



Engineering properties of seawater-mixed mortar with batching plant residual waste as aggregate replacement



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Abstract

This research showcased the use of leftover trash as a substitute for aggregate in mortar combined with saltwater. The raw waste materials underwent analysis using X-ray fluorescence (XRF) in order to determine the component materials and crystalline phases present. The choice of Portland composite cement (PCC) was made because of its durability in a hostile environment. Seawater is used to combat the water crisis and prevent corrosion, thanks to its exceptional resistance to corrosion. The attributes of mortar were assessed in terms of its fresh characteristics (slump and flow table) as well as its mechanical properties (compressive strength, split tensile strength, flexural strength, density, and shrinkage). The findings indicate that the dried mortar waste is suitable as a patch repair material for a substrate with a strength of 20 MPa, but only when utilized in a maximum quantity of 20% and with a water-to-cement ratio of 0.3. The repaired concrete with a strength of 25 MPa did not need any waste containment and had a maximum water-to-cement ratio (W/C) of 0.3, whether combined with saltwater or tap water. The possible role of the mortar containing the dried waste was to be the species for brick and other non-structural. Additionally, the use of an alternative cementitious substance is suggested to enhance the effectiveness of the patch repair material, particularly when paired with cathodic corrosion protection in damaged concrete.

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INTRODUCTION

Concrete is a popular construction material due to its resilience, adaptability, and low cost [1, 2, 3, 4, 5, 6]. Due to the increased demand for concrete in the construction industry, researchers and engineers compete to develop various types of concrete, such as those with high performance, high compressive strength, high environmental resistance, and seismic shock resistance, among others [7, 8, 9].

Manufacturers use batching facilities to produce vast quantities of concrete in order to meet market demand. The company uses low-strength mortar to moisten all equipment used to convey concrete products during the production

process. After that, the mortar is no longer necessary and is discarded. The remaining mortar deposits were permitted to cure and accumulate at a daily production rate of 12.5 m³. Large quantities and continuous production in the absence of regular consumption pose a problem for which a solution must be found. However, there were also issues identified due to the fact that the leftover mortar from the batching machine was generated using cement. As a result, the quantity of cement utilized increased in direct proportion to the amount of trash accumulated. Nevertheless, when considering environmental security, there are apprehensions over the substantial carbon

emissions resulting from global cement manufacturing, which is a cause for concern [10]. The cement industry contributes approximately 5 to 7% of anthropogenic CO₂ emissions, with 60% of these emissions arising from the decarbonation process of carbonate rock during clinkerization [10][11]. With the projected increase in population, it is expected that the demand for Portland cement will reach 6 billion tons by 2050 [12]. The rise in demand is mostly due to the need of constructing and maintaining the physical infrastructure, as well as resolving the shortage of housing and infrastructure, especially in less developed countries [12, 13, 14].

The immediacy of the problem with cement production's impact on the environment and its depletion of natural resources motivates this experimental work. Fly ash, silica fume, GGBS, metakaolin, fine materials, and quartz flour are just a few of the numerous alternatives to cement that have been considered for use in concrete [15]. The production of industrial garbage is an unavoidable consequence of modern manufacturing processes. As more and more businesses demonstrate concern for the environment, the significance of trash reduction is increasing [16]. However, efforts to improve waste management might inadvertently exacerbate environmental deterioration that is already underway [7, 17, 18, 19]. The use of recycled glass in Portland cement and concrete is an area that has garnered significant attention from several countries and provides compelling evidence of this urgent requirement [20], [21]. Many countries don't have what they need to develop their industries because of their dense populations and lack of land. The sustainability movement's emphasis on circular development has made industrial garbage recycling a popular subject at the moment. The main goals of waste management should be material recovery and source reduction [8, 10, 22, 23]. All aspects of waste management, from recycling and reduction to resource recovery, are included in this comprehensive strategy for the future [3], [4], [24], [25], [26]. The improvement of concrete as a product with environmentally conscious, economically viable, practically useful, and aesthetically pleasing characteristics should be the primary goal of future sustainability initiatives. With the use of smart technology, researchers have been able to document the technical properties of several industrial by-products when combined with concrete. They have previously utilized comparable methods to find the optimal mixture ratio as well [7, 10, 15, 16, 19, 27].

Several previous researchers have development of concrete by using waste as a material replacement such as waste concrete powder [8], lightweight foam concrete incorporating recycled waste and by product [7], plastic waste in geopolymer concrete [17], polypropylene fiber [6], brick and concrete waste [18], glass powder waste [19], cardboard kraft fibres [25], bakelite plastic waste [22], coal mine waste rock, F-class fly ash, and nano silica [28]. The utilization of trash in concrete is a novel approach that provides a sustainable resolution to the issue of waste management, while simultaneously tackling the environmental apprehensions associated with the disposal of non-biodegradable substances. These studies offer a pragmatic approach to the development of environmentally friendly and economically viable construction materials, while simultaneously advocating for the adoption of sustainable waste management strategies.

