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Utilization Of Recycled Polyester for Road Casting Covering

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Abstract: *Polyester is a type of polymer commonly used in the production of bottle packaging and textile products. However, polyester takes hundreds of years to decompose naturally, making polyester waste management a critical issue. One of the emerging solutions is the production of recycled polyester. In Indonesia, the utilization of recycled polyester has seen significant growth, particularly in the textile and fashion industries. Several studies have shown that recycled polyester exhibits the same tensile strength and tear resistance as virgin polyester, but with higher stiffness, making it more suitable for geotextile applications. For example, polyester-based plastics are often used as protection in road casting. This study aims to develop nonwoven geotextile using a blend of recycled polyester and low melt polyester fibers with a basis weight of 150 g/m2. Test results indicate that the geotextile fabric has a tensile strength of 240 N, a tear strength of 109.06 N, and a concrete compressive strength of 18.91 MPa.*
Keywords: *Recycled polyester; geotextile; concrete compressive strength*

1. Introduction

The increasing need for sustainable and cost-effective materials in civil engineering has prompted the exploration of alternatives to conventional construction components. One such area is the curing process of concrete pavement, where plastic sheets are commonly used to retain moisture and support hydration [1]. While effective, these sheets are single-use, costly, and environmentally burdensome due to the large volume of waste they generate. This study investigates the potential use of recycled polyester nonwoven geotextiles as a substitute for plastic sheets in concrete curing applications, aiming to reduce environmental impact while maintaining sufficient concrete compressive strength and curing performance.

1.1 Concrete Road Construction Process

In the standard concrete road construction process, plastic sheets are used both beneath and above the cast concrete layer. Initially, they serve as a barrier to prevent water from seeping into the subgrade during casting, and later as a cover to reduce evaporation and protect the curing concrete from direct sunlight. This process requires regular water spraying for up to 23 days to ensure optimal hydration and strength development. However, despite its utility, plastic has notable drawbacks—its single-use nature contributes to environmental waste, and its high cost adds to project expenses, especially over extended road sections [2-4].

The widespread use of plastic sheeting in road construction also raises concerns from both environmental and economic perspectives. As a non-biodegradable material, plastic contributes significantly to long-term waste accumulation when discarded after a single use [1]. In large-scale infrastructure projects, the volume of plastic waste generated can be substantial, placing additional

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strain on waste management systems and the environment. Moreover, with rising material costs, the continuous use of disposable plastic increases overall project expenditures, making it an inefficient solution, particularly for projects with extended lengths and repeated curing needs [5].

Given these limitations, alternative materials that are more cost-effective and environmentally sustainable are being explored. One promising candidate is geotextile, a permeable textile made from polymer-based materials, available in woven, knitted, or nonwoven forms. In geotechnical and civil engineering applications, geotextiles are widely used for filtration, separation, reinforcement, and protection [6]. When applied as a curing cover, geotextiles must perform comparably or better than plastic—specifically in retaining moisture and shielding concrete from direct sun exposure [7].

1.2 Geotextile

Geosynthetics are flexible polymer-based sheet materials used in conjunction with soil, rock, or other geotechnical materials as an integral part of civil engineering systems (ASTM D4439). These materials are typically composed of synthetic polymers, formed through polymerization processes involving monomers such as ethylene into longer chain molecules like polyethylene. The most commonly used polymers in geosynthetics include polyethylene and polypropylene—collectively referred to as polyolefins—due to their durability and resistance to environmental factors [6-8].

Geosynthetics serve multiple functions: as separators, reinforcements, filters, drainage media, barriers, and protective layers. Their ability to fulfill several engineering roles makes them essential in infrastructure development. One widely used geosynthetic product is geotextile, which is characterized by its porous, thin, and flexible structure. Depending on the manufacturing process, geotextiles can be classified as woven, nonwoven, or knitted. Woven geotextiles are made by interlacing yarns derived from polymer fibers, while nonwoven types are bonded mechanically (e.g., through needle punching [9]), thermally, or chemically. Knitted geotextiles, though less common, offer advantages for specific three-dimensional structural applications [10-11].

1.3 Concrete Constuction with Geotextile

In concrete construction, particularly for road pavement, proper curing is essential to ensure optimal strength, durability, and crack resistance. Curing methods are designed to maintain adequate moisture and temperature conditions during the hydration of cementitious materials. Traditional curing approaches include wet coverings using burlap, sand, or sawdust, continuous water spraying, ponding, and the use of plastic or impervious sheets [12]. While plastic sheets are effective at preventing evaporation, their single-use nature and environmental impact have prompted interest in alternatives such as geotextiles, which can offer similar or improved performance with greater sustainability [6].

