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Classification of geotextiles and analysis on tests for their tensile properties

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Abstract: Geotextiles are classified into various types which are Synthetic staple fibers needle-punched nonwoven geotextiles, Synthetic filament spunbond and needle-punched nonwoven geotextiles, Synthetic filament woven geotextiles, Slit and splitfilm yarn woven geotextiles, Plastic woven film yarn geotextile based on different weaving methods and property parameters. The applicability of wide-width strip method and narrow strip method for testing the tensile properties is compared and analyzed.

1. Introduction

Geotextiles are classified into various types which are Synthetic staple fibers needle-punched nonwoven geotextiles, Synthetic filament spunbond and needle-punched nonwoven geotextiles, Synthetic filament woven geotextiles, Slit and splitfilm yarn woven geotextiles, Plastic woven film yarn geotextile. And there are two main tensile property tests of geotextiles, "wide-width strip method" and "narrow strip method". To compare the applicability of "wide-width strip method" and "narrow strip method" to different types of geotextiles, a total of 15 groups of geotextile samples were selected from 5 kinds of geotextiles. Then, the applicability of different types of geotextiles to "wide-width strip method" and "narrow strip method" in tensile property testing is explored through comparative tests.

2. Classification of geotextiles

"Geotextiles" which is the material of permeable geosynthetics was first recorded by J.P.Giroud and J.Berfetti in 1977[1].Based on weaving process and performance parameters, geotextiles are classified into nonwoven geotextile and woven geotextile. Furthermore, non-woven geotextile is classified into Synthetic staple fibers needle-punched nonwoven geotextiles, Synthetic filament spunbond and needle-punched nonwoven geotextiles. While woven geotextile is classified into Synthetic filament woven geotextiles, Slit and splitfilm yarn woven geotextiles, Plastic woven film yarn geotextile.

3. Comparison of tensile properties tests

The followings are standards of tensile properties tests: GB/T15788-2017 *Geosynthetics—Wide-width tensile test* (hereinafter referred to as GB/T15788) issued by the Standardization Administration of China and GB/T 3923.1-2013 *Textiles—Tensile properties of fabrics—Part 1:Determination of maximum force and elongation at maximum force using the strip method(sample method)* (hereinafter referred to as GB/T 3923.1-2013) and JTG E50-2020 *Test Methods for Geosynthetics for Highway Engineering*(hereinafter referred to as JTGE50) and the water conservancy industry standard



SL235-2012 *Specification for test and measurement of geosynthetics* (hereinafter referred to as SL235) issued by the Ministry of Water Resources [2]. These three ministries standardized differently on adjusting temperature and humidity, adjusting time, sample width and stretching rate of samples in tensile test. However, there are two main tensile property tests of geotextiles, "wide-width strip method" and "narrow strip method".

The main difference between the "wide-width strip method" and "narrow strip method" test methods is the specimen width. To specify, samples for wide-width strip method are restricted in effective width of 200mm with the actual width of the fixture no less than 210mm while samples for narrow strip method are restricted in effective width 50mm with the actual width of the fixture no less than 60mm [3]. For spun geotextiles, sample width is restricted in 210mm or 60mm and then approximately the same amount of side yarn on both sides are deducted to 200mm or 50mm.

Among different methods and standards, there are different requirements on stretching rate, temperature and humidity of state adjustment and time, etc., and brief comparison is shown in Table 1 and Table 2.

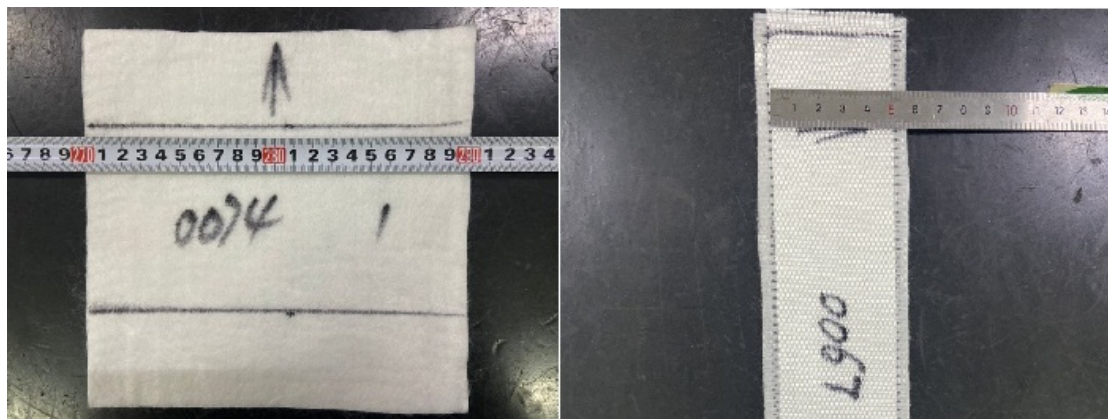


Figure 1 The wide-width stripsample of Synthetic filament spunbond and needle-punched nonwoven geotextiles and the narrow stripsample of Synthetic filament woven geotextiles

