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Analysis of The Addition Polypropylene Fibre and 8670 Mn Viscocrete added Material on The Split Tensile Strength and Modulus of Elasticity of Concrete

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Abstract: This study used waste coconut fibre and HDPE plastic as partial aggregate replacement materials. Coconut fibre ash has pozzolanic properties, which contain high silicate elements. High-density polyethene (HDPE) plastic has more potent, complex, opaque material properties and is more resistant to high temperatures. Superplasticizer is an admixture added to concrete during mixing and during placing to improve its strength performance. This study aims to study the effect of adding HDPE plastic as a substitute for coarse aggregate, coconut fibre ash as a substitute for fine aggregate and Viscrocrete-8670 MN on absorption, concrete compressive strength and elastic modulus of concrete. With variations in the addition of BN HDPE plastic, 0.5%, 1%, and 1.5%, the coarse aggregate passed 3/8 filter retained by filter no 4, 3% coconut fibre ash for each variation of concrete and Viscrocrete-8670 MN by 0.8% by weight of cement. The maximum value for each concrete test is the absorption value of concrete (4.23% for regular concrete), compressive strength (32.49 MPa for 1.5% HDPE concrete), and the modulus of elasticity (3152 MPa for 1.5% HDPE concrete).

Keywords: Additive 8670 Mn; Modulus of Elasticity; Polypropylene Fibre; Tensile Strength

Introduction

The development of science and technology at this time dramatically influences all aspects of human life, including the construction field. As we know today, results in the construction field, especially civil engineering, have increased quite rapidly, especially in the construction of buildings and infrastructure. Concrete is a construction material commonly used for buildings, bridges, roads, and others (Purnomo & Dewi, 2016). Concrete generally comprises cement, fine aggregate, coarse aggregate, water and other additives when needed. However, along with the development of science and technology, concrete constituents can also change or be combined with organic or inorganic materials such as plastic and other waste materials (Ahmed et al., 2021; Tavakoli et al., 2018; Wibowo, 2018).

Fibre concrete is made from Portland cement or other hydraulic binding agents added with fine and coarse aggregates and water and reinforced with fibres (Ragavendra et al., 2017; Shaikh et al., 2020). Incorporating fibre into the concrete will achieve higher performance (Junwei et al., 2021), such as increasing energy absorption, reducing plastic cracking at the beginning of the concrete's life, and controlling cracks and spalling when the concrete has cracked (Khalel et al., 2021). The physical properties of fibre concrete will make the concrete stiffer, thereby reducing the slump value and speeding up the initial setting time. The mechanical properties of fibre concrete will increase the split tensile strength and modulus of elasticity. However, they will decrease the compressive strength when the fibre added has reached the optimum limit (Alkhaly & Syahfitri, 2017; Alluhri, 2016).

One waste that needs to be appropriately utilized is coconut coir ash. Coconut fibre is usually considered waste only left under the coconut plants and left to rot or dry. Its utilization is mainly used only as a burning tool. Traditionally, the community processes coconut fibre into rope and woven it into mats. Coconut fibre is

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a relatively large part of the coconut fruit, 35% of the total weight. Coconut fibre consists of fibre and cork, which connects one fibre to another. Coconut fibre ash comes from the processing of coconut fibre waste which is burned and then becomes ash. Coconut fibre ash has pozzolanic properties, which contain high silicate elements (Affandy & Bukhori, 2019; Boni et al., 2019; Ginting, 2019). Because it has pozzolanic properties, coconut coir ash makes it possible to use it as a filler to manufacture regular concrete.

On the other hand, economic growth and changes in human consumption and production patterns have led to a sharp increase in plastic trash globally. Since plastic does not originate from biological substances, it is difficult to degrade. Plastic garbage takes 100 to 500 years to disintegrate. In cities, garbage is an extremely complicated issue. Interestingly, plastic is required as a relatively straightforward container. According to BPS data for 1999, there was an increase of 34.15% in the volume of commerce in imported plastic from Indonesia, particularly polypropylene (PP), from 1995 to 1999, from 136,122.7 tons to 182,523.6 tons. It is anticipated that this figure will keep rising over time. It follows that plastic trash will inevitably increase (Bachtiar et al., 2021; Khonado et al., 2019).

