

Influence of Fibreglass Percentage on the Tensile Strength of Fibreglass-Polyester (Hybrid) Nonwoven Paving Mats

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Abstract: Paved roads will continue to play a critical role with our growing transportation needs. Pavement reinforcement in highway construction gives extra life to roads. Increasing concern over road safety issues has led to the use of polymers-based road surface materials which make a significant contribution in improving pavement performance while reducing maintenance cost. One such application to reinforce the pavement section is use of hybrid fibreglass-polyester (FGP) nonwoven paving mats. In this study, experimental work is performed in laboratory to know the influence of fibreglass percentage on tensile strength of hybrid FGP nonwoven paving mats. Paving mats with varying fibreglass percentage i.e., 0% (control sample), 15 %, 30 %, 45% and 60 % are selected for laboratory tensile test and elongation. The results showed that with an increase in glass fibre percentage upto 60 % by weight leads to an improvement in the tensile strength.

Index Terms - Paving mat, tensile strength, fibreglass, polyester

1. INTRODUCTION

Pavement is a fundamental transportation infrastructure system with the main purpose of sustaining vehicular traffic. Common construction materials for pavement systems include soil, aggregates, concrete and asphalt. Due to repeated traffic and/or environmental loads, pavement undergoes a process of deterioration. Its longevity can be cut short due to both poor construction technique and poor surface preparation or aging and long term exposure to the natural elements. Pavement deterioration, if unchecked, gives rise to problems in two principal areas – safety and economics. The pavement degradation leads to slower travelling speeds, increased consumption and less efficient transportation of goods. This may cause significant costs to the economy of a region or a country. Also, the process of deterioration cause massive maintenance costs for road authorities. The rehabilitation or the reconstruction solutions are time consuming and may lead to important problems in traffic infrastructure. Geosynthetic interlayer's are able to contribute to the strength of the pavement system. The benefits of using them are economical rehabilitation and delay in reflective cracks which lead to long lasting road network (Leibniz, et al., 2015).

Most plastic resins are not suitable for structural applications. Although many resins are extremely tough, most lack strength, stiffness, and deform under load with time. By mixing strong, stiff, fibrous materials into the plastic matrix, variety of structural composite materials can be formed. The properties of these composites can be tailored by fibre selection, orientation, and other factors to suit specific applications. Glass fibres are brittle, but in drawing very thin fibres (with a diameter of several microns) from molten glass, a fibrous material is obtained, having flexibility sufficient for textile processing and utilization as a finished product. In general, textile glass fibres have a high tenacity at a low elongation combined with extremely low density. This results in favorable tenacity or modulus values relative to their weight.

One of the forms of polymeric textile and glass fibres is hybrid fibreglass-polyester (FGP) nonwoven paving mat. It is also called paving mat, produced from the mixture of high strength glass fibres and polyester fibres to enhance the performance of asphalt pavement. After mixing the two fibres together, the paving mat keeps good features of both fibers and minimizes shortcomings of both fibers. The continuous glass fibres mesh, coated in elastomeric polymer and embedded between polyester mat and fibreglass mat is the key to its performance, the bottom side of fibreglass mat minimized the mat shrinkage during the overlay process, the polyester mat on the up side minimized the possibility of the paving mat to be punctured by some sharp object, as this material being reinforced by fibreglass mesh. The hybrid paving mats have low elongation and high tensile strength to reinforce the asphalt pavement section, these features extends the life of pavement overlays through the delay in reflective cracking. Paved roads built with paving mats are smarter and enhances the performance of pavement through the following function as shown in Table 1.

Yi Chaojue and Zhai Pengcheng (2012) summarized the characteristics of fibreglass-polyester paving mat. Based on the forming mechanism of cracks, article describes the engineering application of fibreglass- polyester paving mat in the prevention of reflection crack of bituminous pavement. Application of fibreglass-polyester paving mat in waterproofing of the paving layer in tunnels and cohesive layer on bridge deck has also been covered.

Wazery M.S. et al. (2017) carried out laboratory test on glass reinforced polyester composite fabricated in house by using hand lay-up technique keeping different glass fibre percentage from 15 to 60 % by weight. The results showed that mechanical properties like tensile strength, flexural strength and impact energy has been improved by a great extent with the increasing percentage of glass fibre by weight up to 60 %.

