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Material Study Of Linear Low-Density Polyethylene (Lldpe) For The Application Of Geotube Structurer

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Abstract My Flexitank Industries Sdn Bhd (MYF) is proposing a new Geotube material composed of Linear Low-density Polyethylene (LLDPE) to be tested for its suitability as a non-dewatering Geotube substitute for the conventional dewatering method. The aim of the study is to determine if LLDPE is suitable to increase the Geotube's durability by testing its tensile strength and water permeability. The research will use the Universal Tensile Machine to evaluate mechanical properties. The result of high tensile strength upon the testing will create a LLDPE bag with a tubular shape by double-sealing the edges of the LLDPE sheet to imitate the Geotube structure and withstand wave impact along the shoreline. Throughout this research, the yield strength, and the stress at maximum load value of the sealed LLDPE sheet portrayed a great value in which can conclude that the sealed LLDPE sheets can be use as the non-dewatering Geotube structurer. The research will focus on testing the seal's tensile strength and water permeability properties to improve MYF Industries' future operations.

Keywords: Geotube, Linear Low-Density Polyethylene, Non-dewatering

1. Introduction

Geotube structure is a low-cost and basic geobag used for sludge dewatering operations. Fast production, lightweight shipping, and a relatively simple building process are all advantages of structures made of compact, high-tensile-strength geosynthetics; strength and reliability can be chosen according to the goal. This Geotube has been used for shoreline protection, land reclamation, island development, wetlands creation, building platforms, revetments, dykes, groynes, and offshore structures to produce an artificial coastal structure like a breakwater, dune, or levee [1]. It is a well-built system that can be customized and manufactured utilizing modern textile technology. My Flexitank Industries Sdn Bhd (MYF) recently proposed a new Geotube material to be used, Linear Low-Density Polyethylene (LLDPE), which allows for the use of non-dewatering Geotube technology in Malaysia.

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Linear Low-Density Polyethylene (LLDPE) is a type of inexpensive polymers that is broadly used and have favourable mechanical and chemical properties. Physically, LLDPE is semi-rigid and translucent milky-coloured material which can easily be process by most methods from granules shape to any types of manufacturing usage. LLDPE has a density between the range of 0.941 to 0.965g/cm3 [4], which makes it a great choice for molding and shaping processes in manufacturing industries. The manufacturing of LLDPE varies in grades with different properties which corresponds to its wide application requirements. Hence, LLDPE was chosen to portray as a great substitute material for the non-dewatering method of Geotubes in Malaysia by applying the heat seal to the material to avoid water escape and strengthen the tube.

LLDPE sheets are sealed into enormous tubular-shaped bags using the heat-sealing technique to create the non-dewatering geotubes. Due to its softness, flexibility, and ease of shaping, LLDPE is a good material for sealing. An earlier study suggested double-sealing the LLDPE tubes to enable a more secure structure and prevent sludge leakage from the newly developed LLDPE Geotubes. The LLDPE tubes are positioned in the desired location, loaded with sludge through an opening port, and then sealed when the sludge has been added. The non-dewatering technique Geotubes material selection comprises of a material that primarily satisfies a few mechanical and physical criteria. To accommodate the non-dewatering concept, a low permeability material is required to prevent water from entering and going out through the Geotubes. As a result, the non-dewatering method Geotubes is used in conjunction with plastic film; Linear Low-Density Polyethylene (LLDPE).

Non-dewatering, as stated by its name, is a method that suggests the application of low water permeability materials to the Geotube structure, that stops the water to go in or out of the Geotube. This technology eliminates the need for dewatering after installing Geotubes in application areas, saving time and ensuring robust, long-lasting Geotubes that replicates the Geotube structure that is suitable to be placed along the shoreline to withstand the wave impact and to be used in a long term. It is best to identify the best sealing method to allow a higher durability of Geotube bag. The bag will be filled with sludge to get a maintained Geotube shape [3]. The pros difference between the non-dewatering and the dewatering method of the Geotube is the time-effectiveness of the sludge filling process and low-cost properties, besides an easy access resource rather than the dewatering geotextile technology.

In order to meet the requirements of the Geotube technology, it is necessary to conduct a study on the Linear Low-Density Polyethylene (LLDPE) material as to whether it portrays as a good Geotube structurer of the non-dewatering method based on its mechanical properties, such as high tensile strength with low permeability properties. A few tests must be conducted to demonstrate the Geotube's suitability for MYF Industries Sdn Bhd's future activities in terms of the seal tensile strength of the seal and its water permeability features.

