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SUSTAINABILITY 2022, 14(3)

Long-term Durability of Bio-Polymer Modified Concrete in Tidal Flooding Prone Area: A Challenge of Sustainable Concrete Materials

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PROSES REVIEW SAMPAI PUBLIKASI

A. **Judul Artikel:** "Long-term Durability of Bio-Polymer Modified Concrete in Tidal Flooding Prone Area: A Challenge of Sustainable Concrete Materials"

B. **Penulis:** Rr. M. I. Retno Susilorini, Iskhaq Iskandar, dan Budi Santosa

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Abstract	The need for durable concrete in marine environments such as areas prone to tidal flooding is important due to its ability to deteriorate the structures. This led to the design of a durable and strong Polymer-Modified Concrete (PMC) using natural or bio-polymer modified concrete. However, the use of biopolymer-modified concrete is very limited. Therefore, this research developed a bio-polymer modified concrete using Gracilaria Sp., Moringa oleifera, and honey for column retrofitting. The research aimed to retrofit and improve the compressive strength and durability of broken columns submerged by tidal flooding by applying bio-polymer modified concrete with Gracilaria Sp., Moringa oleifera, and honey. A field application of column retrofitting was conducted in areas prone to tidal flooding. The retrofitted columns performance was observed for 14 months and validated by non-destructive and destructive tests. The result showed that the compressive strength of the retrofitted column achieved 32.37 MPa, which is a 92.34% increase compared to the baseline. This research provides answers to the challenge of concrete materials sustainability by promoting bio-polymer modified concrete that significantly increased its performance and long-term durability using Gracilaria Sp., Moringa oleifera, and honey.
Keywords	durability; bio-polymer; concrete; tidal flooding sustainable.
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Semarang, 20 December 2021

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Dear Sir,

We would like to submit our manuscript entitled "Long-term Durability of Bio-Polymer Modified Concrete in Tidal Flooding Prone Area: A Challenge of Sustainable Concrete Materials" to "Sustainability– MDPI".

The need for durable concrete in marine environments such as areas prone to tidal flooding is important due to its ability to deteriorate the structures. This led to the design of a durable and strong Polymer-Modified Concrete (PMC) using natural or bio-polymer modified concrete. However, the use of biopolymer-modified concrete is very limited. Therefore, this research developed a bio-polymer modified concrete using *Gracilaria Sp.*, *Moringa oleifera*, and honey for column retrofitting.

In our article, we retrofitted and improved the compressive strength and durability of broken columns submerged by tidal flooding by applying bio-polymer modified concrete with *Gracilaria Sp.*, *Moringa oleifera*, and honey. A field application of column retrofitting was conducted in areas prone to tidal flooding. The retrofitted columns performance was observed for 14 months and validated by non-destructive and destructive tests. The result showed that the compressive strength of the retrofitted column achieved 32.37 MPa, which is a 92.34% increase compared to the baseline. This research provides answers to the challenge of concrete materials sustainability by promoting bio-polymer modified concrete that significantly increased its performance and long-term durability using *Gracilaria Sp.*, *Moringa oleifera*, and honey.

Since "Sustainability – MDPI" is a reputable journal and has broader readers, we believe that our submission will become advantage in the sustainability, especially in sustainable concrete materials studies.

This manuscript has not been previously published and is not under consideration in the same or substantially similar form in any other peer-reviewed media.

Thank you very much. We would like to hear from you about our submission.

Sincerely,

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Long-term Durability of Bio-Polymer Modified Concrete in Tidal Flooding Prone Area: A Challenge of Sustainable Concrete Materials

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Article

Long-term Durability of Bio-Polymer Modified Concrete in Tidal Flooding Prone Area: A Challenge of Sustainable Concrete Materials

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Abstract: The marine environment and tidal flooding prone have responsible to the deterioration of concrete structures. Hence, it is necessary to assure that concrete structures must have good performance and durability. The need of durable concrete in aggressive environment such as tidal flooding prone area has been fulfilled by Polymer-Modified Concrete (PMC) which has advantage to increase concrete durability and bond strength. However, the use of natural or bio-polymer modified concrete was very limited. Hence, this study had developed the bio-polymer modified concrete using Gracilaria Sp., Moringa oleifera, and honey use for column retrofitting. The research aimed to retrofit and improve the compressive strength and durability of broken column which submerged by tidal flooding by appliying bio-polymer modified concrete with Gracilaria Sp., Moringa oleifera, and honey. A field application of columns retrofitting was conducted in tidal flooding prone and the retrofitted columns performance were observed for 14 months and validated by non-destructive and destructive test. It was found that the compressive strength of retrofitted column achieved 32.37 MPa as it was increased of 92.34% compared to the baseline. This research answer the challenge of concrete materials sustainability by promoting bio-polymer modified concrete which used Gracilaria Sp., Moringa oleifera, and honey that significantly increase its performance and long-term durability of concrete structures.

Keywords: durability; bio-polymer; concrete; tidal flooding sustainable.

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1. Introduction

The deterioration of concrete structures caused by tidal flooding have become a consideration in issue of coastal infrastructure damage. Hence, it is important to assure the durability of concrete structure in aggressive environment such as tidal flooding prone area. It is obvious that the concrete deterioration may be caused by several aspects for example chemical attack of seawater constituents during the hydration process of cement, alkali-aggregate expansion, crystallization pressure of salts in concrete, frost action in cold climates, corrosion of reinforced steel embedded in concrete structures, and physical erosion such as wave and floating objects contacted to the concrete structures, and also the carbonic acid attack that leaching away the calcium from hydrated cement [1,2]. Therefore, it is necessary to assure that materials of concrete must have good performance and durability.

Several studies have reported the durability of concrete structures in marine environment, included long-term investigation of concrete performance that exposed to seawater [3–6]. There were several findings that the concrete which mixed by seawater such

as by [7–9] achieved a good performance of mechanical properties even though it was slightly lower than the ones using plain water. It was also reported by those studies that concrete that mixed by seawater had provided more resistant product against deterioration and higher compressive strength at early-age. Others investigations also reported the concrete materials innovation have improved its durability in marine environment. Progressive development of concrete materials also conducted by the development of Polymer-Modified Concrete (PMC) which has advantage to increase concrete durability and bond strength by mixing a polymer material into Portland Cement concrete mix [10]. Several thermoplastics were used in PMC for examples epoxy resins, elastomers or rubbers, naturals polymers cellulose, lignin proteins, latex, re-dispersible polymer powder, water soluble powder, and liquid resins, SF (Silica Fume), RHA (Rice Husk Ash), and also SF with nano-silica [11,12]. However, the use of natural or bio-polymer modified concrete and mortar still very rare. Previous studies of authors have revealed the advantages of several bio-polymer that added into concrete mix which increased compressive strength and concrete durability [13–17].

It is important to implement sustainable concrete materials which are strong, durable, and sustainable. Hence, this research purposed to implement column retrofitting in tidal flooding area with bio-polymer modified concrete using Gracilaria Sp., Moringa oleifera, and honey. This research conducted by field application of columns retrofitting in tidal flooding prone area which its performance was observed for 14 months and validated by non-destructive and destructive test. It was found that the bio-polymer modified concrete which used Gracilaria Sp., Moringa oleifera, and honey has increased the performance and long-term durability of concrete columns.

2. Materials and Methods

This research was conducted by field application and also non-destructive and destructive tests in a site which is tidal flooding prone area as explained. The methods and stages of the research will be explained in the next paragraphs.

- **On site column retrofitting and control column construction**
  Two broken columns have been retrofitted in the site and a control column was constructed in the same site as defined by Table 1. Each specimen identity was represented by one column.

Table 1. Detail of Column Experiment

No	Specimen Identity	Status	Mix Composition
1	K1	retrofitted column	Mix I
2	K3	retrofitted column	Mix III
3	K	control column	Mix-Normal

The column retrofitting and construction was conducted by grouting it with bio-polymer modified concrete which added by Gracilaria Sp. powder (which is an agar-agar product sold in marketplace), Moringa oleifera powder (made by grinding the Moringa oleifera seeds) and honey (which is also natural honey product sold in marketplace) as presented by Figure 1 and Table 2. The concrete mix composition of Mix I and Mix III I Table 2 were implemented in producing concrete bricks [16] in previous research of authors. All concrete columns were designed for compressive strength of f'_c = 30 MPa with dimension of 15 cm x 15 cm x 100 cm that described by Figure 5. The concrete mixture was calculated by Indonesian National Standard for Procedure of Concrete Mixing Design (SNI 03-

2834-2000). It should be noted that the Mix-Normal in Table 4 wasn't added by bio-polymers.

Figure 1. The materials used in columns production as bio-polymers modified concrete: (a) and (b) Gracilaria Sp. powder which agar-agar product sold in marketplace; (c) raw Moringa oleifera seeds with skin; (d) raw Moringa oleifera seeds without skin; and (e) honey which is which is also honey product sold in marketplace.

- **Non-destructive test for retrofitted and control columns**

This stage was taken on site after the broken columns were retrofitted and control columns were constructed. The Rebound Hammer test conducted as a non-destructive test that aimed to study the columns compressive strength with Matest 2H1Q17. All columns were tested at age of 7, 14, and 28 days, and some of them tested again at ages 12, 13, and 14 months with mix K3 which contains Moringa oleifera and mix normal.

In this research, the procedure of non-destructive test followed ASTM C 805 - Standard Test Method for Rebound Number of Hardened Concrete. Figure 2 describes the equipment of Rebound Hammer. Several shootings were applied onto the columns surface that was prepared as clean and flat surface (zone A, B, C). Each zone was shot ten times as shown by Figure 3.

Figure 2. Hammer Test Matest 2H1Q17 used in this research as non-destructive test equipment

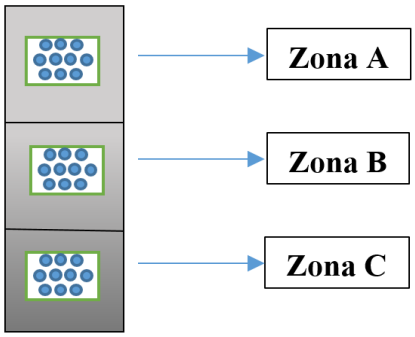

Figure 3. The zones for shooting at column surface for Rebound Hammer Test

The Rebound Value was read by the equipment and then correction for inclination can be applied by Table 3. After the corrected Rebound Value was calculated as R, then the strength of concrete (W_m) that referred to concrete cubes can be calculated by using Table 4 depends on the age of concrete.

Tabel 3. Correction of the Test Hammer Indications for Non-Horisontal Impacts (Manual Book Hammer Test Matest 2H1Q17)

Rebound Value Rα	Correction for inclination angle α			
	Upwards		Downwards	
	+90°	+45°	-45 °	-90 °
10			2.4	3.2
20	-5.4	-3.5	2.5	3.4
30	-4.7	-3.1	2.3	3.1
40	-3.9	-2.6	2	2.7
50	-3.1	-2.1	1.6	2.2
60	-2.3	-1.6	1.3	1.7

Tabel 4. Cube Compressive Strength (W, in kg/cm²) as a function of the Rebound Number R Type N

R	Age of Concrete			
	14 to 56 days		7 days	
	W_m	W_{min}	W_m	Wmin
20	101	54	121	74
21	113	64	132	83
22	126	75	145	94
23	139	86	157	104
24	152	98	169	115
25	166	110	183	127
26	180	122	196	138
27	195	135	210	150
28	210	149	225	164
29	225	163	239	177

30	241	178	254	191
31	257	193	269	205
32	274	209	285	220
33	291	225	300	234
34	307	240	315	248
35	324	256	331	263
36	342	273	348	279
37	360	290	365	295
38	370	307	381	311
39	395	324	398	327
40	413	341	416	344
41	432	359	434	361
42	450	377	451	378
43	469	395	470	396
44	488	414	488	414
45	507	432	507	432
46	526	450	526	451
47	546	470	546	570
48	565	489	565	489
49	584	508	584	508
50	604	527	604	527
51	623	546	623	546
52	643	565	643	565
53	663	584	663	584
54	683	603	683	603
55	703	622	703	622

- **Destructive test for retrofitted and control columns**

  After Rebound Hammer test had been conducted, the next stage was to investigate the inner concrete's compressive strength by Core Drill method. This method was purposed to obtain compressive strength of the drilled core of concrete which followed ASTM C 42/C 42M – 04 and SNI 03-2492-2002 about Standard test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete. A versatile diamond drilling system with diameter of 3 mm used in HILTI DD 150-U machine (Figure 4). The Core Drill method was applied only to columns K3 at age 14 months. The samples had been drilled from the inner columns at point A, B, and C, as described by Figure 5. As a compliance to the ASTM code, the drilled concrete cylinder had diameter of 70 mm and height of 140 mm and tested for compressive strength. In this research, the Computer Control Servo Hydraulic Concrete Compression Testing Machine, Hung-Ta serial HT 8391PC used to obtain compressive strength of concrete cylinder as shown by Figure 6.

Figure 4. The Core Drill method was using HILTI DD 150-U machine with versatile diamond drilling

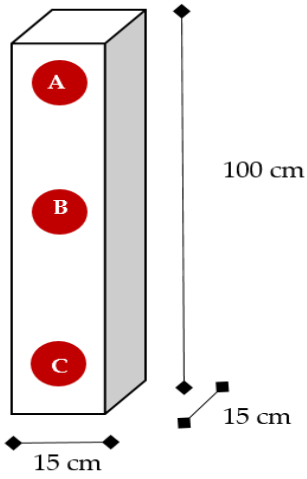

Figure 5. Column dimension and The zones A, B, C, for drilling concrete cores

Calculation of compressive test followed the expression of Equation (1).

$$\sigma = \{\left(\frac{P}{A}\right) . f_{l/d} . f_{dia} . f_d\} \quad (1)$$

where σ is characteristic compressive strength (MPa), P is compressive load (N), A is compressive area (mm2), l is height of sample (mm), d is diameter of sample (mm), $f_{l/d}$ is correction factor of core diameter, f_d is correction factor of damage caused by drilling. The correction factor of core diameter referred to ASTM C 42/C 42M – 04 and ACI 214.4R-03 while correction factor of damage caused by drilling referred to ACI 214.4R-03.

Figure 6. The Computer Control Servo Hydraulic Concrete Compression Testing Machine, Hung-Ta serial HT 8391PC

3. Results

3.1. On site column retrofitting and construction

This reseserach had been retrofitted 2 (two) broken columns which marked by red circle as presented by Figure 7-(a) chosen to be retrofitted. Those two columns seemed previously pinning the masonry wall that also broken. It was observed that the concrete's cover and even most parts of columns were peeled off while the steel reinforcement had been corroded. Later, in the next few months, the left column had almost collapsed and left the half part of column as shown by Figure 7-(b).

Figure 7. The broken columns which were determined to be retrofitted by applying bio-polymer modified concrete; (a) Situation at the time the left column still existed; and (b) Situation in the next few months that the left column had been almost collapsed.

First step of colum retrofitting as shown by Figure 8-(a) had been done by peeling the cover of old concrete and unnecessary debris and then followed by applying the formwork of 1 m from the base floor. The next step of the activities was grouting the column with bio-polymer modified concrete consisted of Gracilaria, Sp., Moringa oleifera, and honey. After the retrofitted column was getting harder (the next day after construction), it was wrapped by jute sack and then curing was applied for about a week by watering it as described by Figure 8-(b).

