Utilization Of PDL Cadet Clothing Waste As An Admixture For The Manufacture Of Fiber Concrete To Support Defense Architecture Building

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Abstract. Military service clothing waste, especially PDL (Field Service Clothing) for Military Academy Cadets reaches more than 5,000 sets of waste every year. This condition allows the misuse of waste to be used for crimes in the name of the TNI. Material design by utilizing this waste as a concrete mixture is one solution. Fiber concrete is concrete with added fiber to obtain a higher tensile strength. The aim of the research is to obtain building materials in the form of textile fiber concrete from military uniforms (PDL clothes) which can be implemented as building materials. Quantitative research method using an experimental approach, namely by making fiber concrete with a mixture composition: cement: sand: gravel: fabric residue PDL = 1: 2: 3: 1 and testing the hardness of the concrete using a hammer tester and shooting test with an SS-gun. 2 (Assault Rifle version 2) 5.56 mm rounds and SP-2. gun (Rifle Long version 2) with 7.62 mm rounds fired at 50 m and 100 m. The results showed that PDL fabric fiber concrete is less easily damaged than standard concrete, so it can be used as a building material for defense architecture, such as guard posts and border guard houses.

Keywords: fiber concrete; Utilization of TNI PDL clothing waste: hammer test; firing test.

1 Introduction

Engineering of military building materials is an effort to find building materials by utilizing the potential of the surrounding environment as well as utilizing waste by recycling it into usable materials or by mixing waste into materials that are useful for the life of the nation and state, especially in the military world. The design engineering in this research is by utilizing waste PDL Taruna clothes as a mixed material for making fiber concrete as a form of innovation and creativity in creating building materials that can be used in military environments to strengthen defense architecture, namely means as part of defense science which discusses the phenomena related to planning and design for the national defense system [1].

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Utilizing waste is a form of caring for the environment, and based on field data it is known that the number of PDL Akmil Cadet clothes thrown away in one year is approximately 1255 x 4 = 5,020 sets, because these clothes are no longer suitable for use because they are damaged and worn out due to training activities.

If the waste PDL clothing is thrown away, it could cause problems if the clothing is used by certain individuals for unlawful activities in the name of the TNI. On the other hand, it will be unsightly if the PDL clothes are worn by civilians for curve activities, manual work and other things that reduce the prestige of the PDL clothes themselves, for that they had to be disciplined. By law, TNI uniforms may only be used by TNI Soldiers who are still on active service (Skep Panglima TNI No. Skep/346/X/2004) and while controlling their use is in accordance with the Telegram of the TNI Commander No. STR/509/2006 concerning controlling the wearing of TNI uniforms and attributes, which in its activities promotes, prohibits, confiscates, secures and gives sanctions to the perpetrators of these violations.

Utilization of PDL Taruna uniform waste as a mixed ingredient in concrete functions as a fiber that can strengthen the compressive strength of the concrete. Fiber concrete itself is defined as normal concrete engineered with the addition of certain fiber materials in order to obtain tensile strength, compressive force and modulus of elasticity so that the concrete does not crack easily [2], [3]; [4].

In general, the TNI's striped cloth is made of a 35:65% polyester/cotton blend with a woven plate construction and is made domestically with guaranteed quality. It is proven that there are 31 countries in the world that ordered their military uniforms from Indonesia [5]. In terms of quality, PDL clothing has good quality as soldier clothing, but if it is used for mixing concrete, can it work? Utilization of PDL fabric waste as a mixed material for the manufacture of fiber concrete wall materials is in line with research that uses jeans cloth as a mixture of fiber concrete [6] which shows that the addition of jeans fiber can make the concrete weight lighter and can be used as non-structural concrete. The difference with jeans fabric is that PDL fabric fibers are finer and stronger, so this research is expected to produce superior quality fiber concrete. The addition of cloth fibers aims to prevent cracking due to loading, reduce hydration heat which causes shrinkage and improve the mechanical properties of concrete, so that concrete is resistant to compressive, tensile and bending forces caused by weather, climate and temperature factors that usually occur in concrete. which has a large surface [6], [7].

In the study, the addition of banner fiber as an added ingredient in concrete was not good for making concrete because the compressive strength and split tensile strength of concrete decreased [8]. The addition of used cloth fibers for the manufacture of lightweight cellular concrete will increase its bending strength. Cellular lightweight concrete that is not reinforced with used clothing fibers based on the results of bending tests carried out with a universal testing machine is broken apart, whereas cellular lightweight concrete is reinforced in the form of cracks that are still connected. [7].