2. Methodology

The purpose of the project is to fabricate a sample Geotube Structure and establish whether the LLDPE material from MYF is suitable for usage as a new material for Geotube structures. The seal tensile test and the water permeability test were the two physical tests used to determine whether the linear low-density polyethylene (LLDPE) material was suitable for use as a Geotube structurer. Physical tests were utilized to assess the tensile strength and water permeability of the Geotube samples' mechanical properties. The tests were carried out in Engineering Laboratory, UTHM, and Pagoh Residential College.

2.1 Materials

In this study, Linear Low-Density Polyethylene (LLDPE) plastics from My Flexitank Industries Sdn. Bhd. with a thickness of 0.3mm were used as samples to study the maximum capability of LLDPE material. The highest suitability and durability to replace the current material of the existing Geotube. LLDPE material is physically translucent and have natural milky color. The LLDPE samples have the

same physical properties where the surface is non-porous, which means the material has low water permeability properties compared to the existing woven Geotube material.

2.2 Seal Tensile Test

Sample for the seal tensile test are fabricated by cutting into a standard measurement specified in the ASTM D882 guide, which is 25mm wide by 100 mm long with an overlap and double seal gap of 0.5cm. The specimens are clamped into machine grips and jaws with a gauge length of 800mm, where they are dragged or stretched until the material reaches a specified elongation or failure point with a speed of 100mm/min as a constant variable to test the double heat-seal LLDPE durability. This tensile testing is done to gauge the strength, yield strength, and stress at maximum load of the material. This research aims to find a material that is suitable for a long-term use and can withstand the harsh conditions in coastal areas.

Figure 1: Seal Tensile Test

2.3 Water Permeability Test

The experiment described involves using LLDPE samples with a measurement of 20 cm width and 35 cm length sealed with a step seal machine, filled with water, and left in the sun for a lengthy period straight. The fabrication of sample will apply the double sealing technique. The weight of the samples is then measured daily to determine the water permeability properties of the material. If the material has low permeability, the weight of the sample is expected to decrease or remain constant. If the material has high permeability, the weight of the sample is expected to decrease dramatically.

Figure 2: Water Permeability Test

3. Results and Discussion

The results and discussion section presents data and analysis of the study. This section discusses the data and result that is obtained from the physical experiments; seal tensile test and water permeability test, that will be conducted along the period of completing this final year project. After the Linear Low-density Polyethylene (LLDPE) samples preparation and sealing process were completed, the tests were conducted in the Engineering Laboratory, UTHM. The period of the tests varies according to its result collection.

3.1 Seal Tensile Test Result

The result of the Seal tensile test for 3 LLDPE fabricated samples were extracted and are shown in Table 1.

Table 1: Seal Tensile Test of LLDPE

Properties	Sample 1	Sample 2	Sample 3
Maximum Load (N)	91.668	89.608	84.229
Deflection at Maximum Load (mm)	47.275	50.908	172.525
Stress at Maximum Load (MPa)	0.0367	0.036	0.0337
Percentage Strain at Maximum Load	59.094	63.635	215.656
Work to Maximum Load (J)	3.992	4.176	13.089
Stiffness (N/mm)	34.120	34.773	28.758
Young's Modulus (MPa)	1.092	1.113	0.920
Load at Break (N)	87.598	84.682	71.493
Deflection at Break (mm)	197.125	119.658	199.372
Stress at Break (MPa)	0.035	0.0339	0.0286
Percentage Strain at Break	249.215	149.573	249.215
Work at Break (J)	17.205	10.116	15.259

Based on the result obtained, a stress-strain graph was computed to allow a better data comparison of the three samples.

