Material Properties Analysis of Acid-alkali Resistance Geosynthetics for Highway

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Abstract. In this paper, the engineering application characteristics for polypropylene filament geotextiles have been explored and analyzed. Besides, test about physical, chemical and mechanical properties has been conducted and conclusions have been drawn as below: engineering application characteristics for polypropylene geotextiles are good and corresponding physical parameters are excellent, especially good tensile property. The ageing resistance is outstanding, while breaking strength and elongation at break after aging test remain and show no obvious change. In addition, due to excellent acid and alkali resistant properties, the material can be applied to bituminous pavement and cement concrete pavement.

Keywords: geosynthetics; acid-alkali resistance property; engineering application; experimental analysis.

1. Introduction
The combined action of physical, chemical and biological factors results in damage of overall structure for pavement. The raw materials for overall structure of pavement usually include bituminous mixture and concrete which will result in acid or alkali pavement structure under various environmental factors. When geotextiles are used to prevent and control pavement crack, the engineering service life (i.e. engineering conformance) shall be considered. Chen Weidong[1] concluded good physical and chemical properties during disease control for pavement with geotextiles. Xie Jingkun[2] et al applied different testing factors and tested geotextiles with different specifications and then concluded good acid and alkali resistant properties of polypropylene fiber geotextiles under strong acid and alkali environment. Zheng Zhineng[3] explored acid-base properties of polypropylene reinforced belt and concluded its strong acid and alkali resistant properties. Chen Jie[4] studied chemical resistance of geosynthetics and indicated small mass change and high reduction in strength and high influences of temperature on strength of geotextile in alkaline solution. Shen Lei[5] implemented different mechanical property tests for different geosynthetics, applied saline solution to conduct indoor accelerated corrosion test for geosynthetics, conducted different tests for disposed geosynthetics, compared and analyzed data before and after test, and concluded the property of optimal engineering application. Zhang Baosen[6] et al tested and studied engineering application properties of geosynthetics of same and different varieties and concluded large differences in quality property of geosynthetics and that different geosynthetics should be selected upon engineering practice. Yang Guangqing[7] concluded production, actual application and property of geotextile and proposed that high-strength and environmental resistance type polypropylene filament needle punched geotextiles would be footstone for geotextiles in the future.
2. Measurement for Physical and Mechanics Parameters

2.1. Test Surface Parameter Specification

For functions of polypropylene filament geotextiles (hereinafter referred to as “geotextiles”), physical and mechanical parameters are measured to get 600g/m² in this test. According to related standards, physical and mechanical parameters such as area, thickness and breaking strength of monomer are measured for standard sample.

**Table 1. 600g geotextile parameter table**

| Parameter                        | Unit/Area | Value   |
|----------------------------------|-----------|---------|
| Mass per unit area for monomer g/m² | 600       |
| Thickness mm                      |           | 3.5     |
| Breaking strength kN/m            | Lateral   | 45      |
|                                  | Longitudinal |        |
| Elongation at break %             | Lateral   | 40-110  |
|                                  | Longitudinal |        |
| Tearing strength kN               | Lateral   | 1.3     |
|                                  | Longitudinal |        |

2.1.1. Test Deviation of Mass per Unit Area for Monomer of Geotextiles. The typical samples shall be selected when monomer area of geotextiles is measured. For engineering materials such as geotextile with spare property, ensuring mechanical parameters under maximum mass per unit area for monomer will reduce production cost and also cost for engineering materials. When mass deviation for geotextiles is measured, the following formula shall be applied to calculate and test:

\[
\rho_A = \frac{m \times 10000}{A}
\]

Where, \(\rho_A\) refers to mass per unit area (g/m²); \(m\) refers to mass of sample (g); \(A\) refers to area of sample (cm²).

According to sampled data, the average value and deviation of mass per unit area can be calculated.

2.1.2. Measure Thickness of Geotextile. When geotextiles are used as reinforced cloth and laid between pavement surface and basement layer to prevent and control reflection crack, thickness of geotextiles has relatively large influences on anti-cracking effect. If thickness of geotextiles is large, effect of combination between surface layer and base layer will be influenced, and then geotextiles will act as isolated layer to influence cementation condition. The proper thickness gauge shall be selected to measure thickness. At least 10 samples shall be taken and designed with proper size based on related regulations of thickness gauge. The diameter of sample shall be 1.75 times of diameter of pressure foot for thickness gauge. The average value shall be calculated based on measured results.

