Control of temperature and humidity in geosynthetics test

Airong Zheng*, Yuhang Fang
CCCI Tianjin Port Engineering Institute Ltd., Key Laboratory of Geotechnical Engineering, Ministry of Communications, PRC, Key Laboratory of Geotechnical Engineering of Tianjin, Tianjin, 300222, China, CCCC First Harbor Engineering Company Ltd., Tianjin, 300461, China
*Corresponding author’s e-mail: zhengairong@tpei.com

Abstract. The temperature and humidity of conditioning and test environment are one of the important factors affecting the test results of geosynthetics. The raw materials of geosynthetics are various, and the manufacturing processes are different, so the sensitivity to temperature and humidity is quite different. Determining reasonable temperature and humidity control requirements are of great significance to the quality control of geosynthetics. In order to grasp the status quo of temperature and humidity control in geosynthetics testing, a statistical analysis was carried out on the temperature and humidity control requirements in 55 geosynthetics tests and product standards, and the temperature and humidity control status of 29 laboratories were investigated.

1. Introduction
Geosynthetics is an engineering material made of synthetic polymers, such as plastics, chemical fibers, and synthetic rubbers. The history of geosynthetics is relatively short, and its development is inseparable from the development of synthetic materials. The earliest application record is that polyvinyl chloride film was used in swimming pool anti-seepage in the 1830s [1], and China began to use it in the 1960s. It has developed rapidly since the 1980s. Geosynthetics can be divided into geotextiles, geomembranes, geosynthetics and special geosynthetics. Compared with traditional engineering materials, it has excellent anti-seepage, drainage, filtration, isolation, reinforcement, protection and other properties, and is widely used in many fields such as water conservancy, transportation, environmental protection, etc., which is a very important engineering material [2].

In order to select suitable geosynthetics, it is necessary to test their engineering properties. There are many factors affecting the test results, such as material inhomogeneity, testers, instruments and equipment, methods, environment, management system, etc. [3]. In environmental factors, the influence of temperature and humidity on the test results, especially on the mechanical parameters, has always been the concern of the test personnel, but the research is less. There are two opinions on the state adjustment industry: one is that the temperature and humidity adjustment before the test has little influence on the test results; the other is that it has a certain influence on the test results, and this influence cannot be ignored [4]. In order to master the current situation of temperature and humidity control in geosynthetics test, the temperature and humidity control requirements in the current standards of geosynthetics were statistically analyzed, and the temperature and humidity control conditions of various types of laboratories were investigated. There are many testing standards for geosynthetics, and the requirements for the temperature and humidity of the test environment are...
different. The temperature and humidity control in the laboratory is also a difficult problem for testing and testing.

2. Temperature and humidity control requirements in the standard

The requirements of sample condition adjustment and test temperature and humidity in 55 current standards are counted, as shown in Table 1 and Table 2. These standards are divided into product standards and test standards [5]. Most of the product standards only point out the test standards used, and no longer stipulate the temperature and humidity. However, some of the standards stipulate the temperature and humidity control requirements. The test standard is the regulation of the whole process of the test, including the preparation and state adjustment of the sample, and the temperature and humidity conditions of the test.