(a)

(b)

Figure 8. The column retrofitting activities: (a) Peeling, formwork, grouting with bio-polymer modified concrete consisted of Gracilaria, Sp., Moringa oleifera, and honey; (b) Curing by watering the column for a week.

Another work have been done in conjuction with columns retrofitting. There was a control colomn which constructed as shown by Figure 9. The procedure of column construction included: mixing the concrete materials (cement, split, sand, and water) reffered to Mix Normal in Table 2, doing steel reinforcement and framework work, and curing.

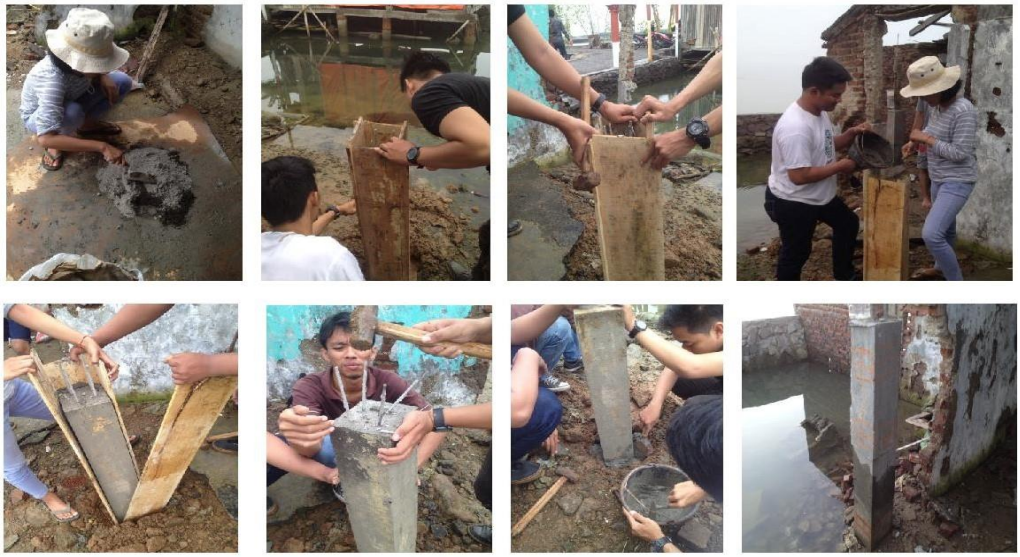

Figure 9. Construction of control column.

3.2. Non-destructive test for retrofitted and control columns

The retrofitted and control columns were tested by non-destructive test to investigate its compressive strength. A Rebound Hammer Test was conducted as shown by Figure 10-12. Figure 10 describes the test was conducted by shooting at the necessary points (A, B, C) in condition of the house submerged by tidal flooding at age 28 days. A year later, the retrofitted and control columns were tested at age of 12, 13, and 14 months as shown by Figure 11 and Figure 12.

Figure 10. Rebound Hammer Test that was conducted to retrofitted columns at age of 7, 14, and 28 days

Figure 11. Rebound Hammer Test that was conducted to retrofitted columns at age of 12, 13, and 14 months

Figure 12. Rebound Hammer Test that was conducted to control column at age of 14 months

The baseline of the Rebound Hammer Test was conducted by shooting the old broken column at point A, B, C, to obtain the baseline of compressive strength before columns retrofitting procedures as presented by Figure 13 and Figure 14. It was found that the baseline compressive strength of the old broken columns were 17.3 MPa at poin A, 18.63 MPa at point B, and 16.6 at point C MPa.

Figure 13. The Rebound Hammer Test was at conducted at the points that marked by red circles

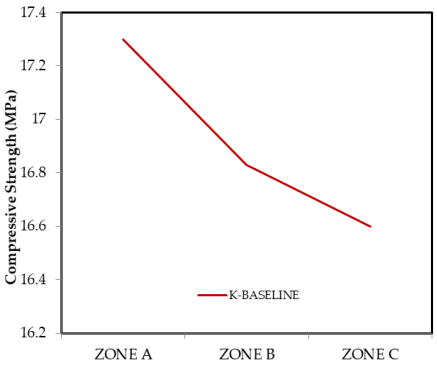

Figure 14. Compressive strength of old column broken column that become baseline value

The results of Rebound Hammer Test observed that the retrofitted column of K1 had performed lower compressive strength to K3 at point A, but higher at point B and C at age 7, 14, and 28 days as described by Figure 15. It is interesting that Figure 16 presented a very high compressive strength value at point B at age 14 months despite of other ages that has a little bit lower compressive strength compared to retrofitted column. The research also found that compressive strength of K1 at point C have been decreased at all ages as shown by Figure 17. Rebound Hammer Test results also noted that at age of 14 months, the compressive strength values of retrofitted and control columns were decreased as explained by Figure 18.

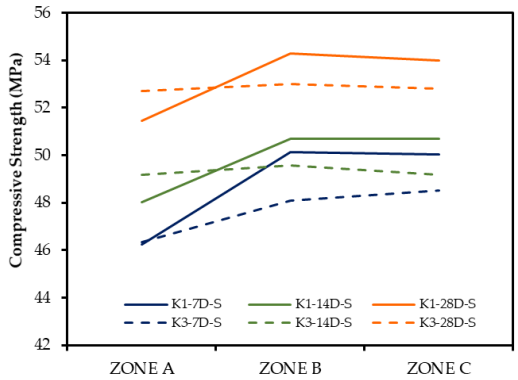

Figure 15. Compressive strength of retrofitted columns of K1 and K3 at age of 7, 14, 28 days

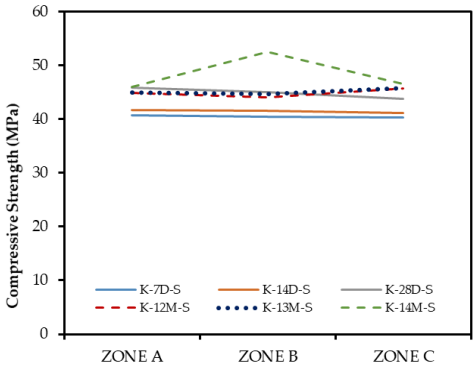

Figure 16. Compressive strength of control column at age of 7, 14, 28 days, and also 12, 13, 14 months

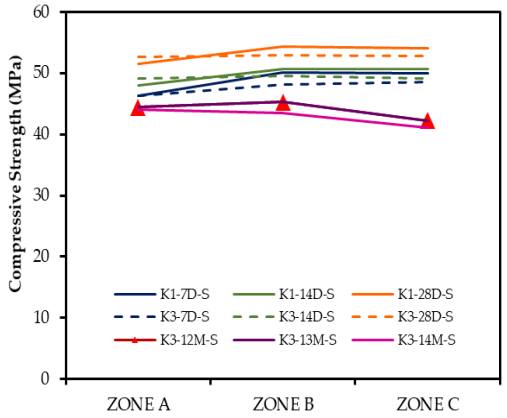

Figure 17. Compressive strength of retrofitted columns of K1 at age of 7, 14, 28 days, and K3 at age 7, 14, 28 days, and also 12, 13, 14 months

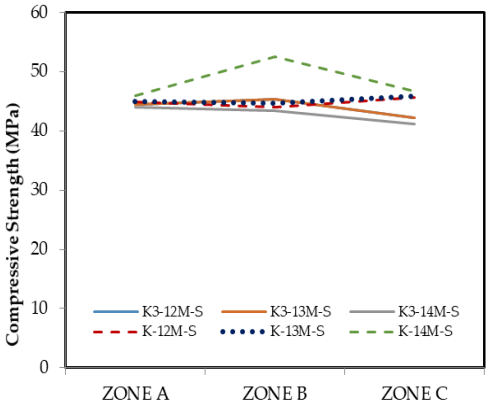

Figure 18. Compressive strength of control column at age of 12, 13, 14 months

3.3. Destructive Test for column specimens

The research applied a Destructive Test to investigate the compressive strength of retrofitted and control columns by the Core Drill method. Figure 19 and Figure 20 describe the Core Drill implementation to obtain the core's concrete sample of all columns which were concrete cylinders. Those drilled concrete cylinders then being tested for compressive strength. Figure 21 describes the results that the retrofitted column of K3 has about stable compressive strength at all points (A, B, C) of about 30 MPa. As a note, point B has a slightly higher value of compressive strength. The phenomenon did not happen to the control column. The research found that the compressive strength at point A was very high (52.44 MPa) while at points B and C were lower (42.76 MPa and 45.98 MPa).

Figure 19. Core Drill method of retrofitted and control columns that was conducted to obtain samples which used for compressive strength test.

Figure 20. A drilled concrete cylinder that was tested for compressive stress

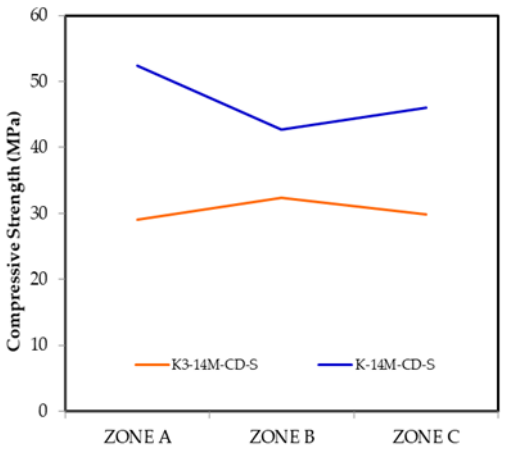

Figure 21. Compressive strength of drilled concrete cylinders of retrofitted and control columns at age 14 months

It was found by the destructive test result that the compressive strength at age 14 months control column surface by Rebound Hammer Test (K-14M-RH-S) was higher than the retrofitted one (K3-14M-RH-S), especially in the middle of the column height at point B. However, the retrofitted column has shown the averaged compressive strength along the column height (at point A, B, and C) as presented by Figure 22. The inner columns compressive strength of Core Drill Test (K-14M-CD-S and K3-14M-CD-S) had been found lower than the results of Rebound Hammer Test The baseline value of compressive test of column before it was retrofitted (K-Baseline) was the lowest (16.91 MPa) compared to the test results of Rebound Hammer and Core Drill. Figure 23 desribes that the increase of compressive strength at point B of retrofitted column of Core Drill Test (K3-14M-CD-S) was found of 92.34% higher (32.37 MPa to 16.83 MPa) at point B than the baseline column (K-Baseline).

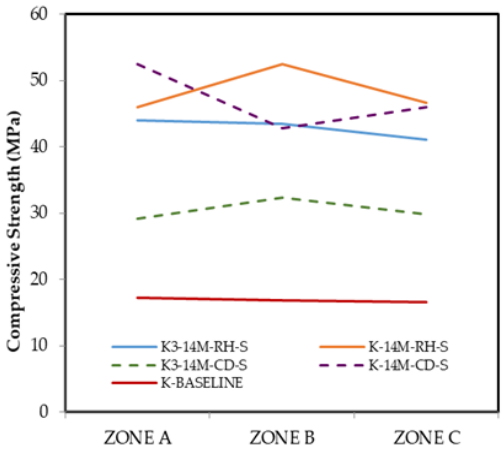

Figure 22. Compressive strength of retrofitted and control columns that were obtained from Rebound Hammer Test and Core Drill method

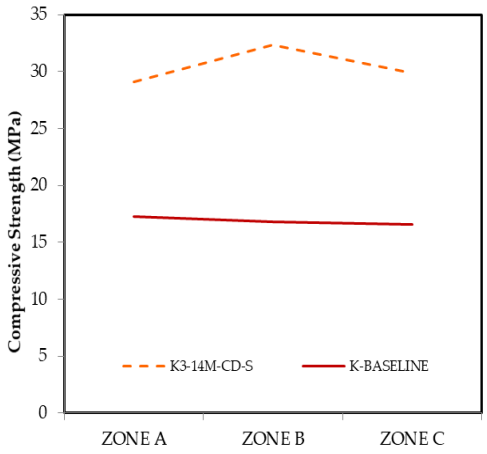

Figure 23. Compressive strength of baseline column compared to the retrofitted column that was obtained from Core Drill method

4. Discussion

Since the PMC (Polymer Modified Concrete) has been developed to increase concrete durability and bond strength [10], new innovation of PMC will be advantages in reducing the damage of concrete structures in tidal flooding prone area. A report by [11] found that Styrene Butadiene Rubber (SBR) latex that is applied into PMC had increased the concrete compressive strength about 72% as well as fiber reinforced polymers (FRP) of 86.64% to become high strength concrete. The experiment conducted by [12] about the addition of SF, RHA, and SF with nano silica into concrete as polymer had proven the increase of compressive strength of the PMC had increased of 82.9 MPa.

There is no doubt that the durability of concrete in tidal prone area takes an important role in achieving sustainable concrete. As a reference, a study conducted by [4] found that Indonesia's climate has relative humidity of 70-90% where the corrosion in carbonated concrete had become serious problem in concrete sustainability in marine environment as well as tidal flooding prone area. Hence, according to BS 6349-1, the concrete designed with 50 years of service life that subjected to a marine environment need to be stronger and durable with compressive strength of 25-40 MPa [4]. Previous studies of authors reported the concrete structure's elements retrofitting using polymer modified concrete bonding of adhesive agent for columns [14], premixed mortar additive for brick-wall [13], and concrete-bricks production with concrete mix of K1 and K3 [16] which explained by Table 1. Those studies found that the columns which was using premixed mortar additive as polymer had achieved compressive strength at age 28 days of 60.69 MPa. The compressive strength was 34.87% higher than the control ones (45 MPa). It was also reported by

that the compressive strength at age 14 months of the center of brick-wall surface tested by Rebound Hammer found as 42.3 MPa [13] while in the same age, the compressive strength of inner brick-wall (concrete brick with mix-K3) tested by Core Drill found as 58.60 MPa [16].

It is obvious that the using of natural or bio-polymer into concrete mix, especially PMC mix, is still rare especially when it is applied to aggressive environment such as tidal flooding prone area. In this research, the innovation of biopolymer modified concrete using Gracilaria Sp., Moringa oleifera, and honey, were applied to the old-broken columns retrofitting to get more durable and resistant concrete structure. The result of field application and column tests found that the compressive strength of retrofitted column achieved 32.37 MPa and the increase of concrete compressive strength of 92.34% compared to the baseline (the old broken column before being retrofitted).

All columns in the research were submerged by tidal flooding intensively for 14 months. Hence, the aggressive environment must contribute the concrete's structure degradation. A useful lesson learnt of [3] has reported that concrete compressive strength with ordinary normal Portland Cement exposed to marine environment for 20 years will significantly dropped in the 10^{th} year from about 50 MPa to 30 MPa. Hence, it confirmed the fact that sea water will attack the performance of concrete by catastrophic damage. The columns retrofitting biopolymer modified concrete using Gracilaria Sp., Moringa oleifera, and honey had increase its compressive strength in tidal flooding prone area of about 100% from the baseline after 14 months as shown by Figure 23. As an end-note, it seemed that the need of strong and durable concrete for aggressive environment such as tidal flooding prone area had been fulfilled by the innovation of bio-polymer modified concrete using Gracilaria Sp., Moringa oleifera, and honey which has ability to increase the concrete compressive strength and durability in aggressive environment.

5. Conclusions

It is necessary to develop concrete material which are good in performance and also best in durability. This research has proven that the bio-polymer modified concrete which used Gracilaria Sp., Moringa oleifera, and honey can significantly increase the performance and long-term durability of concrete columns. The findings reported that the compressive strength of retrofitted column achieved 32.37 MPa as it was increased of 92.34% compared to the baseline. A challenge to get sustainable concrete materials for tidal flooding prone area could be fulfilled by the bio-polymer modified concrete with Gracilaria Sp., Moringa oleifera, and honey.

