DEGRADATION BEHAVIOR OF STRESSED POLYESTER REINFORCING PRODUCTS UNDER ALKALINE CONDITIONS EMBEDDED IN ELUATES AND SOILS

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Abstract. *The use of geosynthetic reinforcements in different applications has been proven over the last decades to be a very beneficial and valid technique. For a safe design of such structures the long-term behavior and especially the available resistant tensile force over the time under variable boundary conditions, such as temperature, chemical influences or loading conditions, must be well known and understood. The known effects, which lead to a reduction in tensile strength, are considered in the design by applying so called reduction factors. So far, those reduction factors are determined separately without considering a possible interdependency. Latest research results are indicating that this can lead to major misjudgements. The main mechanism of the chemical degradation of polyester in high alkaline environment is the so called alkaline or "external" hydrolyses. In contrast to the internal hydrolyses, which provokes an evenly distributed, very slow degradation of the whole cross-section of the synthetic material, the external degradation generates a much faster "surface corrosion" with creation of fissures or cracks. If this does occur while the material is loaded, the fissures are widened, and their propagation are dramatically accelerated. The understanding and consideration of chemical degradation under mechanical stress is from crucial importance. This research will present results for products made of PET with different production technologies, where above-described mechanism has been investigated in more detail and conclude with a recommendation, how to proceed based on those findings. Tests have been conducted with samples embedded in eluate as well as in partially and fully saturated soils under a constant load, which approximately equals the design strength.*

1 INTERNAL AND EXTERNAL HYDROLYSIS OF PET IN ALKALINE ENVIRONMENT

Hydrolysis is the process of splitting a chemical bond by reaction with water. Two types of hydrolysis can be observed in PET. The so called internal and external hydrolysis. Internal hydrolysis occurs in neutral conditions with pH-values in-between 4 and 9. The corresponding mechanical degradation occurs evenly over the entire cross-section. Degradation by internal hydrolysis is relatively slow, and strength loss over a 120-year period is low. For geosynthetic reinforcing products in general around a few percent. Under alkaline conditions with pH values above 9, external hydrolysis also sets in. In contrast to internal hydrolysis, external hydrolysis progresses much faster and causes surface corrosion leading to voids, cracks, and perforation. The loss of strength is disproportionately higher.

2 DEGRADATION OF PET IN ALKALINE ENVIRONMENT UNDER STRESS IN A LEACHATE

Müller-Rochholz and Bronstein (1994) analysed the influence of high pH-values in combination with stress (tensile load) on the degradation process of PET fibres. They found that the degradation process does speed up significantly under these conditions. This is because the tensile forces widen the microcracks and the cracks propagate, which leads to a reduction in the cross-sectional area and thus to a lower tensile strength. Also, the specific surface area has an influence on the degradation process. To analysis this, geogrids made of PET strands have been tested. The samples have been tensioned by 35% of their ultimate strength, which corresponds approximately to the design strength of the material. It could be observed that the former transparent strands became milky, which is because micro cracks occurred in the material and changed the light refractive index. The whiter the surface the more micro cracks have appeared. After 28 days at a temperature of 50°C the geogrid failed. In a repeated test at 20°C it was observed that the degradation process decreases in speed but still occurs. After 64 days in those conditions the residual strength reduced by 45%.

3 DEGRADATION OF PET IN ALKALINE ENVIRONMENT UNDER STRESS EMBEDDED IN SOIL

All those tests have been executed by placing the samples in an eluate. This might not reflect the real conditions, where the material is embedded in soil. Therefore, further test series have been developed, where the samples are embedded in soil and loaded at the same time. Within a master thesis at the TU Deggendorf a test set-up has been developed, which allows the testing of the samples embedded in partially saturated and saturated soils (Strahberger, 2023). As a result, it was found out, that also embedded in a lime-sand mixture under ambient temperature between 13°C and 19°C the PET strands ruptured both in the saturated soil and in the partially saturated soil.

4 CONCLUSIONS

The presentation reports on the inner and outer hydrolysis of PET with special focus on reinforcement applications. Whereas the inner hydrolysis is a relatively slow and homogeneous degradation process, the degradation due to external hydrolysis can have a major impact on the safety level of the structure. Different research results are presented and show that this degradation process occurs with PET fibres as well as with PET strands, which are placed under tension in an eluate or embedded in partially saturated or saturated soils. If reinforcing PET products are planned to be used within high alkaline environments their suitability should be tested under tension and embedded in the planned material. A possible test set-up is presented, and reference is made to a test procedure.

REFERENCES

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