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IDENTIFYING THE INFLUENCE OF SPLIT TENSILE STRENGTH TO CRACK WIDTH OF HIGH-STRENGTH REINFORCED CONCRETE BEAM WITH POLYPROPYLENE FIBER FROM MEDICAL MASK WASTE

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Cracks in concrete structures due to tensile weakness can be repaired by using fiber concrete, including medical mask waste as an additive in high-strength concrete mixes. This research the influence of polypropylene fiber from medical mask waste on the mechanical characteristics, flexural behavior, and crack width of high-strength reinforced concrete (RC) beams. The initial stage involved examining the properties of the concrete constituent materials. The testing process was based on a high-strength concrete mix design using the Aitchin method mix design sheet. Compressive strength and split tensile strength were tested at fiber content (0 %, 0.15 %, 0.20 %, and 0.25 %). The three-point flexural testing procedure was carried out at 28 days on 1200×100×150 (mm) RC beams. The use of LVDT, strain gauge, and other measuring devices supported the acquisition of the required data. The results showed that the split tensile strength reached the optimum value of 66.19 MPa at 0.24 % fiber content. Polypropylene fiber from medical mask waste in RC beams showed a positive impact on reducing crack width at increased split tensile strength. Waste mask fiber content of 0.15 %, 0.20 % and 0.25 % gave stable and better results compared to 0 % content (no fiber). With high steel stress (fs), and high strain, it offers the potential to improve the mechanical properties of high-strength concrete, thereby reducing the width of cracks that occur. This improves the tensile weakness of the concrete. The effect of split tensile strength on the crack width (w) of beams with the formula approach: $w_{exp}=3.74ftf^{-1.513}$, $w_{an}=0.187ftf^{-0.022}$ shows that the experimental results have a significant effect on decreasing the crack width that occurs in high-strength RC beams, thereby improving the quality of concrete

Keywords: split tensile strength, crack width, high-strength, reinforced concrete beam, medical mask waste, polypropylene fiber

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1. Introduction

In general, construction elements made of reinforced concrete (RC) that experience cracks more often are beam elements compared to other structural elements, where reinforced concrete beams are seen as rods that primarily carry transverse loads. The width and distribution of cracks are influenced by the diameter of the reinforcement, where reinforcement with a small diameter will produce relatively small widths and distances between cracks, while reinforcement with large diameters tends to produce relatively large widths and distances between cracks. Concrete that is weak in tensile strength is the main cause of cracks in RC structures under working load conditions. Cracks that occur in reinforced concrete structures will certainly affect the behavior of the structure, causing strength degradation, where the actual strength cannot be restored to its original state even though the crack has been closed. Therefore, cracks must be limited in width and distribution to prevent the possibility of corrosion in the reinforcement.

Fibre concrete, which is composed of cement, aggregate, and a minute quantity of fibre added in a random orientation and specific proportions, represents an endeavour to enhance the characteristics of concrete. In this research, medical mask waste was used as an addition to the concrete mixture. This research began in 2021 during the Covid-19 pandemic, where the use of masks was mandatory and mask waste was simply thrown away, leaving a lot of waste used from using masks. The most popular medical masks currently used are made from polypropylene plastic [1]. It takes more than 25 years for polypropylene, the main type of plastic used in disposable medical masks, to break down in landfills [2]. The masks change, though, when they get into our rivers. microplastics, which then get into our fragile environment and might end up in the food we eat [3].

Fiber concrete [4] is an attempt to improve the properties of concrete, fiber concrete is composed of cement, aggregate and a small amount of fiber as an additive that is evenly distributed randomly oriented and with certain proportions.

In this study utilizing medical mask waste as an addition to the concrete mix. Research [5] as an initial study to investigate the feasibility of polypropylene fiber from Covid-19 medical mask waste applied in concrete, the result is that the fiber can improve the properties of concrete characteristics. Furthermore, the characteristics of high-strength concrete with various variations in fiber dimension size and various percentage levels of fiber to concrete volume have been obtained by [4]. It is found that medical mask waste polypropylene fibers were able to increase the split tensile strength and flexural tensile strength at all fiber dimensions and fiber percentage levels applied to fibers high-strength concrete. So that it can improve the weakness of concrete that is weak against tensile.

Therefore, the results of such research are significant necessary to provide a solid overview of the scientific foundation for engineers and building construction practitioners to design high-strength concrete that can reduce crack width. So, this can reduce building construction maintenance costs and extending the service life of infrastructure. In addition, the results of such research have the potential to refine existing technical guidelines and contribute to building construction maintenance standards. This explains the relevance of this scientific topic.

