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IDENTIFICATION OF PATTERNS OF STRENGTH FORMATION OF CONCRETE USING CEMENT PORT LAND POZZOLAN (PPC) AND WASTE TIRE POWDER IN THE CONDITION OF SEAWATER CURING

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According to the national standard body in Indonesia, the compressive strength of 20 MPa concrete is medium quality concrete. Medium-strength concrete is usually used for floors, light construction, houses, warehouse factories, and sidewalks. The use of medium-strength concrete is very broad, it is necessary to continuously conduct research to produce new innovations. Previous research on the utilization of waste rubber tires has been carried out. Research on the development of concrete with the use of waste tire rubber powder is very interesting to do considering the waste of used tires that continues to increase along with the increase in the number of motorized vehicles in Indonesia. Portland Cement (OPC) and Portland Pozzolan Cement (PPC) are the two types that will be used in this research to see its effect on concrete with waste rubber powder. These two cements also have different corrosion resistance. And seawater is one of the triggers of high concrete corrosion. Research on the development of concrete with the use of waste tire rubber powder is very interesting to do considering the waste of used tires that continues to increase along with the increase in the number of motorized vehicles in Indonesia. Portland Cement (OPC) and Portland Pozzolan Cement (PPC) are the two types that will be used in this research to see its effect on concrete with waste rubber powder. These two cements also have different corrosion resistance. And seawater is one of the triggers of high concrete corrosion.

This study aims to analyze how the compressive strength of PPC concrete compares with OPC and the addition of used tire powder under seawater treatment conditions. Six concrete variants were made and then tested for compressive strength. The compressive strength values of variants 1 to 6 were obtained as 20.78 MPa, 18.26 MPa, 19.56 MPa, 16.58 MPa, 13.03 MPa. The results show that tile powder is not effective in increasing construction strength, but the use of PPC cement is more effective than the use of OPC in improving construction, especially for cement use in buildings close to sea water

Keywords: compressive strength, waste tile powder, portland cement, portland pozzolan

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1. Introduction

Concrete is one of the most widely used materials. In addition to concrete having compressive and tensile strengths that can be planned, concrete is also a structure that is resistant to fire. According to the Indonesian national standard (SNI 03-2834-2000) concrete is classified into several types according to its compressive strength. The classification of concrete will affect the use of the concrete itself. Concrete innovation continues to increase and the use of waste as a concrete additive is very developed and varied.

The increase in the use of motorized vehicles in Indonesia is very significant for the increase in tire rubber waste. Vehicle tire rubber has a much shorter lifespan than the lifespan of motor vehicles. This makes a huge increase in waste rubber tires.

Waste Rubber tires are increasing making a strong reason to be used as an additive or substitute material for concrete. The use of waste tires in asphalt mixtures has been developed where waste rubber at certain temperatures can melt and become homogeneous with other materials in the asphalt mixture.

From previous studies on the utilization of waste rubber tires, it is known that there is a decrease in mechanical properties, one of which is the compressive strength of concrete. So that the utilization of this waste cannot be used with high quality concrete. High-strength concrete is used for structures that withstand very large loads.

Low-strength concrete with a strength between 20–30 MPa is an alternative choice in this study. Where the use of low-strength concrete is used for structures such as houses, as well as sidewalks and roads.

The two types of cement used in concrete mixes are OPC and PCC. Both have good material binding ability and ease of availability. The difference between the two is the content of additives present in PCC cement. And the heat generation properties of OPC cement are higher so that it can affect the temperature and the surrounding environment.

The impact of environmental sustainability considerations has influenced the use of cement in the construction industry. According to experts who are involved in observing global warming, 7 % of the production of CO_2 emissions in nature comes from cement production and every reduction of 1 ton of cement production results in a reduction of

1 ton of CO_2 emissions [1]. Pozzoland cement can product high CO_2 emission [2].

Previous research states that 10–20 % substitution of cement by artificial pozzolans, namely fly ash, rice husk ash or 10 % palm oil fuel ash results in an increase in bending strength and strain, bending toughness, and water absorption from a mixture of glass fibre concrete (glass fibre-reinforce concrete) [3]. Thus, this material is recommended to be used as a commercial product in concrete construction, namely as a cement substitution material of up to 20 % by weight of the mixture. Some of the advantages of using this material are saving construction costs, improving the mechanical properties of the mixture and reducing the production of CO_2 exhaust emissions. If all the use of cement in construction projects in the world replaces the use of cement by 25–30 % with fly ash or other pozzolanic materials, there will be a reduction in exhaust emissions.