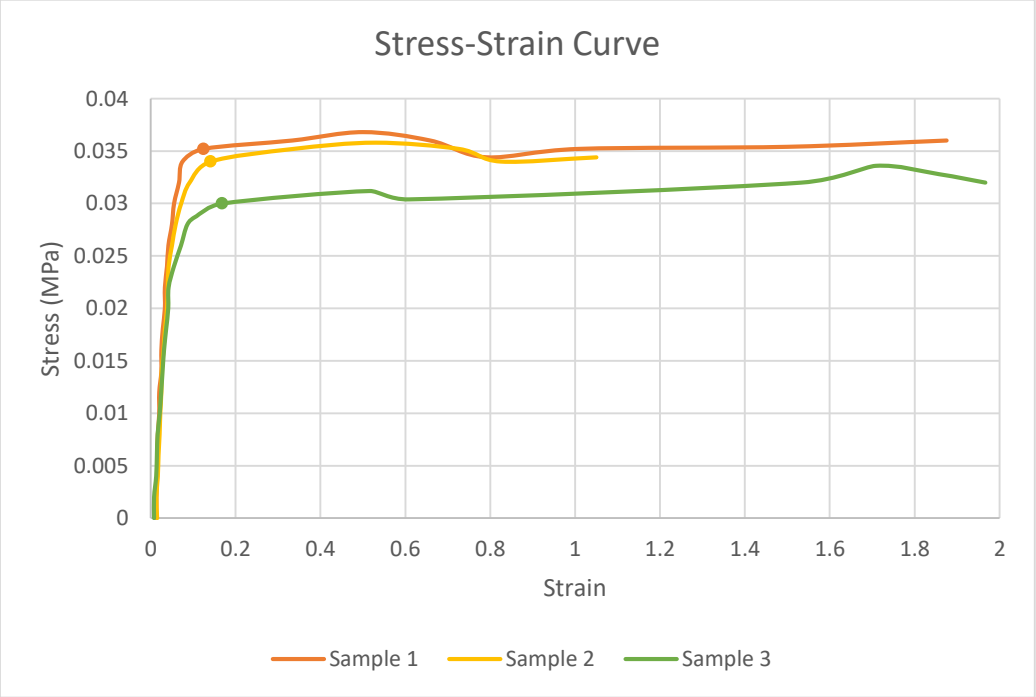

Figure 3: Stress-strain curve of LLDPE Seal Tensile Test

In general, the sealed LLDPE can withstand a great load, with an average of 88.49 N. The stress-strain curve shown in the research indicates that the yield point of the samples ranges from 0.075 to 0.168. Yield strength is a measure of the stress at which a material begins to deform plastically or permanently [5]. It is a key mechanical property of materials, particularly metals, and is often used in design calculations. The yield strength of a plastic material is the maximum stress that it can withstand without permanent deformation. In this research, it was found that the LLDPE Geotube sample sealing section can withstand up to an average of 0.03428 MPa of stress at maximum before it fails. In the context of a Geotube, the maximum load is the highest amount of stress that the Geotube material can withstand before it breaks or bursts. Finding the highest stress at maximum load is crucial to avoid any damage during its construction and for a prolonged placement along the shorelines. It is important to note that the maximum load is a critical factor to consider when selecting a Geotube material as it needs to be able to withstand the specific loads and stresses that it will be subjected to in its intended application [4]. The maximum load is also related to the yield strength and tensile strength of the material that is selected to make the Geotube. The research concludes that the double sealed method in this study provides a high strength of the sealed LLDPE which can be applied as the Geotube structure to provide higher durability to withstand pressure in Malaysian coastal areas and does not rupture easily when pressure is applied.

3.2 Water Permeability Result

The experiment was conducted in the Pagoh Residential College for 42 days straight. The samples were let out to dry under direct sunlight to test the permeability rate of the double-sealing method to the samples. The mass of the samples was weighed daily to obtain the permeability result. Table 2 shows the summarized data obtained from the conducted permeability test of the sealed samples every 7 days.

Table 2: Permeability Test weekly result

Date	Mass (kg)		
	Sample 1	Sample 2	Sample 3
24 November 2022	3.580	3.101	3.101
30 November 2022	3.580	3.101	3.101
7 December 2022	3.577	3.101	3.101
14 December 2022	3.575	3.101	3.098
21 December 2022	3.574	3.102	3.097
28 December 2022	-	3.101	3.097
4 January 2023	-	3.101	3.097

According to table 4.1, the samples' initial weights were determined on November 24, 2022, and they were 3.58 kg, 3.101 kg, and 3.101 kg, respectively, after the water filling procedure. Due to a sealing fault where water spilled out of the tube hole, the initial masses of each sample differ somewhat from one another. In comparison to samples 2 and 3, sample 1 findings show the most mass reduction change overall. Figure 4 allows for the observation of the data.