Building materials engineering that is cheap, easy and fast is needed to support buildings in military installations such as guard posts/border posts/security posts because the condition of these buildings does not yet reflect defense installation buildings because they serve as signs and guard places so they are made to simply protect against the weather, heat, rain and wind,

not yet considered as a building of defense architecture (not paying attention to security and defense factors) [9]. Testing fiber material by firing test with bullets aims to obtain materials that are able to reduce or stop the rate of movement of bullets [10]. The addition of textile fabric waste from PDL military uniforms is predicted to function as fiber concrete which binds concrete cracks when subjected to pressure or bullet shots.

This study used a hammer test followed by a firing test. Testing with a hammer test [11] intended with the consideration that the test object is not damaged [12]. The hammer test is a simple, lightweight, inexpensive and easy to do concrete test method to find out the criteria for concrete hardness based on the reflection value [13] and violence [14].

On the other hand, in order to give an idea to soldiers that used PDL clothing will have an effect on further strengthening the concrete mixture when hit by a shot, for this reason, it is necessary to continue the experiment with shooting tests using firearms of the SS-2 type (Assault Rifle version 2) and SP-2 (Long Rifle version 2).

Based on the description above, a design research was carried out on materials engineering by utilizing waste fiber from military uniforms (PDL) as a mixed material in the manufacture of fiber concrete which is expected to be useful for supporting special defense architecture materials that can be used as building materials for military purposes . In order to support the validation results of the research on the strength of the PDL fabric fiber concrete, the researchers combined research using the Hammer Test for hardness tests supported by firing tests using SS-2 5.56 mm caliber ammunition and SP-2 7.62 mm caliber ammunition at ranges 50 m and 100 m, to determine the level of damage/friction power of the fiber concrete.

1.1 Problems

Based on the description above, regarding the need for alternative materials for defense architectural building materials through research on the Design and Construction of Utilizing PDL Waste as a Mixture for Making Fiber Concrete to Support Defense Architecture, this research will reveal:

a. What are the results of the hardness test using the hammer test on the design of the use of PDL cloth waste for military academy cadets as a mixed material for the manufacture of fiber concrete ?
b. What are the results of the firing test using the SS-2 5.56 mm caliber ammunition and the SP-2 7.62 mm caliber ammunition in the Design and Build of Utilization of PDL Taruna Akmil Clothing Waste as a Mixture for Fiber Concrete Production ?; And
c. Whether the results of the hammer test with the design test for the utilization of PDL Taruna Akmil clothing waste as a mixed material for the manufacture of fiber concrete can be implemented in defense architectural building materials ?

2 Research Methods

The research used is an experimental research method, namely a research method used to seek influence with a certain treatment [15]. Experimental research methods are also used to explain and predict the motion or trend direction of a variable in the future. Therefore this experimental

research method is used and aims to predict [16]. Experimental research was carried out by testing using the Hammer Test and Shooting Test. The experimental hypothesis is that the addition of fiber will reduce the level of hardness so that the concrete does not break easily.

2.1. 5 (five) stages of the research approach as follows.

a. The first stage is a documentation study, by studying documents/references assembling fiber concrete, hardness testing with a hammer tester and firing tests.

b. The second stage is the manufacture of molds and formwork of the test object in the form of molds made of wood and plywood.

c. The third step is the manufacture of normal/standard concrete and fiber concrete with the addition of PDL fabric fiber which is waste from PDL Taruna Akmil.

d. The fourth stage is testing:

1) test the hardness of the fiber concrete specimen using a Hammer Tester;

2) continued with firing tests at a distance of 50 m and 100 m, using both SS-2 guns with 5.56 mm caliber ammunition and SP-2 with 7.62 mm caliber ammunition;

3) in order to find out the specification data and characteristics and composition of the fiber concrete test object, followed by evaluation and interpretation as well as analysis and discussion of the test results data.

e. The fifth stage is drawing conclusions and recommendations, which contains conclusions from the discussion analysis with the results of a concept or recommendation formula that can be implemented in everyday life based on the results of the research.

2.2. Tools and Materials for Making Test Objects.

a. The tools**,** that used in this study include:

1) the tools for making the test object consist of: hoes, shovels, trowels, buckets, hammers, saws, and tape measure and brushes,

2) equipment for testing the test object consists of: office stationery, firearms SS-2 (Assault Rifle-2), SP-2 (Length-2 rifle), 5.56 mm and 7.62 mm caliber ammunition and binoculars.