Because these materials are accessible and have not yet been used to their full potential, it is crucial and urgent to turn waste into valuable materials, including using domestic plastic garbage as a concrete aggregate. Artificial lightweight aggregates made from garbage will be used in this study. plastic bottles made of high-density polyethene (HDPE). High-density polyethene (HDPE) is a thermoplastic polyethene type that is often used, according to Harper Plastic. At room temperature, polyethene is insoluble in all solvents. Although this polymer is resistant to both acids and bases, strong nitric acid can harm it. The recycling symbol's number 2 indicates that HDPE is recyclable. Additionally, HDPE is more durable and resistant to high temperatures (up to 120 °C). High density has the characteristics of a tougher, more opaque, and more heat-resistant substance (Rommel et al., 2015).

A thermoplastic polyethene manufactured from petroleum is called HDPE (Salah et al., 2019). To produce 1 kilogram of HDPE, 1.75 kg of petroleum must be used as both energy and raw material. The recycling symbol's number 2 indicates that HDPE is recyclable. The amount of HDPE produced in 2007 was 30 tons. Due to the choice of catalyst used in its manufacturing (the Ziegler-Natta catalyst) and the parameters of the reaction, HDPE has extremely few branches. HDPE has a high tensile strength and strong intermolecular tensions because of its modest branching. Additionally, being more robust and highly chemically resistant, HDPE has a wide range of uses, (Purnomo & Dewi, 2016; Tomayahu, 2016; Umar, 2019). Adding plastic trash to the concrete mix can boost compressive strength, according to the Indonesian Journal Of Applied Physics 2012 (Pratomo, 2016; Purnomo & Dewi, 2016).

This study also used the added material Superplasticizer type Sika Viscrocrete – 8670 MN. Superplasticizer, or SP, reduces water in concrete mixtures to obtain a small w/c factor but normal workability (Chakkamalayath et al., 2022). Sika Viscocrete – 8670 MN is the third-generation Superplasticizer for concrete and mortar. For High range water reducing Superplasticizer. Sika Viscocrete – 8670 MN is a unique multi-purpose Superplasticizer which is especially suitable for concrete production, which requires high early strength with extended workability. In order to obtain high concrete compressive strength and good workability, it is necessary to use admixtures combined with cement. The average value of the split tensile strength of concrete obtained according to the variations is; BN (2.4 MPa), BPF 0.3%(2.6 MPa), BPF 0.7%(2.1 MPa), and BPF 1%(1.32 MPa). Concrete's optimum average split tensile strength was obtained at a variation of BPF 0.3% and Viscocrete 8670 MN 1% of 2.6 MPa. Whereas for the elastic modulus test, the highest value was obtained in the 1% BFP variation mixture of 97311 MPa with a maximum compressive strength of 31.12 MPa.

Method

The method used in this research is the manufacture of concrete specimens by adding polypropylene fibre and discrete as an experimental method. The variations in the amount of polypropylene fibre used are 0%, 0.3%, 0.7% and 1%. The specimens will be printed as a cylinder with a diameter of 15 cm and a height of 30 cm, and 1 sample will be printed for each variation to test the split tensile strength and elastic modulus in concrete. Concrete will be tested when the age of concrete reaches 28 days.

Next, determine the mix design. Determine the percentage or composition of each component of the concrete forming material to obtain an economical concrete mix that meets the planned strength and durability and has appropriate workability to facilitate the work process by SNI-03-2834-2000 (Zendrato, 2022). Research planning, including literature review, material preparation, material inspection, mix design, specimen manufacture, slump test, specimen moulding, specimen maintenance, concrete split tensile strength test, concrete elastic modulus test, data analysis.

Test Object Design

The study used cylindrical specimens (Fujianti, 2022) with a diameter of 15 cm and a height of 30 cm, with a sample of 12 pieces of concrete with 4 (four) variations, each variation totaling three samples. The composition of the test object mixture and the test object code can be seen in the following Table 1.