Given the phenomenon of global warming and the concurrent increase in urban population worldwide, the availability of freshwater is progressively diminishing, thereby becoming it a precious resource. The utilization of freshwater in the manufacturing process of concrete constitutes a substantial proportion (9%) of the overall freshwater extraction dedicated to industrial activities. Seawater, as an alternative water supply for concrete manufacturing, requires minimum preparation, mostly including the removal of sediment through filtration. Alternative approaches, such as using wastewater derived from industrial effluent or employing desalination techniques for treating hard waters, need a substantial energy input, so contributing to the overall emissions associated with concrete manufacturing. In recent decades, researchers have dedicated significant efforts towards comprehending the characteristics and properties of concretes composed of seawater-mixed and sea sand. Several studies examine the properties of seawater mixed concretes, including early-age hydration, fresh state, mechanical strength, and durability performance and the corrosion behavior of the embedded reinforcement in these concretes [29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41]. The result shows that the use of seawater mixed concrete is not so bad in the strength and durability point of views.

So far, no scholarly investigations have been undertaken to explore the utilization of batching plant refuse and seawater as mixing water in the mortar for patch repair material, specifically with regards to the mechanical characteristics of the materials that facilitate

their application as construction materials. Patch repair is important rehabilitation method due to corrosion damage by removing the deteriorated concrete material and change to the new chloride free mortar material [42, 43, 44, 45]. Numerous prior investigations have substantiated the viability of utilizing waste materials for the production of dependable building elements, hence offering notable benefits in terms of environmental concerns [2, 7, 8, 17, 26, 46, 47, 48]. This study is the first investigation to provide empirical evidence on the material qualities of dried mortar waste as an aggregate replacement on sea-water mixed mortar.

MATERIAL AND METHODS

Material

This research utilizes two distinct forms of fine aggregate as a comparison. The accumulative dried mortar waste at the batching plant is presented in Figure 1. Figure 2 and Figure 3 show the two types of aggregate. The first type is natural river sand sourced from the Progo River, located in Kulon Progo, D.I. Yogyakarta. The second type is Batching Plan waste, which possesses a filter pass size of 4.75 mm.

The waste generated by the Batching Plan for the East Side Bogowonto River Estuary Protection Project, located in Temon District, Kulon Progo, D.I. Yogyakarta, is referred to as batching plan waste. The waste mortar generated by this batching machine consists of a blend of Portland pozzolan cement, fine aggregate sourced from the Progo River, and water, with a proportion of 1 part cement to 2.75 parts fine aggregate to 0.48 parts water. The mortar's compressive strength, as measured after 28 days, was reported to be 3.53 MPa.

Mix proportion and specimen design of mortar

In this study, a total of sixty variations of mortar specimens with three repetitions were produced for each test method (compressive strength test, split tensile strength test, and flexural strength test). Three types of water to binder ratio were used. While half variations were prepare using seawater as mixing water and different quantity of dried mortar waste and another half variations were prepare using tap water and different quantity of dried mortar waste. The different quantity of dried mortar waste used in this experiment were 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, and 100% by weight of total aggregate. The design and number of specimens used are shown in Table 1.



Figure 1. The deposited dried mortar waste at the batching plant location



Figure 2. The detail of mortar waste appearance



Figure 3. The natural river sands

Fresh and hardened properties tests of mortar

Fresh properties of mortar including the slump and flow table test were conducted after material mixing and before pouring into the mold. After the casting process, the specimens were kept in the laboratory air condition until one day, then demold and moved to the curing chamber immersed in tap water. After 28 days, the specimens were moved to the surface saturated dry condition before hardened properties including compressive strength, split tensile strength, and flexural strength tests were started.

RESULTS AND DISCUSSION

Grain size analysis

The objective of material testing is to determine the characteristics of the mortar waste material that will be used as a component in the manufacturing of newly produced concrete. The test results will impact the computation of the proportion of novel concrete component components in the mix design. The mix design calculation will determine the exact proportion of components used in the manufacturing of the new concrete. Material testing is performed using specified protocols and criteria to get results that satisfy certain specifications.

In order to determine the grain size distribution, we used the procedures outlined in SNI ASTM C136: 2012, which deals with the sieve examination of both fine and coarse aggregate. The acquired waste granule gradation test results were in the range of 1.5-3.8, which satisfied the necessary categorization, and had a fine grain modulus of 2.6382. According to the results, the examined waste falls into the medium sand category, which is number two in the fine aggregate gradation table found in SNI 03-2834-2000. Figure 4 shows the graph of the grain size distribution.

Characteristic and chemical composition of mortar waste material

The chemical composition of dried waste samples passing through number 200 sieves was analyzed using X-ray fluorescence (XRF) techniques. This method is employed to determine the elemental composition of concrete or mortar, particularly focusing on the binder and aggregates. XRF is a non-destructive technique that is effective for analyzing large volumes of cement materials. It operates through wavelength-dispersive spectroscopy: high-energy X-rays excite minerals, causing ionization and the release of lower energy radiation known as fluorescence radiation. This released radiation serves as a distinct marker for

specific elements, facilitating their identification and measurement. Proper sub-sampling procedures are essential to obtain a representative sample from a 20-kilogram batch of concrete or mortar.