Author Contributions: "Conceptualization, R.S. and I.I.; methodology, R.S.; validation, R.S., I.I. and B.S.; formal analysis, R.S.; investigation, I.I. and B.S.; resources, B.S.; data curation, R.S.; writing—original draft preparation, R.S.; writing—review and editing, I.I.; visualization, B.S.; supervision, I.I.; project administration, B.S.; funding acquisition, R.S. All authors have read and agreed to the published version of the manuscript."

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Conflicts of Interest: The authors declare no conflict of interest.

References

1. Akshat Dimri; Jay Kr. Varshney; V. K. Verma; Sandeep Gupta A Review on Strength of Concrete in Seawater. *Int. J. Eng. Res.* **2015**, *V4*, 844–847, doi:10.17577/ijertv4is030890.

2. Chandrasekaran, S.; Jain, A. *Materials for Ocean Structures*; 2016; ISBN 9781315366692.
3. Fukute, T.; Hamada, H. A Study on the Durability of Concrete Exposed in Marine Environment for 20 Years. *Rep. Port Harb. Institute, Minist. Transp. Japan* **1993**, *51*, 251–272.
4. Irmawaty, R.; Hamada, H.; Witanto, H. Durability Design for Indonesian Climate. In Proceedings of the Proceedings of the 2nd International Seminar on Infrastructure Development In Cluster Island Eastern Part of Indonesia (ISID 2014); Balikpapan, Indonesia2014.
5. Nanukuttan, S. V; Basheer, P.A.M.; McCarter, W.J.; Tang, L.; Holmes, N.; Chrisp, T.M.; Starrs, G.; Magee, B. The performance of concrete exposed to marine environments: Predictive modelling and use of laboratory/on site test methods. *Constr. Build. Mater.* **2015**, *93*, 831–840, doi:https://doi.org/10.1016/j.conbuildmat.2015.05.083.
6. Khanzadeh-Moradllo, M.; Meshkini, M.H.; Eslamdoost, E.; Sadati, S.; Shekarchi, M. Effect of Wet Curing Duration on Long-Term Performance of Concrete in Tidal Zone of Marine Environment. *Int. J. Concr. Struct. Mater.* **2015**, *9*, 487–498, doi:10.1007/s40069-015-0118-3.
7. Younis, A.; Ebead, U.; Suraneni, P.; Nanni, A. Fresh and hardened properties of seawater-mixed concrete. *Constr. Build. Mater.* **2018**, *190*, 276–286, doi:10.1016/J.CONBUILDMAT.2018.09.126.
8. Susilorini, M.. R.; W, K.R.D.; Wibowo, T. The Performance of Early-Age Concrete with Seawater Curing. *J. Coast. Dev.* **2013**, *8*, 89–95.
9. Guo, Q.; Chen, L.; Zhao, H.; Admilson, J.; Zhang, W. The Effect of Mixing and Curing Sea Water on Concrete Strength at Different Ages. *MATEC Web Conf.* **2018**, *142*, 02004, doi:10.1051/matecconf/201814202004.
10. ACI Committee 548 *Report on Polymer-Modified Concrete*; 2009;
11. Bothra, S.R.; Ghugal, Y.M. Polymer-Modified Concrete: Review. *Int. J. Res. Eng. Technol.* **2015**, *04*, 845–848, doi:10.15623/ijret.2015.0404146.
12. Alhazmi, H.; Shah, S.A.R.; Anwar, M.K.; Raza, A.; Ullah, M.K.; Iqbal, F. Utilization of Polymer Concrete Composites for a Circular Economy: A Comparative Review for Assessment of Recycling and Waste Utilization. *Polym. 2021, Vol. 13, Page 2135* **2021**, *13*, 2135, doi:10.3390/POLYM13132135.
13. Retno Susilorini, M.I.; William, S.S.; Rianto; Kartikowati, S.; Setiawan, M.H.; Ludfie Hardian, P.; Kurniawan, E. Masonry Walls Retrofitting with Eco-Concrete Bricks in Tidal Flooding Prone Area. *Int. J. Eng. Res. Technol.* **2020**, *13*, 560–569.
14. Susilorini, R.M.I.R.; Rejeki, V.G.S.; Santosa, B.; Caresta, F.D.; Putro, M.S. Polymer modified mortar with bonding adhesive agent for column repairing in tidal flooding prone area. *AIP Conf. Proc.* **2018**, *1977*, doi:10.1063/1.5042969.
15. Retno Susilorini, M.I.; Suryanto, R.; Pramana, Y. Carbohydrate polymers for green multi-purpose mortar. *Int. J. Eng. Res. Technol.* **2020**, *13*, 580–585.
16. Susilorini, R.M.I.R.; Suwarno, D.; Santosa, B.; Putra, L.H.; Kurniawan, E. Rebound Hammer Test result of old repaired masonry wall using premixed mortar additive in tidal flooding prone area. *AIP Conf. Proc.* **2018**, *1977*, 1–6, doi:10.1063/1.5042982.
17. Susilorini, R.M.I.R.; Santosa, B.; Rejeki, V.G.S.; Riangsari, M.F.D.; Hananta, Y.D. The increase of compressive strength of natural polymer modified concrete with Moringa oleifera.; 2017.

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Journal: Sustainability (https://www.mdpi.com/journal/sustainability) (ISSN 2071-1050)

Manuscript ID: sustainability-1541735

Type: Article

Title: Long-term Durability of Bio-Polymer Modified Concrete in Tidal Flooding Prone Area: A Challenge of Sustainable Concrete Materials

Authors: Rr. M. I. Retno Susilorini * , Iskhaq Iskandar , Budi Santosa

Abstract: The need for durable concrete in marine environments such as areas prone to tidal flooding is important due to its ability to deteriorate the structures. This led to the design of a durable and strong Polymer-Modified Concrete (PMC) using natural or bio-polymer modified concrete. However, the use of biopolymer-modified concrete is very limited. Therefore, this research developed a bio-polymer modified concrete using Gracilaria Sp., Moringa oleifera, and honey for column retrofitting. The research aimed to retrofit and improve the compressive strength and durability of broken columns submerged by tidal flooding by applying bio-polymer modified concrete with Gracilaria Sp., Moringa oleifera, and honey. A field application of column retrofitting was conducted in areas prone to tidal flooding. The retrofitted columns performance was observed for 14 months and validated by non-destructive and destructive tests. The result showed that the compressive strength of the retrofitted column achieved 32.37 MPa, which is a 92.34% increase compared to the baseline. This research provides answers to the challenge of concrete materials sustainability by promoting bio-polymer modified concrete that significantly increased its performance and long-term durability using Gracilaria Sp., Moringa oleifera, and honey.

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Are the research design, questions, hypotheses and methods clearly stated?	( )	(x)	( )	( )
Are the arguments and discussion of findings coherent, balanced and compelling?	(x)	( )	( )	( )
For empirical research, are the results clearly presented?	( )	(x)	( )	( )
Is the article adequately referenced?	(x)	( )	( )	( )
Are the conclusions thoroughly supported by the results presented in the article or referenced in secondary literature?	( )	( )	( )	( )

Comments and Suggestions for Authors

In order to improve the corrosion resistance and durability of conventional concrete, the experimental study of biopolymer-concrete was carried out and the reliability of the trial experiment was confirmed. The research results are of great help to improve the durability of marine engineering concrete, and the engineering application value is outstanding. The reviewer suggested that publication could be considered after appropriate revision.

The following questions need to be explained by the author.

(1)If the author can explain the action mechanism based on experimental research and test data, the academic value of the paper can be greatly improved; For example, the specific addition ratio of biopolymer, concrete mix ratio.

(2)Can the authors further explain why honey is used as an added material.

(3)The mechanical performance test results of the addition of cast-in-situ concrete are only the strength test of site drill core sampling, which lack certain comparison.

(4)The article shows a large number of work photos on the site. Although it is of certain value, it is not helpful to the content analysis of the article. It is suggested to delete them appropriately and retain the necessary research photos.

(5)The sampling method of the drill core of the reinforced column is questionable. The compressive direction of the column is vertical direction (perpendicular to the ground), but the author takes the

samples as horizontal, which is not consistent with the actual force direction. It is worth discussing whether the sampling method has any impact on the results.

(6)The strength of the concrete column after the reinforcement is too simple and not deep enough.

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	Yes	Can be improved	Must be improved	applicable

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Are the research design, questions, hypotheses and methods clearly stated?	( )	( )	(x)	( )
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Is the article adequately referenced?	( )	( )	(x)	( )
Are the conclusions thoroughly supported by the results presented in the article or referenced in secondary literature?	( )	( )	( )	( )

Comments and Suggestions for Authors

1. **Comments**:

Title: Flooding area should be replaced by flood area (Check everywhere)

Abstract: Repetition of “Gracilaria Sp., Moringa oleifera, and honey” should be avoided (Refer the abstract this is repeated three times).

Abstract: Line 17: Why is it used ‘or’? It should be ‘and’. Use of ‘or’ does not have meaning here. Check the same in page 2; line 55 also.

Key words: Tidal flood sustainable is not a proper keyword and should be revised.

Page 2; line 50: Though reference numbers are given as “According to [11,12]” it is necessary to mention authors like ‘According to Bothra et al. and Hirde et al. [11,12]’ ---.

Page 2; line 52 and 53: Follow first expansion and then abbreviations (example: Silica fume (SF); Rice husk ash (RHA)).

Page 2; line 54: Remove i.e. before [14-19].

Page 2; line 69: Sub sectional number can be given as 2.1 instead of bulletin point. (the same way for other bullet points also)

Table 1: Title caption is not clear; Number column is not necessary since only three items; why K1 and K3 what happened to K2? Why is the letter K chosen, does it have any meaning? Similarly why M I and M III what happened to M II? Control column should be placed as the first one (always control specimens should come at first). First letter should be started with upper case (refer the status column).

Mix I and Mix III proportion details are not found in this section 2.

Figure 1: Caption given should be very short and sweet and not a sentence.

Page 2; line 77: Mentioned Table 2 but it was not found anywhere.

Figure and Tables are to be presented in the order of sequences. Example: Figure 2 should come after Figure 1 not as Figure 5. Necessary change of positions and numbers to be reordered for both Figures and Tables. That too once citation statements are introduced then Tables and Figures should be available in the immediate vicinity of the citations.

Section 2: Materials and methods: No materials and their properties are given.

Standards referred are not included in the list of references.

Figure 2: It does not have any uniqueness.

Figure 3: It shows only a schematic representation (no dimensions are for the divided zones are given). The same should be marked on the real element and should be presented aside of the schematic diagram.

Figure 3: Title caption should be shortened.

Table 3 and 4: Title caption should be shortened.

Table 4: Notations used are not explained.

Page 5: Line 115 & 116: compressive strength was obtained using the Core Drill method. Core drilling is not a method, it is a technique to get the sample to test for.

Figure 4: Title caption should be shortened (remove the name of equipment – already stated in the text).

Figure 4: Equipment is dominated in the photo and hence it should be replaced significantly to show core cutting.

Why was core cutting done only to column K3 at 14 months?

Figure 5: Instead of giving a schematic diagram and location A, B, and C (it is not in a impressive way), it can be given in the form of a statement with the dimension for positioning to take the core cutting.

Page 5: Line 123: used the ASTM code to test. What is that ASTM code and its reference?

This is in addition to the use of Computer Control Servo Hydraulic Concrete Compression Testing Machine and Hung-Ta serial HT 8391PC to obtain compressive strength of concrete cylinder as shown in Figure 6. This sentence should be restructured.

No uniformity is maintained to indicate the compressive strength (kg/cm^2 or MPa). Why is the MKS system? The SI system of the unit should be followed.

Page 6: Line 134: Superscript is not followed for mm2; it should be mm^2.

Figure 6: Caption should not be only with the name of the equipment which is already given in the text. Specific focus should be on what is significant from the Figure.

There should be one or two sentences between the sectional numbers. (Example: Section 3 and Section 3.1

Figure 7: (a) and (b) before and after does not have any innovation.

Selected columns for retrofitting seem to be very ordinary element that supports tiled roofs.

Section 3.1: First paragraph is not the results of this study and it is only a seasonal progressive failure.

Section 3.1: Second paragraph is also not the results of this study and it is only a retrofitting process.

Figure 8: (a) contains 6 photographs but no proper citations are given. The same way for Figure 9 as well.

Page 7: Line 170-172: This is only a basic and hence not necessary. However, what is that split? Once again Table 2 is mentioned but not found. What is that conducting steel reinforcement?

Generally the rebound hammer test gives an approximate quality only. Therefore conduct of rebound hammer tests and their results alone not good enough to decide that too in a marine environment. Permeability tests should be conducted in these cases.

Page 9: Line 191: 18.63 MPa is not matched properly in Figure 14. Also since the statement is given already Figure 14 (It is a very simple graphical representation) is not necessary.

Section 4: Discussion: First two paragraphs discussed on the others' works. When the heading is given as discussion authors should discuss their research results only. It is lacking here in these two paragraphs. These discussions should have been included in the introduction part only.

Section 4: Third and fourth graphs talked about durability without any sound technical results from this research. The same in the conclusion section also.

More self-citations are found.

Testing only rebound hammer test and compressive strength tests on core cutting specimens after 14 months alone cannot be considered long term durability.

1. **English Language:**

Language used in the manuscript was not in the expected level of standard. Throughout the manuscript language corrections are to be done with the help of native speakers.

Here few Examples given for reference:

Section 1: Line 58: This research aims to and ~~implement~~ implemented in the column retrofitting in tidal ~~flooding~~ flood areas with bio-polymer modified concrete using Gracilaria Sp., Moringa oleifera, and honey.

Section 1: Line 63: performance and long-term durability.

Section 2: Line 65: This research was conducted ~~by~~ for field application as ~~by as well as~~ both non-destructive and destructive ~~tests in sites prone to tidal flooding~~.

Page 2: Line 71: Each specimen identity was represented by one column

Page 2: Line 75: product ~~sold~~ available in the open market ~~place~~

Page 3: Line 90~~:~~ This stage was conducted on-site

Page 4: Line 105: The Rebound Value was read by the equipment

Page 5: Line 115 & 116: compressive strength was obtained using the Core Drill method / This technique was purposed to obtain.

Page 5: Line 123: used the ASTM code to test

Figure 13: The Rebound Hammer Test was column at conducted at the points that marked by red circles

Figure 14: Compressive strength of old broken column that become baseline value

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Abstract: The need for durable concrete in marine environments such as areas prone to tidal flooding is important due to its ability to deteriorate the structures. This led to the design of a durable and strong Polymer-Modified Concrete (PMC) using natural or bio-polymer modified concrete. However, the use of biopolymer-modified concrete is very limited. Therefore, this research developed a bio-polymer modified concrete using Gracilaria Sp., Moringa oleifera, and honey for column retrofitting. The research aimed to retrofit and improve the compressive strength and durability of broken columns submerged by tidal flooding by applying bio-polymer modified concrete with Gracilaria Sp., Moringa oleifera, and honey. A field application of column retrofitting was conducted in areas prone to tidal flooding. The retrofitted columns performance was observed for 14 months and validated by non-destructive and destructive tests. The result showed that the compressive strength of the retrofitted column achieved 32.37 MPa, which is a 92.34% increase compared to the baseline. This research provides answers to the challenge of concrete materials sustainability by promoting bio-polymer modified concrete that significantly increased its performance and long-term durability using Gracilaria Sp., Moringa oleifera, and honey.