Table 1. Composition of the test object mixture

Test Object Code	Coarse Aggregate (%)	Fine Aggregate (%)	HDPE plastic (%)	Fiber ash Coconut (%)	Viscocrete 8670-MN (%)	Number of Samples (%)
Concrete Normal	100	100	0	0	0.8	3
B. HDPE0.5% and ASK 3%	99.5	97	0.5	3	0.8	3
B. HDPE 1% and ASK 3%	99	97	1	3	0.8	3
B. HDPE 1.5 % and ASK 3%	98.5	97	1.5	3	0.8	3
Amount						12

Information

B. HDPE 0.5% and ASK 3%: Concrete with a mixture of 0.5% HDPE plastic by weight of coarse aggregate and 3% coconut coir ash by weight of fine aggregate with the addition of viscocrete 8670 MN. B. 1% HDPE and 3% ASK : Concrete with a mixture of 1% HDPE plastic by weight of coarse aggregate and 3% of coconut coir ash by weight of fine aggregate with additional viscocrete 8670 MN. B. HDPE 1.5% and ASK 3% : Concrete with a mixture of 1.5% HDPE plastic by weight of coarse aggregate and 3% of coconut coir ash by weight of fine aggregate with additional viscocrete 8670 MN.

Result and Discussion

The development of science and technology at this time dramatically influences all aspects of human life, including the construction field. As we know today, results in the construction field, especially civil engineering, have increased quite rapidly, especially in the construction of buildings and infrastructure. Concrete is a construction material commonly used for buildings, bridges, roads, and others (Purnomo & Dewi, 2016). Concrete generally comprises cement, fine aggregate, coarse aggregate, water and other additives when needed. However, along with the development of science and technology, concrete constituents can also change or be combined with organic or inorganic materials such as plastic and other waste materials (Wimaya et al., 2020).

Utilizing plastic waste of the HDPE type and coconut coir ash to create concrete calls for the employment of an experimental process, which is carried out by carrying out test operations to gather data. The research stages, namely : preparation, preparation of equipment to be used, and testing of the primary materials for making concrete test objects (coarse aggregate, fine aggregate, Portland cement and water) will be done at the Civil Engineering Laboratory of the Muhammadiyah University of North Sumatra; inspection of Concrete Stacking Materials, this inspection is carried out to determine the nature and characteristics of concrete stacking materials and whether they meet the specified requirements when used in mixing concrete (mix design); mixed planning, SNI 03-2834-2000 carries out a mixed design. Concrete mixing is planned based on the inspection findings of each prior component, beginning with cement, fine aggregate, coarse aggregate, and water. The outcomes of this mix design take the form of comparisons between the components of concrete, and these comparisons will be the foundation for creating test specimens; making Test Objects, at this stage, the following jobs are carried out: making concrete mix, the slump test refers to SNI 1972:2008. C, casting into cylindrical moulds, removing the test object from the cylinder mould.

Treatment of the test object, is carried out by immersing the concrete in the tub for 28 days. Concrete Testing: at this stage, testing of concrete's absorption, compressive strength, and modulus of elasticity is carried out. Data Analysis and Discussion, at this stage, data processing is carried out from tests that have been carried out with the help of the Microsoft Excel program. Then discussions are carried out regarding the test results obtained. Concluding, this stage is the last stage of this research. In this stage, the data that has been analyzed is made a research conclusion related to the research objectives, and that suggestions are also made for further research.

The data obtained from the results of research in the laboratory, namely: Aggregate sieve analysis (SNI 03-1968, 1990); Specific gravity and absorption of coarse aggregate (SNI 1969, 2008); Specific gravity and absorption of fine aggregate (SNI 1970, 2008); Aggregate weight check (SNI 03-4804, 1998); Examination of aggregate moisture content (SNI 1971, 2011); Examination of sludge content (SNI 03-4141, 1996); mix design (SNI 03-2834-2000); manufacture and maintenance of concrete specimens (SNI 2493:2011);

absorption test (SNI 03-6433-2000); concrete compressive strength test (SNI 1974:2011); and concrete modulus of elasticity test (ASTMC-469 02) (Budiman, 2023).