Table 1. Functions of Hybrid Fibreglass-Polyester (FGP) nonwoven paving mat

Sr. No	Function	Description
1	Retards reflective cracking	The fibre glass structure of paving mats provide significantly greater tensile strength at low strain compared to conventional paving fabrics. The higher strength at low strain helps extend pavement life by delaying reflective cracking which is a common contributor to costly repairs and the eventual failure of asphalt applications.
2	Effective moisture Barrier	The non-woven matrix structure of paving mats allows for the asphalt binder to penetrate and fill voids within the fabric to limit moisture infiltration into the pavement structure. Preventing water ingress into the lower layers of a pavement structure is critical to preserve the integrity and long-term performance of the pavement section. Even in the harsh environment, fibre glass paving mats will provide significant improvement to the service life of the road.
3	Thermal Stability	Paving mats has high temperature stability. Their melting point is over 230 °C. Due to the ability of the fibre glass matrix to resist asphalt's high application temperature, paving mat will not shrink or change dimensions when hot mix asphalt of 170 °C comes into contact with them. This feature eliminates the risk of premature slippage or loss of bond.
4	Improves fatigue resistance in flexible pavements	High tensile strength improves flexural pavement performance under loading and reduce rutting
5	More Robust than Conventional Paving Fabrics	The additional stiffness of Glass fibre Paving Mats, compared to conventional paving fabrics, makes them more durable and less prone to on-site installation damage.

2. EXPERIMENTAL WORK

An experimental work is performed in laboratory to understand the influence of fibreglass percentage on tensile strength and elongation of hybrid fibreglass-polyester (FGP) nonwoven paving mats. The mechanical properties (i.e., tensile strength and elongation) discussed here are very important in applications where hybrid FGP nonwoven paving mats are required to perform a structural role, or it is required to survive installation damage and stresses mobilized from applied loads.

2.1 Materials

Paving mat made up of nonwoven paving polyester fabric and high strength continuous glass fibres, coated in an elastomeric polymer and embedded between polyester mats are taken for study. Paving mats having similar mass per unit area in the range of 139 gm/m² and having varying percentage of fibreglass by weight i.e., 0%, 15 %, 30 %, 45% and 60 % are selected for laboratory tensile test and elongation.

2.2 Testing Machine

Universal tensile testing machine (UTM) of FIE make of constant rate of extension (CRE) type and having accuracy $\pm 1\%$ was used. The machine is equipped with recording and display panel and a printer. The machine is capable of providing constant test speed, recording force and displacement reading. It has facility of cross head which can move in upward and downward direction as per the requirement of test. This machine can be assembled with various jaws and fixtures to perform test like wide width tensile strength, trapezoidal tear, static CBR Puncture test etc. at a specified rate of extension. Figure 1 shows narrow strip jaws and fixtures assembled in UTM and a recording panel.



Fig. 1. Narrow strip jaws and fixtures assembled in UTM and a recording panel

2.3 Tests and Methods

In order to investigate the mechanical properties of FGP nonwoven paving mats, strip tensile test were conducted in the laboratory according to ASTM D 5035 and ASTM D 7239 method. In this test method breaking force and elongation of nonwoven fabrics is assessed using narrow cut strips of specimen of size 250 mm (length) x 50 mm (width) and gauge length of 180 mm between jaw faces as shown in Fig. 2. The jaw faces must be sufficiently wide to grip the entire width of the samples. Upper and lower jaws are assembled in the UTM as shown in Fig.1. Upper jaw is supported by a free swivel which allows the clamp to rotate in the plane of fabric. A test specimen is clamped in a UTM and longitudinal force is applied at a speed of 50 mm/min until the specimen breaks to determine the breaking force and elongation. Average of the breaking force and elongation is calculated for all acceptable specimens. The clamps and jaw faces with the specimen during the test is shown in Fig.2.