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Comments and Suggestions for Authors

The aim of this paper is to present an solution to retrofit and improve the compressive strength and durability of broken columns submerged by tidal flooding by applying bio-polymer modified concrete with Gracilaria Sp., Moringa oleifera, and honey

The document must be carefully checked as there are inaccuracies and style errors. Listed below are some comments

1. I understand that the aim of this article is applying bio-polymer modified concrete with Gracilaria Sp., Moringa oleifera, and honey but these words, only in the abstract, are repeated 3 times (Lines 19, 22, 28). The same is repeated below in the text. It doesn't fit the scientific style of the article. I recommend using synonyms or abbreviations
2. Figure 4: The Core Drill method. Not informative. It's just a tool.
3. Figure 4: Not informative
4. Figures 8-12 Not informative, and it is not clear what the authors wanted to show them
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Long-term Durability of Bio-Polymer Modified Concrete in Tidal Flooding Prone Area: A Challenge of Sustainable Concrete Materials

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Abstract: The need for durable concrete in marine environments such as areas prone to tidal flooding is important due to its ability to deteriorate the structures. This led to the design of a durable and strong Polymer-Modified Concrete (PMC) using bio-polymer modified concrete. However, the use of biopolymer-modified concrete is very limited. Therefore, this research developed a bio-polymer modified concrete for column retrofitting. The research aimed to retrofit and improve the compressive strength and durability of broken columns submerged by tidal flooding by applying bio-polymer modified concrete with *Gracilaria Sp*., *Moringa oleifera*, and honey. A field application of column retrofitting was conducted in areas prone to tidal flooding. The retrofitted columns performance was observed for 14 months and validated by non-destructive and destructive tests. The result showed that the compressive strength of the retrofitted column achieved 32.37 MPa, which is a 92.34% increase compared to the baseline. This research provides answers to the challenge of concrete materials sustainability by promoting bio-polymer modified concrete that significantly increased its performance and long-term durability.

Keywords: durability; bio-polymer; concrete; materials; tidal; flooding; sustainable.

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1. Introduction

The deterioration of concrete structures caused by tidal flooding is one of the major causes of coastal infrastructure damage. Therefore, it is important to ensure concrete structures' durability in an aggressive environment, such as areas prone to tidal flooding. Some of the major causes of concrete deterioration are chemical attack of seawater constituents during the hydration process of cement, alkali-aggregate expansion, crystallization pressure of salts, frost action in cold climates, and corrosion of reinforced steel embedded in concrete structures. Others include physical erosion, such as wave and floating objects contacted to the concrete structures, as well as the carbonic acid attack that leaches away the calcium from hydrated cement [1,2]. Hence, it is necessary to ensure that concrete materials have good performance and durability.

Several research have reported the durability of concrete structures in the marine environment, including long-term investigation of concrete performance exposed to seawater [3–6]. Research by [3] reported that concrete compressive strength with ordinary, normal Portland Cement exposed to the marine environment for 20 years is

likely to significantly drop in the 10th year from approximately 50 MPa to 30 MPa. Furthermore, concrete mixed with seawater achieved a good mechanical properties performance even though it was slightly lower than those using plain water [7–9]. It is also reported to provide a more resistant product against deterioration and higher compressive strength at an early age.

Preliminary reasearch also conveyed the improved durability and bond strength of concrete structures in the marine environment was achieved due to the development of Polymer-Modified Concrete (PMC) by mixing a polymer material into Portland Cement [10–13]. According to Bohtra, et.al. and Hirde, et.al. [11,12], thermoplastics, such as epoxy resins, elastomers or rubbers, natural polymers cellulose, lignin proteins, latex, re-dispersible polymer powder, water-soluble powder, liquid resins, Silica Fume (SF), Rice Husk Ash (RHA), and SF with nano-silica were used in PMC. There were also several studies reported the advantage of PMC for marine environment as reported by Zhao, et.al., Madhani, et.al., Seyed, et.al., Binti Noruman, et.al., Wang, et.al., and Kantharia, et.al. [14–19]. Previous research also reported the retrofitting of concrete structure elements using polymer-modified concrete with adhesive bonding agents [20], premixed mortar additive [21], and concrete-bricks production. However, research on the utilization of natural or bio-polymer modified concrete and mortar are still very rare irrespective of the advantages such as increased compressive strength and durability [20–24].

One of the most effective ways to increase concrete durability and bond strength in areas prone to tidal flooding is using PMC (Polymer Modified Concrete) [10]. Research by [11] found that the application of Styrene-Butadiene Rubber (SBR) latex into PMC and fiber-reinforced polymers (FRP) increased the concrete compressive strength by 72% and 86.64%, respectively. The experiment conducted by [13] on the addition of SF, RHA, and SF with nano-silica into concrete as polymer proved an increase in the compressive strength of the PMC by 82.9 MPa. It was also found by previous studies [21,23] that the columns designed with premixed mortar additive as polymer achieved compressive strength 34.87% higher than the control.

Subsequently, concrete durability in tidal-prone areas plays an important role in achieving sustainable concrete. According to research conducted by [4], Indonesia's climate has relative humidity ranging from 70-90%. The corrosion in carbonated concrete has become a serious problem in concrete sustainability in the marine environment and areas prone to tidal flooding. Therefore, concretes designed with a life span of 50 years when subjected to a marine environment, such as BS 6349-1, need to be stronger and durable with compressive strength of 25-40 MPa [4].

This research aims to implement column retrofitting in tidal flooding areas with bio-polymer modified concrete using *Gracilaria Sp.*, *Moringa oleifera*, and honey. It was conducted by field application of columns retrofitting in areas prone to tidal flooding for 14 months and validated by non-destructive and destructive tests. The result showed that the bio-polymer modified concrete using *Gracilaria Sp.*, *Moringa oleifera*, and honey increased concrete columns' performance and long-term durability.

2. Materials and Methods

This research was conducted by field application as well as non-destructive and destructive tests in sites prone to tidal flooding. The materials, methods and stages are outlined in subsequent sub-sections.

2.1. On-site column retrofitting and control column construction

The materials and mix-composition of bio-polymer modified concrete used in this study has presented by Table 1 and Table 2. The concrete mixture was calculated by SNI 03-2834-2000 Method for Normal Concrete Mix-Design [25] as shown in Table 2. Two broken columns were retrofitted in the site, and a control column was constructed with

bio-polymer modified concrete as described in Table 3. Each specimen code was represented by one column.

Table 1. Mix composition of bio-polymer

Mix Composition	Specimen Code	*Gracilaria Sp.*	honey	*Moringa oleifera*
		% of cement weight		
Mix I*	K1*	0.05	0.03	0
Mix III*	K3*	0.025	0	0.075
Mix-Normal	K	---	---	---

*the mix composition and specimen code referred to author's previous study of [23]

Table 2. Mix composition of concrete for 1 column production

Cement (kg)	Sand (kg)	Crushed Stone (kg)	Water (l)	Bio-Polymer (% of cement weight)
8	8	8	3.6	see Table 1

Table 3. Detail of Column Retrofitting and Construction

No	Specimen Code	Status	Mix Composition
1	K1*	retrofitted column	Mix I*
2	K3*	retrofitted column	Mix III*
3	K	control column	Mix-Normal

*the mix composition and specimen code referred to author's previous study of [23]

The column retrofitting and construction was carried out by grouting it with bio-polymer modified concrete. The materials used as described by Table 1 were *Gracilaria Sp.* powder, which is an agar-agar product sold in the market, *Moringa oleifera* powder from its seeds, and honey. Those materials have advantages that will be explained as follow. The *Gracilaria Sp*. contains agarans, carrageenans, agarose, and agaropectin, that will form hard gel and also has rheological properties as thickening and gelling agents [26,27]. It was reported that *Moringa oleifera* had some advantages such as: performs as coagulant and also clarifying agent for water and also contains glyceride which known as esters formed by glycerol (or glycerine) and fatty acids that whenever it is combined with litharge it will generate quick setting in the fresh mortar to become stronger and harder [28–30]. The honey also used in the concrete mixture because of its advantages. Honey compounds mainly consist of fructose (38.4%), glucose (30.3%), some acids, and minerals. Since honey characteristic is sticky and viscous, that could improve bonding mechanism when it is added into other materials [31–33].

In this study, *Gracilaria Sp*., *Moringa oleifera*, and honey were added together into the mixture, as shown in Figure 1 and Table 1. The concrete mix composition of Mix I and Mix III were previously implemented in producing concrete bricks [23]. It should be noted that the specimen's code of "K1" and "K3" and also mix-composition of "Mix I" and "Mix III" were the original code in the previous research of author [23] which is maintained in this current research. All concrete columns were designed for compressive strength of $f'_c = 30$ MPa with a dimension of 15 cm x 15 cm x 100 cm and zones of A, B, C, for Rebound Hammer Test and Core Drill as shown in Figure 2.

Figure 1. The materials used in this study: (a) and (b) *Gracilaria Sp.* powder; (c) raw *Moringa oleifera* seeds with skin; (d) raw *Moringa oleifera* seeds without skin; and (e) honey.

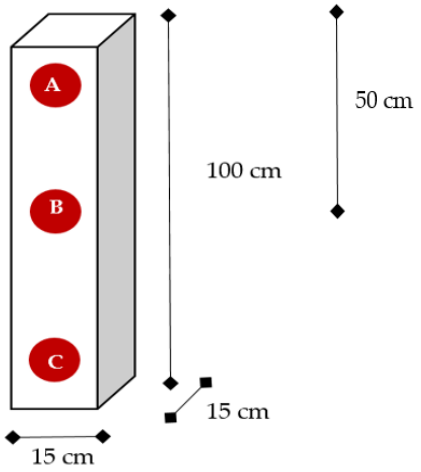

Figure 2. Column dimension and the zones for Rebound Hammer Test and Core Drill

2.2. Non-destructive test for retrofitted and control columns

This stage was conducted on-site, which led to the construction of the control columns after the broken sections were retrofitted. The Rebound Hammer test was carried out as a non-destructive test to analyze the columns compressive strength with Matest 2H1Q17. All columns were tested at 7, 14, and 28 days, while K3 and K were also tested at 12, 13, and 14 months.

The non-destructive procedure used in this test followed ASTM C 805 - Standard Test Method for Rebound Number of Hardened Concrete. Several shootings were applied to the clean and flat surfaces of zone A, B, and C described by Figure 2. Each zone was shot ten times by Matest 2H1Q17 as shown by Figure 3.

Figure 3. Matest 2H1Q17 equipment for Rebound Hammer Test

The Rebound Value was read by the equipment and then corrected for inclination as indicated in Table 3. After the corrected Rebound Value was calculated as R, the concrete strength (W_m) that referred to the cubes was calculated in accordance with the age, as shown in Table 4. The concrete strength (W_m) written as a function of Rebound Number (R type N).

Table 3: Correction of the Test Hammer Indications for Non-Horizontal Impacts*

Rebound Value Rα	Correction for inclination angle α			
	Upwards		Downwards	
	+90°	+45°	-45 °	-90 °
10			2.4	3.2
20	-5.4	-3.5	2.5	3.4
30	-4.7	-3.1	2.3	3.1
40	-3.9	-2.6	2	2.7
50	-3.1	-2.1	1.6	2.2
60	-2.3	-1.6	1.3	1.7

* Manual Book Hammer Test Matest 2H1Q17

Table 4. Rebound Number based on age of concrete

R	Age of Concrete			
	14 to 56 days		7 days	
	W_m	W_{min}	W_m	Wmin
	(kg/cm^2)			
20	101	54	121	74
21	113	64	132	83
22	126	75	145	94
23	139	86	157	104
24	152	98	169	115
25	166	110	183	127
26	180	122	196	138
27	195	135	210	150
28	210	149	225	164
29	225	163	239	177
30	241	178	254	191
31	257	193	269	205
32	274	209	285	220

33	291	225	300	234
34	307	240	315	248
35	324	256	331	263
36	342	273	348	279
37	360	290	365	295
38	370	307	381	311
39	395	324	398	327
40	413	341	416	344
41	432	359	434	361
42	450	377	451	378
43	469	395	470	396
44	488	414	488	414
45	507	432	507	432
46	526	450	526	451
47	546	470	546	570
48	565	489	565	489
49	584	508	584	508
50	604	527	604	527
51	623	546	623	546
52	643	565	643	565
53	663	584	663	584
54	683	603	683	603
55	703	622	703	622

2.3. Destructive test for retrofitted and control columns

After the Rebound Hammer test, the inner concrete's was taken out by core drilling the column and then the core drilled specimens were tested for compressive strength. This technique of core drill followed the ASTM C 42/C 42M – 04 Standard test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete [34] and SNI 03-2492-2002 [35] Standard test Method for Obtaining and Testing Drilled Cores. The machine used for core drill was HILTI DD 150-U with a diameter of 3 mm, as shown in Figure 4. The Core Drill method was applied only to columns K3 and K at 14 months since column K1 had broken because of the high tide disaster attack in the 13th month and it was impossible to conduct core drill to column K1.

The drilled concrete cylinder specimen with a diameter and height of 70 mm and 140 mm being tested for compressive strength which followed the ASTM C 42/C 42M – 04 Standard test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete to test for compressive strength. A Computer Control Servo Hydraulic Concrete Compression Testing Machine and Hung-Ta serial HT 8391PC used to obtain compressive strength of concrete cylinder as shown in Figure 5.

Figure 4. The Core Drill machine with versatile diamond drilling system

Calculation of compressive test followed the expression of Equation (1).

$$\sigma = \{\left(\frac{P}{A}\right) . f_{l/d} . f_{dia} . f_d\} \quad (1)$$

where σ is characteristic compressive strength (MPa), P is compressive load (N), A is compressive area (mm2), l is the height of sample (mm), d is the diameter of the sample (mm), $f_{l/d}$ is correction factor of core diameter, and f_d is correction factor of damage caused by drilling. The correction factor of core diameter referred to ASTM C 42/C 42M – 04 and ACI 214.4R-03, while the correction factor of damage caused by drilling is referred to ACI 214.4R-03.

Figure 5. The Computer Control Servo Hydraulic Concrete Compression Testing Machine, Hung-Ta serial HT 8391PC

3. Results

3.1. On-site column retrofitting and construction

This research retrofitted 2 broken columns marked by a red circle, as shown in Figure 6-(a). Those two columns were used to pin the broken masonry wall and observed that the concrete's cover, as well as most parts of the columns were peeled off while the steel reinforcement was corroded. After several months, almost half of the left column collapsed, as shown by Figure 6-(b).

Figure 6. The broken columns at situation of (a) The initial work when the two broken columns still existed, and (b) The next few months after initial work when the half part of left column had been collapsed.

Figure 7-(a) shows that the first step in column retrofitting is conducted by peeling the cover of old concrete and unnecessary debris and applying the formwork of 1 m from the base floor. The next step of the activities was grouting the column with bio-polymer modified concrete consisting of *Gracilaria, Sp*., *Moringa oleifera*, and honey. After the retrofitted column hardness increased, it was wrapped by jute sack, and curing was applied for about a week by watering it as shown in Figure 7-(b).

(a)

(b)

Figure 7. The column retrofitting activities: (a) Peeling, formwork, grouting with bio-polymer modified concrete consisting of Gracilaria, Sp., Moringa oleifera, and honey; (b) Curing by watering the column for a week.