Table 2. Fine aggregate inspection results

Sieve Number	Holding Weight				Cumulative	
	Semple I (gr)	Semple II (gr)	Total Weight (gr)	Percentage %	Restrained (%)	Get away (%)
4.75 (No. 4)	78	83	161	6.44	6.44	93.56
2.36 (No. 8)	91	102	193	7.72	14.16	85.84
1.18 (No. 16)	142	157	299	11.96	26.12	73.88
0.60 (No. 30)	450	394	844	33.76	59.88	40.12
0.30 (No. 50)	329	368	697	27.88	87.76	12.24
0.15 (No. 100)	103	82	185	7.40	95.16	4.84
PAN	57	64	121	4.84	100	0
Total	1250	1250	2500	100		

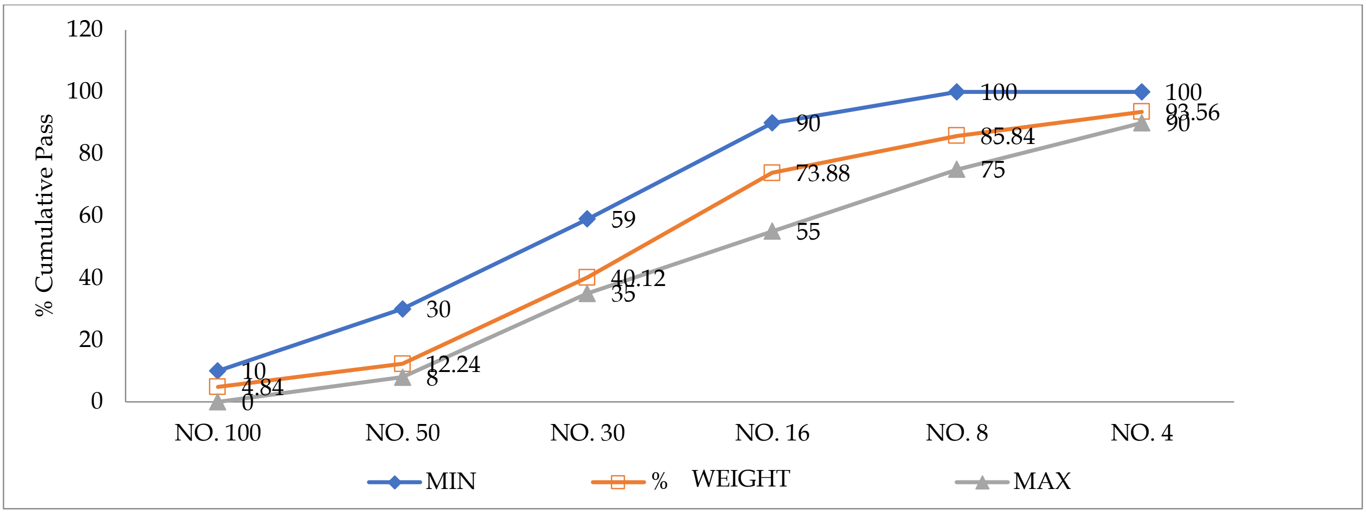

Figure 1. Graph of fine aggregate gradation

Table 3. Results of Examination of Specific Gravity and Absorption of Fine Aggregate

Fine Aggregate (Passed Sieve No.4)	Sample 1 (gr)	Sample 2 (gr)	Average (gr)
Saturated surface dry SSD sample weight (B)	500	500	500
Sample weight of oven-dried SSD (E)	486	488	487
The weight of the pycnometer full of water (D)	689	692	690.5
SSD weight in pycnometer full of water (C)	993	995	994
Dry specific gravity [E / (B + D – C)]	2.47	2.47	2.47
SSD specific gravity [B / (B + D – C)]	2.55	2.53	2.54
Apparent specific gravity [E / (E + D – C)]	2.67	2.63	2.65
Absorption [(B – E) / E] x 100%	2.88	2.45	2.67

The nuanced aggregate sieve analysis results obtained an FM of 2.89%. This value is still permitted to be included as fine aggregate, where the allowable value is 1.5% - 3.8% in zone 2. The inspection results of specific gravity and OK aggregate absorption tests obtained an average SSD (Saturated Surface Dry) Specific Gravity of 2.54. They can be categorized as an average fine aggregate because it is still within the allowable value limits between 2.2 and 2.7. Water absorption (Absorption) obtained an average of 2.67%. The results show that the ability of a fine aggregate to absorb water from dry to saturated dry is 2.67% of the dry weight of the aggregate itself.