2. Literature review and problem statement

The building industry and academia have been interested in using plastic fibres in concrete for a while now. This is because plastic fibres are more environmentally friendly than steel reinforcement. [6] studied fiber-reinforced concrete and found that when cellulose fibres were used at a dosage of 1.5 kg/m^3, the compressive strength of the concrete went up by up to 12 %. However, when polyvinyl alcohol fibres were used at a dosage of about 4.0 kg/m^3, the compressive strength went down by 35 %. [6] When cellulose fibres were given the same dose, their split tensile strength dropped by 23 %. Polyvinyl alcohol fibres' split tensile strength dropped by 55 %, and polyolefin fibers split tensile strength started to drop at a dose of 2.0 kg/m^3.

Based on [7] in reinforced concrete RC the amount of tensile force due to external forces that work is borne by steel reinforcement, but if the tensile force borne by the concrete is getting bigger and exceeds its critical stress, the crack will get bigger. [8] explains that if the cracks continue to grow and are wide enough, it will endanger the state of the steel reinforcement which becomes exposed and prone to corrosion and reduces its stress capacity. To anticipate the crack width, the planning of reinforced concrete structures must consider the required maximum crack width limit. In addition, the crack width limitation also considers aesthetic aspects because concrete cross-sections that have a large crack width will have a major effect on the perception of strength for users and cause large deflections [9].

The crack width associated with the corrosion rate depends on the external environment around which the concrete structure is built. According to the results of research [10], crack width (w) is influenced by the reinforcement ratio (ρ). At the same load, the greater the reinforcement ratio (ρ), the smaller the crack width (w) of the rigid pavement. The bigger the reinforcement number (ρ), the less stress there is in the steel at the same crack thickness. When the stress in the steel stays the same, the crack thickness gets smaller as the reinforcement ratio goes up. The crack width limit must be thought about so that the outside look of the concrete building isn't harmed. The crack width limit depends on a number of factors, such as the crack's location, length, and the texture of its surface. According to [11], the crack width is between 0.25 mm and 0.38 mm to make it look better.

Hybrid SHCC/concrete beams with different types of contacts were tested as part of the study [12]. The outcomes were contrasted with stronger concrete beams that did not have SHCC in their covering. Digital Image Correlation (DIC) was used to see how the crack pattern and depth changed over time as the beams were bent in four points. According to the results, mixed beams could hold the same amount of weight as the control beam, but they cracked much less easily.

There were several tests done to see how the polypropylene fibres from Covid-19 throwaway masks affected the strength of concrete [5]. When testing the general quality of concrete, masks measuring 2 cm long and 0.5 cm wide were used to add 0 % (control), 0.10 %, 0.15 %, 0.20 %, and 0.25 % to the volume of concrete. The tests looked at the compressive strength, tensile strength, modulus of elasticity, and ultrasonic speed. There were no used medical masks in this study, though. Instead, new ones were used. Overall, the features and quality of concrete get better as a result.

Furthermore, the characteristics of high-strength concrete with various variations in fiber dimension size and various levels of fiber percentage to concrete volume have been obtained by [13]. It was found that medical mask waste polypropylene fibers were able to increase split tensile strength and flexural tensile strength in all fiber dimensions and fiber percentage levels applied to fiber high-strength. So that it can improve the weakness of concrete that is weak to tensile strength.

Based on the research that has been carried out above, all of them are still at the stage where polypropylene fiber from medical mask waste Covid-19 is applied to normal concrete and high-strength concrete, but research has not yet been carried out on polypropylene fiber from medical mask waste to be applied to reinforced concrete structures which are part of building construction. So this requires further, more in-depth research. So further research that will be carried out is to review the influence of polypropylene fibers from medical mask waste on the characteristics of high-strength RC in an effort to reduce the width of cracks that occur in RC beam structures using split tensile strength parameters.