Figure 8 shows a control column constructed in conjunction with columns retrofitting. The procedure included: mixing the concrete materials consisting of cement, split, sand, and water referred to Mix Normal as shown in Table 3. The steel reinforcement placed in the formwork and the concrete mix was poured into the formwork. After the column hardened, the curing was conducted. When the concrete was tough enough, the formwork was opened.

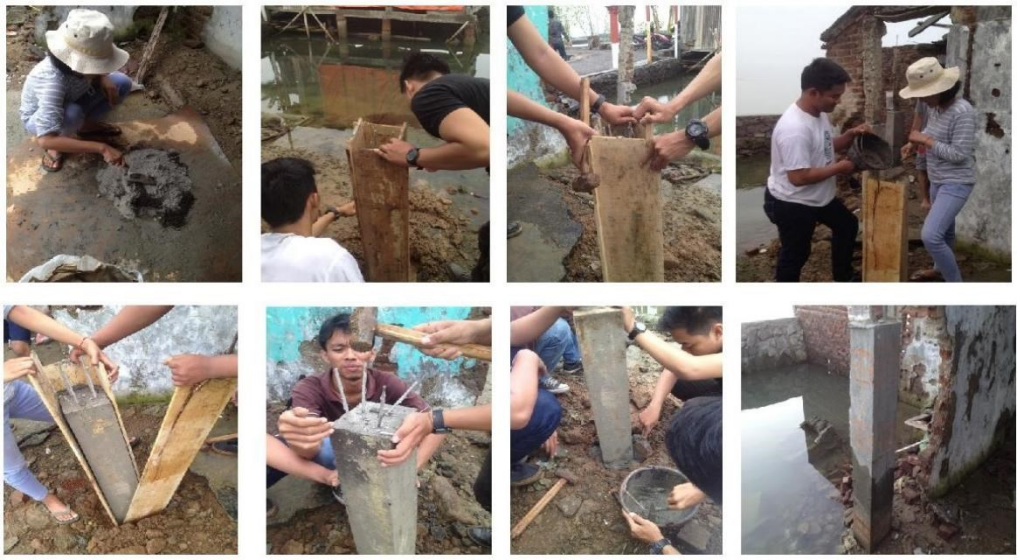

Figure 8. Construction of control column.

3.2. Non-destructive test for retrofitted and control columns

The non-destructive test examined the retrofitted and control columns to investigate their compressive strength. A Rebound Hammer Test was also used by shooting at the necessary points (A, B, C) in the house submerged by tidal flooding at 28 days, as shown in Figures 9-11. About a year later, the retrofitted and control columns were tested at 12, 13, and 14 months as shown by Figures 10 and 11.

Figure 9. Rebound Hammer Test that was conducted to retrofitted columns at 7, 14, and 28 days

Figure 10. Rebound Hammer Test that was conducted to retrofitted columns at 12, 13, and 14 months

s

Figure 11. Rebound Hammer Test that was conducted to control column at 14 months

The baseline of the Rebound Hammer Test was conducted by shooting the old broken column at points A, B, C to obtain the baseline of compressive strength before column retrofitting procedures, as shown in Figures 12 and 13. It was found that the baseline compressive strength of the old broken columns was 18.63 MPa, 17.3 MPa, and 16.6 MPa at points A, B, and C.

Figure 12. The Rebound Hammer Test was column at conducted at the points that marked by red circles

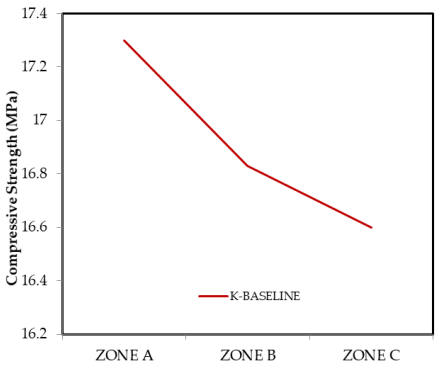

Figure 13. Compressive strength of old broken column that become baseline value

The Rebound Hammer Test result observed that the retrofitted column of K1 performed lower compressive strength to K3 at point A, which was higher at B and C within 7, 14, and 28 days as indicated in Figure 14. Furthermore, a very high compressive strength value was obtained at point B within 14 months compared to the lower value in the retrofitted column, as shown in Figure 15. The research also found that the compressive strength of K1 at point C was decreased at all ages, as shown in Figure 16. Rebound Hammer Test results also noted that at 14 months, the compressive strength values of retrofitted and control columns decreased, as shown in Figure 17.

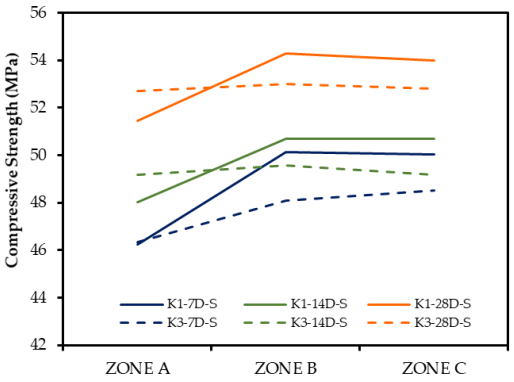

Figure 14. Compressive strength of retrofitted columns of K1 and K3 at 7, 14, 28 days

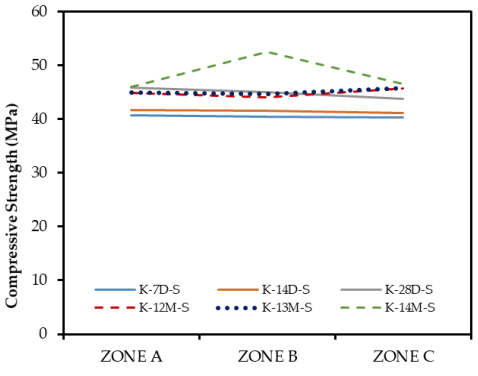

Figure 15. Compressive strength of control column at 7, 14, 28 days, and also 12, 13, 14 months

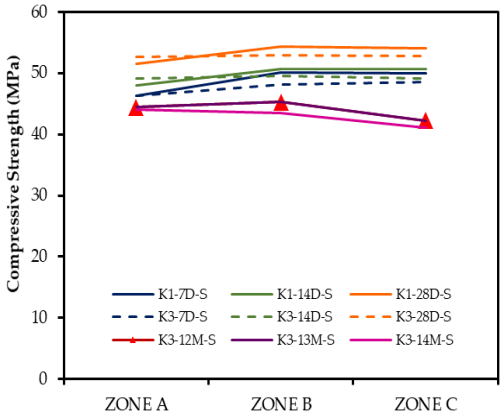

Figure 16. Compressive strength of retrofitted columns of K1 at 7, 14, 28 days, and K3 columns at 12, 13, 14 months

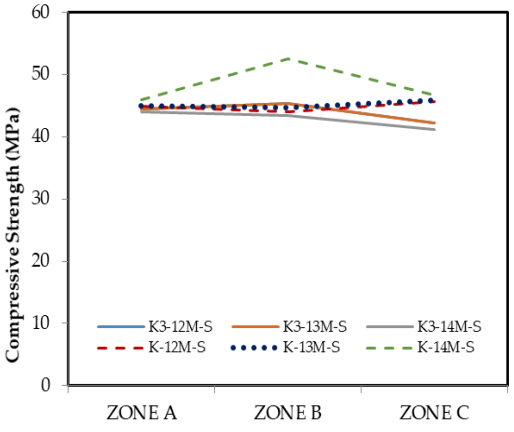

Figure 17. Compressive strength of control columns at at 12, 13, 14 months

3.3. Destructive Test for column specimens

The research applied a Destructive Test to investigate the compressive strength of retrofitted and control columns by testing the core drilled specimens for compressive strength. Figures 18 and 19 describe the Core Drill implementation process needed to obtain the core's concrete sample using concrete cylinders. Figure 20 illustrates that the retrofitted column of K3 has stable compressive strength at all points (A, B, C) with 30 MPa. Point B has a slightly higher compressive strength value, which did not occur on the control column. The research found that the compressive strength at point A was very high (52.44 MPa) and low (42.76 MPa and 45.98 MPa) at points B and C.

Figure 18. Core Drill method of retrofitted and control columns conducted to obtain samples used for the compressive strength test.

Figure 19. A drilled concrete cylinder tested for compressive stress

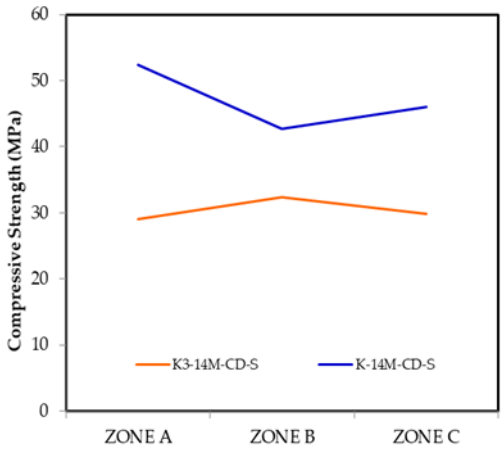

Figure 20. Compressive strength of drilled concrete cylinders of retrofitted and control columns at 14 month

4. Discussion

This research found that the non-destructive and destructive test results of the compressive strength at 14 months of control columns (K-14M-RH-S and K-14M-CD-S) were higher than the retrofitted columns (K3-14M-RH-S and K3-14M-CD-S), especially in the middle of point B as described by Figure 21. However, the retrofitted column has shown the averaged compressive strength along with the column height (at points A, B, and C), as shown in Figure 21. The compressive strength of core drilled specimens K-14M-CD-S and K3-14M-CD-S were found lower than the ones tested by Rebound Hammer at the same age. The baseline value of the compressive test of the column before it was retrofitted (K-Baseline) was the lowest (16.91 MPa) compared to the test results of Rebound Hammer and Core Drill. Figure 22 illustrates an increase in compressive strength at point B of the retrofitted column which were core drilled specimen (K3-14M-CD-S) was 92.34% higher (32.37 MPa to 16.83 MPa) at point B than K-Baseline.

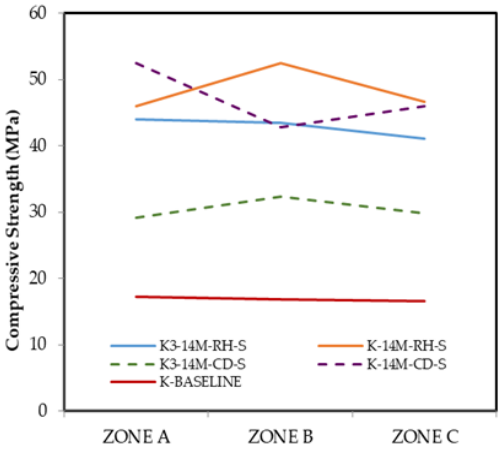

Figure 21. Compressive strength of retrofitted and control columns were obtained from Rebound Hammer Test and Core Drill method

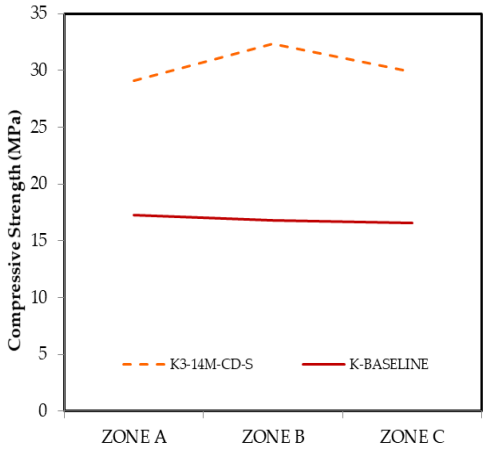

Figure 22. Compressive strength of baseline column was obtained from Core Drill method

It is obvious that the research on the use of natural or bio-polymer to mix concrete, such as PMC is still rare, especially when applied to areas prone to tidal flooding. In this research, the innovation of biopolymer modified concrete using *Gracilaria Sp.*, *Moringa oleifera*, and honey were applied to the old-broken columns retrofitting to get a more durable and resistant concrete structure. The field application results and column tests found that the compressive strength of the retrofitted column achieved 32.37 MPa, increasing 92.34% compared to the baseline.

All columns in the research were submerged by tidal flooding intensively for 14 months because the aggressive environment contributes to the concrete's structure degradation. Hence, it confirmed that seawater has the ability to attack the performance of concrete by catastrophic damage. The columns retrofitting biopolymer, which modified concrete using *Gracilaria Sp.*, *Moringa oleifera*, and honey, increased its compressive strength by 100% from the baseline after 14 months, as shown in Figure 22. Therefore, the concrete structure with the addition of *Gracilaria Sp.*, *Moringa oleifera*, and honey has strong and durable characteristics to be used in aggressive environments such as areas prone to tidal flooding.

5. Conclusions

In conclusion, it is necessary to develop concrete materials that are strong and durable in a marine environment prone to trial flooding. This research proved that the bio-polymer modified concrete that used *Gracilaria Sp.*, *Moringa oleifera*, and honey

significantly increased concrete columns' performance and long-term durability. The findings also showed that the compressive strength of the retrofitted column achieved 32.37 MPa, a 92.34% increase compared to the baseline. Therefore, the challenges of getting sustainable concrete materials for areas prone to tidal flooding can be fulfilled by using bio-polymer modified concrete with *Gracilaria Sp.*, *Moringa oleifera*, and honey.

Author Contributions: Conceptualization, R.S. and I.I.; methodology, R.S.; validation, R.S., I.I. and B.S.; formal analysis, R.S.; investigation, I.I. and B.S.; resources, B.S.; data curation, R.S.; writing—original draft preparation, R.S.; writing—review and editing, I.I.; visualization, B.S.; supervision, I.I.; project administration, B.S.; funding acquisition, R.S. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest: The authors declared no conflict of interest.

References

1. Akshat Dimri; Jay Kr. Varshney; V. K. Verma; Sandeep Gupta A Review on Strength of Concrete in Seawater. *Int. J. Eng. Res.* **2015**, *V4*, 844–847, doi:10.17577/ijertv4is030890.
2. Chandrasekaran, S.; Jain, A. *Materials for Ocean Structures*; 2016; ISBN 9781315366692.
3. Fukute, T.; Hamada, H. A Study on the Durability of Concrete Exposed in Marine Environment for 20 Years. *Rep. Port Harb. Institute, Minist. Transp. Japan* **1993**, *51*, 251–272.
4. Irmawaty, R.; Hamada, H.; Witanto, H. Durability Design for Indonesian Climate. In Proceedings of the Proceedings of the 2nd International Seminar on Infrastructure Development In Cluster Island Eastern Part of Indonesia (ISID 2014); Balikpapan, Indonesia2014.
5. Nanukuttan, S. V; Basheer, P.A.M.; McCarter, W.J.; Tang, L.; Holmes, N.; Chrisp, T.M.; Starrs, G.; Magee, B. The performance of concrete exposed to marine environments: Predictive modelling and use of laboratory/on site test methods. *Constr. Build. Mater.* **2015**, *93*, 831–840, doi:https://doi.org/10.1016/j.conbuildmat.2015.05.083.
6. Khanzadeh-Moradllo, M.; Meshkini, M.H.; Eslamdoost, E.; Sadati, S.; Shekarchi, M. Effect of Wet Curing Duration on Long-Term Performance of Concrete in Tidal Zone of Marine Environment. *Int. J. Concr. Struct. Mater.* **2015**, *9*, 487–498, doi:10.1007/s40069-015-0118-3.
7. Younis, A.; Ebead, U.; Suraneni, P.; Nanni, A. Fresh and hardened properties of seawater-mixed concrete. *Constr. Build. Mater.* **2018**, *190*, 276–286, doi:10.1016/J.CONBUILDMAT.2018.09.126.
8. Susilorini, M.. R.; W, K.R.D.; Wibowo, T. The Performance of Early-Age Concrete with Seawater Curing. *J. Coast. Dev.* **2013**, *8*, 89–95.
9. Guo, Q.; Chen, L.; Zhao, H.; Admilson, J.; Zhang, W. The Effect of Mixing and Curing Sea Water on Concrete Strength at Different Ages. *MATEC Web Conf.* **2018**, *142*, 02004, doi:10.1051/matecconf/201814202004.
10. ACI Committee 548 *Report on Polymer-Modified Concrete*; 2009;
11. Bothra, S.R.; Ghugal, Y.M. Polymer-Modified Concrete: Review. *Int. J. Res. Eng. Technol.* **2015**, *04*, 845–848, doi:10.15623/ijret.2015.0404146.
12. Hirde, S.K.; Dudhal, O.S. Review on Polymer Modified Concrete And Its Application To Concrete Structures. *Int. J. Eng. Res.* **2016**, *ISSN*, 766–769.