In this research, an experiment was conducted to mix concrete with added waste material in the form of used tire waste powder with a mixture of Port land Pozzolan cement (PPC) and carried out under seawater submerged conditions.

The reason for using Port land Pozzolan and used tire waste is because Port land Pozzolan cement is relatively more able to reduce CO_2 emissions due to the presence of fly ash or other pozzolanic materials and tire waste is one of the biggest waste contributors.

This type of Port land Cement (PC) requires water to carry out a chemical reaction when hydration occurs, namely the cement process begins to bind the concrete constituents, then hardens and forms a solid mass. According to the requirements, concrete may not be made from: water containing oil, acids, alkalis, salts or organic substances, or other substances which are detrimental to concrete and reinforcement; preferably clean fresh water, which can be drunk [4]. In reality, concrete buildings are not always located on land that is free from the influence of the sea. Indonesia, as the largest archipelagic country in the world, has many concrete buildings which are always submerged or affected by sea water. As it is known that there are many occurrences of sea water intrusion in several areas in Indonesia including the Jakarta and Bekasi areas as well as the surrounding areas, it is increasingly worrying, in the sense that the areas affected by sea water intrusion are increasingly expanding. For this reason, it is necessary to know the impact that may arise as a result of this intrusion, especially on concrete.

Therefore, the research conducted is concrete with the addition of waste rubber and the use of OPC and PCC cement in water and seawater curing. in addition to reducing waste rubber tires, the research is expected to be used for buildings with moderate concrete quality.

2. Literature review and problem statement

Plan compressive strength for medium-strength concrete typically ranges from 20 to 40 MPa. In precast concrete kerbs, reinforced concrete culverts, diaphragms, and under-buildings, medium-strength concrete is utilized in place of reinforced concrete [5]. Previous research on the utilization of waste rubber has been carried out, where for waste rubber bukub has reached 2.9 % and there is evidence of an increase in the strength of concrete.

The properties and standards of the concrete forming materials, which have been specified in several standards, have an impact on the compressive strength of concrete. Waste-based concrete has been researched extensively for both economic and environmental reasons. One of the issues is the usage of concrete using leftover rubber powder. Concrete research with rubber powder used as aggregate has been carried out with treatment using saline solution (NaOH) and saline coupling agent has been carried out to bind rubber powder in concrete [6] the added rubber particles can decrease concrete strength due to their low stiffness and surface bonding with cement paste. This study aims to improve the rubber concrete performance by employing different surface treatment and coating methods. Particularly, two surface treatment methods (NaOH, and Silane Coupling Agent. 10 sample variants using normal cement, silica cement and cement with sodium silica admixture. Soaking with NAOH can significantly increase the strength of rubber concrete and qualify it for construction of footpath structures. Therefore, it is necessary to conduct research again using seawater where in seawater there is NaOH and several other chemicals considering the large availability of seawater.

Utilizing NaOH and Silane Coupling, concrete research has been conducted using 25 % recycled rubber tire aggregate. To determine the permeability and durability of concrete, electrical resistivity measurements and concrete compressive strength tests were performed [7]. Concrete is a very commonly used construction material due to its flexibility and dynamic nature in accepting the addition of various additives. This study does not know the size of the waste rubber used, so it is necessary to conduct research with waste rubber as a substitute for what aggregate Many studies have been conducted by researchers around the world to study the intrinsic properties of concrete both with and without various additives, replacement agents, and chemicals. The use of natural resources continues to increase, and this is also an important concern, especially in the context of concrete production, which is one of the main industries that produce CO_2.

Research with rubber admixtures in concrete has shown to reduce the weight of concrete compared to concrete without rubber. This is due to the low specific gravity of rubber. And the mechanical strength of concrete decreases when rubber is used as a partial replacement for coarse aggregate [2]. Therefore, research on rubber powder as a substitute for fine aggregate needs to be done.

Processing of waste tires with various methods has been carried out but only for tires that have reached the end of their useful life (ELT) [3].