The procedure involves obtaining an appropriate quantity of around 5 grams of cement binders and aggregates using methods like coning and quartering or riffler splitting. These samples will then undergo analysis using X-ray fluorescence (XRF) technology. Specifically, the study will utilize a PANalytical Philips Axios Advanced XRF spectrometer, featuring a 4kW Rhodium (Rh) anode end window and super sharp ceramic technology X-ray tube. Sample preparation includes dissolving the concrete/mortar powder in a lithium tetraborate flux at temperatures exceeding 1000 °C. The resulting mixture is transferred into a crucible made of platinum or gold to produce consistent fused beads measuring 32 mm in diameter. Quantitative elemental analysis is conducted using the PANalytical SuperQ system, equipped with IQ+ and WROXI apps. The results of the XRF test as presented in Figure 5.

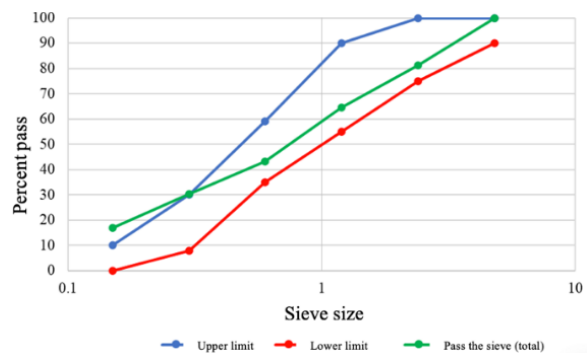


Figure 4. Grain size analysis test result of dried mortar waste generated by batching plant facility

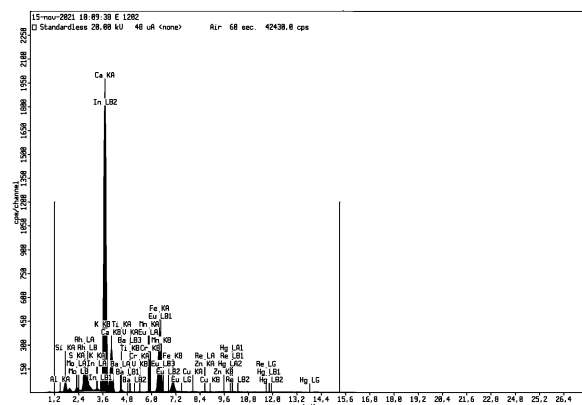


Figure 5. The result of XRF test of the waste material

According to the XRF analysis of the dried mortar waste, a number of chemical constituents were found to be above the authorized threshold. These constituents include aluminum (Al), sulfur (S), potassium (K), vanadium (V), chromium (Cr), manganese (Mn), iron (Fe), copper (Cu), zinc (Zn), molybdenum (Mo), indium (In), barium (Ba), europium (Eu), rhenium (Re), and mercury (Hg). However, the elements Si, Ca, and Ti were portrayed as still lacking recognition within the established framework of value. In the XRF test results, the percentage of each element was presented such as 2.6% Al, 10.7% Si, 0.59% S, 0.19% K, 71.5% Ca, 0.74% Ti, 0.03% V, 0.051% Cr, 0.13% Mn, 10.7% Fe, 0.091% Cu, 0.02% Zn, 0.5% Mo, 1.5% In, 0.1% Ba, 0.3% Eu, 0.2% Re, and 0.2% Hg.

Specific gravity, water absorption, water content, and mud content

Tests for specific gravity and water absorption adhere to the procedures outlined in SNI 1970:2008, a standard detailing method for evaluating these properties in fine aggregate. The tests are conducted according to the specified processes within the standard. Results, presented in Table 1, include: an average dry bulk specific gravity of 2.0114, an average apparent specific gravity of 2.4296, an average surface dry saturated specific gravity (SSD) of 2.1830, and an average water absorption of fine aggregate (mortar waste) at 8.5%.

Portland composite cement (PCC) was utilized as the binder of the mortar in this experiment due to its better prevention to the several chemical [6]. The mixing proportions employed in this study has been mentioned at Table 2 with a superplasticizer content equivalent to 0.75% of the cement requirement, and the water cement ratio (W/C) of 0.3-0.5. Seawater from Parangkusumo Beach, in the Special Region of Yogyakarta, Indonesia was used as the mixing water with the specific gravity of 1.03 g/m³. This study utilized two distinct

forms of fine aggregate, specifically sand sourced from the Progo River and mortar waste obtained from a batching plant.

The water content was evaluated with reference to SNI 1971: 2011 about the technique of determining the total aggregate moisture content by drying. This was done in order to confirm the results of the evaluation. The garbage has an average water content of 8.5%, which is contained inside it.

The test for the mud content was carried out in accordance with the regulations of SNI 03-4142-1996, which provide the procedure for determining the quantity of material in aggregate that is able to pass through sieve No. 200 (0.075 mm). According to the results of the tests that were carried out, it was discovered that the grain content was able to pass through the sieve No. 200 with an average of 24.7%. The value of the mud content that is included in the garbage does not satisfy the norms that are necessary, which calls for a limit of five percent.

Special treatment was conducted on both aggregates such as drying, gradation analysis, and washing, and keep the material in the saturated dry condition. The characteristic of both aggregates was presented in Table 3.