3) report preparation tools, namely laptops and printers as well as related office stationery.

b. Materials**,** in terms of materials used for the manufacture of test objects, include: cement, sand, freshly broken/split ½, water, wood, plywood, nails, pilox paint and pieces of cloth from PDL clothes and oil.

2.3. Making Test Objects.

a. Prepare formwork/molds, which are made of wooden planks and plywood with a size of 4 x 40 x 50 cm as many as 12 moulds.

b. Prepare a concrete mix with the following composition: cement : sand : gravel plus enough water.

c. The mold is covered with oil so that it can be easily opened after drying.

d. Do a concrete mix Slump Test, to find out the level of workability of the concrete mix or how to find out, as well as determine the consistency or level of stiffness of the fresh concrete mix.

e. Put the concrete mix into the concrete mold according to the test requirements, namely:

1) Standard/Normal Concrete:

a) mixture composition: cement : sand : gravel = 1 : 2 : 3,

b) the dimensions are 4 x 40 x 50cm
c) total 4 plates

2) Loose Fiber Concrete
a) composition of the mixture: cement : sand : gravel : cloth scraps PDL = 1 : 2 : 3 : 1
b) the dimensions are 4 x 40 x 50cm
c) total 4 plates

3) Woven Fiber Concrete
a) the composition of the mixture: cement : sand : gravel = 1 : 2 : 3, in the middle of which is spread PDL cloth (3 x 38 x 48 cm)
b) the dimensions are 4 x 40 x 50cm
c) total 4 plates

Each type of concrete was made into 4 plates because it was in accordance with the treatment it would receive, namely 1) shot at a distance of 50 m with an SS-2 weapon - 5.56 mm ammunition; 2) shot at a distance of 50 m with the SP-2 gun, 7.62 mm ammunition; 3) shot at a distance of 100 m with the SS-2 gun - 5.56 mm ammunition; 2) shot at a distance of 100 m with the SP-2 gun, 7.62 mm ammunition.

f. The concrete is grouped according to its composition and left for 28 days, during this maintenance period, the concrete is doused with water.

g. Furthermore, the concrete is painted with white pilox at the base and painted with a black circle, a 10 cm diameter circle in the middle to facilitate the firing test.

j. Documentation for the manufacture of test objects.

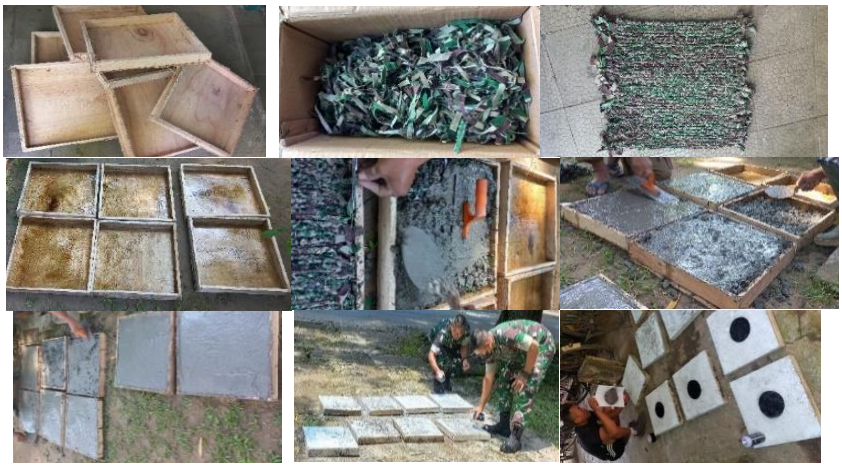


Fig. 1. Making test objects

2.4. Execution of Testing.

a. Hardness test using hammer test, is a test method on hardened concrete and without damaging the structure (non-destructive)[17]. By means of the hard concrete reflectance number test method [18].

The way to use the hammer test is to press the tool slowly towards the surface of the test object, until the hammer hits the head of the hammer. After pounding, hold down the

pressure and if necessary lock the upstream in position by pressing the button on the side. See the number of test results listed on the tool and record.

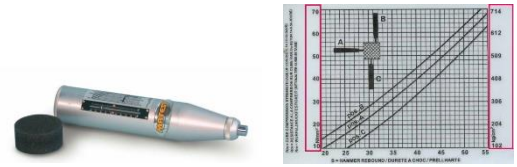


Fig. 2. Hammer tester and hammer test results table

Fig. 3. Testing concrete with a hammer test

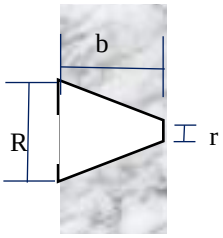
b. The level of damage using the shot test on PDL fabric waste fiber concrete is calculated based on the damage from the shot using the truncated cone formula.