The resulting powdered rubber is proven to be usable for the production of asphalt and concrete with rubber admixtures.

The trend of using alternative materials in concrete production is receiving increasing attention, and many materials that have been tested in the laboratory have also been used in the field. This research focuses on concrete production using crumb rubber as an additive to improve the strength and durability of concrete. Two different concrete strengths, M25 and M35, were studied in this research with various proportions of rubber added to the concrete mix. The results obtained through the experimental design showed that the addition of crumb rubber from 10 % to 30 % resulted in a decrease in concrete strength. This may be due to the formation of voids due to the addition of crumb rubber which can be filled by the addition of other additives. In terms of compressive, tensile, and flexural strengths, M25 grade concrete was found to be weaker than the control concrete by about 18 %, 39 %, and 26 %, respectively. The compressive, tensile, and flexural strength of M35 grade concrete decreased by about 20 %, 47 %, and 33 % respectively compared to the control concrete. Consequently, the use of crumb rubber is only recommended at an optimal level as it causes the strength to drop [8–10]. The percentage of waste admixture in this study is not clearly mentioned, it is not known at what percentage there is a decrease.

The application of lightweight concrete in dynamic environments would greatly benefit from this improvement [11]. The large and complete sample size used in the experiment was commended by the critical examination of the study, which strengthens the reliability and validity of the results. This paper examines the use of used rubber as aggregate in lightweight concrete. According to the study, the addition of rubber can make a material stronger and more flexible. Research needs to be conducted to determine how waste rubber can bind to lightweight aggregates and increase their compressive strength. The findings of the experimental investigation into the mechanical characteristics of rubber-containing lightweight concrete point to the following: There is a transition point between 40 % and 80 % rubber content, however static mechanical characteristics tend to decline as rubber content rises. When the rubber content reaches 80 % and 100 %, structural toughness dramatically increases, although variations below 80 % are less noticeable. According to the study's findings, this material is appropriate for uses where energy absorption is the primary concern, particularly at high rubber [12]. The study essentially proves that this rubber-infused lightweight concrete is suitable for applications that prioritize energy absorption, especially when using a high rubber content. The results provide useful recommendations for specialized material use in situations when maximizing energy absorption is of utmost concern.

An in-depth research on lightweight concrete with rubber recycled aggregate has been conducted using 38 cylinder specimens and 36 beam specimens. Six different mix designs were used, with rubber replacement ratios from 0 % to 100 % in place of coarse aggregate made from expanded brick chips.

The results show that the use of rubber aggregate can reduce the mechanical strength of the specimens, but increase the flexibility and toughness of the material. This improvement is very beneficial for dynamic applications of lightweight concrete [6]. In this study, the potential benefits of using rubber particles in lightweight concrete are highlighted. Although there is a trade-off in terms of lessened mechanical strength, the material is still an excellent choice, especially in situations where dynamic performance is required. The results open the door to maximizing the use of rubber aggregate and provide specialized answers for diverse construction applications.

It has been demonstrated that the use of old tyres as fibres can improve the characteristics of PCC and reduce environmental degradation. The flexibility, compressive strength, and abrasion resistance of concrete reinforced with steel and tyre fibres at various concrete volume proportions of 0 %, 0.25 %, 0.75 %, and 1 % were investigated in this paper. At 1 % addition, the compressive strength value of concrete increased [13]. In particular, the results showed that the compressive strength of concrete increased significantly when 1 % tyre fibre was added. This indicates that the addition of tyre fibre can significantly improve the performance of concrete, especially in terms of strength. This study describes an environmentally friendly method to reinforce concrete, highlighting the use of rubber. According to this study, the addition of rubber causes the compressive strength to increase up to the most amount of rubber added, which is 1 %. This leads to the conclusion that there is a need for additional investigation with rubber additions greater than 1 %. Further research needs to be conducted with a percentage of waste rubber above 1 %, with the aim of finding out if the compressive strength will continue to increase.