13. Alhazmi, H.; Shah, S.A.R.; Anwar, M.K.; Raza, A.; Ullah, M.K.; Iqbal, F. Utilization of Polymer Concrete Composites for a Circular Economy: A Comparative Review for Assessment of Recycling and Waste Utilization. *Polym. 2021, Vol. 13, Page 2135* **2021**, *13*, 2135, doi:10.3390/POLYM13132135.
14. Zhao, C.; Jia, X.; Yi, Z.; Li, H.; Peng, Y. Mechanical performance of single-graded copolymer-modified pervious concrete in a corrosive environment. *Materials (Basel).* **2021**, *14*, doi:10.3390/ma14237304.
15. Madhani. B; Palson. P Comparative Study of Corrosion Resistance of Polymer Modified Concrete and Concrete with Corrosion Inhibiting Agent. *Int. J. Eng. Res.* **2016**, *V5*, 314–319, doi:10.17577/ijertv5is050403.
16. Seyed Farhad Nabavi, B. Performance of Polymer-Concrete Composites in Service Life of Maritime Structures, University of Technology, Sydney, 2014.
17. Binti Noruzman, A.H. Performance of Polymer Modified Concrete Incorporating Polyvinyl Acetate Waste, Universiti Teknologi Malaysia, 2019.
18. Wang, K.; Liu, Z.; Wang, Z.; Yang, W. Study on polymer modified cement-based coating with healing effect on rusty carbon steel. *Int. J. Corros.* **2014**, *2014*, doi:10.1155/2014/628191.
19. Kantharia, M.; Mishra, P.K.; Trivedi, M.K.; Gogoi, R. Effect of chemical exposure on mechanical strength of polymer mortar. *Int. J. Recent Technol. Eng.* **2019**, *7*, 944–948.
20. Susilorini, R.M.I.R.; Rejeki, V.G.S.; Santosa, B.; Caresta, F.D.; Putro, M.S. Polymer modified mortar with bonding adhesive agent for column repairing in tidal flooding prone area. *AIP Conf. Proc.* **2018**, *1977*, doi:10.1063/1.5042969.
21. Retno Susilorini, M.I.; William, S.S.; Rianto; Kartikowati, S.; Setiawan, M.H.; Ludfie Hardian, P.; Kurniawan, E. Masonry Walls Retrofitting with Eco-Concrete Bricks in Tidal Flooding Prone Area. *Int. J. Eng. Res. Technol.* **2020**, *13*, 560–569.
22. Retno Susilorini, M.I.; Suryanto, R.; Pramana, Y. Carbohydrate polymers for green multi-purpose mortar. *Int. J. Eng. Res. Technol.* **2020**, *13*, 580–585.
23. Susilorini, R.M.I.R.; Suwarno, D.; Santosa, B.; Putra, L.H.; Kurniawan, E. Rebound Hammer Test result of old repaired masonry wall using premixed mortar additive in tidal flooding prone area. *AIP Conf. Proc.* **2018**, *1977*, 1–6, doi:10.1063/1.5042982.
24. Susilorini, R.M.I.R.; Santosa, B.; Rejeki, V.G.S.; Riangsari, M.F.D.; Hananta, Y.D. The increase of compressive strength of natural polymer modified concrete with Moringa oleifera.; 2017.
25. BSN SNI 03-2834-2000 - Tata Cara Pembuatan Rencana Campuran Beton Normal (Method for Normal Concrete Mix-Design) 2000.
26. Susilorini, R.M.I.R.; Hardjasaputra, H.; Sri, T.; Galih, H.; Reksa, W.S.; Ginanjar, H.; Joko, S. The advantage of natural polymer modified mortar with seaweed: Green construction material innovation for sustainable concrete. *Procedia Eng.* **2014**, *95*, 419–425, doi:10.1016/j.proeng.2014.12.201.
27. Barros, F.C.N.; Da Silva, D.C.; Sombra, V.G.; MacIel, J.S.; Feitosa, J.P.A.; Freitas, A.L.P.; De Paula, R.C.M. Structural characterization of polysaccharide obtained from red seaweed Gracilaria caudata (J Agardh). *Carbohydr. Polym.* **2013**, *92*, 598–603, doi:10.1016/j.carbpol.2012.09.009.
28. Susilorini, R.M.I.R.; Santosa, B.; Rejeki, V.G.S.; Riangsari, M.F.D.; Hananta, Y.D. The increase of compressive strength of natural polymer modified concrete with Moringa oleifera. In Proceedings of the AIP Conference Proceedings; 2017; Vol. 1818.
29. Bain L., M.K. Properties of Litharge and Glycerine Mortars, Oregon State Agricultural College, 1933.
30. Farobie, O.; Achmadi, S.S.; Darusman, L.K. Utilization of Glycerol Derived from Jatropha ' s Biodiesel Production as a Cement Grinding Aid. *World Acad. Sci. Eng. Technol.* **2012**, *6*, 793–798.

31. Rr. M. I. Retno Susilorini, Budi Santosa, N. Febri Satrio, R.P.B. Compressive and Splitting Tensile Strength of Polymer Modified Concrete Using Amylum and Honey. *J. Eng. Appl. Sci.* **2018**, *13*, 7192–7197, doi:http://dx.doi.org/10.3923/jeasci.2018.7192.7197.
32. Susilorini, R.M.I.R.; Sri Rejeki, V.; Santosa, B.; Haryanto, A.T.; Pangestu, F. Increasing Compressive Strengh of Natural Polymer Modified Mortar with Honey and. In Proceedings of the International Conference on Concrete and Infrastructure; 2015; pp. 20–24.
33. Ball, D.W. The Chemical Composition of Honey. *J. Chem. Educ.* **2007**, *84*, 1643, doi:10.1021/ed084p1643.
34. ASTM International ASTM C 42/C 42M – 04 - Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete 2004.
35. BSN SNI 03-2492-2002 - Metode pengambilan dan pengujian beton inti (Method for Obtaining and Testing Drilled Cores) 2002.

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Title: Long-term Durability of Bio-Polymer Modified Concrete in Tidal Flooding Prone Area: A Challenge of Sustainable Concrete Materials

I. **Comments**:

- Title: Flooding area should be replaced by flood area (Check everywhere)
- Abstract: Repetition of "Gracilaria Sp., Moringa oleifera, and honey" should be avoided (Refer the abstract this is repeated three times).
- Abstract: Line 17: Why is it used 'or'? It should be 'and'. Use of 'or' does not have meaning here. Check the same in page 2; line 55 also.
- Key words: Tidal flood sustainable is not a proper keyword and should be revised.
- Page 2; line 50: Though reference numbers are given as "According to [11,12]" it is necessary to mention authors like 'According to Bothra et al. and Hirde et al. [11,12]' ---.
- Page 2; line 52 and 53: Follow first expansion and then abbreviations (example: Silica fume (SF); Rice husk ash (RHA)).
- Page 2; line 54: Remove i.e. before [14-19].
- Page 2; line 69: Sub sectional number can be given as 2.1 instead of bulletin point. (the same way for other bullet points also)
- Table 1: Title caption is not clear; Number column is not necessary since only three items; why K1 and K3 what happened to K2? Why is the letter K chosen, does it have any meaning? Similarly why M I and M III what happened to M II? Control column should be placed as the first one (always control specimens should come at first). First letter should be started with upper case (refer the status column).
- Mix I and Mix III proportion details are not found in this section 2.
- Figure 1: Caption given should be very short and sweet and not as a sentence.
- Page 2; line 77: Mentioned Table 2 but it was not found anywhere.
- Figure and Tables are to be presented in the order of sequences. Example: Figure 2 should come after Figure 1 not as Figure 5. Necessary change of positions and numbers to be reordered for both Figures and Tables. That too once citation statements are introduced then Tables and Figures should be available in the immediate vicinity of the citations.
- Section 2: Materials and methods: No materials and their properties are given.
- Standards referred are not included in the list of references.
- Figure 2: It does not have any uniqueness.
- Figure 3: It shows only a schematic representation (no dimensions are for the divided zones are given). The same should be marked on the real element and should be presented aside of the schematic diagram.
- Figure 3: Title caption should be shortened.
- Table 3 and 4: Title caption should be shortened.
- Table 4: Notations used are not explained.
- Page 5: Line 115 & 116: compressive strength was obtained using the Core Drill method. Core drilling is not a method, it is a technique to get the sample to test for.
- Figure 4: Title caption should be shortened (remove the name of equipment – already stated in the text).

- Figure 4: Equipment is dominated in the photo and hence it should be replaced significantly to show core cutting.
- Why was core cutting done only to column K3 at 14 months?
- Figure 5: Instead of giving a schematic diagram and location A, B, and C (it is not in a impressive way), it can be given in the form of a statement with the dimension for positioning to take the core cutting.
- Page 5: Line 123: used the ASTM code to test. What is that ASTM code and its reference?
- This is in addition to the use of Computer Control Servo Hydraulic Concrete Compression Testing Machine and Hung-Ta serial HT 8391PC to obtain compressive strength of concrete cylinder as shown in Figure 6. This sentence should be restructured.
- No uniformity is maintained to indicate the compressive strength (kg/cm^2 or MPa). Why is the MKS system? The SI system of the unit should be followed.
- Page 6: Line 134: Superscript is not followed for mm2; it should be mm^2.
- Figure 6: Caption should not be only with the name of the equipment which is already given in the text. Specific focus should be on what is significant from the Figure.
- There should be one or two sentences between the sectional numbers. (Example: Section 3 and Section 3.1
- Figure 7: (a) and (b) before and after does not have any innovation.
- Selected columns for retrofitting seem to be very ordinary element that supports tiled roofs.
- Section 3.1: First paragraph is not the results of this study and it is only a seasonal progressive failure.
- Section 3.1: Second paragraph is also not the results of this study and it is only a retrofitting process.
- Figure 8: (a) contains 6 photographs but no proper citations are given. The same way for Figure 9 as well.
- Page 7: Line 170-172: This is only a basic and hence not necessary. However, what is that split? Once again Table 2 is mentioned but not found. What is that conducting steel reinforcement?
- Generally the rebound hammer test gives an approximate quality only. Therefore conduct of rebound hammer tests and their results alone not good enough to decide that too in a marine environment. Permeability tests should be conducted in these cases.
- Page 9: Line 191: 18.63 MPa is not matched properly in Figure 14. Also since the statement is given already Figure 14 (It is a very simple graphical representation) is not necessary.
- Section 4: Discussion: First two paragraphs discussed on the others' works. When the heading is given as discussion authors should discuss their research results only. It is lacking here in these two paragraphs. These discussions should have been included in the introduction part only.
- Section 4: Third and fourth graphs talked about durability without any sound technical results from this research. The same in the conclusion section also.
- More self-citations are found.
- Testing only rebound hammer test and compressive strength tests on core cutting specimens after 14 months alone cannot be considered long term durability.

II. English Language:

- Language used in the manuscript was not in the expected level of standard. Throughout the manuscript language corrections are to be done with the help of native speakers.

  Here few Examples given for reference:

  Section 1: Line 58: This research aims to and ~~implement~~ implemented in the column retrofitting in tidal ~~flooding~~ flood areas with bio-polymer modified concrete using Gracilaria Sp., Moringa oleifera, and honey.

  Section 1: Line 63: performance and long-term durability.

  Section 2: Line 65: This research was conducted ~~by~~ for field application as ~~by as well as~~ both non-destructive and destructive ~~tests in sites prone to tidal flooding~~.

  Page 2: Line 71: Each specimen identity was represented by one column

  Page 2: Line 75: product ~~sold~~ available in the open market ~~place~~

  Page 3: Line 90~~:~~ This stage was conducted on-site

  Page 4: Line 105: The Rebound Value was read by the equipment

  Page 5: Line 115 & 116: compressive strength was obtained using the Core Drill method / This technique was purposed to obtain.

  Page 5: Line 123: used the ASTM code to test

  Figure 13: The Rebound Hammer Test was column at conducted at the points that marked by red circles

  Figure 14: Compressive strength of old broken column that become baseline value

******

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Title	Long-term Durability of Bio-Polymer Modified Concrete in Tidal Flooding Prone Area: A Challenge of Sustainable Concrete Materials
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Sincerely,

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Type: Article

Title: Long-term Durability of Bio-Polymer Modified Concrete in Tidal Flooding Prone Area: A Challenge of Sustainable Concrete Materials

Authors: Rr. M. I. Retno Susilorini * , Iskhaq Iskandar , Budi Santosa

Abstract: The need for durable concrete in marine environments such as areas prone to tidal flooding is important due to its ability to deteriorate the structures. This led to the design of a durable and strong Polymer-Modified Concrete (PMC) using natural or bio-polymer modified concrete. However, the use of biopolymer-modified concrete is very limited. Therefore, this research developed a bio-polymer modified concrete using Gracilaria Sp., Moringa oleifera, and honey for column retrofitting. The research aimed to retrofit and improve the compressive strength and durability of broken columns submerged by tidal flooding by applying bio-polymer modified concrete with Gracilaria Sp., Moringa oleifera, and honey. A field application of column retrofitting was conducted in areas prone to tidal flooding. The retrofitted columns performance was observed for 14 months and validated by non-destructive and destructive tests. The result showed that the compressive strength of the retrofitted column achieved 32.37 MPa, which is a 92.34% increase compared to the baseline. This research provides answers to the challenge of concrete materials sustainability by promoting bio-polymer modified concrete that significantly increased its performance and long-term durability using Gracilaria Sp., Moringa oleifera, and honey.

