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Mechanical Behavior Of Fiber Strapping Band For Infrastructure Rigid Pavement

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ABSTRACT

The advancement of science, particularly in the transportation sector and specifically highways, necessitates adequate infrastructure such as rigid roads or sidewalks that align with field conditions. This study aims to analyze the addition of fiber binding tapes at 0.75%, 1.25%, and 1.75% to enhance the compressive and tensile strength of concrete. The Experimental Research Method was conducted in the Civil Engineering laboratory of the University of Muhammadiyah Parepare. The study's results included tests on fine aggregates with 0% (normal), 0.75%, 1.25%, and 1.75% fiber content. Testing 28-day-old concrete revealed that normal concrete had a compressive strength of 22.74 MPa, concrete with 0.75% fiber binding tape had 21.137 MPa, concrete with 1.25% fiber had 16.70 MPa, and concrete with 1.75% fiber had 17.26 MPa. The tensile strength test results at 28 days showed normal concrete at 5.889 MPa, concrete with 0.75% fiber binding tape at 6.111 MPa, concrete with 1.25% fiber binding tape at 5.556 MPa, and concrete with 1.75% fiber binding tape at 5.778 MPa. The study indicates that using binding tape as a substitute for fine aggregate in concrete significantly influences compressive strength at certain percentages. Therefore, concrete with 0.75% fiber binding tape yields a planned compressive strength suitable for rigid pavement applications.

Keywords: *Analysis, Strapping band, compressive strength, tensile strength, Rigid Pavement*

Introduction

Waste is generated from production processes, both industrial and domestic. One specific type of waste is the fiber strapping band used in rigid pavement for road infrastructure. Incorporating waste into concrete mixtures is an effective approach to mitigate waste management issues that persist today. In developed countries like the United States and the United Kingdom, researchers have sought to enhance the subpar properties of concrete by adding fibers to counteract early deterioration caused by heat hydration and load stress. Various fibers that have been shown to improve concrete properties include steel, plastic, glass, and carbon. A fiber strapping band is a type of packaging strap used for various packaging needs. The benefits of strapping bands as packaging tools include their lightweight nature and ease of use for securing items up to 500 kg. These bands exhibit high tensile strength, ranging from 60 to 250 kg/cm^2 [1].

The advancement of science, particularly in transportation, necessitates robust infrastructure that can endure the weight of passing vehicles and is environmentally friendly. Therefore, rigid pavement that meets field conditions is essential.

In the industry, particularly in the production of conventional concrete, a fresh concrete design mix is required that is highly plastic and flows easily under its own weight to fill the mold, while also having the ability to solidify on its own. Self-compacting

concrete design mix is an experimental research method conducted in a laboratory with a 28-day curing period. This paper is part of an ongoing investigation into concrete made with PCC (Portland Composite Cement) and fiber strapping tape materials. The test results on the workability of fresh concrete, its compressive strength, and the relationship with the tensile strength of hardened concrete are discussed. [2-4].

Metodh

Table 1 shows the characteristics of aggregate coarse. The prominent compound is Sludge content, Wear Maks, Water content, Bv. Loose condition, Bv. Solid Condition, Absorption, Bj. Real, Bj. dry base, Bj. dry surface, and Modulus of subtlety.

Table 1. Characteristics of aggregate coarse.

Characteristics of aggregate coarse									
Sludge content Maks 1%	Wear Maks 50%	Water content 0,5% - 2%	Bv. Loose condition 1,6 - 1,9 kg/liter	Bv. Solid Condition 1,6 - 1,9 kg/liter	Absorption Maks 4 %	Bj. Real 1,6-3,3	Bj. dry base 1,6-3,3	Bj. dry surface 1,6-3,3	Modulus of subtlety 6,0 - 8,0
0.86	27.6	0.76	1.27	1.44	1.52	2.59	2.49	2.53	7.04

Table 2 shows the characteristics of sand aggregate. The prominent compound is Sludge content, organic content, Water content, Bv. Loose condition, Bv. Solid Condition, Absorption, Bj. Real, Bj. dry base, Bj. dry surface, and Modulus of subtlety

Table 2. Characteristics of sand aggregate.

Characteristics of sand aggregate									
Sludge content Maks 5%	Organic content < No. 3	Water content 2% - 5%	Bv. Loose condition 1,4 - 1,9 kg/liter	Bv. Solid Condition 1,4 - 1,9 kg/liter	Absorption Maks 0,2-2 %	Bj. Real 1,6-3,3	Bj. dry base 1,6-3,3	Bj. dry surface 1,6-3,3	Modulus of subtlety 1,5 - 3,8
3.79	1	4.71	1.09	1.38	1.66	2.50	2.40	2.44	2.91

Fiber strapping bands are an innovative solution to the growing problem of uncontrolled plastic waste, which poses a threat to environmental sustainability. These strapping bands, produced by PT Jetset Polychrome under the brand name Superior Pack, are designed to be incorporated into fresh concrete to prevent early cracking caused by heat hydration and loading. Various types of fibers, including steel, plastic (polypropylene), glass, and carbon, can enhance the properties of concrete. This research focuses on using polypropylene fiber, specifically PP strapping bands, as an additive (admixture) to improve concrete performance.