When concrete is hardened with seawater, salts from the ocean seep into the mixture and weaken its strength. These salts also corrode the steel by attacking the RC components that provide as reinforcing. A layered double hydroxide with a high-water content that mimics talc is called hydrotalcite. Hydrotalcite that has been calcined can be utilized for adsorption since it has a higher adsorption capability [14]. When concrete is subjected to the seawater's hardening effects, sea salts seep into the mixture and adversely degrade its structural integrity. In addition to weakening the concrete, these salts also cause corrosion in the steel parts, especially in the reinforced concrete (RC) reinforcement elements. Hydrotalcite is a particular type of layered double hydroxide that is distinguished by its talc-like appearance and high-water content. Due to its enhanced adsorption capacity, hydrotalcite can be used successfully for adsorption purposes when treated to a calcination procedure. Because of this characteristic, hydrotalcite may be used in adsorption-based processes, demonstrating the material's adaptability and usefulness outside of its natural condition.

Waste tires have been proven in research to improve the mechanical quality of concrete and are economical and environmentally friendly [5]. What these studies lack is the bonding effect between the rubber and the aggregate.

Seawater is an extremely abundant source of water. It is vital to take into account using seawater as an ingredient in concrete and the usage of seawater for curing due to the rising use of groundwater.

The composition of water influence compressive strength of concrete. Its caused of the chemical element insisted. The properties of the concrete test were performed with four different mixings and curing water sources. These water sources show a relative influence on the mechanical properties of concrete [14, 15]. Four sources of water can be investigated before. This study needs to investigated for seawater comparing water with the tire than can reduce the CO_2 production.

From the results of previous research that has been described, there are results of changes in the mechanical properties of concrete with the addition of waste rubber with a certain percentage, research with curing several kinds of water sources. So it is necessary to conduct a study that covers everything. How are the mechanical properties of concrete with rubber waste, OPC and PCC cement and curing with sea water.

3. The aim and objectives of the study

The aim of this study is to ascertain how much OPC, PPC, waste rubber tires, and concrete treatment (curing) using two soaking methods, specifically with water and seawater, can affect the compressive strength of concrete. This will make it possible to the economical and responsible use of trash, it is hoped by this research that the best product will be produced.

To achieve this aim, the following objectives are accomplished:

– investigate the effect of fine aggregates gradation, coarse aggregates gradation, sludge presentation of fine and coarse gradation, water content on concrete compressive strength;

– investigate the effect of concrete slump value on concrete compressive strength;

– investigate the effect of using OPC, PCC, waste tire rubber powder and concrete treatment using water and seawater on the compressive strength of concrete.

4. Materials and methods

The object of this research is concrete. The subject of this study is the addition of waste tyre fibre to concrete using OPC and PCC by curing with water and seawater.

Rubber scrap from tires is widely available, simple to collect, and reasonably priced, and seawater is also a readily available substance, making it possible to conduct this research.

The main hypothesis of the study is there is no significant difference in the compressive strength of concrete between OPC and OCC cement variations with the addition of waste tyre fibre cured using water and seawater. This study assumed that the seawater content used for curing is salt water. Simplification adopted in this study is the plan compressive strength of concrete is 20 MPa. The method used in this research is the experimental method.

This research was conducted at the Laboratory of the Civil Engineering Study Programme, Faculty of Engineering, Krisnadwipayana University, Bekasi.

The materials used in this study were PPC with the addition of used tyre powder with fine aggregate substitution of 5 % and 10 % respectively using 9 cylindrical samples measuring 15x30 cm tested at 7, 14, and 28 days of age. The cement used was PPC and OPC. The fine aggregates were black sand and coarse aggregate, water from laboratory wells, and used tyre powder.

The stages used in this research were to carry out testing with the following steps:

1. Finding back ground.
2. Define problems and objections of the research.
3. Prepare tools, materials (cement OPC and PPC, used tires, aggregate, fresh water and sea water).
4. Check and test materials (yes or no).
5. Mix design concrete.
6. Slump test (yes or no).
7. Testing concrete 45 samples (yes or no).
8. Analysis.
9. Research results.
10. Conclusions and suggestions.

Before making concrete test specimens, tests are carried out on the characteristics of fine and coarse aggregate. The examination of aggregate characteristics carried out in this research refers to ASTM and SNI which includes.

The hypothesis of this study is that there is an increase in the compressive strength value of concrete with the addition of waste tyre fibre with seawater curing.

To prove the hypothesis, the research made several concrete variants as in Table 2.