3. The aim and objectives of the study

The aim of this study is identifying the influence of split tensile strength to crack width of high-strength RC beam with polypropylene fiber from medical mask waste. To achieve this aim, the following objectives are accomplished:

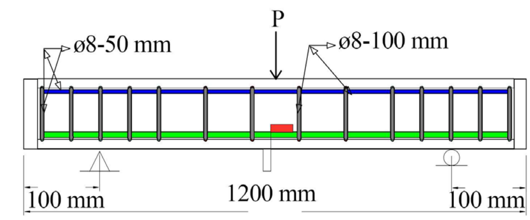
– analyze the relationship between split tensile strength (ftf) and polypropylene fiber content (cf) of medical mask waste;

– analyze the relationship between crack width (w) and steel stress (fs);

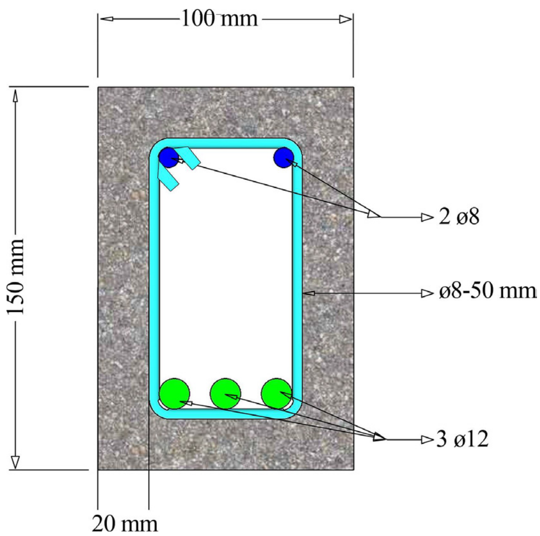
– analyze the relationship between crack width (w) and split tensile strength (ftf) of polypropylene fiber high-strength RC beam from medical mask waste.

4. Materials and methods

Object of study is to high-strength RC beam with polypropylene fiber from medical mask waste. The RC beams with dimensions of 0.1×0.15×1.2 m; using reinforcement 3ø12 (Fig. 1) which were provided with split tensile strength (*ftf*) variations of fiber content (*cf*) 0 %, 0.15 %, 0.20 % and 0.25 %. The test specimens were designed with the characteristics of compressive strength (*fc*) of concrete grade 70 MPa, and steel strength (*fs*) 360 MPa.



a



b

Fig. 1. Reinforced concrete (RC) beam: *a* – dimensions of the RC beam *fc*' 70 MPa and loading position in the middle for RC beam; *b* – details reinforcement of the RC beam

The main research hypothesis in the research that will be proven in this research fiber reinforcement in the form of fiber polypropylene from medical mask waste can reduce crack width (*w*) on high-strength fiber concrete block structures. Fiber reinforcement will affect the concrete's ability to increased splitting tensile stress (*ftf*). This is indicated by the increase in the tensile strength value of high-strength fiber concrete (in preliminary research [13]. By increasing the tensile strength, it will affect the effectiveness of the bond between the concrete and steel reinforcement in high-strength fiber concrete beams, resulting in a reduction in flexural crack width (*w*) in high-strength fiber RC beam elements at the same service load.

The constituent materials of polypropylene fiber RC are as follows Fig. 2.

Medical mask waste was used with 0 %; 0.15 %; 0.20 % and 0.25 % mask waste fiber content with 5×0.5 cm fiber size. Examination of the properties of high-strength concrete constituent materials was carried out for the purpose of making a structural high-strength concrete mix-design. The constituent materials examined were the materials used in this study, Lumajang sand, gravel in the form of mountain crushed stone from the Pasuruan region. Materials directly used from distributor purchases are PCC cement, silica fume, Sika® ViscoCrete®-3115 N superplasticizer and polypropylene fiber from sterilized mask waste.

The mix design sheet method prepared by [14] and [15] which is based on (ACI 211.1-91 1991) as the basis for planning high-strength concrete mixes, obtained a concrete mix plan for each m^3 as shown in Table 1.

Table 1

Material and polypropylene fiber requirement of medical mask waste per m^3

Material	Unit	0 %	0.15 %	0.20 %	0.25 %
Water	liter	97.22	97.22	97.22	97.22
Cement	kg	393.75	393.75	393.75	393.75
Silicafume	kg	43.75	43.75	43.75	43.75
Coarse aggregate	kg	1,088.33	1,088.33	1,088.33	1,088.33
Fine aggregate	kg	675.15	675.15	675.15	675.15
Superplasticizer	liter	9.04	9.04	9.04	9.04
Medical mask waste	gram	0	136.5	182	227.5

Table 2 presents the test parameters in research high-strength RC beams from medical mask waste of polypropylene fiber.