The effectiveness of curing directly influences concrete quality. According to standards such as ACI 318 [13], and ASTM C42 [14], proper curing can lead to compressive strength development of at least 85% of the specified target. Inadequate curing may lead to strength loss, increased permeability, and surface deterioration. Several modern curing methods, such as membrane-forming compounds and insulating blankets, have been developed to address specific climatic or structural conditions. Additionally, steam curing, electrical heating, and fogging are employed in precast or cold-weather environments, emphasizing the critical nature of curing in diverse construction contexts [2, 3, 12].

Given these developments, the use of recycled nonwoven geotextiles—particularly those derived from textile waste such as denim or polyester—is gaining attention as an environmentally friendly alternative for concrete curing covers. These materials have the potential to reduce costs, minimize waste, and maintain or enhance curing performance, aligning with the goals of sustainable infrastructure development.

2. Methodology

2.1 Materials

The materials utilized in this study consisted of recycled polyester fiber and low-melt polyester fiber, the latter with a melting point range of 110–180°C. These fibers were blended at a ratio of 90% recycled polyester to 10% low-melt polyester. The addition of low-melt polyester fiber was intended to improve the bonding strength within the fiber matrix, enhancing cohesion in the final nonwoven geotextile product. For the compressive strength testing of concrete, a standard concrete mix was prepared using the following composition: 300 kg of Portland cement, 360 kg of fine aggregate (sand), 700 kg of coarse aggregate (gravel or crushed stone), and 180 liters of water. This mix was designed to simulate practical field conditions and ensure consistency across test samples.

2.2 Equipment

The primary equipment used in this study was a needle-punching machine, model SPL-03+SVP, manufactured by Shoou Shyng (Taiwan). This machine was used to mechanically bond the blended polyester fibers into nonwoven geotextile sheets suitable for application in concrete curing [9].

2.3 Standard References

The testing procedures and evaluation methods in this study were conducted in accordance with both international and national standards. The temperature of freshly mixed concrete was measured following ASTM C1064/C1064M-03 [15]. The use of curing sheet materials adhered to the guidelines set out in ASTM C171-03 [16]. To evaluate hardened concrete, core samples were obtained and tested based on ASTM C42/C42M-03 [14].

For compressive strength testing using cylindrical specimens, the procedures followed Indonesia's national standard SNI 1074:2011 [17]. The preparation and curing of concrete specimens in the laboratory complied with SNI 2493:2011 [18]. Additionally, the structural design and quality requirements for concrete structures were referenced from SNI 2847:2013 [19].

3. Results and Discussion

3.1 Fabric Result

The recycled polyester nonwoven fabric produced using the needle-punching machine resulted in a material with a basis weight of 150 g/m², as shown in Figure 1 below.

Figure 1. Non-Woven Recycled Polyester

3.2 Geotextile Testing

To evaluate the mechanical performance of the recycled polyester nonwoven fabric, tensile and tear strength tests were conducted in both the machine direction (MD) and cross direction (CD). These tests are essential in assessing the suitability of the geotextile material for civil engineering applications, particularly where durability and resistance to mechanical stress are required.

Table 1. Geotextile Strength Test Result

Sample type	Basis weight (g/m^2)	Tensile Strength (N)		Tear Strength (N)	
		MD	CD	MD	CD
Recycled Polyester	150	240	160	109.06	82.19

3.3 Compressive Strength Testing of Concrete

The characteristic compressive strength of concrete (f'c) specified for this study was 25 MPa (equivalent to 300 kg/cm² or K-300), evaluated after a 28-day curing period.

Table 2. Compressive Strength Test Result of Concrete

Sample type	Minimum (MPa)	Maximum (MPa)	Average (MPa)
Non-Woven Recycled Polyester Fabric	15.91	21.91	18.91
Polyester-based Plastic Sheet	22.15	23.80	22.98

The compressive strength of concrete covered with recycled polyester fabric was lower than that of concrete covered with plastic. This reduction is likely attributed to differences in the density and moisture retention capabilities of the covering materials. Polyester-based plastic sheet, being non-porous, effectively prevents water loss through evaporation, maintaining optimal internal moisture during the curing process. In contrast, the recycled polyester fabric contains pores that allow partial evaporation of water, which may negatively impact the concrete's compressive strength development.

4. Conclusion

The results of this study demonstrate that a nonwoven fabric produced from a blend of recycled polyester and low-melt polyester fibers achieved a basis weight of 150 g/m², with a tensile strength of 240 N, tear strength of 109.06 N, and an average concrete compressive strength of 18.91 MPa. Although the use of recycled polyester nonwoven geotextile resulted in lower concrete compressive strength compared to polyester-based plastic sheet, the material presents a viable and more sustainable alternative for use as a protective layer in road casting applications.

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