Before mixdesign with the desired compressive strength, several material tests were conducted where the test used the standard in the Table 1.

Table 1

Fine and coarse aggregate standard

No.	Testing	Standard
1	Filter Analysis Check	ASTM/SNI C136-2012
2	Specific Gravity and Absorption Examination	SNI 1970:2016
3	Volume Weight Check	SNI-03-4804-1998
4	Water Content Check	SNI-1971-2011
5	Sludge Content Check	ASTM/SNI-C117-2012

Concrete mixdesign is used based on standard SNI-03-2834-2000 method. 45 sample cylinders were made in five variants as shown in Table 2.

Table 2

Number of research test objects

No.	Sample Type	Curing	Number of Test Objects
1	Normal OPC (var. 1)	Water	9
2	Normal OPC (var. 2)	Seawater	9
3	Normal PPC (var. 3)	Seawater	9
4	PPC 5 % waste tire powder (var. 4)	Seawater	9
5	PPC 10 % waste tire powder (var. 5)	Seawater	9

The main equipment used in this research is: concrete compression testing machine, concrete compressive strength test, Los Angeles Machine, Concrete Mixer Electrical, Oven Machine, Abrams cone and scales. A total of 45 cylindrical test objects were soaked (cured) in a soaking place in fresh water for up to 28 days.

Compressive strength testing is carried out based on SNI 1974:2011. This test is carried out using a compression testing machine with capacity according to requirements, the implementation procedure consists of several stages.

5. Results of research compressive strength of concrete using OPC, PCC and additives of waste tire in the condition of cure with sea water

5. 1. Fine and coarse aggregate gradation and aggregate mud content

Before to made mixdesign there are some test for the material used. Some of it is sand and spilt aggregate gradation testing [4]. The following are the results of the fine and coarse aggregate gradation tests below in Table 3.

The fineness modulus of 4.46 is found from Table 4 while the standardized FM lies between 2.3 and 3.1. This result indicates that the sand used is considered to be of the coarse grade.

Next material testing to have best perform for concrete is coarse aggregate gradation test. Coarse aggregate gradation test result in Table 4 [4].

Table 3

Fine aggregate gradation test

Passed the Sieve (mm)		Suspended Weight (gr)	Amount Stuck (gr)	Stuck (%)	Pass (%)	Cumulative Hold
9.52 mm	3/8"	0	0	0	100	–
4.75 mm	No. 4	11.10	11.10	0.44	99.56	0.44
2.36 mm	No. 8	111.00	122.10	4.44	95.12	4.88
1.18 mm	No. 16	469.30	591.40	18.77	76.34	23.66
0.6 mm	No. 30	595.50	1186.90	23.82	52.52	47.48
0.3 mm	No. 50	667.80	1854.70	26.71	25.81	74.19
0.15 mm	No. 100	547.80	2402.50	21.91	3.90	96.10
0.075 mm	No. 200	79.80	2482.30	3.19	0.71	99.29
Pan		17.7	2500	0.71	0	100
Amount		2500	–	100	–	446.04
Fineness Modulus (FM)						4.46

Table 4

Coarse aggregate gradation test

Passed the sieve (mm)		Suspended weight (gr)	Amount stuck (gr)	Stuck (%)	pass (%)	Cumulative hold
25.50 mm	1"	0	0	0	100	0
19.10 mm	¾"	423	423	8.46	91.54	8.46
12.50 mm	½"	1215	1638	24.30	67.24	32.76
9.52 mm	3/8"	1535	3173	30.70	36.54	63.46
4.75 mm	No. 4	1674	4847	33.48	3.06	96.94
Pan	–	153	5000	3.06	0	100
Amount		5000	–	100	100	883.26
FM						8.83

The FM result on spilt aggregate is 8.83 (Table 4), this shows that the split used in this study is categorized as coarse material.

The condition of specific gravity (Gs) and water absorption from the material is known. The results of the saturated Gs test have been averaged and the Gs value for each sand is 2.617 and the water absorption value for fine aggregate with an average result of 1.63 %. The results obtained in this study are included in the normal fine aggregate category because the Gs is between 2.5 to 2.7. And the following test data, test results and recapitulation of fine aggregate test results can be seen in Table 5.

For concrete making materials to meet mixdesign specifications, testing is necessary. The following test, which can be seen in Table 6, is specific gravity (Gs).