Table 2

Test parameters

No.	Testing	Dimension of test piece (mm)	Fiber content
1	Compressive strength test SNI 03-1974-1990	Cylinder 150/300	0 %; 0.15 %; 0.20 %; 0.25 %
2	Split tensile strength test	Cylinder 150/300	0 %; 0.15 %; 0.20 %; 0.25 %
3	Beam bending test three point bending SNI 03-4154-1996	Beams 100×150×1200 with *As*=3ø12=339 mm^2	0 %; 0.15 %; 0.20 %; 0.25 %

In this research study using concrete beam bending test, where the setting up of experimental setup RC beam bending three-point test as shown in Fig. 3.

Fig. 3 shows experimental setup high-strength waste mask fiber RC beam of waste mask fiber supported by joint and roller supports with a span of 1200 mm and each support 100 mm away from the edge of the beam. A pump is used to pressurize a hydraulic jack mounted on a standard frame system. The hydraulic jack will press the load cell and the load in kN will be read on the load indicator. The load is transmitted to the beam surface by a lateral load divider into a line load towards the beam width. When the load is applied, the beam flexes and compresses the LVDT installed in the middle of the span and the amount of deflection in mm will be read on the data logger. The longitudinal reinforcement strains and the magnitude in 10^{-6} is measured by a strain gauge at the installation location of one of the reinforcements and will be read on the strain-meter.

Fig. 2. Materials for polypropylene fiber high-strength concrete

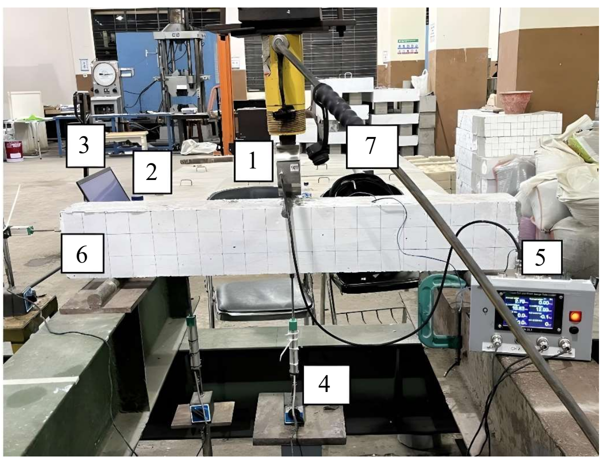


Fig. 3. Experimental setup: 1 – load cell; 2 – crack detector microscope; 3 – laptop; 4 – LVDT; 5 – logger data; 6 – specimen; 7 – hydraulic jack

The research procedure for three-point flexural testing was carried out at 28 days of age, all RC beams were simply supported with a span of 1200 mm and a point load at the center of the span. The loading was done manually with a hand pump, hydraulic jack and load cell, the point load was then transferred by a rigid lateral load divider as a line load to the beam surface. Deflection was measured with a Linear Variable Differential Transducer (LVDT) while reinforcement strain was measured with 1 strain gauge that had been attached to one of the center longitudinal bars. Load output data was read on the load indicator, deflection was read on the data logger and reinforcement strain was read on the strain-meter. The beam was given an initial load of 0.5 kN to eliminate any movement at the support and then the load was removed again and all equipment was zeroed. Loading was carried out monotonically at intervals of 100 kg until collapse occurred. For each load interval, deflections and strains of the longitudinal reinforcement were measured. Deflection measurements were taken with a USB digital microscope for each loading interval. The results of the deflection measurements were digital photographs of the cracks, which were then measured with the equipment's complementary software. Along with the RC beam bending tests, concrete cylinder compressive tests were also conducted to determine the compressive strength and split tensile strength.

5. Result is the influence of split tensile strength to crack width of high-strength RC beam with polypropylene fiber from medical mask waste

5. 1. Relationship between split tensile strength (*ftf*) and polypropylene fiber content (*cf*) of medical mask waste

Mechanical characteristic tests of high-strength polypropylene fiber concrete from medical mask waste carried out in this research were compressive strength tests and split tensile strength tests. The implementation is as shown in Fig. 4.

a *b*

Fig. 4. Mechanical characteristic tests of high-strength concrete: *a* – compressive strength test; *b* – split tensile strength test

The compressive strength tests and split tensile strength tests were conducted at 28 days of age. With the number of test specimens at fiber levels (0 %, 0.15 %, 0.20 % and 0.25 %) each totaling 10 pieces.

Table 3 is obtained from the average cylindrical test specimens of each variation of fiber content of 10 pieces so that a total of 40 test specimens for compressive strength test and 40 test specimens for split tensile strength test.