Table 1 Requirements for stretching rates in different standards

Tensile test method	Standard		
	GB/T 15788 or GB/T 3923.1	JTG E50	SL 235
wide-width strip method	20±5mm/min	20±1mm/min	20mm/min
narrow strip method	elongation rate at break < 8%:20mm/min ≥8%:100mm/min	/	20mm/min

"/" in the table indicates that there is no relevant content in the standard.

Table 2 Requirements for state adjustment in different standards

Tensile test method	Standard		
	GB/T 15788 or GB/T 3923.1	JTG E50	SL 235
wide-width strip method	Temperature: 20±2°C, Relative humidity: 65±4% Continuous weighing changes of less than 0.25% sample mass at an interval of 2h	Temperature: 20±2°C, Relative humidity: 65±5% Time: 24h	Temperature: 20±2°C Relative humidity: 60%±10% Time: 24h
narrow strip method	Temperature: 20±2°C, Relative humidity: 65±4% Time: ≥24h	Temperature: 20±2°C, Relative humidity: 65±5% Time: 24h	Temperature: 20±2°C Relative humidity: 60%±10% Time: 24h

4. Selection of test methods for tensile properties of geotextiles

Currently, the priortest for the properties of geotextiles used in hydraulic engineering is the standard SL235-2012 *Specification for test and measurement of geosynthetics* in which Chapter 10 introduces two methods of the tensile properties of geotextiles in detail, which is applicable to all kinds of geotextiles and sheet form. However, there is lack of applicability guidance of selection of methods for different types of geotextiles, therefore, it provide difficulties to performance tester when selecting the applicable test method according to the type of geotextile. This leads to some differences in the selection of test methods for tensile properties of geotextiles, which causes effect on the accuracy of test results.

To compare the applicability of "wide-width strip method" and "narrow strip method" to different types of geotextiles, a total of 15 groups of geotextile samples were selected from 5 kinds of geotextiles, including Synthetic staple fibers needle-punched nonwoven geotextiles, Synthetic filament spunbond and needle-punched nonwoven geotextiles, Synthetic filament woven geotextiles, Slit and splitfilm yarn woven geotextiles, Plastic woven film yarn geotextile. The "wide-width strip method" and "narrow strip method" were compared based on SL235-2012 *Specification for test and measurement of geosynthetics*.

We aim to find some rules through comparative tests to explore the applicability of different types of geotextiles to the "wide-width strip method" and "narrow strip method" in the tensile property test.

5. Comparison of test methods for tensile properties of Geotextiles

There are corresponding national standards (product standards) for five kinds of geotextiles, including Synthetic staple fibers needle-punched nonwoven geotextiles, Synthetic filament spunbond and needle-punched nonwoven geotextiles, Synthetic filament woven geotextiles, Slit and splitfilm yarn woven geotextiles, Plastic woven film yarn geotextile. The respective product standards are GB/t17638-2017 *Geosynthetics—Synthetic staple fibers needle-punched nonwoven geotextiles*, GB/t17639-2008 *Geosynthetics—Synthetic filament spunbond and needle-punched nonwoven geotextiles*, GB/t17640-2008 *Geosynthetics—Synthetic filament woven geotextiles*, GB/t17641-2017 *Geosynthetics—Slit and splitfilm yarn woven geotextiles*, and GB/t17690-1999 *Geosynthetics—Plastic woven film yarn geotextile*. As defined by product standard, the specifications of geotextile products are expressed by nominal breaking strength.

According to the performance index requirements of Geotextiles in the product standards, three common specifications with nominal breaking strength of 10kN/m, 20KN/m and 40kN/m are selected as representative samples for Synthetic staple fibers needle-punched nonwoven geotextiles, Synthetic filament spunbond and needle-punched nonwoven geotextiles. And three common specifications with nominal breaking strength of 50kN/m, 100kN/m and 160kN/m are selected as representative samples for Synthetic filament woven geotextiles, three common specifications with nominal breaking strength

of 50kN/m, 100kN/m and 180kN/m are selected as representative samples for Slit and splitfilm yarn woven geotextiles, and three common specifications with nominal breaking strength of 20-15kN/m, 50-35kN/m and 100-70kN/m are selected as representative samples for Plastic woven film yarn geotextile[4].