2.1.3. Test Related Parameters of Breaking Strength for Geotextiles. The strength value of geotextiles depends on roughness of monofilament and raw material and is closely related to structural form of geotextile knitmesh and combined technology. Therefore, the property of strength can be reflected when geotextiles resist changes of external force. At least five pieces of lateral and longitudinal geotextiles shall be selected to measure parameters. When samples are held, test length and tensile direction shall be in parallel in lateral and longitudinal test. The breaking strength shall be calculated upon formula as below:

\[
\alpha_f = \frac{F_f}{B}
\]

Where, \(\alpha_f\) refers to breaking strength (kN/m); \(F_f\) refers to maximum load (kN); \(B\) refers to width of sample(m).

The average value can be calculated based on measured lateral and longitudinal breaking strength.
2.1.4. Test Tearing Strength of Geotextiles. When geotextiles are used on roads as anti-cracking cloth to prevent and control extension of reflection crack, the anti-tearing property has played an important role. The standard sample shall be selected and then an isosceles trapezoid shall be drawn in cloth with trapezoid sample plate to test anti-tearing property of geotextiles. Besides, the sample shall be held along both unparalleled sides of isosceles trapezoid.

| Table 2. Geotextiles physical parameter checklist |
|-----------------------------------------------|
| Mass deviation per unit area for monomer, %   | 3  |
| Thickness, mm                                 | 3.83 |
| Breaking strength, kN/m                       |     |
| Lateral                                       | 51.6 |
| Longitudinal                                  | 54.2 |
| Elongation at break, %                        |     |
| Lateral                                       | 84  |
| Longitudinal                                  | 68  |
| Tearing strength, kN                          |     |
| Lateral                                       | 1.65 |
| Longitudinal                                  | 1.28 |

2.2. Aging Test for Xenon Lamp
In consideration of durability of geotextiles, xenon lamp is applied to conduct aging test and simulate and accelerate influences of light and heat in nature on geotextiles. Actually, climate and environmental factors have influences on aging of geotextiles during application. At present, it has been known that spectral energy distribution of xenon arc lamp among artificial light sources is most similar to ultraviolet and visible light. Therefore, we have selected xenon lamp to conduct ageing test for geotextiles. When ageing test is conducted for xenon lamp, control for various factor variables shall be paid attention to and then breaking strength and retention rate of elongation at break for 500 hours shall be calculated. The breaking retention rate has been calculated as below:

\[
R_F = \frac{F_e}{F_c}
\]

Where, \( R_F \) refers to retention rate of strength for sample (%); \( F_e \) refers to breaking strength of sample (N); \( F_c \) refers to breaking strength of reference sample (N).

\[
R_\varepsilon = \frac{\varepsilon_e}{\varepsilon_c}
\]

Where, \( R_\varepsilon \) refers to retention rate of elongation (%); \( \varepsilon_e \) refers to breaking elongation of sample (mm); \( \varepsilon_c \) refers to breaking elongation of reference sample (mm).

| Table 3. 500 hours xenon lamp aging data |
|------------------------------------------|
| Retention rate for breaking strength, %  | Lateral 96 |
|                                          | Longitudinal 94 |
| Retention rate of elongation at break, % | Lateral 80 |
|                                          | Longitudinal 82 |

3. Measurement for Chemical Properties
From the view of current wide application of geotextiles, geotextiles are usually applied to strengthen roadbed, protect slope, coast and river embankment, control water and soil loss, and prevent leakage of landfill, hazardous wastes treatment plant and mineral tailing pond. The properties of solid and liquid wastes in different landfill are different and properties of mineral waste residue from various mines are different. Therefore, liquid waste from landfill and tailing pond has different acid and alkaline properties. For example, due to organic degradation, sanitary landfill usually generates a mass of acidic materials, resulting in acidic liquid waste. Due to application of strong alkaline sodium hydroxide as dissolution agent during smelting process for aluminium oxide for red mud tailing pond,
red mud and liquid waste show strong alkaline property. During road engineering application, due to mixture of various engineering application materials, different materials have various acid and alkali properties. Besides, pH is 10-12 for gold tailings and 1.5-4.5 for ardealite. During engineering application, different acid and alkali environment usually results in decline of physical and chemical properties of geotextiles to some extent. From the view of protection, strengthening, isolation, filtration and drainage for geotextiles, geotextiles shall directly contact with acid and alkali in soil or DO water solution. The geotextiles can resist erosion of such chemical substances, on the one hand, depending on composition, production technology, formed structure and current damage of raw materials, on the other hand, depending on composition of liquid and environmental conditions.

