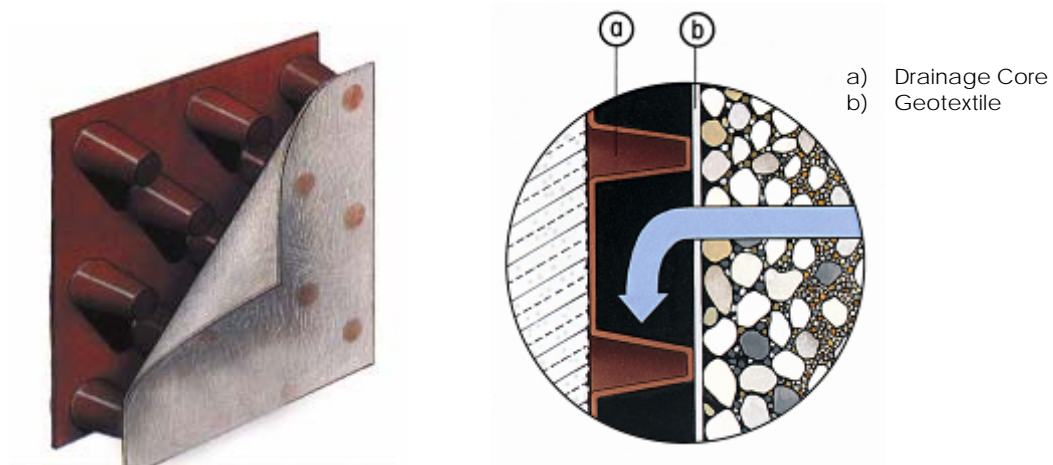


Figure 1: Drainboard comprised of polymer core with geotextile (filter fabric)

Dimple sheets function based on the simple principle of an air gap, formed by a waterproof plastic sheet with a 3-dimensional dimple structure, to keep soil moisture away from foundations. The combination of a waterproof membrane and the air-gap provide a reliable capillary break. Stopping inward moisture migration contributes to controlling the humidity of the protected structure's materials in order to decrease their rates of degradation, and thus helps to avoid mold and fungus growth in basements. An obvious advantage over conventional spray applied dampproofing and waterproofing products is that cracks in the concrete, which occur due to shrinkage and settlement, are bridged by the dimple sheet, ensuring that moisture remains unable to migrate inwards. The function of dimple sheets for foundation wall moisture protection is illustrated in Figure 2.