Cylindrical specimens, 15 cm in diameter and 30 cm in height, were prepared for compressive strength and split tensile strength tests. Following casting, the specimens were stored under laboratory air conditions. After 24 hours of curing, they were demolded, and the mortars were subjected to 28 days of immersion curing in tap water. All tests were performed after the 28-day curing period.

Table 1. The results of specific gravity and water absorption of the waste

Parameter	Result
Bulk specific gravity	2.01
Saturated surface dry	2.18
Apparent specific gravity	2.42
Water absorption (%)	8.35

Table 2. Design and number of mortar specimens

Specimen code	Percentage of dried mortar waste by weight of total aggregate	Mixing water type	Water to cement ratio (W/C)	Number of compressive strength specimens	Number of split tensile strength specimens	Number of flexural strength specimens
S-3-0 to S-3-100	0% - 100%	Seawater	0.3	3	3	3
S-4-0 to S-4-100	0% - 100%	Seawater	0.4	3	3	3
S-5-0 to S-5-100	0% - 100%	Seawater	0.5	3	3	3
T-3-0 to T-3-100	0% - 100%	Tap water	0.3	3	3	3
T-4-0 to T-4-100	0% - 100%	Tap water	0.4	3	3	3
T-5-0 to T-5-100	0% - 100%	Tap water	0.5	3	3	3

Table 3. The properties of aggregates (natural river sand and dried mortar waste)

Parameter	Natural River Sand	Dried Mortar Waste
Fineness modulus	2.53	2.64
Bulk specific gravity	2.59	2.01
Saturated surface dry gravity	2.68	2.18
Apparent specific gravity	2.83	2.43
Water absorption (%)	3.21	8.53
Water content (%)	4.49	9.29
Sludge level (%)	4.43	24.66

Flow table test result

During the initial stage of mortar formation, testing is conducted to assess the qualities of the fresh mortar. This testing primarily examines the characteristics of the constituent materials after

they have been mixed but before they have hardened. The mortar tested in this study was prepared according to the proportions determined through mix design computation.

The mean slump measurement obtained from this experiment was determined to be 7.6 cm, 8.2 cm, and 9.6 cm for W/C 0.3, W/C 0.4, and W/C 0.5 of 50% dried mortar waste in seawater mixed mortar. The slump test is conducted to assess the workability of the new mortar mixture. The flow table test shares a similar purpose to the slump test, which is to assess the workability of the mortar mixture. The experiment was conducted in accordance with the specifications outlined in SNI 6882:2014. The permissible workability criterion in flow table testing is $110 \pm 5\%$. The findings of the flow table test of mortar mixed by seawater and tap water are presented in Figure 6 and Figure 7.