Table 3

Results of compressive strength test and split tensile strength test of polypropylene fiberized high-strength concrete from medical mask waste

Fiber content (*cf*), %	Compressive strength (*fc'*), MPa	Split tensile strength (*ftf*), MPa
0.00	71.17	4.90
0.15	66.58	5.98
0.20	62.41	6.19
0.25	60.83	6.17

Below is presented one of the results of effect of fiber content to split tensile strength of high-strength test, shown in Fig. 5.

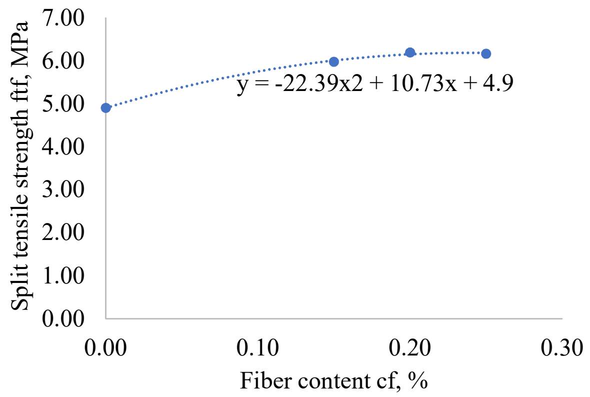


Fig. 5. Relationship between split tensile strength and fiber content of mask waste

Fig. 5 shows that at fiber content (cf) of 0.15 %. 0.20 % and 0.25 %, there is an increase in the split tensile strength (ftf) of polypropylene fiber concrete from medical mask waste compared to the value without fiber (0 %). The relationship equation between the two is:

$$ftf = -22.39cf^2 + 10.73cf + 4.90. \tag{1}$$

It reached the optimum value at split tensile strength, ftf=6.19 MPa at cf=0.24 % fiber content.

5. 2. Relationship between crack width (w) and steel stress (fs)

The formula includes the mixdesign-sheet high-strength concrete by Aitchin [14] planned concrete quality fc'=70 MPa, and quality of steel used fy=360 MPa (primary data). Based on previous research [7, 11, 10, 16] obtained the greater the value of steel stress (fs), the more w (crack width) increases. From the formula in the graph there is still a spread so that the average is obtained the average:

$$w = 0.0005fs. \tag{2}$$

Existing research that is close to the equation is taken from JSCE codes [12]:

$$w_{\max} = 0.0005fs. \tag{3}$$

The equation value is even the same as the average crack width formula equation.

The following presents one of the observations of the flexural strength and crack width tests of polypropylene-fibered high-strength RC beam from medical mask waste. Below is presented one of the results of observations of the RC beam flexural tensile test, shown in Fig. 6 and the presented crack width on RC beam, shows Fig. 7.

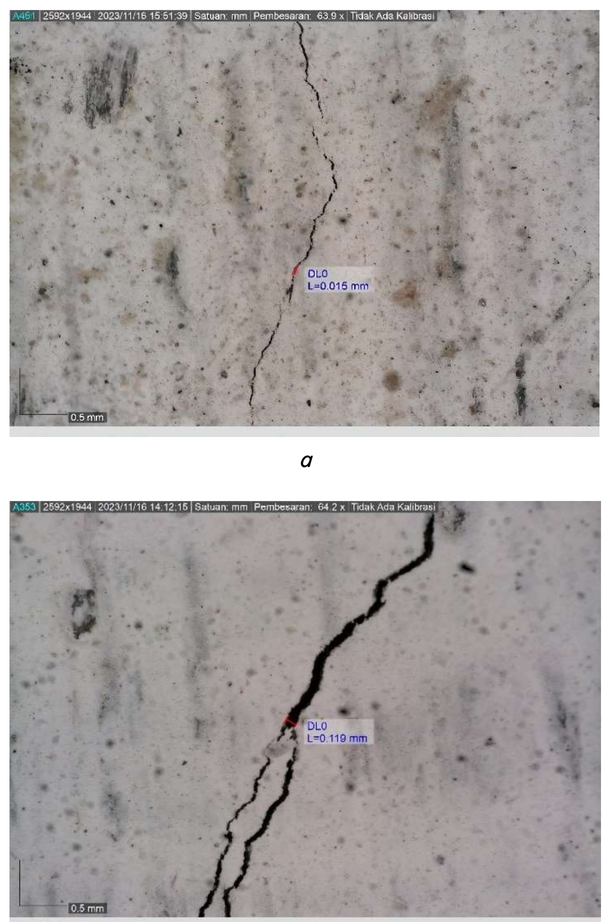
Fig. 8 shows the width of the cracks width that form in RC beam of the load on each beam on ftf=6.17 MPa and reinforcement area As=3ø12. The following are the crack width formulas of previous researchers and the crack width of the codes used in this study as reference guidelines in analyzing the crack width of RC beams with split tensile strength parameters and fiber high-strength RC beam and reinforcement area parameters (As).