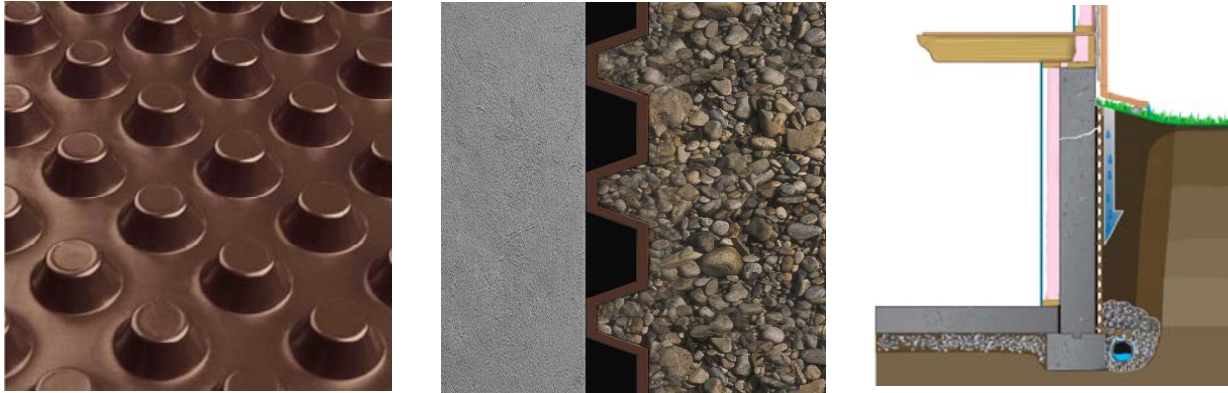
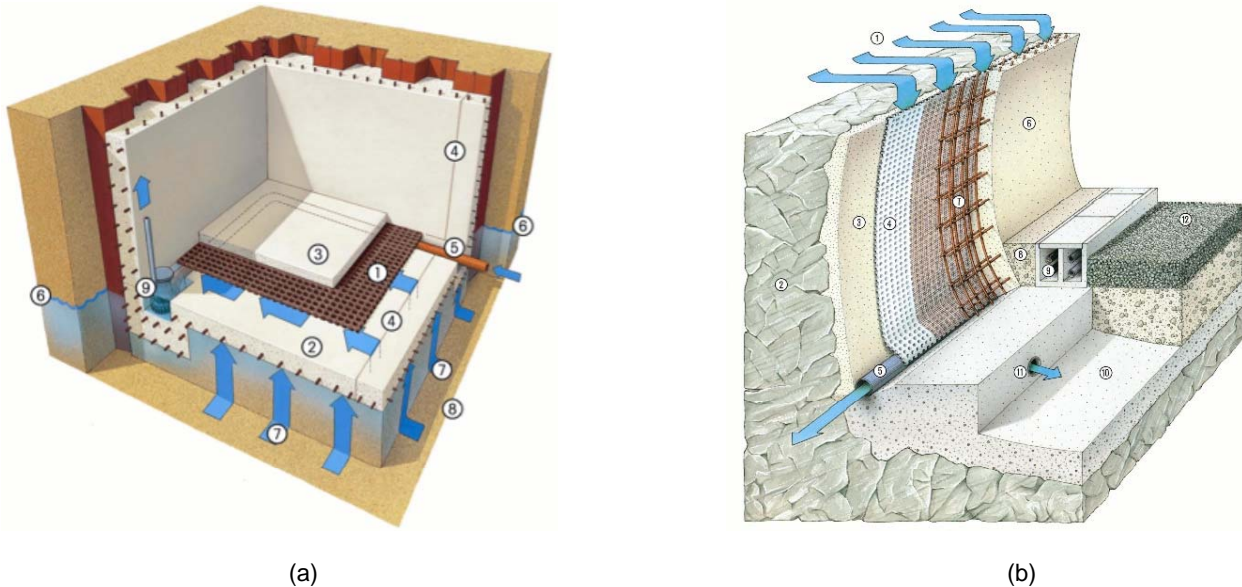


Figure 2: 'Air gap' function of dimple sheet

Dimple sheets are also commonly used in civil engineering construction to provide high capacity drainage on deep foundations in vertical or horizontal applications in order to eliminate the destructive forces of hydrostatic pressure. This principle also applies to tunnel construction where dimple sheets are commonly used to intercept artesian, fissure, and seepage water in order to prevent the build-up of hydrostatic pressure against the concrete liner inside the tunnel. Pictures (a) and (b) in Figure 3 illustrate these applications.



(a) (b)
Figure 3: Dimple sheet for artesian and fissure water drainage

1.2 Performance Criteria for Dimple Sheets and Drainboards

When specifying a dimple sheet or drainboard for a below grade application there are several key performance criteria to consider. For such membranes to function throughout the lifetime of the structure that they are intended to protect, these key performance criteria must be evaluated also with respect to long term durability. Performance criteria for dimple sheets and drainboards can be categorized into mechanical properties, hydraulic properties, and durability. Mechanical properties comprise the compression behavior of the geocomposite (drainboard core with geotextile bonded to its studded side) or the dimple sheet. This material characteristic is fundamentally important since the 3-dimensional membrane will be exposed to soil pressure at varying levels depending on the installation depth, and its functionality, especially with respect to generating and maintaining an air-gap between the foundation wall and the adjacent soil is dependent on its compression resistance. An appropriate test method for determining the short-term compression behavior of the dimple sheet or drainboard is ASTM D6364. While this test standard can give an indication of the

momentary compression behavior of the material, it cannot, by itself, characterize the long term compression behavior of the product.