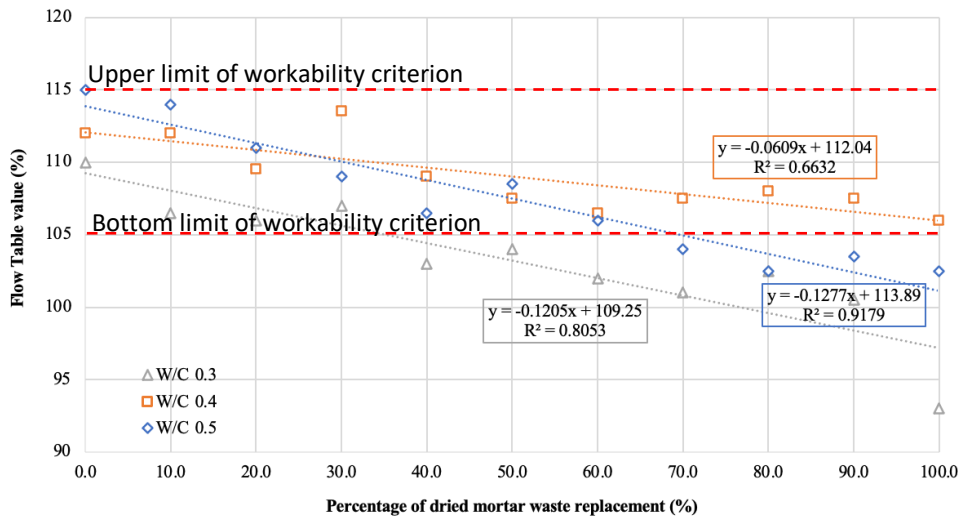


Figure 6. Flow table value of the fresh mortar on seawater-mixed

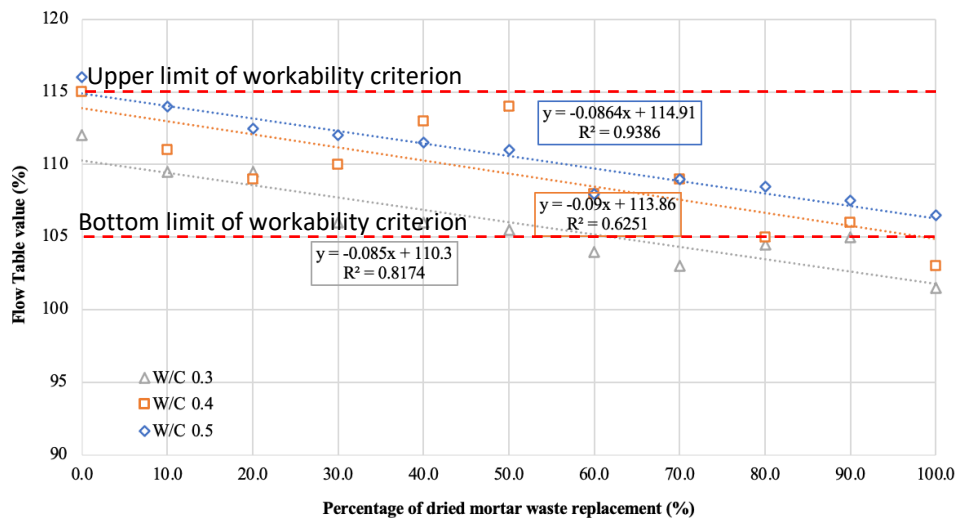


Figure 7. Flow table value of the fresh mortar on tap water-mixed

According to the findings shown in the figures, it can be concluded that the workability of the fresh mortar both in seawater-mixed and tap water-mixed examined aligns with the stipulated parameters. The number falls within the range of $110 \pm 5\%$. Additionally, it was determined that the mean height of the new mortar samples examined was 3.575 cm. Based on these data, the dried mortar waste can be used as the fine aggregate replacement if the seawater was applied as mixing water with a maximum of 30% at W/C 0.3, 100% at W/C 0.4, and 60% at W/C 0.5. A slightly different test result on the applicability of tap water, is that the allowable amount of dried mortar waste is 50% at W/C 0.3, 90% at W/C 0.4, and 100% at W/C 0.5.

Compressive strength test result

The evaluation of compressive strength is conducted after a curing period of 28 days for the mortar mixed with seawater and tap water. Cylindrical mortar specimens were subjected to

experimental testing, utilizing Portland Pozzolan Cement (PPC) with a water to cement ratio (W/C) ratio of 0.3, 0.4, and 0.5. The results of compressive strength test on seawater-mixed and tap water-mixed mortar by using dried mortar waste as fine aggregate replacement were presented in Figure 8 and 9, respectively. The objective of understanding the compressive strength value of mortar is to choose which parent concrete or substrate that suitable to use the mortar as the patching material, due to the patching material requirement being equal to the original concrete quality [42, 49, 50, 51, 52].

Based on the test results in Figure 8, the seawater-mixed mortar containing dried mortar waste can be used to be the patch repair material for 25 MPa parent concrete with the 10% allowable waste material with W/C 0.3 and W/C 0.4. If the compressive strength of the original damaged concrete was 20 MPa, a maximum 40% at W/C 0.3, 10% at W/C 0.4, and 0% at W/C 0.5.

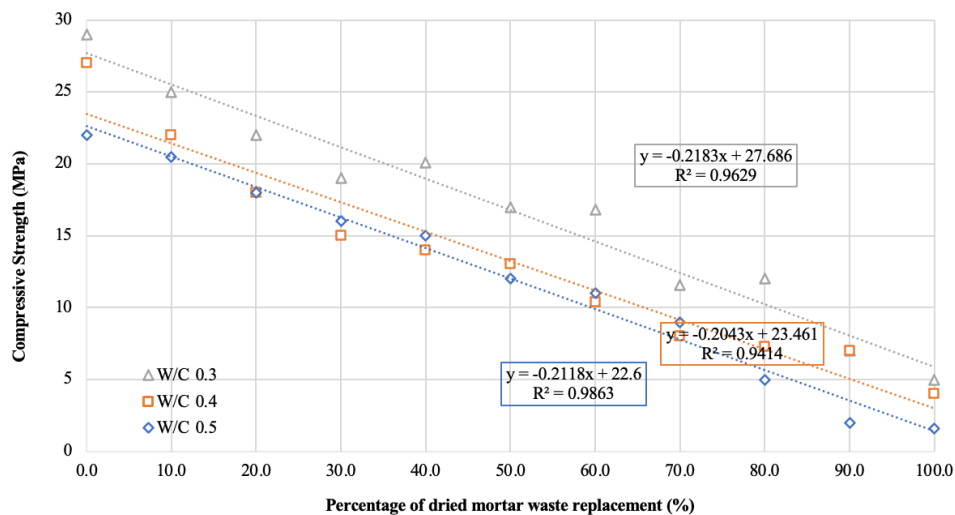


Figure 8. Compressive strength test results of the fresh mortar on seawater-mixed