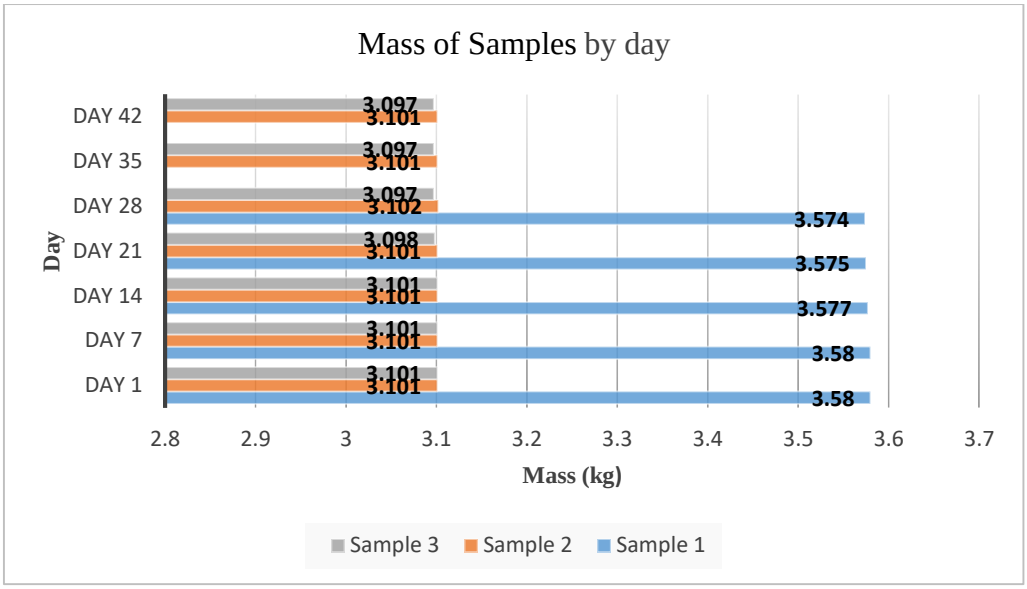

Figure 4: Graph of weekly Mass changes of Permeability Test

The permeability test was conducted to measure the water permeability of a heat-sealed low-density polyethylene (LLDPE) material. Sample 1 was found to have the highest changes in mass, decreasing by 60g over a period of 28 days due to a minor leak caused by an improperly closed seal. Samples 2 and 3 had consistent mass for two weeks, with a small increase on day 28 and a modest decrease of 4g for sample 3 respectively. The results suggest that the heat-sealing double-seal method was effective in reducing leakage and ensuring the bags remained dry after 42 days of exposure to sunlight. However, it is important to carefully control the temperature, duration, and pressure of the sealing process to achieve a heat seal with low water permeability and improve the seal strength and quality by finding the optimal sealing time for a given application.

4. Conclusion

In conclusion, this research aimed to develop a non-dewatering method of Geotube by studying the suitability of the Linear Low-Density Polyethylene (LLDPE) material suggested by My Flexitank Industries Sdn Bhd. The study found that the LLDPE material with double-sealing method can be used as the non-dewatering Geotube method due to its low chance of permeability and high seal durability. Tensile test and water permeability tests were conducted on the LLDPE samples to evaluate the mechanical and physical properties of the material. The results showed that the LLDPE samples have yield strengths in the range of 0.075 to 0.168 MPa, and a maximum load of 0.03428 MPa. Additionally, the LLDPE samples showed low water permeability properties, which is an important property for materials used in applications where fluid or gas flow is a factor. This research suggests that the LLDPE material and double-sealing method is suitable for use as the Geotube structurer in coastal areas of Malaysia. However, future research can improve the error in results that resulted leakage of sample during the sealing process.

In order to improve the research in the future, there are several measures that should be taken into consideration. These include extending the permeability test experiment to observe alternative methods to the double-seal method, increasing the observation period of the experiment to allow for more accurate results, conducting permeability tests with sludge filling to simulate the proposed non-dewatering method, and improving the seal quality by experimenting with different seal conditions such as temperature, pressure, and duration. By implementing these measures, the research can achieve more accurate and reliable results, and provide a better understanding of the suitability of the LLDPE material for use as the Geotube structurer in coastal areas of Malaysia.

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