Other important mechanical properties of such membranes are breaking force and elongation, measurable according to ASTM D5035, as they help to characterize the behavior of the products during the backfill process. It has also been used for determination of the number of anchors per surface area to be applied to ensure stability of the product on a vertical wall. Also of relevance for the characterization of mechanical properties is the static and dynamic puncture resistance of these membranes. Dynamic puncture resistance reflects the product's ability to sustain the shock induced by the fall of a boulder during the backfilling process, which is likely to occur either accidentally or during normal operations. On the other hand, static puncture reflects the ability of the product to sustain a local pressure that would be induced by a boulder in direct contact with the geocomposite or drainboard. Appropriate test standards are readily available, i.e. CGSB 37-GP-56M and CGSB 37-GP-52M.

The characterization of hydraulic properties is especially important for drainboards, as their main function is to safely drain water away from the foundation wall in order to prevent or eliminate hydrostatic pressure. Hence, the hydraulic transmissivity and in-plane flow rate of a geocomposite (drainboard) as determined with ASTM D4716, are vitally important performance characteristics. Since dimple sheets are intended to not only provide protection against liquid water intrusion into foundations, but also to protect against moisture ingress via other transport mechanisms, it is also important to describe the water vapor transmission rates of such materials. An appropriate test method is described in ASTM E96, Procedure A.

In order to characterize the long term durability of dimple sheets and drainboards, a number of standard test methods can be employed. For characterization of aging and oxidation of these membranes, an oven aging test as per ASTM D5721 and an OIT (Oxidative Induction Time) test as per ASTM D3895 are suggested in combination with compression behavior testing at different intervals of aging. This procedure was inspired by the classical aging test used in the polyethylene geomembrane industry. Similar conclusions regarding associated lifetimes and degradation mechanisms can indeed be drawn as both products are using similar base materials (high density polyethylene).

Finally, the last significant degradation mechanism that is likely to develop on HDPE drainboards – as well as on many other polymeric products – is environmental stress-cracking. Although this property is also very well handled in the geomembrane industry, the particular structure of drainboards, the sheet thickness involved and the presence of recycled polyethylene in only the central section of the product (see Figure 4) do not allow the use of one of the common tests addressing this property. These are either ASTM D1693 in most of the plastics industry, ASTM D5397 in the HDPE geomembrane industry, or ASTM F2136 in the HDPE pipe industry. The most significant issue restraining the use of these methods is the fact that some HDPE drainboards are co-extruded sheets involving recycled and non-recycled polyethylene in three separate layers, the two outer – virgin HDPE – layers providing the product its endurance properties, while the central layer, made of recycled HDPE, essentially contributes to the mechanical and other performance properties of the finished product. This particular composition makes it impossible to regrind and re-mold a 3.2 mm thick sheet to conduct ASTM D1693, and also makes irrelevant the use of specimens notched to a depth of 20% of the sheet. This would bring the notch into the recycled polyethylene layer and would thus not adequately reflect the actual product performance. As a consequence, a specific method had to be developed to address this intrinsic material property. It is currently referenced as Sageos GD001 (Stress Cracking Resistance of Dimpled Sheets), until further standardization work at an upper level such as ASTM or ISO. In the meantime, the procedure is further developed in this paper. The aforementioned performance criteria are similarly referred to in the European Standard EN13252, Geotextiles and geotextile-related products – characteristics required for use in drainage systems, Table 1.