Table 4. Results of Coarse Aggregate Sieve Analysis

Sieve Number	Holding Weight					Cumulative
	Sample I (gr)	Sample II (gr)	Total Weight (gr)	Percentage %	Restrained (%)	Get away (%)
38.1 (1.5 In)	0	0	0	0	0	100
19.0 (3/4 In)	90	69	159	6.36	6.36	93.64
9.52 (3/8 In)	705	669	1374	54.96	61.32	38.68
4.75 (No. 4)	455	512	967	38.68	100	0
Total	1250	1250	2500	100		

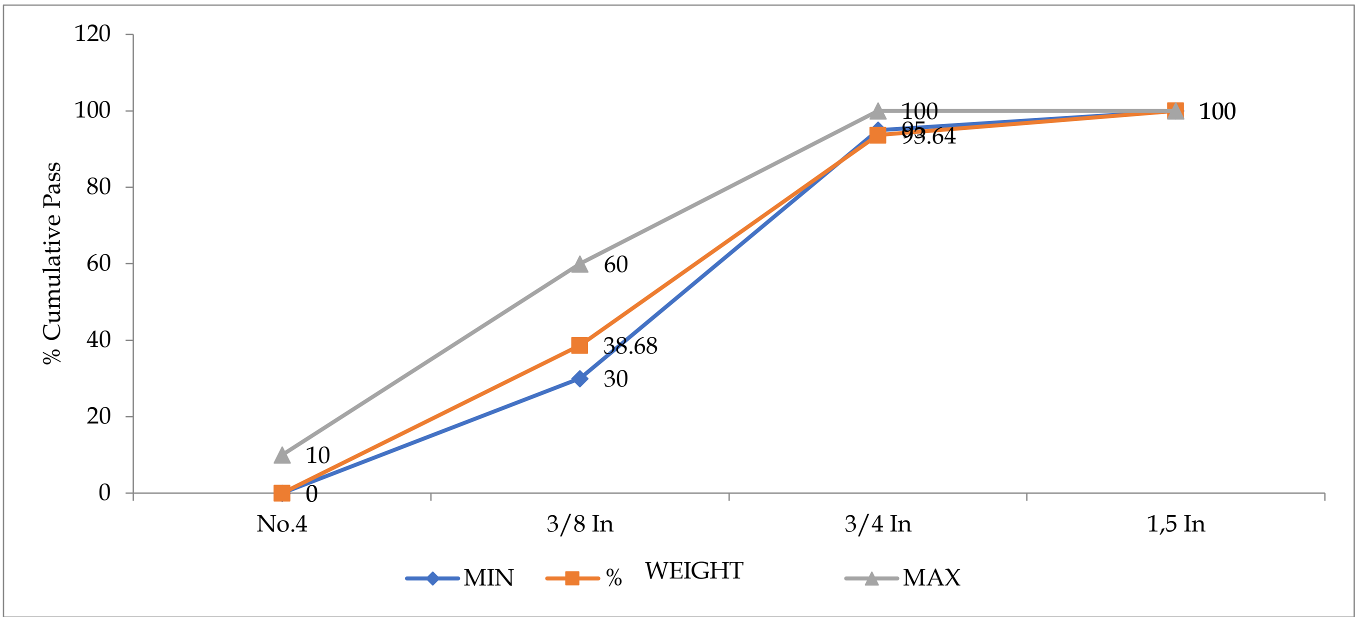

Figure 2. Graph of coarse aggregate gradation.

The results of the coarse aggregate sieve analysis obtained FM of 6.67%. The results of the percentage of cumulative weight that passes the filter means that the sand is still in the gravel range of a maximum of 40 mm.

Table 5. Results of Examination of Specific Gravity and Application of Coarse Aggregate

Fine Aggregate	Sample 1 (gr)	Sample 2 (gr)	Average (gr)
Saturated surface dry SSD sample weight (A)	2482	2446	2464
Sample weight of oven-dried SSD (C)	2470	2449	2459.5
SSD weight in water (B)	1540	1519	1529.5
Bulk gravity dry (C/(A-B))	2.62	2.64	2.63
Bulk gravity SSD (A/(A-B)	2.63	2.64	2.65
Apparent specific gravity (C/(C-B))	2.66	2.63	2.65
Absorption [(A – C)/C] x 100%	0.48%	-0.12%	0.18%

The specific gravity test results and coarse aggregate absorption obtained an average SSD (Saturated Surface Dry) Specific Gravity of 2.65. They can be categorized as an average coarse aggregate because it is still within the allowable value limits between 2.2 and 2.7. Water absorption (Absorption) obtained an average of 0.18%. The results show that the ability of a coarse aggregate to absorb water from dry to saturated dry is 0.18% of the dry weight of the aggregate itself.