Fig. 2. Clamps and jaws faces and specimen during testing

3. TEST RESULTS AND DISCUSSION

Strip tensile test were conducted in the laboratory for FGP nonwoven paving mats with varying percentage of glass fibre i.e., 0% (control sample), 15 %, 30 %, 45% and 60 %. It was found from the figure 3, the tensile strength increased from 199.9 N to 550 N with the maximum tensile strength being for the paving mat with 60 % glass fibre by weight. From the figure 4, elongation varies from 47 % to 3.2 % with the variation in glass fibre percentage from 0 % to 60 % by weight. Elongation property at 60 % glass fibre is 3.2 %, showing higher modulus which gives resistance to damage during and after installation of paving mat.

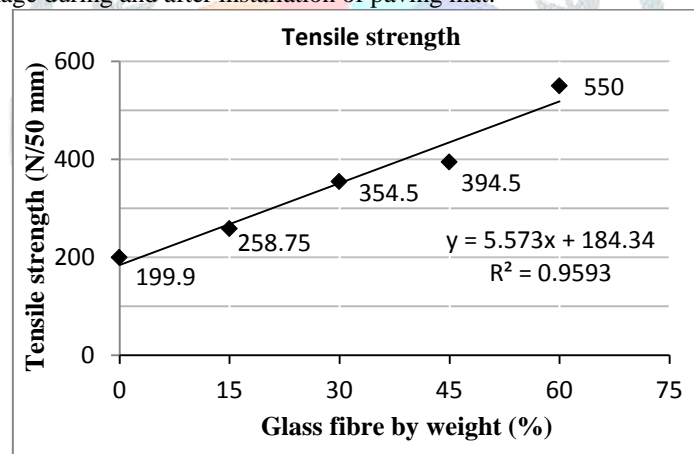


Fig. 3. Strip tensile strength of paving mats with varying percentage of glass fibers

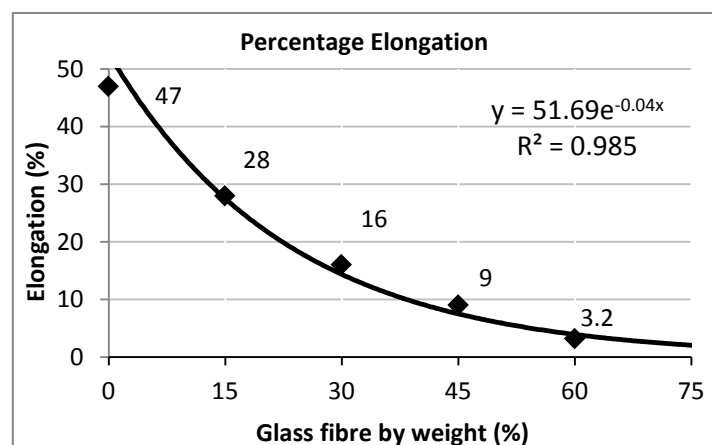


Fig. 4. Percentage elongation of paving mats with varying percentage of glass fibers

Results obtained from the test shows that with an increase in percentage of fibre glass by weight up to 60 % there is an increase in tensile strength while the elongation property decreases. Increase in tensile strength may be due to optimum amount of glass fibres percentage placed in the web. Higher amount of glass fibres leads to brittleness of the materials and loosening of interfacial bond between the matrix reinforcement and will not suffice the purpose of reinforcing the pavement. A 60 % glass fibre by weight in mat gives the optimum combination of fibre glass and non woven paving polyester which leads to an improvement in the tensile strength and elongation less than 5 %.

4. CONCLUSION

In this study, effect of increase in percentage of fibre glass by weight has been studied for FGP nonwoven paving mats. Tensile strength has been improved by a great extent with the increase of fibre glass by weight upto 60 %, while the elongation property decreases with the increase in fibre glass percentage by weight. The results obtained demonstrate improvement in the mechanical properties with the increase of fibre glass by weight upto 60 %. The results show that FGP nonwoven paving mats ensures best performance at 60 % glass fibres by weight. The presented results can be helpful when it comes to choosing a good quality of materials.

FGP nonwoven paving mats has a feature of high strength, low elongation, good compatibility with bitumen, resistance to high temperature and corrosiveness. It can be placed within a bituminous pavement system during new construction, rehabilitation or surface treatment. These interlayer's can help pavement surface last longer, provide a smoother ride throughout the life of the pavement by delaying reflective cracking and require less maintenance in the future.

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