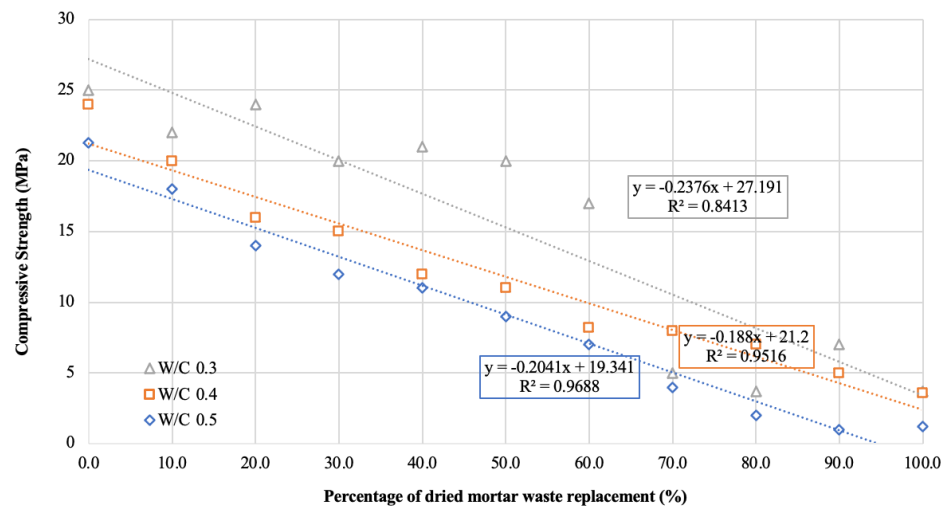


Figure 9. Compressive strength test results of the fresh mortar on tap water-mixed

The results of tap water-mixed mortar strength were lower than the seawater-mixed mortar, as indicated in this research and previous report [29, 30, 33, 53]. The allowable amount of dried mortar waste in seawater-mixed that is suitable for patch repair material for 25 MPa parent concrete is 0% at W/C 0.3 and the dried mortar waste could not be used to be the patch material on W/C 0.4 and W/C 0.5. Even though, the 0% at W/C 0.3, 10% at W/C 0.4, and 50% at W/C 0.5 can be used to be the patching material for 20 MPa damaged concrete. The tap water-mixed by using 0% at W/C 0.3 only can be used to be repair material for 25 MPa concrete. For 20 MPa concrete, 30% at W/C 0.3, 10% at W/C 0.4, and 0% at W/C 0.5 can be applied.

Split tensile strength test result

The split tensile test was conducted on the cylindrical test specimens, each having a diameter of 150 mm and a height of 300 mm. The specimens were subjected to the test after being cured for a period of 28 days. The results of split tensile strength test results were demonstrated in Figure 10 and Figure 11, respectively. As the split tensile strength test result is 8-12% of the compressive strength test [54], the required values of 25 MPa and 20 MPa parent concrete are around 2.5 MPa and 2 MPa, respectively. For the seawater mixed mortar, only 40% at W/C 0.3 can be used to patch repair of 25 MPa parent concrete and 50% at W/C 0.3 and 10% at W/C 0.4 for 20 MPa substrate concrete. The tap water-mixed mortar with 0% and 20% W/C 0.3 are allowable to

be patch material of 25 MPa and 20 MPa damaged concrete, respectively.

Flexural strength test result

The flexural strength testing procedure involved the use of specimens with each possessing dimensions of 50 cm in length, 10 cm in width, and 10 cm in height. The specimens were reinforced with a diameter of 8 mm. The evaluation of the flexural strength of the mortar was conducted after a curing period of 28 days. The standard for measuring the tensile strength of the steel used in the flexural test specimens is known as SNI 07-2529-1999. This standard addresses the procedures for measuring the tensile strength of concrete steel. The diameter of each of the three samples was 12 millimeters, and the steel that was employed was ordinary reinforcing steel. The results of the tensile tests conducted on steel revealed an average value of 570.09 MPa, an average yield strength of 401.25 MPa, an average breaking strain of 18.14%, and an average elastic modulus of 190,571.07 MPa. The comprehensive results of the flexural strength of mortar with seawater and tap water as mixing water were depicted in Figure 12 and Figure 13.

Based on ASTM C580, the minimum flexural strength for patch repair and cathodic protection applied on the area is 700 psi (= 4.8263 MPa). For both the seawater-mixed and the tap water-mixed mortar, the allowable waste amount that be used is 100% at W/C 0.3, 90% at W/C 0.4, and 80% at W/C 0.5.

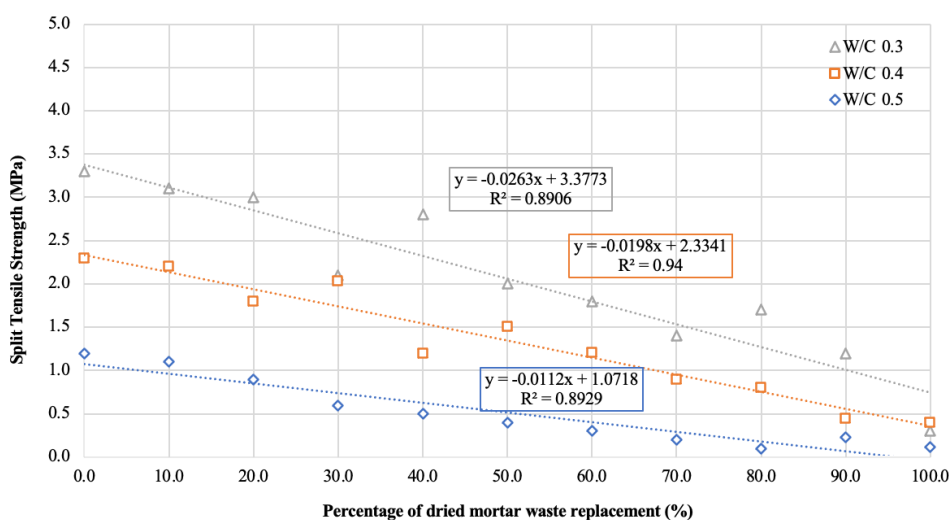


Figure 10. Split tensile strength test results of the fresh mortar on seawater-mixed