Table 6. Results of Inspection of Coarse Aggregate Weight

Testing	How to implement			Average	Unit
	Free	Skewer	shake		
Aggregate weight	17725	18726	19412	18622	Gr
Container weight	4225	4225	4225	4225	Gr
Aggregate weight + receptacle	21950	22951	23637	22846	Gr
Container volumes	11125.4	11125.4	11125.4	1125.4	cm^3
Fill weight	1.59	1.68	1.74	1.67	gr/cm^3

Table 7. Results of Examination of Coarse Aggregate Sludge Content

Testing	Sample 1	Sample 2	Unit
SSD sample weight	1000	1000	Gr
SSD sample weight after washing	957	973	Gr
Aggregate dirt weight passes through No.200 sieve	43	27	Gr
The percentage of aggregate impurities passing through No.200 sieve	4.3	2.7	%
Average		3.5	%

The results of the coarse aggregate silt content examination obtained an average percentage of 3.5%. This value is still within the allowable value limit of a maximum of 5% (SK SNI S-04-1989-F), so the aggregate does not need to be rewashed.

Mix design

Amount of water (B) = 185 kg/m^3
Total fine aggregate (C) = 739.59 $kg/m3$
Total coarse aggregate (D) = 1064.3 kg/m^3
Absorption of fine aggregate (Ca) = 2.67%
Absorption of coarse aggregate (Da) = 0.18%
Moisture content of fine aggregate (Ck) = 1.16%
Moisture content of coarse aggregate (Dk) = 0.30%

Material Requirements

Based on the results of the moderate quality normal concrete mix design, it is known that the amount of material needed for 1 $m3$ is as follows :

- Cement = 411.11 kg/m^3
- Fine aggregate = 728,42 kg/m^3
- Coarse aggregate= 1065.58 kg/m^3
- Water = 199.26 kg/m^3

The volume requirement for one test object with a cylindrical mold is as follows:

- Tall = 30 cm = 0,3 m
- Diameter = 15 cm = 0,15 m
- Cylinder volume = $\frac{1}{4} . \pi . d^2 . T = \frac{1}{4} . 3{,}14 . 0{,}15^2 . 0{,}30$ = 0.0053 m^3

Table 8. The need for concrete constituents for various types of mixtures

Test Object Code	Volume 1 x Mix Per (m^3)	Ingredients					
		PPC (kg)	Aggregate or Smooth (kg)	Coarse Aggregate (kg)	Water (kg)	Polypo-pylene Fiber (kg)	Visco-crete 8670 (kg)
BN	0.01166	4.793	8.493	12.425	2.323	0%	0
BPPF 0.3%	0.01166	4.793	8.493	12.425	2.323	0.3% 0.0143	1% 0.0479
BPPF 0.7%	0.01166	4.793	8.493	12.425	2.323	0.7% 0.0335	1% 0.0479
BPPF 1%	0.01166	4.793	8.493	12.425	2.323	1% 0.0479	1% 0.0479
Total	0.04664	19.17	33.97	49.700	9.292	0.0957	0.1437

Information:
BN : Normal Concrete
BP 0,3% : 0.3% Polypropylene Fiber Concrete with added silica viscocrete 8760
BPF 0,7% : 0.7% Polypropylene Fiber Concrete with Sika added viscocrete 8760
BPF 1% : 1% Polypropylene Fiber Concrete with the addition of Sika Viscocrete 8760

While the volume requirement for each variation or one mix of mixer is three specimens. However, the author will only make 2 x 0.0053 $m3$ = 0.0106 $m3$ in one mixer. As a tolerance for losses during manufacture, the material requirement for the amount of each total variation is added 10% of the total variation, namely = 0.0106 $m3$ + (0.0053 $m3$ x 10%) = 0.0111 $m3$. So that all the material requirements for each variation or one mix of mixer are obtained as follows Table 8.