Table 1. Requirements for temperature and humidity in standards

| Standard | Temperature and humidity control |
|----------|----------------------------------|
| GB/T 2918-2018: Plastics—Standard atmospheres for conditioning and testing | The recommended standard environment is 23°C/50% and 27°C/65%, the adjustment time is not less than 88H, the level 1 tolerance is ±1°C/±5%, and the level 2 tolerance is ±2°C/±10%. When the temperature and humidity have no significant effect on the performance, it can be adjusted at room temperature of (18 ~ 28) °C for not less than 4h. Unless otherwise specified, the test should be performed under the same environment or temperature as the condition adjustment, and the test should be performed immediately. |
| GB/T 6529-2008: Textiles—Standard atmospheres for conditioning and testing | Standard atmosphere is 20.0°C±2.0°C, 65.0%±4.0%; specific standard atmosphere is 23.0°C±2.0°C, 50.0%±4.0%. State balance standard is that weight change does not exceed 0.25% |
| SL 235-2012: Specification for test and measurement of geosynthetics | Under the condition of (20±2) °C and (60±10) %, the state is adjusted for 24h. If the sample is not affected by the environment, no state adjustment is required. |
| JTG E50-2006: Test Methods of Geosynthetics for Highway Engineering | Geotextile is adjusted for 24 hours at (20±2) °C and (65±5) %; plastic geosynthetics is adjusted for at least 4 hours at (23±2) °C. If the sample is not affected by the environment, no state adjustment is required. |
| JTS/T 232-2019: Testing Specification of Materials for Port and Waterway Engineering | The sample is conditioned at (20±2) °C and (60±10) % for 24h. The sealing film should be adjusted at (20±2) °C for not less than 24 hours. |
| GB/T 17643-2011: Geosynthetics—Polyethylene geomembrane | The standard environment is temperature (23±2) °C and relative humidity (50±10) %. The state adjustment time for arbitration is 4h, and the state adjustment time for non-arbitration is 1h. |
| GB/T 21825-2008: Glass fibre geogrid | Adjust for 24 hours under the standard atmospheric conditions specified in GB/T 6529. When the temperature and humidity have no significant effect on the performance, the sample cannot be adjusted. |
| GB/T 13762-2009: Geosynthetics—Test method for the determination of mass per unit area of geotextiles and geotextile-related products | The sample should be adjusted and tested under the conditions of (20±2) °C and (65±5) %. |
| GB/T 13761.1-2009: Geosynthetics—Determination of thickness at specified pressures—Part 1: Single layers | Condition the sample at (23±2) °C for at least 1h. |
| GB/T 14799-2005: Geotextiles and geotextile-related products—Determination of the effective opening size—Dry sieving method | Before the test, the sample should be kept at the set temperature for at least 12h with the temperature deviation of ±2°C. Before the tensile strength test, the sample is adjusted at (20±2) °C for at least 4h. |
| GB/T 6672-2001: Plastics film and sheeting—Determination of thickness by mechanical scanning | The test should be carried out at (23±2) °C. |
| GB/T 2854-2007: Creep testing and evaluating method on plastic geogrids | Before the mechanical test, the sample is adjusted at (20±2) °C for at least 24h. |
| GB/T 19470-2004: Geosynthetic—Plastic geonet | |
| GB/T 9647-2015: Thermoplastic pipes—Determination of ring stiffness | |
| GB/T 17689-2008: Geosynthetics—Determination of ring stiffness Plastic geogrids | |
Control of temperature and humidity in geosynthetics test includes two aspects, one is the temperature and humidity and time of state adjustment, the other is the temperature and humidity during the test. Textiles—Standard atmospheres for conditioning and testing (GB/T 2918-2018) and Plastics—Standard atmospheres for conditioning and testing (GB/T 6529-2008) are special procedures for standardizing the temperature and humidity conditions in the test, which are prepared with reference to ISO 291 and ISO 139 of the International Association for standardization respective. It can be seen from Table 1 and Table 2 that most of the other standards refer to these two standards, and the temperature is basically divided into $(23\pm 2) ^\circ C$ and $(20\pm 2) ^\circ C$; the humidity varies greatly, with tolerance of 4%, 5% and 10%. Most plastic products have no requirements for humidity. Moreover, more and more standards require that the temperature and humidity during the test should be the same as that under the condition adjustment.

It is worth mentioning that the state adjustment requirements of plastic geosynthetics in the revised version of Test Methods of Geosynthetics for Highway Engineering (JTG E50) are changed to that in the environment of $20 ^\circ C \pm 2 ^\circ C$ for not less than 4h, and the temperature is changed to be consistent with that of geotextiles.

Although most of the standards have temperature and humidity requirements, there are 12 standards that do not, including 4 national standards for hydraulic test, 1 industry standard for plastic drainage board test and 7 national product standards. Among them, 7 national product standards do not specify the temperature and humidity requirements, but the test standards cited by them have such requirements. In addition, there is no temperature and humidity requirement for some test items in the regulations in Table 1, and it is stipulated that temperature control may not be carried out when the temperature and humidity have little influence on the test results.