Table 5

Fine aggregate specific gravity

Testing	Fine aggregate	Unit
Sieve gradation	Zona 2	–
Fineness nodulus	2.8	–
Specific gravity	2.617	Gram
Absorption	1.3	%

In testing the specific gravity and water absorption of this coarse aggregate in saturated dry surface conditions, an average value of 2.451 was obtained. With a coarse aggregate water absorption value of 2.78 %, the split stone is classified as normal aggregate, which ranges from 2.5 to 2.7 [5] 107 adult onset.

Testing the fine aggregate mud content in the sand used in this study aims to determine the mud content contained in the sand. The results of the mud content testing can be seen in Table 6 below [5] 107 adult onset.

Table 6

Fine aggregate sludge content test

Testing	Result	Unit
Pan weight	846	Gram
Sample oven dry weight±1500 gr (B1)	1500	Gram
Sample oven dry weight±1500 gr after washing (B2)	1430	Gram
Sludge	4.67	%

Testing the coarse aggregate mud content in the split used in this research aims to determine the mud content contained in the sand. The results of the mud content testing can be seen in Table 7 below.

Table 7

Coarse Aggregate Sludge Content Test Data

Testing	Result	Unit
Pan weight	846	Gram
Sample oven dry weight±1500 gr (B1)	1500	Gram
Sample oven dry weight 1500± gr after washing (B2)	1430	Gram
Sludge	4.67	%

According to Table 7, the aggregates sludge content was 4.67 %. The used aggregates have a high silt content, as seen in the figure, so they must first be cleaned to fulfill the 1 % to 5 % criterion.

Testing the water content of fine aggregate in the sand used in this research aims to determine the water content contained in the sand. 3.9 % of the coarse aggregate and 2 % of the fine aggregate contained water. The amount of water used in the concrete mix design will depend on the moisture content of the aggregate. SSD is the chosen moisture content.

5. 2. Slump testing

The slump test was carried out when the concrete was still fresh, this experiment was carried out with an Abram cone or truncated cone which had a top diameter of 10 cm, a bottom diameter of 20 cm and a height of 30 cm, equipped with an ear for lifting the tool so that the fresh concrete could come out and a slump pounder rod with a diameter of 16 mm and a maximum length of 60 cm [16]. The test was carried out with the aim of knowing the workability value of the fresh concrete mix. The lower the slump value, the more difficult it is to stir, pour, transport and compact. The average slump value for the 3 variations is 111.25 mm. The average slump value in this study is still within the original slump design plan, namely 80 until 160 mm. The results of the slump values that have been carried out can be seen in Table 8 below.

Testing of the slump value was carried out in accordance with the slump testing standard [6]. The slump value influences the ease of execution and traceability of the concrete.

Fig. 1 shows that there is no significant difference in the slump values of concrete using OPC and PCC. The slump test values of both can be seen in Table 8.

Table 8

Concrete slump test

–	Slump	Unit
OPC	112	mm
PPC	110	mm
5 % tire powder	111	mm
10 % tire powder	111	mm

a *b*

Fig. 1. Slump test: *a* – for porland cement; *b* – for portland pozzolan

5. 3. Compressive strength determined Portland cement, Portland pozzolan cement, tire powder waste with water and seawater for concrete treatment

The compressive strength test of concrete was carried out on specimens that were 7 days old, 14 days and 28 days of test results are presented in the form of tables and graph determine the trend of increasing concrete strength. According to the explanation before there are five variants of concrete for compressive strength. The full results can be seen in the Table and figure below.

Complete results can be seen in the Table 9.

Concrete compressive strength testing was carried out on test objects that were 7 days, 14 days and 28 days old. The test results were presented in the form of tables, graphs and bar charts to determine the trend of increasing concrete strength. Complete results can be seen in the tables and figures below.