The experiment utilized Portland Composite Cement (PCC) incorporating fly ash from Indonesian cement manufacturers. The characteristics of the PCC employed in this study are detailed in Table 3 and conform to the Indonesian Standard SNI 15-7064-2004 for PCC.

Table 3. Characteristics of PCC.

Physical properties	
Initial setting time (min)	132
Final setting time (min)	224
Specific surface (m^2 /kg)	341
Specific gravity (g/cm^3)	3.08
Bulk density (kg/L)	1.10
Compressive strength:	

- 3 days (kg/cm^2)	162
- 7 days (kg/cm^2)	231
- 28 days (kg/cm^2)	333
Chemical properties %	
MgO	0.99
SO_3	1.81
SiO_2	18.39
Al_2O_3	5.15
Fe_2O_3	3.41
CaO	61.79
LOI	4.61

Table 4 presents the proportions of the concrete mixture prepared in the laboratory. The slump design target is 10 ± 2.5 cm. Fresh concrete is poured into cylindrical molds with a diameter of 10 cm and a height of 20 cm. All specimens are demolded 24 hours after casting and then subjected to curing conditions. The curing process involves immersion in tap water as per the designed protocol.

Table 4. Mix proportion of concrete (1 m^3).

w/c	Fiber strapping band (%)	Water (kg)	Cement (kg/m3)	(Fine aggregate) Marine sand (kg/m3)	(Coarse aggregate) Crushed stone (kg/m3)
0,45	0,75 1,25 1,74	204	372,13	887,04	867,72

The slump test follows the guidelines outlined in SNI 1972-1990 (Test Method for Slump Test). The compressive strength and static modulus are tested according to SNI 1974-2011 (Concrete Compressive Strength Test Method). Vertical displacement and strain under compressive load are measured using two variable load transducer displacement (LVDT). These parameters are recorded by a computerized data logging system to accurately monitor vertical compressive load and strain during testing.

Results and discussion

1. Strapping band fiber

This type of strapping band is most widely used by the public. In addition to its more affordable price, this strapping strap also offers strong and elastic fastening. This type of strapping has a size, ranging from 5 mm to 18 mm wide (figure 1).

Figure 1. Strapping Polypropylene

2. Slump test

The fresh concrete exhibits a slump value of 9 cm, which aligns closely with the slump design range of 10 ± 2.5 cm. Visual observations (Figure 2) indicate that the fresh paste, incorporating binding tape fibers and PCC, maintains good workability and homogeneity throughout the mixture. There is no evidence of separation or bleeding, and coarse aggregates do not accumulate at the bottom of the specimen.

Figure 2. Slump Test.

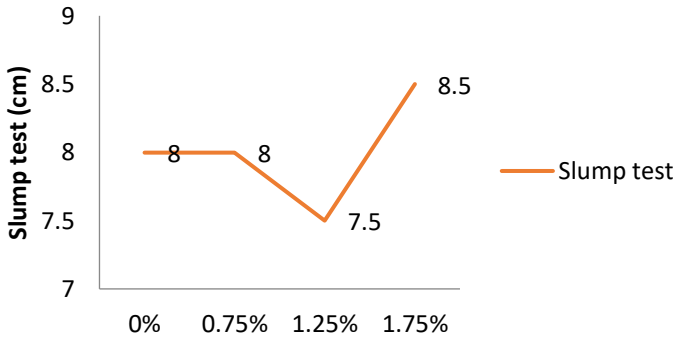


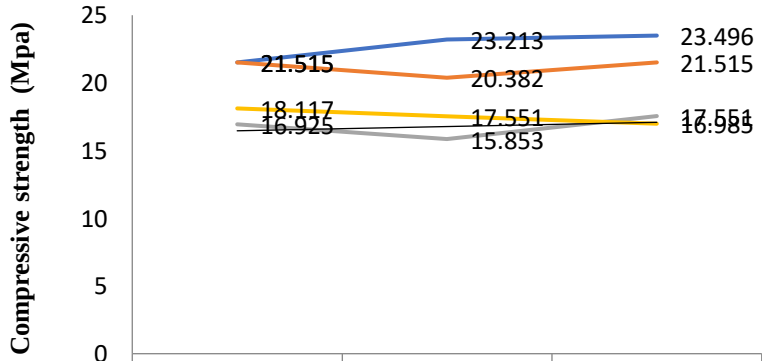
Figure 3. The relationship of strapping band fiber percentage to slump value.

3. Compressive strength and tensile strength behavior

Visual observation of the cylindrical specimen prior to the compressive strength test (Figure 3) reveals a smooth surface on the hardened concrete, free from honeycombing, large air voids, or accumulation of coarse aggregates. The results demonstrate that fresh concrete containing binding tape fibers, sand aggregate, PCC, and crushed river rock can be poured while maintaining the homogeneity of the mixture, thereby achieving effective compaction.

