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Analysis of Surface Temperatures and Expansion Behavior in HDPE and LLDPE Geomembranes with Different Surfaces in Field Applications

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Geosynthetic barriers, utilizing geomembranes, play a crucial role in engineering, serving various purposes such as water and wastewater containment, as well as the containment of waste from different sources. Given the diversity of projects and the mechanical, chemical, and environmental requirements, the global market currently offers a wide range of geomembranes made from different polymers and additives, aimed at optimizing their performance. Among the available types, HDPE geomembranes stand out for their excellent chemical and mechanical resistance, historically recommended for more severe environmental applications, for example bottom protection in Class 1 and 2 waste landfills. Conversely, LLDPE geomembranes exhibit lower chemical resistance than HDPE but offer exceptional flexibility, making them ideal for situations requiring greater pliability, such as temporary covers for landfills, where settlement occurrences are more frequent. The interfaces between the geomembrane and the subgrade, between the geomembrane and other geosynthetics, or between the geomembrane and an overlying soil must be carefully analyzed, as they can become preferential failure planes. When an interface is deemed critical, surface texturization is carried out to enhance the interface strength of the geomembrane, thereby ensuring greater stability and performance of the system. In addition to functional properties, aesthetics plays a significant role, especially in projects seeking landscape integration, including ornamental lakes in farms, condominiums, and parks. Geomembranes can be manufactured in bicolor combinations, such as green and black, blue and black, or white and black. This color scheme is appealing as it facilitates damage detection during installation and minimizes wrinkles resulting from lower temperatures on lighter and colored surfaces. With the increasing application of these materials, it becomes essential to clearly and scientifically document their performance and behavior. The thermal energy exchanged between the Earth's surface and the atmosphere directly impacts air temperature. On sunny days, air temperature rises rapidly in the early hours after dawn, peaking mid-morning before slowing down. The maximum intensity of solar radiation is typically recorded at noon, when air temperature reaches its highest point. After that, temperature begins to gradually decline until sunset, cooling more sharply until reaching its daily minimum just before the next dawn. On hot days, geomembranes can reach surface temperatures exceeding 72°C, hindering the work of installers. This condition adversely affects not only the proper placement and uniform application during installation but also the ability to inspect, weld, and test the material. High temperatures can cause expansion in geomembranes, resulting in wrinkles that compromise the performance of the structures. These wrinkles, if not corrected, affect impermeability, creating failures that increase the risk of leaks and undermine the barrier function. Furthermore, the increased stress generated by the wrinkles can lead to stress concentrations, raising the risk of ruptures due to thermal expansion and contraction. Wrinkles also promote water accumulation, forming pockets that increase hydrostatic pressure and can cause structural damage. Wrinkled geomembranes become more challenging to inspect and maintain, making it difficult to identify damage, for instance, during geoelectric tests. Therefore, surface temperatures and the expansion behavior of geomembranes directly impact the final outcome. In this context, this study investigated the effect of temperature on different types of geomembranes, such as HDPE and LLDPE, with smooth or textured surfaces and black or colored faces (white, green, and blue), in three thicknesses (1 mm, 1.5 mm, and 2 mm). The investigation was divided into three stages. The first stage involved the installation of 48 full-scale panels in the municipality of Jacutinga, Minas Gerais, Brazil. The second stage began 24 hours after the installation was completed, to ensure system equilibrium. During this phase, the surface temperature of the different exposed types of geomembranes was monitored hourly, with analyses conducted in different seasons of the year. Finally, the third stage involved measuring the dimensions of the panels, allowing for the evaluation of expansion and contraction in response to temperature variations over the days. The versatility of geomembranes in various types of works makes it essential to investigate temperature variations and the resulting deformations, as these factors directly influence the effectiveness of the geomembrane as a waterproofing barrier.