1) Based on the results of the shot test, all bullets were able to penetrate the concrete plate because the shooting distance was 50 m and 100 m, the thickness of the concrete plate was 4 cm,

2) Type of damage resulting from the shot 1.

Scaped Cone Volume 1

$= 1/3 \times \pi . b[r . R + r^2 + R^2]$ …. (1)



3) Type of damage resulting from the shot 2.

Scaped Cone Volume 2

$= 1/3 \times \pi . b1[r . R1 + r^2 + R1^2] +$

$1/3 \times \pi . b2[r . R2 + r^2 + R2^2]$ …(2)

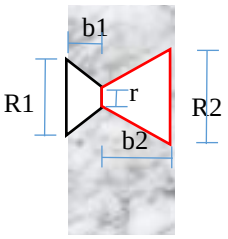


Fig.4. Example of firing test implementation

3. Results And Discussion

3.1. Compression test of PDL fabric fiber concrete using the Hammer Test.

Table 1. Results of hardness/reflective strength using a Hammer Tester
(Source: Primary data analysis, 2023)

FORM HAMMER TEST							
NAME OF ACTIVITY	Hardness Test						
DATE	Des 14, 2022						
LOCATION	Plempungan						
TESTED BY	Agung & Tim						
STRUCTURE ELEMENTS	4cm plate						
BREAKING ANGLE	Horizon-tal / 0°	Horizon -tal / 0°	Horizon -tal / 0°	Horizon -tal / 0°	Horizon - tal / 0°	Avera ge	Corrected Concrete Compressive Strength Estimation (kg/cm²)
TEST OBJECT	1st Poin	2nd Poin	3rd Poin	4th Poin	5th Poin		
Standard Concrete 1	26	24	24	23	22	23,8	
Standard Concrete 2	28	24	25	24	26	25,4	
Standard Concrete 3	23	28	24	24	28	25,4	
Standard Concrete 4	28	23	27	28	26	26,4	
					Average	25,25	162
Loose Fiber Concrete 1	20	22	27	23	21	22,6	
Loose Fiber Concrete 2	22	18	19	19	20	19,6	
Loose Fiber Concrete 3	23	22	25	22	24	23,2	
Loose Fiber Concrete 4	22	20	22	20	23	21,4	
					Average	21,7	112
Woven Fiber Concrete 1	24	24	23	22	22	23	
Woven Fiber Concrete 2	23	26	23	25	27	24,8	
Woven Fiber Concrete 3	23	23	23	24	27	24	
Woven Fiber Concrete 4	22	25	22	24	22	23	
					Average	23,7	143

Based on the data in Table 1, the results of the Concrete Hardness Test using the Hammer Tester, it can be seen that:

1. Standard concrete is the hardest specimen, followed by woven PDL fiber concrete and sprinkled PDL fiber concrete.
2. Addition of PDL uniform fiber, reducing the level of hardness of concrete; and

3. Concrete with the addition of woven PDL fibers is harder than concrete with added pieces of PDL fibers sprinkled.

3.2. Test firing of PDL waste fiber concrete using firearms with a caliber of 5.56 mm (SS2) and 7.62 mm (SP-2).

1. The theory of bullet shots.

The theory is that the bullet spin through the thread of the gun barrel when it hits it is not perpendicular but rotates, causing an increasingly widespread damage effect. The calculation formula used is in accordance with Type of damage resulting from the shot 2, yaitu Scaped Cone Volume 2 :

$= 1/3 \times \pi . b1[r . R1 + r^2 + R1^2] + 1/3 \times \pi . b2[r . R2 + r^2 + R2^2]$ …(2)

2. Test results of firing a 4 cm thick concrete plate at a distance of 50 m with the SS-2 cal ammunition. 5.56 mm.

Table 2. Results of the SS-2 Cal.5.56 mm Fire Test at a distance of 50 m

No	Test object	1st Test	2nd Test	3rd Test	Average
1	Standard Concrete-1	106,66	101,62	101,62	103,30
2	Loose Fiber Concret- 1	26,78	29,33	26,28	27,47
3	Woven Fiber Concrete-1	62,07	70,19	78,83	70,37

3. Test results of firing a 4 cm thick concrete plate at a distance of 50 m with the SP-2 and 7.62 mm caliber ammunition.