Figure 4. Compressive strength test

Figure 5. Tensile strength test



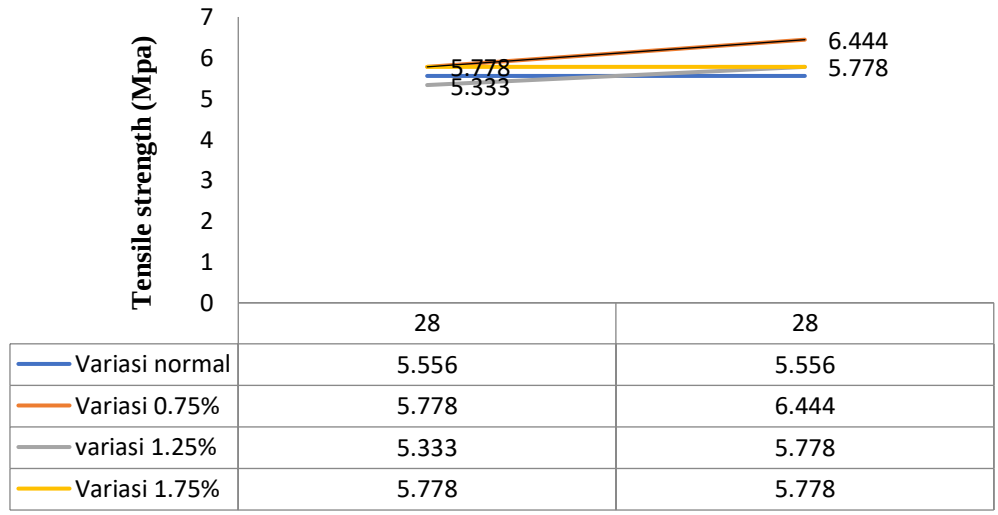
	28	28	28
Variasi normal	21.515	23.213	23.496
variasi 0.75%	21.515	20.382	21.515
variasi 1.25%	16.925	15.853	17.551
variasi 1.75%	18.117	17.551	16.985

Figure 6. Compressive Strength - percentage of cured concrete curve in fastening tape fibers

Figure 6 illustrates the compressive strength behavior curves of three concrete specimens cured with binding tape fibers over a period of 28 days. The specimens varied in fiber content from 0% to 1.75%. The average compressive strength achieved was 21.515 MPa.

Figure 7 illustrates the tensile strength behavior curves of three hardened concrete specimens cured under wet tap water conditions for up to 28 days. The specimens include normal concrete and concrete with fiber strapping tape, ranging in fiber content from 0% to 1.75%. The average tensile strength of the normal concrete specimens tested is 5,778 MPa.

Based on the compressive strength test results, it is evident that the interaction among all materials, facilitated by the bond between the paste containing binding tape fibers and PCC, along with the aggregate, contributes to the concrete's robustness. This includes aggregate sand, PCC, and coarse river aggregate, which collectively enhance the load transfer mechanism between the paste and aggregate. These attributes ensure the concrete's capability to withstand compressive loads effectively.



	28	28
Variasi normal	5.556	5.556
Variasi 0.75%	5.778	6.444
variasi 1.25%	5.333	5.778
Variasi 1.75%	5.778	5.778

Figure 7. Tensile strength - percentage strapping band fiber curve of cured with wet freshwater tap water

Based on Figures 6 and 7, it is noted that there is a 3.99% increase in compressive strength when using normal tap water curing. This observation suggests that the presence of salts in the binding tape and aggregate sand does not adversely affect the hydration process. Therefore, seawater can potentially be used for curing concrete, allowing for proper hydration and achieving good compressive strength.

Additionally, based on a literature review [6], it has been found that the compressive strength and tensile strength values of concrete made with binding tape fibers, aggregate sand, PCC, and crushed river rock are comparable to those of ordinary concrete made with Ordinary Portland Cement (OPC) and fresh water.

Conclusions

The results of the slump test indicate that the fresh concrete exhibits appropriate workability. Upon examining the hardened specimens, it is observed that the mixture retains its homogeneity during pouring into the mold and compaction. This process results in well-compacted specimens without honeycombing or significant voids on the surface.

The compressive strength test revealed that specimens containing binding tape fibers cured in freshwater exhibited higher compressive strength after 28 days compared to values reported in the literature. The strain values of concrete made with freshwater, binding tape fibers, aggregate sand, PCC, and crushed river rock were similar to those of

ordinary concrete made with OPC and freshwater. Moreover, the study demonstrated that substituting fine aggregate with binding tape significantly influenced the concrete's compressive strength, resulting in a notable increase in pressure under certain conditions. Therefore, concrete incorporating 0.75% fiber strapping band achieves planned compressive strength and is suitable for use in rigid pavement applications.

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