Table 9

Concrete compressive strength

Cylindrical test object	Age of concrete (day)	Weight (kg)	Maximum load (KN)	Compressive strength (MPa)	Percentage (%)
Var. 1	7	11.79	197.33	13.46	85.94
Var. 2	7	11.84	144.67	9.87	63.01
Var. 3	7	11.91	163.00	11.12	70.99
Var. 4	7	11.63	144.00	9.82	62.72
Var. 5	7	11.27	113.67	7.75	49.51
Var. 1	14	11.83	251.33	16.42	88.94
Var. 2	14	11.49	190.00	12.96	67.23
Var. 3	14	11.56	204.00	13.92	72.19
Var. 4	14	11.79	184.67	12.60	65.35
Var. 5	14	11.45	140.33	9.57	49.66
Var. 1	28	11.56	314.00	20.78	88.89
Var. 2	28	11.96	267.67	18.26	75.77
Var. 3	28	12.07	286.67	19.56	81.15
Var. 4	28	11.64	243.00	16.58	68.79
Var. 5	28	11.49	191.33	13.03	54.17

This shows that the strength of concrete using PPC is more effective and stronger than using OPC when submerged in seawater, while the use of used tire powder as a substitute for fine aggregate does not provide strength to the compressive strength of concrete, in fact the tendency is that the more used tire powder is used, will reduce the compressive strength of the concrete.

The test results for 7, 14 and 28 days presented in the Fig. 2.

According to Fig. 2, only Variant 1 of the 5 tested concrete variants has a compressive strength greater than the compressive strength of the concrete design. The maximum test occurs after 28 days of concrete age and has a value of 20.78 MPa, which is just slightly higher than the 20 MPa concrete plan.

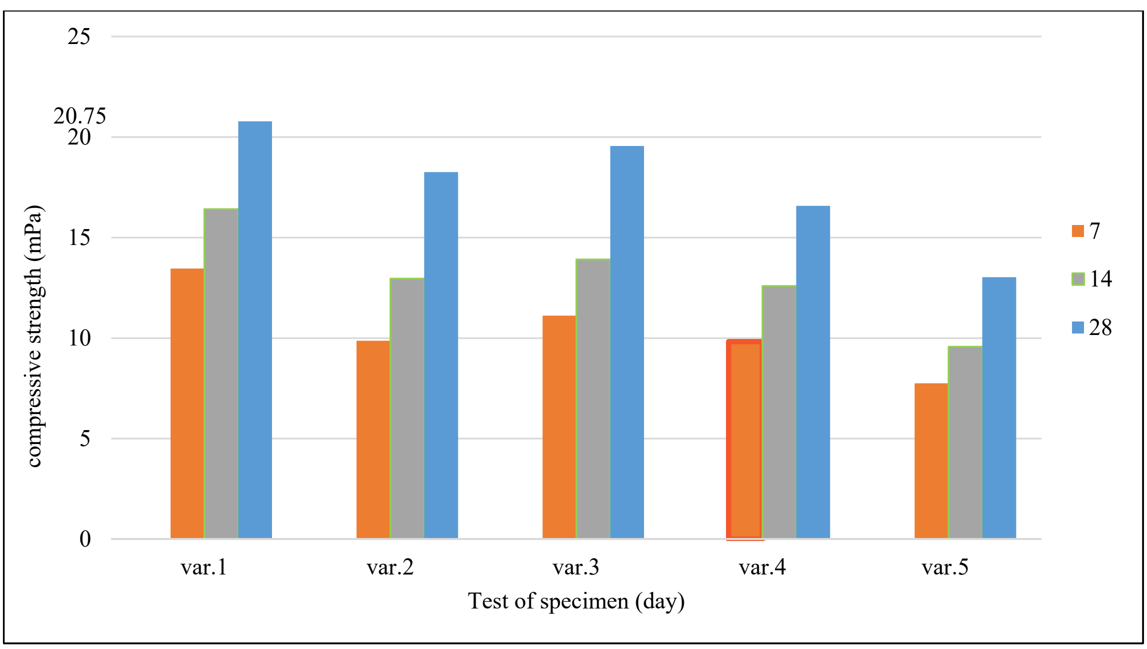

Fig. 2. Concrete compressive strength test

6. Discussion of the result of the fine and coarse aggregate gradation and aggregate mud content, slump testing and compressive strength concrete with tire powder curing water and seawater

The fineness modulus (FM) value of 4.46 does not match the FM value for fine aggregate, as Table 3 demonstrates. The specific gravity and water absorption values for both fine and coarse aggregates meet the standard, and the FM value of 8.83 for the coarse aggregate satisfies the FM value criteria (Table 4) [17].