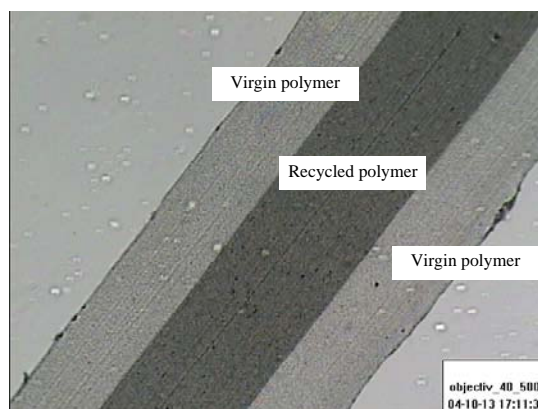


Figure 4: Microscopic section of a HDPE drainboard including a layer of recycled resin

1.3 Possible Durability Concerns associated with the use of HDPE dimple sheets and drainboards

While polymers are being utilized in virtually every area of our life, the volume of polymers used in the above-mentioned applications represents only a small fraction of the entire polymer market worldwide. The use of High Density Polyethylene in foundation protection membranes and drainboards differs from many other applications since these membranes are intended to fulfill their function over long time periods. Where some articles made of HDPE are required to last for short time periods only (i.e. milk bottles), others are intended to last a few years (i.e. kitchen articles). Foundation waterproofing membranes and drainboards are expected to fulfill their function for the lifetime of the structure – typically in the range of at least 50 years.

Durability concerns therefore need to be understood and evaluated. Most situations involving the expertise of a geotechnical engineer are dealt with under the aspect of ground water conditions, seepage, settlement, bearing capacity of soils, etc. Typically the short-term properties of the involved materials are being considered without looking at their durability and potential degradation factors. Important to the durability of foundation protection membranes and drainboards is their raw material formulation, the imposed in-service conditions during their functional lifetime, as well as the environmental conditions to which they will be exposed between manufacturing and the actual service life.

The material formulation deserves special attention when recycled content is used in such membranes, and even more if the membranes are made entirely out of recycled HDPE. In recent years, the utilization of recycled plastic in extrusion of sheet goods, especially in Polyethylene sheets has increased significantly, driven by cost advantages to manufacturers, as recycled material is generally available at a lower cost than virgin material. The rise of environmental concerns has also become influential in the construction industry. A number of green building rating concepts have been generated and implemented, i.e. LEED (Leadership in Energy and Environmental Design), which promote and reward the use of recycled content in the employed construction materials.

The addition of recycled materials to construction products certainly appears responsible under the aspect of environmental concerns. However, it may also raise concerns in regards to the end product's durability and consequential implications, which should be addressed appropriately. This also holds true with respect to adding recycled material into virgin HDPE for the production of plastic sheets. Since the use of recycled content in dimple sheets and drainboards may potentially compromise their long term durability, the intensity of the negative impact must be evaluated and understood in order to ensure that the key performance characteristics of such products are maintained throughout the functional service life of these products. Interestingly, the European Standard EN 13252 even excludes the use of recycled polymers entirely if a drainboard is required to have a service life of up to 25 years.

A designer may be given the choice between different products, of which one may last for the entire lifetime of the structure that it is supposed to protect, while another one – typically cheaper - may have a significantly shorter functional lifespan. Hence, it is critically important that design guidelines are provided, and that the designer has the necessary understanding of the materials and environmental conditions to choose an appropriate product.

In Section 2 the common degradation mechanisms of HDPE sheets are described in order to generate a better understanding of which tests should be performed on such products to assess their long-term performance appropriately.

2. POTENTIAL AGING AND DEGRADATION MECHANISMS RELEVANT TO HDPE SHEETS

Aging and degradation of polymers essentially takes place at the molecular level. Polymers are materials composed of large molecules of very high molecular weight. The cohesive forces of a polymer, which greatly affect the physical and chemical degradation mechanisms that can take place, are determined by the chemical composition of the polymer.

The molecular structure of Polyethylene is shown in Figure 5.

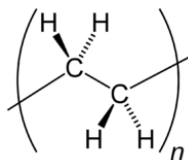


Figure 5: Molecular structure of Polyethylene

The characteristics of the polymer depend on intermolecular forces and are greatly influenced by the chain structure (i.e. chain length, linearity, branching, cross-linking, etc.), morphology (i.e. crystallinity), molecular weight distribution, irregularities (i.e. impurities), additives (i.e. color pigments, Antioxidants, UV stabilizers, flame retardants, antistatic agents, etc.), as well as by the manufacturing process itself, during which the polymer is exposed to thermal and shear stresses that will initiate degradation mechanisms. Process conditions will also determine the effectiveness of mixing additives and stabilizers into the polymer, which can influence the morphology of the end product as well as the degree of stabilization against environmental factors like heat, UV, oxygen, etc.

