Detailed Survey on Tensile and Static Puncture Strength of Non-Woven Fabrics

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Abstract- Non-woven fabrics are made by different methods such as adhesive bonded, needle punching, spun bonded, hydro entangle process, thermal bonding and stitch bonding. The use of needle punched non-woven fabrics has surged these years as they are extensively used in technical textiles. Also, the versatility of the needle punching process lies in the fact that it is the most suitable technique for producing fabrics from unspinnable fibres. Many publications and books contain valuable information on non-woven fabrics. Initially, polyester, viscose, polypropylene used, but later, jute, coir, sisal, banana and flax were used. The non-woven fabrics are successfully used in many technical applications rather than woven and knitted fabrics due to their simple production stages high efficiency of production, lower cost and disposability. In this paper, the detailed survey of tensile and static puncture strength of non-woven fabric has given.

Indexed Terms- Non-woven fabrics, tensile and static puncture strength.

I. INTRODUCTION

Non-Woven fabric is a fabric like material in sheet form made from staple fibres and long fibres bonded together by chemical, mechanical, heat or solvent treatment. Non-woven fabric manufacturing is one of the major fabrics producing techniques besides weaving and knitting. Non-woven fabrics generally find applications in the field other than apparel industry in which only woven and knitted fabrics are used. Several applications of non-woven fabrics range from baby diapers to industrial high-performance textiles. Non-woven are used as materials for building, thermal and sound insulating materials, hygiene and health care textiles, automotive industries, agro textiles, packing materials, aerospace applications and home furnishings.

II. STUDIES ON TENSILE STRENGTH OF NON-WOVEN FABRICS

The tensile strength of the needle punched non-woven fabrics, decides the durability of the fabric in its Geo-textile applications. Higher the tensile strength of the fabric, the better will be the load bearing capacity of such fabrics. Therefore, it is very important to study the tensile strength of non-woven fabrics to be used as Geo-textiles. ASTM D-4632 is the most commonly used test methods to study the tensile strength.

Rawal *et al.* (2006) have found that various civil engineering applications generally utilize needle punched non-woven as Geo-textiles. These Geo-textiles are expected to perform all functions like separation, drainage and filtration in most of the applications. They have studied the influence of feed rate, strokes frequency and depth of needle penetration on the properties of needle punched Geo-textiles. They have also developed on expert system which prescribes the properties of Geo-textiles for various applications.

Rawal *et al.* (2008) have studied the optimization of process parameters for the production of needle punched non-woven Geo-textiles. In order to impart the required functionality of Geo-textiles including drainage and reinforcement, dimensional and mechanical properties of fabrics are also important while producing non-woven fabrics. Dimensional properties like areal density and thickness and mechanical properties like puncture resistance, tensile strengths in the machine and cross direction of the needle punched non-woven Geo-textiles have been studied with respect to the process parameters like punch density, depth of needle penetration and web area density. The multiple regression technique was used for the above study.

Indu and Senthilkumar (2016) have studied the possibilities of producing low-cost light weight doors using sisal and sisal coir blended needle punched non-woven. They found that the tensile strength values were 576 MPa and 177 MPa for sisal and coir fibres. The thermal resistance of 70/30 sisal coir blend was higher than those of other blends. Air permeability and sound absorption were also more in the above fabric. They concluded that for producing light weight low-cost doors 30/70 sisal and coir blend were more suitable.

Fangueiro *et al.* (2011) have studied the effect of areal mass of non-woven on their mechanical properties. As the areal mass of non-woven increased the tensile strength and puncture resistance also increased while the perforation diameter decreased. They also studied the use of a woven fabric as second layer along with non-woven fabrics. These fabrics showed a better effect on the mechanical properties.

Zornberg (2015) has studied the mechanism of individual function of geo synthetics which would contribute to the better performance of roadways.

Midha and Mukhopadyay (2005) have made a comprehensive review on the bulk and physical properties of needle punched non-woven fabrics. These properties were found to be dependent on the nature of the fibre used and the way in which the fibres are arranged in the structure. Greater the fabric strength would result with the use of longer and finer fibre in the web, fibre consolidation was improved with the increase in needle density and penetration. If any special functionalities were required, finishing operation needed to be given.

Rakshik *et al.* (1990) have studied the physical properties of needle punched non-woven fabrics produced from polyester and polypropylene fibres. They also studied the effect of machine and process parameters on the physical properties. The bulk density increased with the increase in depth of needle penetration and punch density. Subsequently compactness of the fabric also increases, which would result in decrease of air and water permeabilities of the fabrics. As the punch density and depth of needle penetration increased bursting strength and cone puncture resistance decreased.

Dias *et al.* (2017) have studied the mechanical and abrasion resistance of non-woven Geo-textile. They subjected the non-woven polypropylene Geo-textile to mechanical damage, abrasion and successive mechanical damage and abrasion. Tensile, tearing and static puncture test were used to evaluate the damage. It was found that more reduction in mechanical strength of the Geo-textile has been experienced by the successive exposure to both degradation tests.