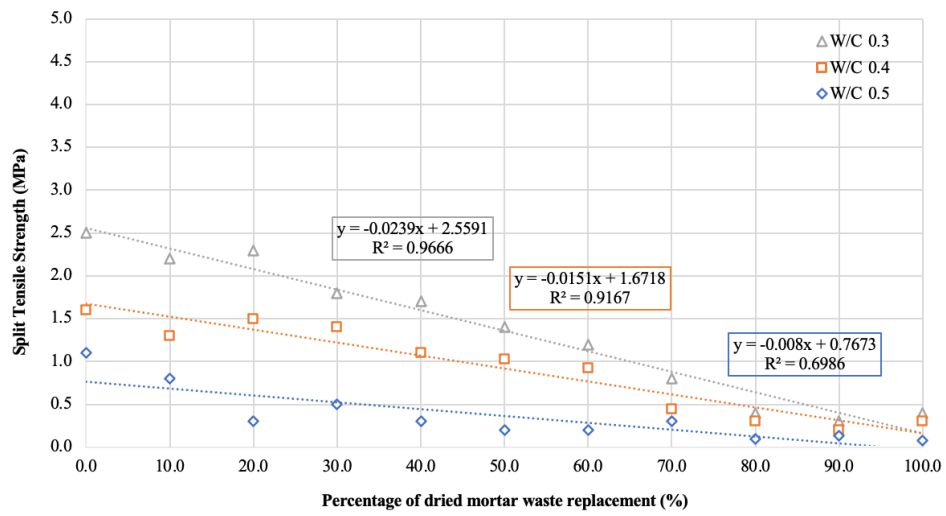


Figure 11. Split tensile strength test results of the fresh mortar on tap water-mixed

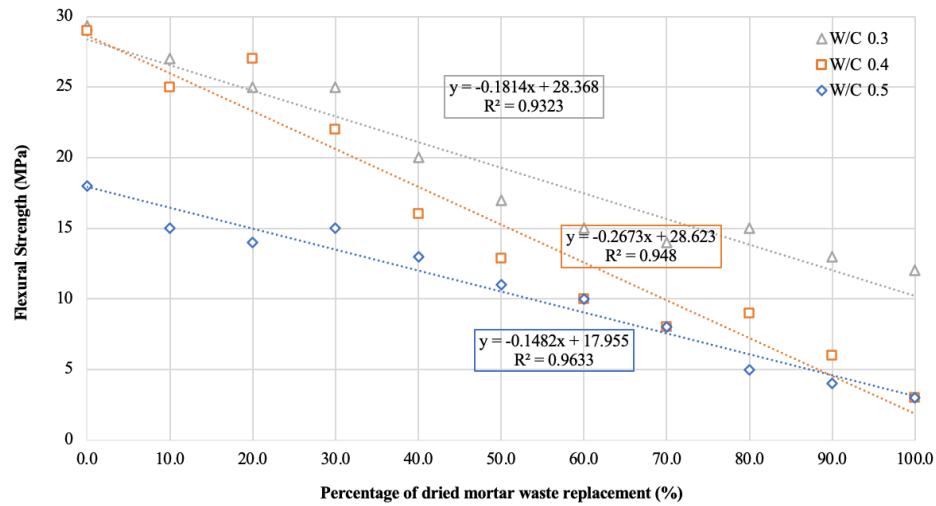


Figure 12. Flexural strength test results of the fresh mortar on seawater-mixed

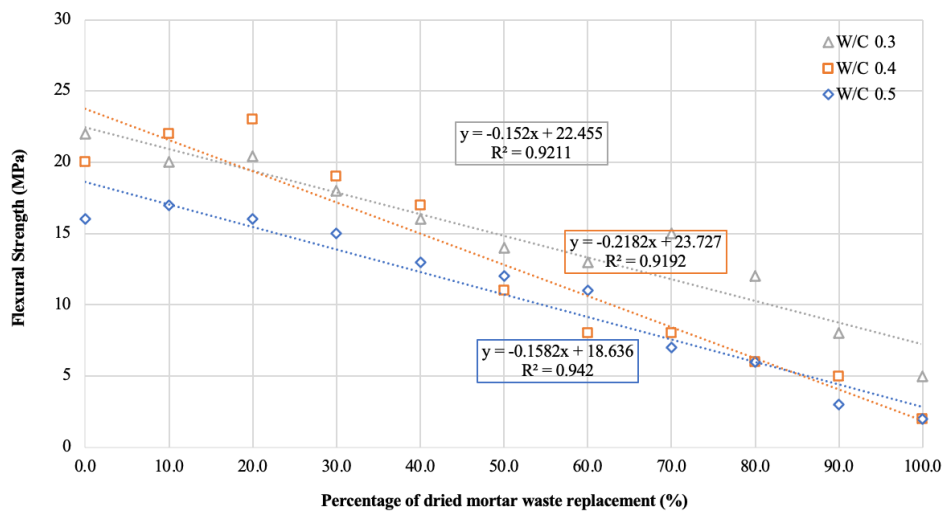


Figure 13. Flexural strength test results of the fresh mortar on tap water-mixed

Density and shrinkage test results

The mortar density was also checked. The objective of density testing is to ascertain the density of the recently prepared mortar mixture, in accordance with the predetermined mix design. The test is conducted in accordance with the specifications outlined in SNI 1973:2016, which pertains to the procedures for density testing, the amount of mix manufactured, and the determination of concrete air content using the gravimetric approach. According to the results obtained from density test calculations, the mean value of fresh mortar density from 10 cylinder specimens was determined to be 2157.91 kg/m³.