Fig. 8 shows that at the content of mask fiber waste, there is an increasing trend in strain and steel stress (fs) and an increase in the crack width of the RC beam. The formula obtained for the relationship between steel stress (fs) and crack width w from experiment (w_{exp}) and w from analysis (w_{an}) is as follows:

$$w_{exp} = 0.0007fs, \tag{4}$$

$$w_{an} = 0.0006fs. \tag{5}$$

Fig. 6. Flexural collapse of polypropylene fiberized high-strength beams from medical mask waste



a

b

Fig. 7. Example of the results of observing crack width with a digital microscope: *a* – crack width at 2 kN load; *b* – crack width at 6 kN load

Based on this analysis, the code JSCE [12] is:

$$w_{an} = 1.1.k_1 k_2 k_3 \left\{4c + 0.7\left(C_s - \phi\right)\right\}\left[\frac{\sigma_{se}}{E_s} + \varepsilon'_{csd}\right], \tag{6}$$

into a formula approach:

$$w_{\exp} = 1.1.k_1k_2k_3\left\{4c + 0.7\left(C_s - \phi\right)\right\}\left[\frac{1.17\sigma_{se}}{E_s} + \varepsilon'_{csd}\right], \quad (7)$$

coefficient 1.17 is fs=0.0007/0.0006.

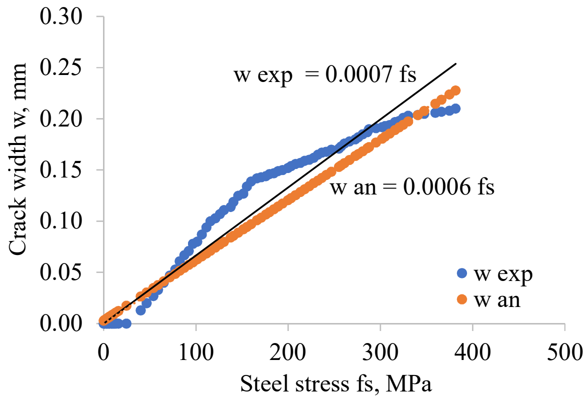


Fig. 8. Relationship between crack width (*w*) and steel stress (*fs*)

5. 3. Relationship between crack width (w) and split tensile strength (ftf) of polypropylene fiber high-strength RC beam from medical mask waste

Result of the effect split tensile strength to crack width on RC beam of the load on each beam on fs=360 MPa reinforcement area MPa and As=3ø12, looks in Fig. 9.

Fig. 9 shows that with split tensile strength taken at steel stress fs=300 MPa and reinforcement area As=3ø12. It is found that with increasing split tensile strength there is a decreasing trend for all crack widths to decrease. So that the effect of varying levels of polypropylene from medical mask waste can increase the tensile strength of concrete and have the effect of decreasing the crack width in the RC beam. The relationship between the experimental crack width (w) and split tensile strength (ftf) on fs=300 MPa and As=3ø12 is:

$$w_{exp}=3.74 ftf^{1.513}, \quad (8)$$

$$w_{an}=0.19 ftf^{0.022}. \quad (9)$$

With this formula approach, the crack width of RC beam at a certain split tensile strength (ftf) can be predicted.

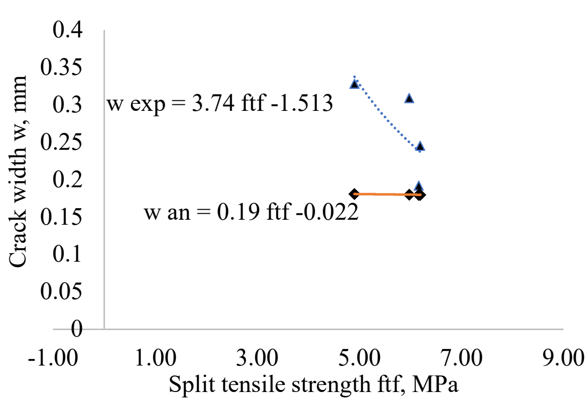


Fig. 9. Relationship between crack width (*w*) and split tensile strength (*ftf*) of polypropylene-fiber high-strength RC beam from medical mask waste