Polyethylene, the highest-volume polymer in the world (Harper, 1999), offers high toughness, ductility, excellent chemical resistance, low water vapor permeability, low water absorption, excellent processability, and hence is a very versatile and attractive material for many different applications. High Density Polyethylene has a low degree of branching and hence strong intermolecular forces and tensile strength. Since it is non-polar, it provides a very high resistance to chemicals. The permeability of Polyethylene to liquids and gases is extremely low. It is also very resilient to alkaline and acidic agents, as well as salt solutions. Polyethylene copolymers (Ethylene can be copolymerized with many non-olefinic monomers) generally provide improved low-temperature flexibility and increased environmental stress crack resistance. Due to its outstanding characteristics High Density Polyethylene (copolymer) lends itself perfectly for the manufacturing of durable 3-dimensional dimple sheets and drainboards.

Essential aging and degradation mechanisms of polymers commonly used in geosynthetics have been described in depth by Kay et al. (2004). HDPE is generally very resilient against environmental factors, which in fact may initiate degradation mechanisms with many other polymers. Hence HDPE seems to be the ideal polymer to be used for dimple sheets and drainboards in below grade applications. However, when recycled PE is used in the extrusion and forming process of dimple sheets, the resilience to degradation mechanisms under specific conditions may be significantly reduced. During their functional service life the HDPE dimple sheets and drainboards described in this paper are exposed to several relevant degradation mechanisms. These aging mechanisms can, under certain circumstances, influence their properties and even reduce their durability and lifetime expectancy. Hence, the characteristics of the material used as well as the actual exposure conditions must be considered in order to evaluate the potential implication of these degradation mechanisms to the final product and its functional service life.

One of the most relevant degradation mechanisms of High Density Polyethylene is oxidation, which can occur in form of thermo-oxidation, photo-oxidation, and chemical oxidation. The long-term durability and performance of Polyethylene membranes can be ensured through adequate stabilization with antioxidants and UV stabilizers.

In the presence of sensitizing agents, HDPE can become sensitive to Environmental Stress Cracking, which – next to oxidation – is the most relevant degradation mechanism of this polymer. As per the definition in accordance with ASTM D883 stress cracking is “an external or internal crack in a plastic caused by tensile stresses less than its short-term mechanical strength.” This typically describes brittle cracking with little or no ductile drawing from the adjacent failure surfaces of the polymeric material. The occurrence of environmental stress cracking of stressed samples is linked to the presence of surface-active wetting agents such as alcohols and surfactants. The surface-active wetting agents don't chemically attack the polymer, nor do they produce any effect other than microscopically brittle-appearing fractures. The fractures initiate at microscopic imperfections in the material, and propagate through the crystalline regions of the polymer structure. In the absence of such surface-active wetting agents, these fractures would not occur in any reasonable time period under the same stress conditions.

A polymer's ability to resist environmental stress cracking is generally known as ESCR (Environmental Stress Crack Resistance). Different polymers exhibit varying levels of ESCR. It is important to know that the stress cracking susceptibility between different types of PE is known to be very different (Hsuan,). Some grades of HDPE have very good resistance against environmental stress cracking, while other grades only show a marginal resilience. The principle variables that affect the ESCR in HDPE include the crystallinity, molecular weight (ESCR improves as molecular weight increases), the molecular weight distribution (generally a narrow molecular weight distribution shows poorer ESCR values than a broader distribution), branch length, and lamellar orientation (Lustiger, 1996). Naturally the ESCR testing conditions (i.e. reagent concentration, testing temperature, applied stress) also have a major influence on the ESCR that the tested sample will exhibit. Recycled content is also known to affect the Environmental Stress-Crack Resistance of polymers. Historically, and practically, recycled materials do not perform as well as virgin polymers when subjected to Environmental Stress-Cracking (Develle et al, 2003).