The mixed batching plan waste mortar that contains PPC cement and W/C of 0.4 was subjected to shrinkage testing on mortar specimens in order to determine the dimensional decrease that takes place as a result of the process. This test pertains to SNI 03-6823-2002,

which discusses several methods for measuring drying shrinkage in the mortar that contains Portland cement. Immediately before and after the curing process, tests are carried out so that a comparison of the product's dimensions and weight may be achieved.

For 10 cylindrical specimens, the average decrease in diameter dimensions was 0.293 millimeters, the average reduction in height was 0.690 millimeters, and the average reduction in weight was 76 grams. Because of the effect of the W/C that was utilized, shrinkage can take place. When the water that was originally included in the mortar mixture evaporates, the mixture shrinks and loses some of its weight. The shrinkage impact on the mortar that is produced will be stronger if the W/C number that is employed is higher [3, 4, 17].

Table 4. The allowable mix proportion of sea water-mixed and tap water mixed with dried mortar waste as a fine aggregate replacement based on several parameters

Repaired concrete quality	Flow table value	Compressive strength value	Split tensile strength value	Flexural strength value	Mix proportions that meet the requirement
Sea water – mixed mortar					
25 MPa	Max 30% W/C 0.3 Max 100% W/C 0.4 Max 60% W/C 0.5	Max 0% W/C 0.3	Max 40% W/C 0.3	Max 100% W/C 0.3 Max 90% W/C 0.4 Max 100% W/C 0.5	Max 0% W/C 0.3
20 MPa	Max 30% W/C 0.3 Max 100% W/C 0.4 Max 60% W/C 0.5	Max 0% W/C 0.3 Max 10% W/C 0.4 Max 0% W/C 0.5	Max 50% W/C 0.3 Max 10% W/C 0.4	Max 100% W/C 0.3 Max 90% W/C 0.4 Max 100% W/C 0.5	Max 0% W/C 0.3
Tap water – mixed mortar					
25 MPa	Max 30% W/C 0.3 Max 100% W/C 0.4 Max 60% W/C 0.5	Max 0% W/C 0.3	Max 0% W/C 0.3	Max 100% W/C 0.3 Max 90% W/C 0.4 Max 100% W/C 0.5	Max 0% W/C 0.3
20 MPa	Max 30% W/C 0.3 Max 100% W/C 0.4 Max 60% W/C 0.5	Max 30% W/C 0.3 Max 10% W/C 0.4 Max 0% W/C 0.5	Max 20% W/C 0.3	Max 100% W/C 0.3 Max 90% W/C 0.4 Max 100% W/C 0.5	Max 20% W/C 0.3

The most suitable mix proportion for patch repair

The summary results of all experimental tests are presented in Table 4. All parameters including flow table, compressive strength, split tensile strength, and flexural strength values of all mix proportions tested in this experiment were summarized. The results showed that the dried mortar waste can be used to be the patch repair material as the tap water mixed material only at the maximum amount of 30% with W/C 0.3 for 20% substrate, especially for corrosion damaged concrete due to corrosion attacked. While the 25 MPa repaired concrete required maximum 0% waste at W/C 0.3 both in seawater and tap water-mixed. A possible function of the mortar containing the dried waste was to be the specie for brick and another non-structural. The use of another cementitious material is also proposed in order to get the better performance to be the patch

repair material, especially for patch repair material that combined with the cathodic corrosion protection in deteriorated concrete [55, 56, 57, 58].

CONCLUSION

This study demonstrated the use of residual refuse as a replacement for aggregate in mortar mixed with seawater. Raw waste materials were analyzed using X-ray fluorescence (XRF) to identify constituent material and crystalline phases. The selection of Portland composite cement (PCC) was based on its resistance to an aggressive environment. Due to its excellent corrosion resistance, seawater is used to address the water crisis and as a corrosion inhibitor. Mortar was evaluated for its fresh (slump and flow table) and mechanical (compressive strength, split tensile strength, flexural strength, density and shrinkage) properties. The result show that the dried mortar waste only could be used to be the

patch repair material for 20 MPa substrate in the 20% of the maximum amount and W/C 0.3. While the 25 MPa repaired concrete required no waste contained at maximum W/C 0.3 both in seawater and tap water-mixed. A possible function of the mortar containing the dried waste was to be the specie for brick and another non-structural. The use of another cementitious material is also proposed in order to get the better performance to be the patch repair material, especially for patch repair material that combined with the cathodic corrosion protection in deteriorated concrete

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