Table 3. Results of SP-2 Cal. 7.62 mm Fire Test at a distance 50 m

No	Test object	1st Test	2nd Test	3rd Test	Average
1	Standard Concrete-2	166,83	179,14	191,98	179,32
2	Loose Fiber Concrete -2	107,12	139,33	128,07	124,84
3	Woven Fiber Concrete-2	203,50	163,43	176,26	181,06

4. Test results of firing a 4 cm thick concrete plate at a distance of 100 m with the SS-2 5.56 mm caliber ammunition.

Table 4. Results of the SS-2 Cal. 5.56 mm Fire Test at a distance 100 m

No	Test object	1st Test	2nd Test	3rd Test	Average
1	Standard Concrete-3	106,13	117,33	94,80	106,09
2	Loose Fiber Concrete -3	71,50	56,83	53,68	60,67
3	Woven Fiber Concrete-3	88,26	91,31	97,43	92,33

5. Test results of firing a 4 cm thick concrete plate at a distance of 100 m with SP-2 7.62 mm caliber ammunition.

Table 5. Results of the SP-2 Cal. 7.62 mm Fire Test at a distance 100 m

No	Test object	1st Test	2nd Test	3rd Test	Average
1	Standard Concrete -4	217,90	203,50	189,62	203,67
2	Loose Fiber Concrete -4	107,12	88,26	60,86	85,41
3	Woven Fiber Concrete-4	189,62	128,07	139,33	152,34

Based on the data in Tables 2nd – 5th, the results of the PDL Fabric Fiber Concrete firing test are as follows:

1. Based on the results of the firing test, all concrete plates with a thickness of 4 cm are penetrated by bullets, but based on the damage caused successively starting on standard concrete, woven fiber concrete and sown fiber concrete. This is due to the role of the fabric fibers which mutually reinforce each other so that the concrete is not brittle/separated easily after being hit by a hard impact.
2. The damage level is calculated based on the truncated cone formula as stated in Table 2, it can be seen that the results of the PDL fiber concrete firing test used the SS-2 weapon with 5.56 mm caliber ammunition and at a distance of 50 m and 100 M, the level concrete with the highest damage was standard concrete, then woven PDL fiber concrete and lastly sprinkled PDL fiber concrete;
3. Based on the data in Table 2. The results of the firing test of the 4 cm thick PDL fiber concrete plate using the SP-2 7.62 mm caliber ammunition at a distance of 50 m and 100 m, show that the highest level of damage to concrete is standard concrete, then woven PDL fiber concrete and lastly sown PDL fiber concrete;

Fig. 5. Differences in the results of the SS-2 Cal.5.56 MM 100M Distance Test on a) Loose Fiber Concrete, b) Woven Fiber Concrete and c) Normal Concrete
Source: Primary data analysis, 2022

4. Conclusion

a. Based on the hardness test with a hammer tester, standard concrete is the hardest test object, followed by woven PDL fiber concrete and sprinkled PDL fiber concrete. This is what causes standard/normal concrete to break/destroy more easily when hit by gunfire.

b. The results of the shooting test of PDL fabric fiber concrete using SS-2 weapons with 5.56 mm caliber sharp ammunition and SP-2 weapons with 7.62 mm caliber ammunition both at distances of 50 m and 100 m, the highest level of damage to concrete is standard concrete. , then woven PDL fiber concrete and finally sprinkled PDL fiber concrete;

c. Based on the hammer test, the addition of cloth fibers to the concrete mixture will trigger hardness in the rebound force, because adding cloth fibers means adding a lighter and softer material which causes the compressive strength to decrease. Meanwhile, based on the concrete fiber shooting test, the level of damage is reduced/smaller because the fiber helps bind and unite the concrete mixture after the initial binding with cement paste [19]. This shows that the concrete is not brittle/easily separated after being hit by a hard impact or bullet shot, so it is relevant when implemented as a building material to support defense architecture in emergency conditions.

5. Recommendations

a. Utilizing PDL clothing waste as a mixture for fiber concrete can reduce misuse of TNI uniforms.
b. Making PDL cloth fiber concrete is relatively easy and simple because it only adds pieces of PDL cloth that are the same size as the volume of cement in the concrete mixture.
c. PDL fiber concrete can be used as a building material for defense architecture, especially in field/combat situations and conditions that are far from sources of steel/iron concrete sellers.

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