The pH value of a soil is perhaps the most important factor governing the rate of degradation of foundation protection membranes, drainboards and the attached geotextiles (Corbet et al, 1993). The rate of degradation increases with an increase in ambient temperature. While typical soil temperatures close to foundation walls are in the area of 10°C to 15°C, significantly higher temperatures are usually encountered close to grade surface, as well as behind retaining walls.

3. LABORATORY INVESTIGATIONS

In this section, only the test procedures that are not typically reported in common drainboard specification sheets are introduced. However, Table 4, provided at the end of this document, includes a minimum list of properties that were found to be relevant for most applications of drainboards. Authors thought it would not be appropriate to re-describe those procedures and test results that are very well handled by the common procedures described in the first section of this document.

3.1 Environmental Stress Crack Resistance

3.1.1 Test Procedure

Various test methods have been developed over the years to measure the Environmental Stress Crack Resistance of products. The most widely used and oldest method is ASTM D1693 - Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics (Bent Strip Test). Other methods are ASTM D5397 – Standard Test Method for Evaluation of Stress-Crack Resistance of Polyolefin Geomembranes; ASTM F1473 – Standard Test Method for Notch Tensile Test to measure the resistance to slow crack growth of PE pipes and resins or F2136 – Standard Test Method for Notched, Constant Ligament-Stress (NCLS) Test to Determine Slow-Crack-Growth Resistance of HDPE Resins or HDPE Corrugated Pipe. However, as described in 1.3, none of these methods apply to HDPE drainboards in their finished or delivered condition, as the layered structure and geometrical properties of the dimpled sheet make them irrelevant. For that purpose, a specific procedure was first developed in Northern Europe by the Swedish Construction Authorities, and further codified by SAGEOS in “Geodrains Testing Method, Stress-Cracking Resistance of Dimpled Sheets using the ‘Sweden Test’” (2006) to address the stress-cracking resistance issue for dimpled sheets.

In this method, four (4) specimens are placed on a flat concrete surface and covered by a fiber-cement board while immersed in a wetting solution (10% Igepal CO-630 / 90% de-ionized water at 55°C) and stressed using dead loads as described in Figure 6. Periodically, the specimens are unloaded for a visual inspection, and a thickness measurement is taken. A rating of the observed cracking is noted, along with the exposure time. The time required to observe the first crack is finally identified, as well as the time for the dimple to collapse.

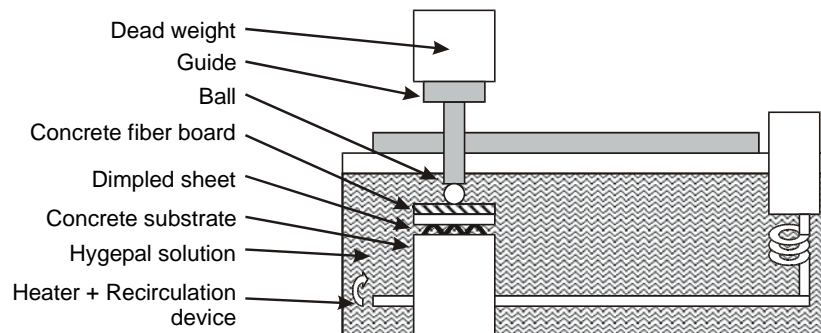


Figure 6: Stress-cracking test for dimple sheets

The visual inspection is done to rate the degradation qualitatively, according to the criteria described in Figure 7.