6. Discussion the influence of split tensile strength to crack width of high-strength RC beam with polypropylene fiber from medical mask waste

According to Fig. 5, adding small amounts of medical mask waste fibres can make high-strength concrete stronger in all types of fibre content. As a result of using the method formula (1), the split tensile strength of fibre high-strength concrete (ftf) was found to be highest at ftf=6.19 MPa and 0.24 % fibre content (cf). According to the data, the tensile strength went up across all size and fibre content ranges. According to studies by [5] and [13], the tensile strength went up to 15 % at 0.10 %, 0.15 %, and 0.20 %, but started to go down at 0.25 % compared to the control variable. In addition to its relatively high weight per cubic meter, structural concrete also has weaknesses, namely low tensile strength and brittleness. [13] states that in structural planning, concrete is considered to be able to withstand only compressive stresses, although concrete is actually capable of withstanding tensile stresses of 27 kg/m^2. However, in designs dominated by tension and bending, cracks can develop in the tension portion of the beam even if the stresses are not that great. This is caused by hairline cracks, which are a natural characteristic of concrete. To overcome these disadvantages, building components subjected to tension are often reinforced with steel bars. In current developments in concrete technology, there are methods being used to improve what I consider to be good properties of concrete, including adding fibers to the concrete mix. The addition of fibers improves the structural properties of concrete. Fibers are mechanical in nature and therefore do not react chemically with other concrete-forming materials. After initial setting with the cement slurry, the fibers help bond and bind the concrete mixture. The concrete paste is stronger or more stable when subjected to load due to the action of the surrounding fibers (fiber connectors). It is desirable that the fibers be evenly distributed in the concrete mixture in random directions to prevent premature cracking due to the heat of hydration or loads acting on the concrete. In this way, it is hoped that the ability of the concrete to support internal stresses (axial, bending and shear) will increase. Medical mask waste containing polypropylene fibers was chosen as the material in this study because in addition to its concrete reinforcement factor, it is also an easily available and corrosion-resistant material due to the porous nature of lightweight concrete. The addition of galvanized wire fibers is expected to make a positive contribution to high-strength concrete, and the addition can also increase the compressive strength, tensile strength and flexural strength of concrete.

Fig. 8 shows the maximum crack width was observed in the RC beam with reinforcement area As=3ø12 and split tensile strength, ftf=6.17 MPa, where the crack width reached 0.21 mm at a steel stress of 381.6 MPa. This finding is consistent with the general view that areas with less reinforcement tend to cause larger cracks. Because reinforcement can inhibit the formation and propagation of cracks, it is reduced, resulting in wider cracks. Furthermore, the data show that for cracks of the same width, an increase in the amount of reinforcement also leads to a decrease in the applied stress. These observations suggest that higher concrete mix densities in RC beam structures can distribute and reduce stresses more effectively, resulting in lower tensile stresses and consequently narrower cracks. This correlation highlights the importance of reinforcement not only in reducing crack width but also in reducing the magnitude of stresses occurring within the reinforced concrete beam. The research results also show that the crack width is influenced by the applied steel stress (*fs*) in the RC beam. As the steel stress increases, the crack width also increases. These findings are consistent with the basic principles of materials science and structural mechanics that higher stress levels lead to greater deformation and wider cracks. Furthermore, the relationship between crack width and steel stress remains linear across all variations in reinforcement width. This consistency simplifies the prediction process and highlights the reliability of the linear regression model, meaning that the relationship between crack width and steel stress follows a consistent pattern regardless of the reinforcement area used, allowing for easier predictions. Result that at the content of mask fiber waste, there is an increasing trend in strain and steel stress (*fs*) and an increase in the crack width of the RC beam. The formula obtained for the relationship between steel stress (*fs*) and crack width w from experiment (w_{exp}) and w from analysis (w_{an}) is as follows formula. Based on this analysis, the code JSCE [16] is (6) into a formula (7).