Table 9. Slump Test Results

Variation Concrete	Day	Slump Test (mm)
Normal Concrete	28	60
Polypropylene Fiber Concrete 0.3%	28	53
Polypropylene Fiber Concrete 0.7%	28	50
1% Polypropylene Fiber Concrete	28	46

Table 11. Testing the modulus of elasticity of concrete

Code Sample	Heavy Sample	Test Object Size		Pmax 40%	ΔL 40%	Voltage		Strain		Modulus Elastic
		d	t			MPa				
	(kg)	(mm)	(mm)	(kN)	(mm)	S2	S1	ε1	ε2	MPa
BN	12.38	150	300	176	0.092	9.96	0.94	0.000307	0.00005	35092
BPF 0.3%	12.57	150	300	208	0.059	11.78	4.04	0.000196	0.00005	52864
BPF 0.7%	12.89	150	300	180	0.011	10.19	11.32	0.000037	0.00005	84926
BPF 1%	12.83	150	300	220	0.041	12.46	3.89	0.000138	0.00005	97311
Average Modulus of Elasticity										67548.25

Slump Test Results

The slump test is carried out to determine the workability of regular fresh concrete or concrete with additives (Li et al., 2021). The slump test was carried out using a tool called the Abrams cone by filling the Abrams cone with three layers of fresh concrete, each with 1⁄3 of the contents of the Abrams cone. Then do the rolling on each layer of the dough 25 times; the rojak stick must go to the bottom of each layer. After the filling is complete, flatten the cone's surface and let it stand for 10 seconds; then, lift the Abrams cone upright until the fresh concrete is released from the mould, and measure the height difference between the fresh concrete and the mould. The number obtained is the result of the slump value.

Modulus of Elasticity

The ASTM C 469-02 methodology is used for this modulus of elasticity test (Humbert et al., 2019; Tampi et al., 2020). A dial gauge (concrete modulus of elasticity test kit) and a concrete compressive strength machine tool were used to conduct the test. When the concrete has been in place for 28 days, both conventional concrete and concrete containing 0.3%, 0.7%, and 1% polypropylene fiber are subjected to this modulus of elasticity test. Up to 40% of the maximum compressive strength is the only amount of concrete's elastic modulus that is tested. At intervals of 50 kN load readings, the dial is read. The specimens were cylindrical, measuring 15 cm in diameter and 30 cm in height.

Conclusion

The more significant the percentage of HDPE plastic aggregate in the concrete, the higher the slump test value of the concrete. Where from the research results obtained a maximum slump value of 8.4 cm at a variation of 1.5% HDPE, 3% coconut fibre ash and 0.8% viscocrete 8670 MN. As well as the lowest slump value of 6 cm in normal concrete variations. Apart from the addition of HDPE plastic, another factor that causes an increase in the slump value is the result of the addition of discrete 8670 MN. As explained on the theoretical basis, adding a discrete 8670 MN superplasticizer causes the dispersion of cement particles, resulting in a diluted mix. The addition of coconut coir ash is also quite influential. It is known that coconut coir ash has pozzolanic properties, which contain silicate elements almost the same as cement; this can cause the concrete mix to become thinner. The maximum absorption value of concrete is 4.23% for the standard concrete variation, while the minimum absorption value is 2% for the 1.5% concrete variation. The higher the percentage of HDPE plastic in the concrete mix, the lower the absorption value of the concrete. This is due to the nature of the HDPE plastic used as coarse aggregate, which has a higher density than ordinary aggregate (Abbas et al., 2022; Aocharoen & Chotickai, 2021). In addition, the lack of concrete compaction in the concrete moulding process causes air bubbles not to come out, causing porous concrete and affecting the high percentage of concrete absorption. The higher the percentage of HDPE plastic in the concrete, the higher the compressive strength of the concrete. This study obtained a maximum compressive strength of 32.49 MPa at 1.5% concrete variation. Moreover, the minimum compressive strength of concrete is 23.32 MPa at 0.5% concrete variation. The maximum concrete elastic modulus value is 94852 MPa at 1% HDPE concrete variation.

Author Contributions

The author of this article consists of three person. This article was well resolved from the research process to completion.

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Conflicts of Interest

The authors declare no conflict of interest.

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