3.1. Acid and Alkali Resistant Property of Geotextiles
The acid-base property test shall be conducted for standard geotextile samples in accordance with related standards. The sulfuric acid with concentration of 10% and sodium hydroxide solution shall be prepared to soak for 168 hours. Then retention rate of breaking strength and elongation at break can be measured.

Table 4. Data sheet for acid and alkali resistance of Geotextiles

| Acid resistant property (10%, H₂SO₄, 168 hours) | Lateral | Longitudinal |
| Breaking strength, kN/m | 49.0 | 50.4 |
| Retention rate for breaking strength, % | Lateral 95 | Longitudinal 93 |
| Elongation at break, % | Lateral 79 | Longitudinal 65 |
| Retention rate of elongation at break, % | Lateral 94 | Longitudinal 95 |

| Alkali resistant property (10%, NaOH, 168 hours) | Lateral | Longitudinal |
| Breaking strength, kN/m | 47.0 | 49.9 |
| Retention rate for breaking strength, % | Lateral 91 | Longitudinal 92 |
| Elongation at break, % | Lateral 77 | Longitudinal 62 |
| Retention rate of elongation at break, % | Lateral 92 | Longitudinal 91 |

3.2. Influences of Monofilament Geotextile on Acid-base Properties
Due to weak polarity, low surface energy and bad hydrophilic performance of polypropylene, formed polypropylene monofilament shows excellent properties and acid and alkali resistant property can be understood through electron microscopy observation.
Figure 1. Surface structure display of geotextiles under electron microscope
According to electron microscopy observation for polypropylene filament geotextiles, polypropylene monofilament has smooth surface and strong hydrophobic property and no obvious roughness, which will be beneficial to flow of waste acid and alkaline liquid. Therefore, there is no obvious waste acid and alkaline liquid under acid and alkaline liquid environment, and acid and alkali resistant property for polypropylene geotextiles is greater than polyester geotextiles based on comparison with polyester filament geotextiles.

Figure 2. Electron microscope photographs of polyester filament Geotextiles
According to surface observation for monofilament of polyester filament geotextiles, surface distribution is small and raised, which is not beneficial to flow of waste acid and alkali liquid. Therefore, liquid locking capacity of polyester filament geotextile is stronger than polypropylene filament geotextiles, which is also one of acid and alkali resistant properties for polypropylene filament geotextiles.

3.3. Micro Exploration for Alkali Resistance of Polypropylene and Polyester
Due to national administration for strong corrosive solution, the polypropylene and polyester filament geotextiles are soaked in 100% strong alkaline solution for 180 days at normal temperature under current conditions for electron microscopy observation.
After 180 days for polypropylene geotextiles soaked in strong alkaline solution, according to surface corrosion of polypropylene monofilament through electron microscopy observation, strong alkaline solution has influences on polypropylene monofilament, but surface of monofilament remains to be complete and has no obvious corrosive characteristics.
After 180 days for polyester geotextiles soaked in strong alkaline solution, according to surface corrosion of polypropylene monofilament through electron microscopy observation, strong alkaline solution has influences on polyester monofilament, but surface of monofilament has been damaged and has obvious pit slot and corrosive characteristics.

4. Conclusions
Through exploration for engineering properties of polypropylene filament geotextiles, conclusions can be drawn as below:
Strong engineering application property and good tensile property; Excellent anti-ageing performance, over 90% retention rate for breaking strength and over 80% retention rate for elongation at break; Strong acid and alkali resistant property, excellent acid resistant property, over 90% retention rate for breaking strength of acid resistant property and over 60% retention rate for elongation at break; over 60% retention rate of elongation at break; over 90% retention rate of breaking strength and over 60% retention rate of elongation at break for alkali resistant property; According to electron microscope observation for polypropylene and polyester filament geotextiles, alkali resistant property for polypropylene geotextiles is greater than polyester geotextiles.

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