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For empirical research, are the results clearly presented?	( )	( )	(x)	( )
Is the article adequately referenced?	( )	( )	(x)	( )
Are the conclusions thoroughly supported by the results presented in the article or referenced in secondary literature?	( )	( )	( )	( )

Comments and Suggestions for Authors

Authors' responses are not incorporated in the revised manuscript. However, the authors' responses are not convincing. Most of the responses are thrown just like that and have no ethics. For the information of the authors revised review is commented against each points given originally (Refer to the attachment)

peer-review-17117332.v1.doc (/user/review/displayFile/23450498/u6L1j039?file=review&report=17117332)

Submission Date 21 December 2021

Date of this review 16 Jan 2022 17:33:47

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Journal Sustainability (https://www.mdpi.com/journal/sustainability) (ISSN 2071-1050)
Manuscript ID sustainability-1541735
Type Article

Title Long-term Durability of Bio-Polymer Modified Concrete in Tidal Flooding Prone Area: A Challenge of Sustainable Concrete Materials

Authors Rr. M. I. Retno Susilorini * , Iskhaq Iskandar , Budi Santosa

Abstract The need for durable concrete in marine environments such as areas prone to tidal flooding is important due to its ability to deteriorate the structures. This led to the design of a durable and strong Polymer-Modified Concrete (PMC) using natural or bio-polymer modified concrete. However, the use of biopolymer-modified concrete is very limited. Therefore, this research developed a bio-polymer modified concrete using Gracilaria Sp., Moringa oleifera, and honey for column retrofitting. The research aimed to retrofit and improve the compressive strength and durability of broken columns submerged by tidal flooding by applying bio-polymer modified concrete with Gracilaria Sp., Moringa oleifera, and honey. A field application of column retrofitting was conducted in areas prone to tidal flooding. The retrofitted columns performance was observed for 14 months and validated by non-destructive and destructive tests. The result showed that the compressive strength of the retrofitted column achieved 32.37 MPa, which is a 92.34% increase compared to the baseline. This research provides answers to the challenge of concrete materials sustainability by promoting bio-polymer modified concrete that significantly increased its performance and long-term durability using Gracilaria Sp., Moringa oleifera, and honey.

Author's Reply to the Review Report (Reviewer 3)

Please provide a point-by-point response to the reviewer’s comments and either enter it in the box below or upload it as a Word/PDF file. Please write down "Please see the attachment." in the box if you only upload an attachment. An example can be found here (/bundles/mdpisusy/attachments/Author/Example for author to respond reviewer - MDPI.docx?1e53c61ae425d6e8).

* Author's Notes to Reviewer

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Paragraph

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English language and style
( ) Extensive editing of English language and style required
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	Yes	Can be improved	Must be improved	Not applicable
Is the content succinctly described and contextualized with respect to previous and present theoretical background and empirical research (if applicable) on the topic?	( )	(x)	( )	( )
Are the research design, questions, hypotheses and methods clearly stated?	( )	( )	(x)	( )
Are the arguments and discussion of findings coherent, balanced and compelling?	( )	(x)	( )	( )
For empirical research, are the results clearly presented?	( )	( )	(x)	( )
Is the article adequately referenced?	( )	(x)	( )	( )
Are the conclusions thoroughly supported by the results presented in the article or referenced in secondary literature?	( )	( )	( )	( )

Comments and Suggestions for Authors

I understand that the aim of this article is applying bio-polymer modified concrete with Gracilaria Sp., Moringa oleifera, and honey but these words, only in the abstract, are repeated 3 times (Lines 19, 22, 28). The same is repeated below in the text. It doesn't fit the scientific style of the article. I recommend using synonyms or abbreviations.

Response: The revision has been made for Abstract, included the words of Gracilaria Sp., Moringa oleifera, and honey.

Revision of the whole text is necessary e.g. On page 14, the text *Gracilaria Sp., Moringa oleifera, and honey.* **was used 5 times**

Figure 4: The Core Drill method. Not informative. It's just a tool.

Figure 4: Not informative

Response: The caption of Figure 4 has been revised. The explanation written in the paragraph.

In my opinion, the photos in the worktools are not suitable for scientific text

All References are styled in different styles.

Response: The reference style is conducted automatically by system of Reference Manager of Mendeley for Sustainability-MDPI.

The Mendeley tool is not working properly e.g.

1. Akshat Dimri; Jay Kr. Varshney; V. K. Verma; Sandeep Gupta A Review on Strength of Concrete in Seawater. 297 *Int. J. Eng. Res.* **2015**, *V4*, 844–847, doi:10.17577/ijertv4is030890. 298
2. Chandrasekaran, S.; Jain, A. *Materials for Ocean Structures*; 2016; ISBN 9781315366692.

References must be handled manually

Submission Date 21 December 2021

Date of this review 10 Jan 2022 12:54:36

View PDF (chrome-extension://dagcmkpagjlhakfdhnbomgmjdpkdklff/enhanced-reader.html?openApp&pdf=https%3A%2F%2Fwww.ijert.org%2Fresearch%2Fa-review-on-strength-of-concrete-in-seawater-IJERTV4IS030890.pdf)

Response to Reviewer 2 Comments
(Round 2)

We appreciate and thank to the comments and advises of the Reviewer 2. In spite of the revision and or response we made based on the Reviewer 2's comments in Round 1 and Round 2, there are some comments from our side which will be explained as follow.

Authors' responses are not incorporated in the revised manuscript. However, the authors' responses are not convincing. Most of the responses are thrown just like that and have no ethics. For the information of the authors revised review is commented against each points given originally (Refer to the attachment)

Response:

1. We strongly emphasize that we, as academician, have made revision, response, and also comments with full ethical manner without anger and unnecessary accusations. Hence, we also expect that the review process also implemented in full ethical manner from both sides, authors and also Reviewers which is called mutual understanding in polite discussion and we believe it definitely also expected by the Editorial Office.
2. We have made substantial revision on our manuscript that were submitted as the revised version of manuscript for Round 1 which fulfilled the requests of Reviewer 2 in Round 1. Reviewer 2 may carefully see and compare the original manuscript and the revised version of manuscript for Round 1 to see before and after Round 1 Review.
3. In the attachment of Reviewer's comments in Round 2 (it is comments for revised manuscript for Round 1), there are 43 items of requests and one part about English Language. For all 43 items, we have already responded and revised some of them and also sustained some parts with clear argument and discussion in the revised manuscript for Round 1, which were presented with full ethical manner. We expect that Reviewer 2 can carefully checked the original manuscript and the revised version of manuscript for Round 1, because 35 items have not been accepted by Reviewer 2. The 35 items have already responded and some of them have been revised but it have been commented by Reviewer 2 as not responded or responded but not corrected as per the response. For English editing, we also have explained in the revised manuscript for Round 1.
4. We remain our response to Reviewer 2's comments in Round 2 as the same as the revised manuscript for Round 1. Some of them have been revised already, but some of them we sustained with explanations and arguments.

Response to Reviewer 3 Comments (Round 2)

We appreciate and thank to the constructive comments and advises of the Reviewer 3 for Round 2. The manuscript has been already revised as the Reviewer's requests which will be explained as follow.

I understand that the aim of this article is applying bio-polymer modified concrete with Gracilaria Sp., Moringa oleifera, and honey but these words, only in the abstract, are repeated 3 times (Lines 19, 22, 28). The same is repeated below in the text. It doesn't fit the scientific style of the article. I recommend using synonyms or abbreviations.
Response (Round 1): The revision has been made for Abstract, included the words of Gracilaria Sp., Moringa oleifera, and honey.
Revision of the whole text is necessary e.g. On page 14, the text Gracilaria Sp., Moringa oleifera, and honey. was used 5 times

Response: The revision has been made for the words "Gracilaria Sp., Moringa oleifera, and honey" that shortened to be "GMH"

Figure 4: The Core Drill method. Not informative. It's just a tool.
Figure 4: Not informative
Response (Round 1): The caption of Figure 4 has been revised. The explanation written in the paragraph.
In my opinion, the photos in the worktools are not suitable for scientific text

Response: Figure 4 has been deleted. Hence, all the figures were reordered.

Figures 8-12 Not informative, and it is not clear what the authors wanted to show them.

Response: Since this research was conducted also by field application that made retrofitting of real column s in site, it is necessary to give real description of situation during the work that it must be very different to any research that had been done only in laboratory. Figure 8-12 had been already give clear information about the procedure of field application in this research. Figure 8-12 has reorder to Figure 7-11.

All References are styled in different styles.
Response (Round 1): The reference style is conducted automatically by system of Reference Manager of Mendeley for Sustainability-MDPI.
The Mendeley tool is not working properly e.g.
1. Akshat Dimri; Jay Kr. Varshney; V. K. Verma; Sandeep Gupta A Review on Strength of Concrete in Seawater. 297 Int. J. Eng. Res. 2015, V4, 844–847, doi:10.17577/ijertv4is030890. 298
2. Chandrasekaran, S.; Jain, A. Materials for Ocean Structures; 2016; ISBN 9781315366692.
References must be handled manually

Response: All the item in References have been checked and some of them have been revised to meet the requirement of Sustainability-Template.

Ms. Ref. No: sustainability - 1541735

Title: Long-term Durability of Bio-Polymer Modified Concrete in Tidal Flooding Prone Area: A Challenge of Sustainable Concrete Materials

Sustainability - MDPI

I. **Comments**:

1. Title: Flooding area should be replaced by flood area (Check everywhere)
2. Abstract: Repetition of "Gracilaria Sp., Moringa oleifera, and honey" should be avoided (Refer the abstract this is repeated three times).
3. Abstract: Line 17: Why is it used 'or'? It should be 'and'. Use of 'or' does not have meaning here. Check the same in page 2; line 55 also.
4. Key words: Tidal flood sustainable is not a proper keyword and should be revised.
5. Page 2; line 50: Though reference numbers are given as "According to [11,12]" it is necessary to mention authors like 'According to Bothra et al. and Hirde et al. [11,12]' ---.
6. Page 2; line 52 and 53: Follow first expansion and then abbreviations (example: Silica fume (SF); Rice husk ash (RHA)).
7. Page 2; line 54: Remove i.e. before [14-19].
8. Page 2; line 69: Sub sectional number can be given as 2.1 instead of bulletin point. (the same way for other bullet points also)
9. Table 1: Title caption is not clear; Number column is not necessary since only three items; why K1 and K3 what happened to K2? Why is the letter K chosen, does it have any meaning? Similarly why M I and M III what happened to M II? Control column should be placed as the first one (always control specimens should come at first). First letter should be started with upper case (refer the status column).
10. Mix I and Mix III proportion details are not found in this section 2.
11. Figure 1: Caption given should be very short and sweet and not as a sentence.
12. Page 2; line 77: Mentioned Table 2 but it was not found anywhere.
13. Figure and Tables are to be presented in the order of sequences. Example: Figure 2 should come after Figure 1 not as Figure 5. Necessary change of positions and numbers to be reordered for both Figures and Tables. That too once citation statements are introduced then Tables and Figures should be available in the immediate vicinity of the citations.
14. Section 2: Materials and methods: No materials and their properties are given.
15. Standards referred are not included in the list of references.
16. Figure 2: It does not have any uniqueness.
17. Figure 3: It shows only a schematic representation (no dimensions are for the divided zones are given). The same should be marked on the real element and should be presented aside of the schematic diagram.
18. Figure 3: Title caption should be shortened.
19. Table 3 and 4: Title caption should be shortened.
20. Table 4: Notations used are not explained.
21. Page 5: Line 115 & 116: compressive strength was obtained using the Core Drill method. Core drilling is not a method, it is a technique to get the sample to test for.
22. Figure 4: Title caption should be shortened (remove the name of equipment – already stated in the text).

Commented [A1]: Responded and accepted

Commented [A2]: Responses are accepted

Commented [A3]: Responded but not corrected as p ... [1]

Commented [A4R3]: The sentence has been alread ... [2]

Commented [A5]: Responded but not corrected as p ... [3]

Commented [A6R5]: The sentence has been alread ... [4]

Commented [A7]: Responded but not corrected as p ... [5]

Commented [A8R7]: The sentence has been alread ... [6]

Commented [A9]: Responded but not corrected as p ... [7]

Commented [A10R9]: The sentence has been alrea ... [8]

Commented [A11]: Responded but not corrected as ... [9]

Commented [A12R11]: The sentence has been al ... [10]

Commented [A13]: Responded but not corrected a ... [11]

Commented [A14R13]: The bullets have been re ... [12]

Commented [A15]: Responded and accepted

Commented [A16]: Not responded

Commented [A17R16]: The current mix-compos ... [13]

Commented [A18]: Not responded

Commented [A19]: Responded but not corrected a ... [14]

Commented [A20R19]: The paragraph after the ... [15]

Commented [A21]: Responded but not corrected a ... [16]

Commented [A22R21]: Table 2 has been revised ... [17]

Commented [A23]: Responded but not corrected a ... [18]

Commented [A24R23]: The Figures order have b ... [19]

Commented [A25]: Responded but not corrected a ... [20]

Commented [A26R25]: The materials has been ... [21]

Commented [A27]: Responded but not corrected a ... [22]

Commented [A28R27]: The standards have been ... [23]

Commented [A29]: Not responded

Commented [A30R29]: Figure 2 described about ... [24]

Commented [A31]: Responded but not corrected a ... [25]

Commented [A32R31]: Figure 3 has been revised ... [26]

Commented [A33]: Responded but not corrected a ... [27]

Commented [A34R33]: The title caption of Figur ... [28]

Commented [A35]: Responded but not corrected a ... [29]

Commented [A36R35]: Table 3 and 4 have been ... [30]

Commented [A37]: Responded but not corrected a ... [31]

Commented [A38R37]: Notation in Table 4 have ... [32]

Commented [A39]: Responded but not corrected a ... [33]

Commented [A40]: Responded and accepted

23. Figure 4: Equipment is dominated in the photo and hence it should be replaced significantly to show core cutting.
24. Why was core cutting done only to column K3 at 14 months?
25. Figure 5: Instead of giving a schematic diagram and location A, B, and C (it is not in a impressive way), it can be given in the form of a statement with the dimension for positioning to take the core cutting.
26. Page 5: Line 123: used the ASTM code to test. What is that ASTM code and its reference?
27. This is in addition to the use of Computer Control Servo Hydraulic Concrete Compression Testing Machine and Hung-Ta serial HT 8391PC to obtain compressive strength of concrete cylinder as shown in Figure 6. This sentence should be restructured.
28. No uniformity is maintained to indicate the compressive strength (kg/cm^2 or MPa). Why is the MKS system? The SI system of the unit should be followed.
29. Page 6: Line 134: Superscript is not followed for mm2; it should be mm^2.
30. Figure 6: Caption should not be only with the name of the equipment which is already given in the text. Specific focus should be on what is significant from the Figure.
31. There should be one or two sentences between the sectional numbers. (Example: Section 3 and Section 3.1
32. Figure 7: (a) and (b) before and after does not have any innovation.
33. Selected columns for retrofitting seem to be very ordinary element that supports tiled roofs.
34. Section 3.1: First paragraph is not the results of this study and it is only a seasonal progressive failure.
35. Section 3.1: Second paragraph is also not the results of this study and it is only a retrofitting process.
36. Figure 8: (a) contains 6 photographs but no proper citations are given. The same way for Figure 9 as well.
37. Page 7: Line 170-172: This is only a basic and hence not necessary. However, what is that split? Once again Table 2 is mentioned but not found. What is that conducting steel reinforcement?
38. Generally the rebound hammer test gives an approximate quality only. Therefore conduct of rebound hammer tests and their results alone not good enough to decide that too in a marine environment. Permeability tests should be conducted in these cases.
39. Page 9: Line 191: 18.63 MPa is not matched properly in Figure 14. Also since the statement is given already Figure 14 (It is a very simple graphical representation) is not necessary.
40. Section 4: Discussion: First two paragraphs discussed on the others' works. When the heading is given as discussion authors should discuss their research results only. It is lacking here in these two paragraphs. These discussions should have been included in the introduction part only.
41. Section 4: Third and fourth graphs talked about durability without any sound technical results from this research. The same in the conclusion section also.
42. More self-citations are found.
43. Testing only rebound hammer test and compressive strength tests on core cutting specimens after 14 months alone cannot be considered long term durability.