The coarse and fine aggregate mud contents, which are extremely high at 4.67 % (Tables 6, 7) and require further testing before they reach the 1 % maximum mud content criterion [17].

Values with concrete using OPC and PPC. While the level of tire powder mixed into the concrete does not affect the magnitude of the slump value. The four concrete variations' slump values are displayed in Table 8. The maximum slump value in concrete including OPC is 112 mm, the maximum slump value in concrete containing PPC is 110 mm, and the maximum slump value in versions containing 5 % and 10 % waste tires is 111 mm. Table 8 indicates that there have been no notable deviations from the standard, which is between 50 and 125 mm [18].

Table 9 shows the value of the compressive strength of concrete with 5 variants and the test was carried out at several ages of concrete. After seven days, the concrete results in variant 1 yielded 67.3 % of the plan's compressive strength, variant 2 yielded 49.35 % of the plan's compressive strength, variant 3 produced 55.6 % of the plan's compressive strength, variant 4 produced 49.1 % of the plan's compressive strength, and variant 5 produced 38.75 % of the plan's compressive strength. Variant 1 is the outcome for seven days, which is in line with the typical concrete aging plan of 65 % [19]. After 14 days, the compressive strength of the 14-day-old concrete in variant 1 was found to be 82.1 % of the planned strength, whereas in variant 2, it was 64.8 % of the planned strength, in variant 3, it was 69.6 %, in variant 4, it was 63 %, and in variant 5, it was 47.85 % of the planned concrete. Out of all the variations, version 1 satisfies the requirement, which is 80 % for the concrete's 14-day age [19]. The compressive strength of 28-day-old concrete was found to be 103.9 % of the planned concrete compressive strength in variant 1, 91.3 % of the planned concrete compressive strength in variant 2, 97.8 % of the planned concrete in variant 3, 82.9 % of the planned concrete in variant 4, and 47.85 % of the planned concrete in variant 5. Out of all the variations of variant 1, 65.15 % of them satisfy the criterion for the age of 28 days of concrete [19].

The most optimum concrete compressive strength occurs in concrete variant 1 with a planned age of 28 days, which is 20.78 MPa. From Fig. 2 it is possible to see that with the concrete plan set, the optimum compressive strength value is in variant 1.

Only var. 1 concrete which has a compressive strength of 20.78 MPa meets the planned compressive strength of concrete which is 20 MPa. Concrete containing OPC and water curing is known as variant concrete. From these findings, it is clear that the addition of PPC, used tyre limbs, or seawater to the mix will not increase the compressive strength of the concrete. The use of seawater as a soaking agent and PCC cement, which minimizes the amount of CO_2 gas produced, both have an impact on the compressive strength of concrete. For the 4 variants with seawater curing, it can be seen that there is a decrease in compressive strength, this is certainly due to the influence of salt possessed by seawater causing a decrease in strength and corrosion for a long time. Previous research with seawater curing also experienced a decrease in the mechanical properties of concrete [7].

The weakness of this study is the lack of in-depth investigation on the brine component used. Due to industrial development and increasing domestic and industrial waste seeping into the environment and emptying into the sea, seawater will contain more and more chemicals. The amount of seawater in one location may differ from the amount of seawater in another location.

Future research should take into account the use of varied seawater from different sources and a thorough analysis of its composition, so that the cause of the decrease in concrete compressive strength can be identified with certainty.

7. Conclusions

1. It is discovered that the gradation of fine aggregate alone does not meet the criteria after testing the fine aggregate, coarse aggregate, mud content, moisture content of the material, and mud content of each material. The fundamental guidelines that have been employed in concrete mix design must be adhered to and put into practice. In order to achieve compressive strength results that are consistent with the strength of the concrete plan, this is done.

2. The value of the slump test produced from concrete with OPC, concrete with PPC, concrete with the addition of 5 % and 10 % rubber tire powder does not experience significant differences. The resulting slump value is still included in the standard of the slump value for medium quality concrete.

3. A 20 MPa compressive strength is intended. Only one of the five variants tested-variant 1 with OPC-met the standard of 20.78 MPa; the other variants-without tire powder and after being soaked in seawater-did not perform well. The compressive strength value fell for all versions.

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

Manuscript has no associated data.

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