Rawal *et al.* (2013) have compared wide-width tensile strength to its axis-symmetric tensile strength of hybrid needle punched non-woven Geo-textile. Axis-symmetric loading on Geo-textile may also result due to concentrated forces perpendicular to the plane of Geo-textile. They have formulated one model for axis- symmetric tensile strength of anisotropic hybrid needle punched non-woven Geo-textile. The theoretical and experimental results of axis-symmetric tensile strength of hybrid needle punched non-woven fabric showed a good correlation.

Hearle *et al.* (1968) have studied the effect of process parameters on the structure and properties of needle punched non-woven fabric. They have taken into account the amount of needling, needle penetration, and the number of passes, the needle arrangement and the shape of holes in the study. They found that the stability of the fabric increased with the increase in the amount of needling and the depth of needle penetration.

Hearle *et al.* (1974) have studied the influence of depth of needle penetration on the needled fabric mechanical and tensile properties. If needles with three barbs with a depth of needle penetration adjusted, it resulted in obtaining the maximum fabric strength.

Wang (2001) developed a tensile test for Geo-textile with confining pressure. He developed a test device and a special test method for this purpose. The specimen was placed between two air tight aluminium chambers covered with flexible rubber membranes. The specimen was pressurized under this condition and tested. He installed this confining pressure equipment along with instron and studied the tensile behaviour of Geo-textile. He observed a significant increase in tensile stiffness at 9.02 to 9.7 K Paconfinements.

III. STUDIES ON STATIC PUNCTURE STRENGTH OF NON-WOVEN FABRICS

Oloo *et al.* (1997) have designed a procedure to determine the ultimate loads in the layered system in low volume rolls. The stress and strain as per elastic layer theory depend on elastic modulus and Poisson ratio. He worked on bearing capacity in two-layer soils of unpaved roads. The shear strength and unit weight of both the base layers and the subgrade of unpaved roads are affected by the thickness of the base layer. Traffic loading has got an upper limit for every given base and subgrade properties. Even if the base layer thickness increases beyond this upper limit of traffic loading, the bearing capacity would not increase.

Som and Sahu (1999) have investigated a bearing capacity of a Geo-textile reinforced unpaved role as a function of deformation. The test bed was used to measure the vertical stresses at subgrade. The authors proposed a low transfer mechanism in explaining the improved bearing capacity of Geo-textile reinforcement soil models.

Senthilkumar and Pandiammal Devi (2011) have studied the effect of coir and jute needle punched non-woven fabric on the CBR strength of soft subgrade. They studied the utilization of these non-woven fabrics for unpaved roads over a soft subgrade. The effect of natural Geo-textile on the soft subgrade has been studied by conducting a CBR test on this Geo-textile. The CBR strength for jute Geo-textile was found to be better than the coir fibre.

Senthilkumar and Rajkumar (2012) studied the performance of woven and non-woven textile using subgrade and unpaved flexible pavement systems. The performance of the road was found to improve with the usage of woven and non-woven Geo-textile.

The puncture resistance of polyester and polypropylene needle punched non-woven Geo-textile has been studied by Koerner and Koerner (2011). Non-woven Geo-textile protect the vehicles from getting punctured by driving on objects like gravels and stones. The above authors tried to compare polyester and polypropylene in this aspect. Three different sized and shaped puncture probes were used and ASTM standards D4833, D5495 and D6241 by them.

Askari *et al.* (2012) studied the effect of test speed and fabric weight on the puncture behavior of needle punched non-woven Geo-textile. They used five speeds to conduct the test. Puncture test was carried out at 300 mm per minute speed. The results were analysed using ANOVA.

Sarma *et al.* (2013) constructed a road in Assam and studied the CBR properties of soil reinforcement with jute Geo-textiles. This work concentrated on engineering properties of soil. The study determined the design thickness of the pavement to be 275mm based on the CBR values of the soil reinforced with jute Geo-textile.

Hsieh *et al.* (2008) studied the influence of clamping mechanism on the puncture resistance test of Geo-textile. The hydraulic clamping mechanism was used to modify the conventional apparatus. Using this clamping apparatus has increased the performance and 20 to 25 minutes of time was saved compared to conventional apparatus.

Van Dyke (2014). The author has conducted CBR and pin puncture strength on various categories of Geo-textiles. ASTMD 4833 and ASTM D6241 were used in the testing. The correlation between CBR and pin puncture strength values were arrived using statistical tools.

Narejo *et al.* (1996) studied the puncture protection of geo membrane. In designing the barrier material, the type, thickness and properties of the protective material were very significant. In another part of research, they focused on giving a comparative analyze of the puncture resistance performance of different of types of protection materials used in geo membrane.

Avinash and Kumar (2017) have discussed the application of the Geo-textile to improve the Californic Bearing Ratio value of the sub grade. The importance of optimum percentage of fibres and the optimum size of Geo-textile is highlighted.

CONCLUSION

The detailed survey shows that how the polyester and viscose non-woven fabrics have been tested for tensile properties. And also, static puncture strength of polypropylene, polyester and viscose blends have been studied. Static puncture strength is a critical property for making the fabric suitable for Geo-textile applications.

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