| GB/T 6529: Textiles—Standard atmospheres for conditioning and testing | GB/T 2918: Plastics—Standard atmospheres for conditioning and testing | JTG E50: Test Methods of Geosynthetics for Highway Engineering |
|---|---|---|
| GB/T 17630-1998: Geotextiles and geotextile-related products—Dynamic perforation test (Cone-drop test) | GB/T 1040.1-2018: Plastics—Determination of tensile properties—Part 1: General guidance | JT/T 480-2002: Geosynthetics in the traffic engineering—Geogrid |
| GB/T 17598-1998: Geotextiles and geotextile-related products—Determination of thickness of single layers of multilayer products | GB/T 1040.2-2006: Plastics—Determination of tensile properties—Part 2: Test conditions for moulding and extrusion plastics | JT/T 514-2004: Geosynthetics in highway engineering—Geonet and geomats |
| 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 | GB/T 1040.3-2006: Plastics—Determination of tensile properties—Part 3: Test conditions for films and sheets | JT/T 515-2004: Geosynthetics in highway engineering—Geosynthetic geolayers forms |
| GB/T 13763-2010: Geosynthetics—Determination of trapezoid tearing force | GB/T 16422.1-2019: Plastics—Methods of exposure to laboratory light sources—Part 1: General guidance | JT/T 518-2004: Geosynthetics in highway engineering—Geosynthetic geolayers forms |
| GB/T 14800-2010: Geosynthetics—Static puncture test (CBR test) | GB/T 11130-91: Test method for right-angle tear performance of plastics | JT/T 665-2006: Geosynthetics in highway engineering—Geosynthetic membranes |
| GB/T 16989-2013: Geosynthetics—Static puncture test (CBR test) | GB/T 17690-1999: Geosynthetics—Plastic woven film yarn geotextile | JT/T 605-2006: Geosynthetics in highway engineering—Plastic drainboard |
| GB/T 15788-2017: Geosynthetics—Tensile test for joints/seams by wide-width strip method | GB/T 18744-2002: Geosynthetics—Plastic three dimensional erosion control mat | |
| GB/T 17637-1998: Geotextiles and geotextile-related products—Determination of the tensile creep and creep rupture behaviour | GB/T 19274-2003: Geosynthetics—Plastic three dimensional erosion control mat | |
| GB/T 19976-2005: Textiles—Determination of bursting strength—Steel ball method | JT/T 669-2006: Geosynthetics in highway engineering—sort capability demand and test method of composite materials | |
3. **Questionnaire survey**

The ability of testing institutions has an important impact on the detection of geosynthetics. In order to analyze the current situation of temperature and humidity control of testing institutions, an anonymous questionnaire survey was conducted and 29 copies were distributed. The respondents came from the laboratories of production, construction, testing and scientific research institutions, with strong coverage.

The control measures of room temperature and humidity in the test are mainly divided into three categories: standard constant temperature and humidity, relatively independent temperature and humidity control, and temperature and humidity regulator control. As shown in Figure 1, the number of laboratories adopting temperature and humidity regulator and relatively independent control of temperature and humidity is 10, accounting for 34.5%. The standard constant temperature and humidity laboratory requires more expensive equipment, and 6 laboratories adopt it, accounting for 20.7%. Another 6.9% of the laboratories only use air conditioning for temperature control.

![Figure 1. Temperature and humidity control method.](image)

Most of the test procedures require that the samples should be cut after the state adjustment. However, due to the limited space of the state adjustment test chamber, some laboratories cut samples before the state adjustment, as shown in Figure 2, accounting for 41%, which means that there are a large number of laboratories cut samples before the state adjustment, ignoring the influence of the state adjustment on the sample size. Individual testing laboratories adopt the sequence of indoor state adjustment first, then sample cutting, and then state adjustment in the test chamber.

![Figure 2. Sequence of state adjustment and sample preparation.](image)
Respondents put forward the following suggestions for state adjustment and environmental requirements during the test:

1. Due to the different sensitivity of various materials to temperature and humidity, the temperature and humidity adjustment range of different materials should be considered;

2. There are many standards, and the requirements for temperature and humidity control are different. It is hoped that the requirements can be unified to facilitate the implementation of tests by testing agencies.

4. Conclusion and Suggestion

Based on the statistical analysis of the requirements of state adjustment and temperature and humidity during the test in the standard, and through the questionnaire on the current situation of temperature and humidity control in the test, it can be concluded that the provisions of temperature and humidity conditions in the test standards for geosynthetics are generally consistent, and the details are quite different. The equipment and methods of temperature and humidity control and sample preparation procedures of the test and testing unit are quite different.

The purpose of state adjustment and temperature and humidity control in the process of geosynthetics test is to make the specimen achieve state balance under a relatively stable temperature and humidity condition, so that the test results can reflect its real performance and make the test results comparable. As most of the standards of geosynthetics come from the textile industry and foreign standards, it is suggested that when formulating and revising the national and industrial standards, we should fully consider the national conditions, combine the characteristics and application environment of geosynthetics, and try to unify the temperature and humidity requirements of state adjustment and test.

References

[1] Staff, C.E. (1984) The Foundation and Growth of the Geomembrane Industry in the United States. Proc. of the Int. Conf. on Geomembranes. New York.

[2] Liu L.F., Chu C.Y. (2002) Development actualities and prospects on geosynthetics in China and abroad. Journal of Qingdao University, 17(2): 50-53.

[3] Yang M.C. (2005) Laboratory error analyses of geosynthetics. Hydro-science and Engineering, 3: 63-70.

[4] He T.W. (2011) Discussion on the problem of geotextile test in practical work. Transportation Science and Technology, 5: 86-88.

[5] Xu C., Ye M., Liang C. (2018) Comparative analysis of test standards for geosynthetics at home and abroad. Journal of Jiamusi University (Natural Science Edition), 36(5): 667-671.