Fig. 9 shows that with increasing tensile strength there is a down trend for all the crack widths to decrease. Concrete has very high compressive strength but low tensile strength. Along with the advantages of concrete, concrete also has weaknesses, namely low tensile strength. One effort to increase the tensile strength of concrete is to add fibers. In this case, polypropylene fibers from medical mask waste are used in a high-strength concrete mix, so that at a certain load level, cracks in the concrete can be avoided or if cracks occur. In concrete, the growth and expansion of cracks in concrete structures can be inhibited by fibers mixed into the concrete mixture. Thus, the tensile strength of fiber-reinforced concrete can be higher than the tensile strength of ordinary concrete. The addition of fibrous material causes the compressive capacity of the concrete cylinder to significantly decrease, while the tensile strength of concrete and the flexural strength of concrete increase. Through the bonding mechanism between the fiber and concrete, the increased flexural strength due to the tensile stress acting on the fiber is transferred to the fiber surface and surrounding concrete [17]. The existence of this bond ultimately causes the tensile strength of the fiber to partially resist the bending stress. The relationship between the experimental RC beam crack width (w) and split tensile strength (*ftf*) of *fs*=300 MPa and *As*=3ø12 is approximated by the formula (8) and (9).

From the results of this relationship, it appears that the split tensile strength of polypropylene fiber high strength RC beam from mask waste has a significant effect on reducing the crack width of the RC beam while the analysis based on code [12] does not have a significant effect. This is because in code [12] mix design concrete is normal without fiber while in the experiment it is fiber high-strength RC beam.

From the research results it was concluded that medical mask waste fibers were able to reduce the crack width of high-strength RC beams. It is also possible that this could be applied to other structures for example slabs and columns, which require further research. The application in research on variation for this mask waste fiber content is 0.15 %, 0.20 %, 0.25 %, for higher fiber content and different fiber dimensions also need to be reviewed.

The limitation of this research is the application of polypropylene fiber from medical mask waste to high-strength *As*=3ø12 RC beams *fc'*=70 MPa. Furthermore, it also needs to be used on beams with different reinforcement, how will this affect the crack width. It could also be applied to normal concrete and varied according to the strength of the concrete used. Research can also vary the fiber dimensions of medical masks but still referring to the dimensions of fiber concrete that are permitted according to SNI or ACI. The crack analysis that has been carried out assumes plane stress conditions. The research aims to observe and find out the relationship beams, as well as measuring strain, stress distribution, crack patterns, crack width, crack spacing, and crack propagation. Crack width measurements are taken from the sides beam, assuming a uniform crack width distribution of one side to side. In addition, this study did not take into account the influence of concrete shrinkage and block rotation in its analysis.

The weakness of this research is the tests carried out by applying a monotonic static load in the form line load at mid-span, without considering other burdens. The results of this research provide recommendations regarding the ratio of the relationship between compressive strength and splitting tensile strength in high-strength polypropylene fiber concrete from medical mask waste. The results of the research obtained an empirical formula for the relationship between split tensile strength and crack width in reinforced concrete beams.

The results of this research can be used as a basis for further research in the field of building construction and further experimental testing or a more detailed mathematical analysis may be used to confirm and expand these findings. But strength concrete and steel materials, and their variations in the field, is a factor that influences research results. Managing this variability may be a challenge this research.

7. Conclusions

1. A small amount of medical mask waste polypropylene fiber can raise the split tensile strength (*ftf*) of high-strength concrete, and this is true for all types of fiber and fiber content. The results of this research showed that the optimum value for splitting tensile strength was 66.19 MPa at a medical mask waste polypropylene fiber content of 0.24 % and fiber dimensions of 5×0.5 cm. Polypropylene fiber from used medical masks waste that was cut into small fibers improved the tensile weakness of concrete by making it stronger in split tension.

2. Steel stress (*fs*) has a large and significant influence on the crack width of high-strength RC beams made of polypropylene fiber medical mask waste. The research results show that the crack width is influenced by the applied steel stress (*fs*) on the RC beam, namely that the more the steel stress (*fs*) increases, the crack width (*w*) also becomes larger. These findings are consistent with the basic principles of materials science and structural mechanics that higher stress levels lead to greater deformation and more extensive cracks.

3. Split tensile strength (*ftf*) influence the crack width (*w*) in reinforced concrete beams made from polypropylene fibre medical mask waste. The increase in split tensile strength (ftf) and drop in crack width (*w*) of RC beam happen at the same level of steel stress (*fs*). With the rise in steel stress (*fs*), the crack width (*w*) also increases. Breakage width was greatly reduced when polypropylene fiber from used medical masks was added to RC beam. All

crack lengths are decreasing as tensile strength rises, which means that fewer cracks happened.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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Data availability

The manuscript has no associated data.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the current work.

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