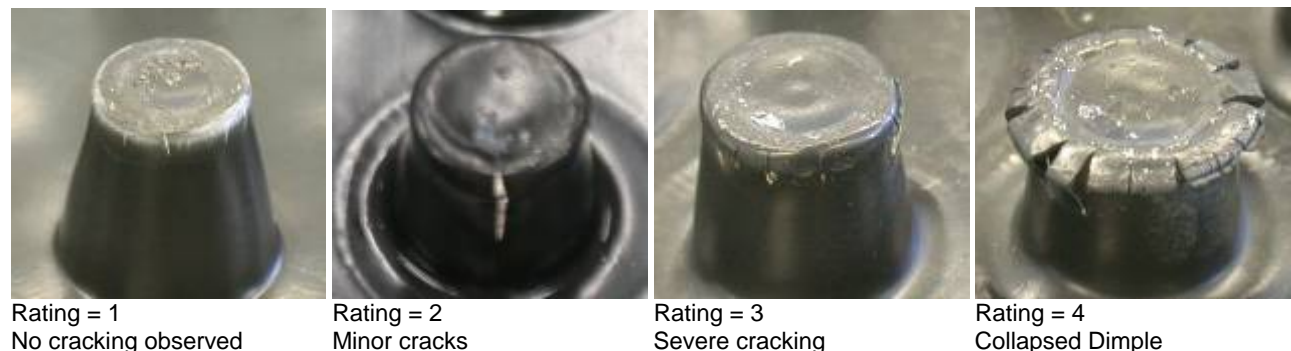


Figure 7: Visual rating for stress-cracking resistance of dimple sheets

3.1.2 Results

Four different products were analyzed using this procedure. Three of them were involving 100% post-consumer recycled resin, and one was co-extruded with two outer layers of pure virgin resin and one central layer of post-consumer recycled resin, as shown in Figure 4. The results are reported in Table 1. They present the observations expressed as the occurrence of the first crack, as well as observation of a severe failure of the product.



(a) No failure (b) Cracking (c) Severe cracking (d) Severe cracking

Figure 8: Observations of the degradation of dimple sheets during a Stress-Cracking test per SAGEOS GD001

Table 1: Time of exposure (hours) for the observation of the first occurrence of a crack and severe failure.

Observation	Co-extruded with virgin and recycled resins	100 % post consumer recycled resin #1	100 % post consumer recycled resin #2	100 % post consumer recycled resin #3
First crack	> 336 hours (2 weeks)	70	70	45
Severe failure		> 336 hours (2 weeks)	70	163
Example picture	Figure 8-a	Figure 8-b	Figure 8-c	Figure 8-d

3.2 Resistance to oxidation

3.2.1 Procedure

Resistance to oxidation was also evaluated on the same four dimpled-sheet products based on ASTM D5721, using temperatures of 40, 50, 60 and 70°C. These temperatures were selected in order to maximize the degradation by oxidation of the product, but minimize the potential influence of other chemicals which could be present (in the recycled fraction), and which would not be active in normal operating conditions. For that reason, test temperatures as high as 85°C were not selected. Aging was monitored using compression resistance, OIT and melt index.

3.2.2 Results

The OIT and compression strength results are presented in Figures 9 and 10 for the reference product (co-extruded virgin & recycled HDPE) and summarized in Tables 2 and 3 for all the tested products. It is shown that OIT varies over time according to the temperature, but that the mechanical properties are not significantly affected by the thermal aging process over the testing period. Similar observations were made for the three other products, that is no significant changes in mechanical properties nor melt index, but a quantifiable decrease of OIT. Results of OIT being the only ones showing some significant variations over time, they were selected to build the Arrhenius model to effectively and objectively compare the relative durability of the products. This durability was defined as the time required to completely consume all the anti-oxidants, calculated for a service temperature of 15°C. This duration was then expressed as a relative value compared to the durability of the reference material, which was arbitrarily selected to be the co-extruded material involving recycled and virgin resins.