Therefore, a total of 15 groups of geotextile samples were tested by "wide-width strip method" and "narrow strip method" respectively according to SL235-2012 *Specification for test and measurement of geosynthetics*.



Figure 2 Comparison of test methods for tensile properties of Geotextiles

5.1. Results

Other variables were strictly controlled in the process of test, which are temperature, humidity and time of state adjustment. The test equipment is WDW-50 electronic universal testing machine produced by Jinhua Julong computer testing machine Co., Ltd. The maximum tensile force of 50kN which meets the Level 1 requirements. The tester is the same person, and the tensile rate is set at 20 mm / min. The test results are summarized in Table 3.

Table 3 Results of comparison

Group	Type of geotextiles	Specification / nominal Breaking strength (kN/m)	Tensile property			
			Longitudinal fracture strength (kN/m)		Transverse fracture strength (kN/m)	
			Wide-width strip method	Narrow strip method	Wide-width strip method	Narrow strip method
1	Synthetic staple fibers needle-punched nonwoven geotextiles	10	12.6	12.3	12.3	12.1
2		20	21.8	21.4	20.9	20.8
3		40	42.1	41.5	41.6	40.8
4	Synthetic filament spunbond and needle-punched nonwoven geotextiles	10	13.5	13.2	13.1	13.0
5		20	22.6	22.3	21.8	21.2
6		40	45.6	44.9	45.0	44.1

Group	Type of geotextiles	Specification / nominal Breaking strength (kN/m)	Tensile property			
			Longitudinal fracture strength (kN/m)		Transverse fracture strength (kN/m)	
			Wide-width strip method	Narrow strip method	Wide-width strip method	Narrow strip method
7	Synthetic filament woven geotextiles	50	54.6	56.2	40.8	42.5
8		100	105.8	115.6	79.8	86.6
9		160	149.5	164.5	105.6	115.8
10	Slit and splitfilmyarn woven geotextiles	50	55.9	53.2	51.6	49.8
11		100	106.8	110.2	98.5	102.5
12		180	185.6	196.8	178.9	186.5
13	Plastic woven film yarn geotextile	20-15	24.5	23.9	16.6	15.9
14		50-35	53.9	51.3	38.9	36.8
15		100-70	111.7	119.9	75.8	82.6

5.2. Comparison and analysis

(1) The results of "wide-width strip method" and "narrow strip method" for geotextiles with low nominal breaking strength are similar.

(2) The test results of non-woven geotextile with "wide-width strip method" are slightly higher than that with "narrow strip method".

(3) When the nominal breaking strength of the spun geotextile is 20kN/m and 50kN/m, the test result of the "wide-width strip method" is slightly higher than that of the "narrow strip method", but the test result of the "narrow strip method" is significantly higher than that of the "wide-width strip method" for the high strength spun geotextile.

(4) The difference in results between "narrow strip method" and "wide-width strip method" are significant for filament woven geotextiles.

6. Conclusion

Three conclusions are drawn based on the understanding of geotextile performance and comparative analysis.

(1) The nominal breaking strength of non-woven geotextiles is generally low, with maximum breaking strength of no more than 50kN/m. As uneven thickness is likely to appear in the weaving process, the "wide-width strip method" sample is more representative, which can reflect the true level of tensile properties of Geotextiles to the greatest extent. The breaking strength is slightly higher than the "narrow strip method". "Wide-width strip method" is recommended to test the tensile properties of non-woven geotextiles.

(2) For high-strength woven geotextiles, especially for those above 100kN/m, the "narrow strip method" is recommended to test the tensile properties of high-strength Woven Geotextiles for routine production inspection. This results from the fact that the maximum tensile force of the "wide-width strip method" sample is theoretically 4 times that of the "narrow strip method" sample, and in order to prevent slipping and wire drawing, it is necessary to clamp the serrated clamp, which is likely to damage the "wide-width strip method" sample, causing slipping and wire drawing after adding gasket unless the drum type wide-width strip clamp [5] is applied. However, the test efficiency of the drum type wide strip fixture is low.

(3) As Synthetic filament woven geotextiles is made from synthetic filament, it is likely to slide and draw compared to other materials. So "narrow strip method" is recommended to test the tensile properties of filament woven geotextiles.

The conclusions could be a reference for further hydraulic engineering project.

Fund project

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