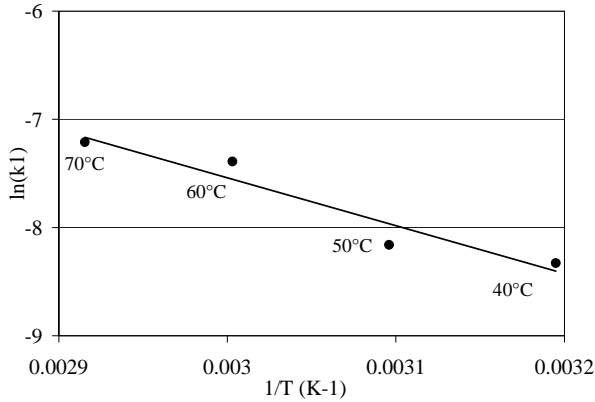


Figure 9: Compilation of OIT results (Arrhenius regression)

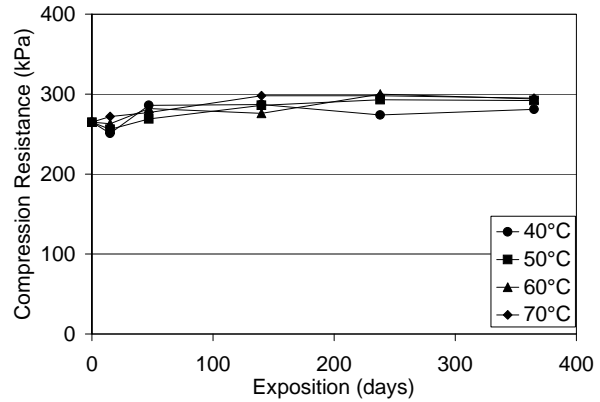


Figure 10: Evolution of the mechanical properties

Table 2: Evolution of the melt index over time at the most critical aging temperature (showing no significant variations)

	Co-extruded with virgin and recycled resins	100 % post consumer recycled resin #1	100 % post consumer recycled resin #2	100 % post consumer recycled resin #3
Initial (g/10min)	0.34	2.35	0.10	0.30
After 365 days at 70°C	0.32	2.34	0.09	0.29

Table 3: Analysis of the OIT and calculation of the relative durability of the tested products

	Co-extruded with virgin and recycled resins	100 % post consumer recycled resin #1	100 % post consumer recycled resin #2	100 % post consumer recycled resin #3
Initial OIT (min)	135	6.9	3.4	15.2
AO depletion rate at 15°C (ln min/day)	0.7×10^{-4}	1.3×10^{-4}	4.8×10^{-4}	1.4×10^{-4}
Relative durability	100% (reference)	15 to 50 %	5 to 10 %	15 to 55 %

Based on these observations it is possible to conclude that the presence of virgin resin on the two outer sides significantly improves the durability of dimpled sheets with respect to oxidation with observed ratios in the range of 2 to 20 depending on the tested materials.

4. RECOMMENDED STRUCTURE FOR THE SPECIFICATION OF DRAINBOARDS

Based on the observations presented above, the specification structure presented in Table 4 was developed. It includes all the testing methods that were found to be relevant either with respect to material performance, survivability, or long term durability.

Table 4: Recommended Specification Structure for drainboards

	Property	Standard	Type
Physical properties	Roll width	/	Typical
	Overall thickness	ASTM D5199	Minimum
Mechanical properties	Dynamic impact resistance	CGSB 37-GP-52	Minimum
	Static puncture	CGSB 37-GP-56	Minimum
	Compression resistance	ASTM D6364	Minimum
	Tensile strength	ASTM D5035	Minimum
Hydraulic properties	Water transmissivity	ASTM D4716	Minimum
	Water vapor transmission	ASTM E96-Proc. A or B	Maximum
Durability	Resistance to heat aging	ASTM D5721 / ASTM D3895	Typical / Minimum

5. CONCLUSIONS

Analysis of the function of dimple sheets and drainboards used in commercial and residential construction has led to the development of a structure for material specifications, which should be used as a minimum guidance to address most of the concerns typically observed in regards to drainboards. However, it shall be mentioned that Table 4 does not include geotextile filter properties, which shall be treated separately according to the function of the product and its environment. On the other hand, if the usage of recycled resin in drainboard manufacturing presents many benefits with respect to either cost or environmental concerns, the laboratory tests presented in this paper have shown that embedment of the recycled resin between two layers of virgin resin adequately protected against oxidation will tremendously improve the overall durability of the product, with observed improvements of projected life times in the range of 2 to 20 depending on the tested materials.

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