Commented [A41]: Responded but it was not conv ... [34]
Commented [A42R41]: Figure 4 has been remov ... [35]
Commented [A43]: Responded but not corrected a ... [36]
Commented [A44R43]: This point has been revis ... [37]
Commented [A45]: Responded but not corrected a ... [38]
Commented [A46R45]: This point has been revis ... [39]
Commented [A47]: Responded but not corrected a ... [40]
Commented [A48R47]: The sentence has been re ... [41]
Commented [A49]: Responded but not corrected a ... [42]
Commented [A50R49]: The sentence has been re ... [43]
Commented [A51]: Responded but not corrected a ... [44]
Commented [A52R51]: There was uniform unit ... [45]
Commented [A53]: Not responded and not corrected
Commented [A54R53]: mm2 has been revised to ... [46]
Commented [A55]: Responded but not corrected a ... [47]
Commented [A56R55]: Figure 6 has been revise ... [48]
Commented [A57]: Responded but it was not conv ... [49]
Commented [A58R57]: Some Sections (Section 2 ... [50]
Commented [A59]: Responded but not corrected a ... [51]
Commented [A60R59]: The caption of Figure 7 ... [52]
Commented [A61]: Responded and accepted
Commented [A62]: Responded but the response se ... [53]
Commented [A63R62]: This points have been ... [54]
Commented [A64]: Responded but not corrected a ... [55]
Commented [A65R64]: These points have been ... [56]
Commented [A66]: Responded but not corrected a ... [57]
Commented [A67R66]: The paragraph has been ... [58]
Commented [A68]: Justification given for permeab ... [59]
Commented [A69R68]: The reason of not ... [60]
Commented [A70]: Not responded
Commented [A71R70]: This point has been resp ... [61]
Commented [A72]: Responded but not done as per ... [62]
Commented [A73R72]: This point has been revis ... [63]
Commented [A74]: Responded but the response se ... [64]
Commented [A75R74]: This points have been ... [65]
Commented [A76]: Responded and agreed.
Commented [A77]: Responded but it was not convincing.
Commented [A78R77]: As our response in Roun ... [66]

II. English Language:

- Language used in the manuscript was not in the expected level of standard. Throughout the manuscript language corrections are to be done with the help of native speakers.

Here few Examples given for reference:

Section 1: Line 58: This research aims to and ~~implement~~ implemented in the column retrofitting in tidal ~~flooding~~ flood areas with bio-polymer modified concrete using Gracilaria Sp., Moringa oleifera, and honey.

Section 1: Line 63: performance and long-term durability.

Section 2: Line 65: This research was conducted ~~by~~ for field application as ~~by as well as~~ both non-destructive and destructive ~~tests in sites prone to tidal flooding~~.

Page 2: Line 71: Each specimen identity was represented by one column

Page 2: Line 75: product ~~sold~~ available in the open market ~~place~~

Page 3: Line 90~~:~~ This stage was conducted on-site

Page 4: Line 105: The Rebound Value was read by the equipment

Page 5: Line 115 & 116: compressive strength was obtained using the Core Drill method / This technique was purposed to obtain.

Page 5: Line 123: used the ASTM code to test

Figure 13: The Rebound Hammer Test was column at conducted at the points that marked by red circles

Figure 14: Compressive strength of old broken column that become baseline value

******

Commented [A79]: Responded by the authors that this manuscript has been proofread by professional Native Proofread Agency, before submission and during the review. But the pointed out examples are not corrected for the language at least.

Commented [A80R79]: This manuscript has been proofread by professional Native Proofread Agency, before submission and during the review.

Page 1: [1] Commented **Admin** **1/16/2022 7:32:00 PM**

Responded but not corrected as per the response

Page 1: [2] Commented **Asus** **1/19/2022 11:55:00 AM**

The sentence has been already revised in Round 1 as per Reviewer's request by deleting words "natural or".

Page 1: [3] Commented **Admin** **1/16/2022 7:33:00 PM**

Responded but not corrected as per the response

Page 1: [4] Commented **Asus** **1/18/2022 8:23:00 AM**

The sentence has been already revised in Round 1 as per Reviewer's request by revising the keywords.

Page 1: [5] Commented **Admin** **1/16/2022 7:34:00 PM**

Responded but not corrected as per the response

Page 1: [6] Commented **Asus** **1/19/2022 12:01:00 PM**

The sentence has been already revised in Round 1 as per Reviewer's request by addition of words "Bohtra, et.al. and Hirde, et.al.".

Page 1: [7] Commented **Admin** **1/16/2022 7:35:00 PM**

Responded but not corrected as per the response

Page 1: [8] Commented **Asus** **1/19/2022 11:57:00 AM**

The sentence has been already revised in Round 1 as per Reviewer's request by changing the words to become "Silica Fume (SF), Rice Husk Ash (RHA)".

Page 1: [9] Commented **Admin** **1/16/2022 7:36:00 PM**

Responded but not corrected as per the response

Page 1: [10] Commented **Asus** **1/19/2022 12:03:00 PM**

The sentence has been already revised in Round 1 as per Reviewer's request by removing "i.e." and added the words "Zhao, et.al., Madhani, et.al., Seyed, et.al., Binti Noruman, et.al., Wang, et.al., and Kantharia, et.al"

Page 1: [11] Commented **Admin** **1/16/2022 7:36:00 PM**

Responded but not corrected as per the response

Page 1: [12] Commented **Asus** **1/21/2022 6:15:00 PM**

The bullets have been revised in Round 1 to sub-sections of 2.1., 2.2., and 2.3., but the section number have been revised back to the bullets by Editor in Round 2 as it is fully Editor's right due to the Template of this journal

Page 1: [13] Commented **Asus** **1/21/2022 6:20:00 PM**

The current mix-compositions were also only M1 and M3 that refer the mix-compositions of previous author's study that had optimum compressive strength. Due to consistency in coding the mix-composition, this research used the original mix-composition of previous study [1].

Page 1: [14] Commented **Admin** **1/16/2022 7:39:00 PM**

Responded but not corrected as per the response

Page 1: [15] Commented **Asus** **1/21/2022 6:22:00 PM**

The paragraph after the Table 3 has been explained the advantage of materials used in this research

Page 1: [16] Commented **Admin** **1/16/2022 7:42:00 PM**

Responded but not corrected as per the response

Page 1: [17] Commented **Asus** **1/21/2022 6:26:00 PM**

Table 2 has been revised and described and existed, as explained in Round 1

Page 1: [18] Commented **Admin** **1/16/2022 8:07:00 PM**

Responded but not corrected as per the response

Page 1: [19] Commented **Asus** **1/21/2022 6:40:00 PM**

The Figures order have been revised in Round 1 and the Tables are just placed in order.

Page 1: [20] Commented **Admin** **1/16/2022 8:08:00 PM**

Responded but not corrected as per the response

Page 1: [21] Commented **Asus** **1/21/2022 6:41:00 PM**

The materials has been described by Table 1 in Round 1 and the explanation of material's advantages has been added in paragraphs.

Page 1: [22] Commented **Admin** **1/16/2022 8:09:00 PM**

Responded but not corrected as per the response

Page 1: [23] Commented **Asus** **1/21/2022 6:35:00 PM**

The standards have been added to References in Round 1, but as Editor's consideration, the standards removed from References in Round 2

Page 1: [24] Commented **Asus** **1/21/2022 6:34:00 PM**

Figure 2 described about the physical performance of Rebound Hammer Test equipment and it doesn't mean to be have any uniqueness.

Page 1: [25] Commented **Admin** **1/16/2022 8:12:00 PM**

Responded but not corrected as per the response

Page 1: [26] Commented **Asus** **1/21/2022 7:03:00 PM**

Figure 3 has been revised as per Reviewer's request in Round 1

Page 1: [27] Commented **Admin** **1/16/2022 8:13:00 PM**

Responded but not corrected as per the response

Page 1: [28] Commented **Asus** **1/21/2022 7:03:00 PM**

The title caption of Figure 3 has been shortened in Round 1 as per Reviewer's request

Page 1: [29] Commented **Admin** **1/16/2022 8:14:00 PM**

Responded but not corrected as per the response

Page 1: [30] Commented **Asus** **1/21/2022 8:00:00 PM**

Table 3 and 4 have been shortened in Round 1 as per Reviewer's request

Page 1: [31] Commented	Admin	1/16/2022 8:16:00 PM

Responded but not corrected as per the response

Page 1: [32] Commented	Asus	1/21/2022 8:02:00 PM

Notation in Table 4 have been explained in Round 1.

Page 1: [33] Commented	Admin	1/16/2022 8:17:00 PM

Responded but not corrected as per the response

Page 2: [34] Commented	Admin	1/16/2022 8:21:00 PM

Responded but it was not convincing. Authors responded that the Figure 4 aimed to present the machine while the core cutting was presented already by Figure 19. In this case why authors have not given this for the previous comment. Also Figure 19 comes after some pages, but authors used the word 'already'.

Page 2: [35] Commented	Asus	1/21/2022 8:05:00 PM

Figure 4 has been removed in Round 2. The explanation related to Figure 19 has been revised, that it placed chronologically.

Page 2: [36] Commented	Admin	1/16/2022 8:26:00 PM

Responded but not corrected as per the response

Page 2: [37] Commented	Asus	1/21/2022 8:12:00 PM

This point has been revised as per Reviewer's request in Round 1 that an explanation has been added, "The Core Drill method was applied only to columns K3 at 14 months since K1 had broken because of the high tide disaster attack and it was impossible to core drill the K1".

Page 2: [38] Commented	Admin	1/16/2022 8:28:00 PM

Responded but not corrected as per the response

Page 2: [39] Commented	Asus	1/21/2022 8:13:00 PM

This point has been revised as per Reviewer's request in Round 1. Figure 5 has been revised and an explanation of the procedure of core drill has already existed in the initial of paragraph of sub-section 2.3.

Figure 5 has been reordered to Figure 4.

Page 2: [40] Commented	Admin	1/16/2022 8:29:00 PM

Responded but not corrected as per the response

Page 2: [41] Commented	Asus	1/21/2022 8:14:00 PM

The sentence has been revised in Round 1 as per Reviewer's request to become "The drilled concrete cylinder with a diameter and height of 70 mm and 140 mm being tested for compressive strength which followed the ASTM C 42/C 42M – 04 Standard test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete to test for compressive strength".

Page 2: [42] Commented	Admin	1/16/2022 8:29:00 PM

Responded but not corrected as per the response

Page 2: [43] Commented	Asus	1/21/2022 8:16:00 PM

The sentence has been revised as per Reviewer's request in Round 1 to become "A Computer Control Servo Hydraulic Concrete Compression Testing Machine and Hung-Ta serial HT 8391PC used to obtain compressive strength of concrete cylinder as shown in Figure 6".

Page 2: [44] Commented	Admin	1/16/2022 8:32:00 PM

Responded but not corrected as per the response (See Table 4 caption)

Page 2: [45] Commented	Asus	1/21/2022 8:18:00 PM

There was uniform unit of SI System for compressive strength, **MPa**, which had been clearly stated in the whole manuscript (see Section 3, 4, and 4; Figure 14-18, 21-23). Table 4 performed original list of conversion from "Manual Book Hammer Test Matest 2H1Q17". In calculation, it should be converted to MPa.

Page 2: [46] Commented	Asus	1/21/2022 8:26:00 PM

mm2 has been revised to become mm^2

Page 2: [47] Commented	Admin	1/16/2022 8:35:00 PM

Responded but not corrected as per the response

Page 2: [48] Commented	Asus	1/21/2022 8:28:00 PM

Figure 6 has been revised in Round 1 as per Reviewer's request

Page 2: [49] Commented	Admin	1/16/2022 8:36:00 PM

Responded but it was not convincing. Authors do not understand what is asked? They responded just like that.

Page 2: [50] Commented	Asus	1/21/2022 8:30:00 PM

Some Sections (Section 2 and 3) have been divided into sub-sections depended on the need of the Sections. Following the template of this journal it didn't have to write sentences between subsections.

Page 2: [51] Commented	Admin	1/16/2022 8:38:00 PM

Responded but not corrected as per the response

Page 2: [52] Commented	Asus	1/21/2022 8:34:00 PM

The caption of Figure 7 didn't mean to perform innovation but the progress of column's deterioration. Hence, the caption of Figure 7 (that reordered to be Figure 6) has been revised to be clearer as "The broken columns at situation of (a) The initial work when the two broken columns still existed, and (b) The next few months after initial work when the half part of left column had been collapsed".

Page 2: [53] Commented	Admin	1/16/2022 8:43:00 PM

Responded but the response seems to be harsh and no ethics are found in the authors response.

Page 2: [54] Commented	Asus	1/21/2022 8:36:00 PM

This points have been responded by no harsh but with full ethical manner in Round 1. As explained in the initial of Section 2, "This research was conducted by field application as well as non-destructive and destructive tests in sites prone to tidal flooding". Hence, the first and second paragraphs are the result of "2.1. On-site column retrofitting and control column construction", which were field activities.

Page 2: [55] Commented **Admin** **1/16/2022 9:02:00 PM**

Responded but not corrected as per the response

Page 2: [56] Commented **Asus** **1/21/2022 8:39:00 PM**

These points have been responded as per Reviewer's request in Round 1.

Response to Figure 8: Figure 8 had already been cited properly in the paragraph of "Figure 8-(a) shows that the first step in column retrofitting is conducted by peeling the cover of old concrete and unnecessary debris and applying the formwork of 1 m from the base floor. The next step of the activities was grouting the column with bio-polymer modified concrete consisting of Gracilaria, Sp., Moringa oleifera, and honey. After the retrofitted column stiffness increased, it was wrapped by jute sack, and curing was applied for about a week by watering it as shown in Figure 8-(b)".

Response to Figure 9: Figure 9 also had been cited properly in the paragraph of "Figure 9 shows a control column constructed in conjunction with columns retrofitting. The procedure included: mixing the concrete materials consisting of cement, split, sand, and water referred to Mix Normal as shown in Table 3. The steel reinforcement placed in the formwork and the concrete mix was poured into the formwork. After the column hardened, the curing was conducted. When the concrete was tough enough, the formwork was opened".

Figure 8 has been reordered to Figure 7.

Figure 9 has been reordered to Figure 8.

Page 2: [57] Commented **Admin** **1/16/2022 9:05:00 PM**

Responded but not corrected as per the response

Page 2: [58] Commented **Asus** **1/21/2022 8:42:00 PM**

The paragraph has been revised to be clearer.

"The procedure included: mixing the concrete materials consisting of cement, split (crushed stone), sand, and water referred to Mix Normal as shown in Table 2. After those works, the steel reinforcement installed inside the framework. Whenever the column hardened in about 48 hours, the curing implemented to column by watering them for about 7 days".

Table 2 had been performed.

Page 2: [59] Commented **Admin** **1/16/2022 9:06:00 PM**

Justification given for permeability tests is not acceptable

Page 2: [60] Commented **Asus** **1/21/2022 8:51:00 PM**

The reason of not implementing on-site permeability has been stated in Round 1. It can also be noted that in Indonesia, there is National Standard for on-site permeability test as well as the reference code, ASTM.

Page 2: [61] Commented **Asus** **1/21/2022 8:55:00 PM**

This point has been responded in Round 1 and the order of compressive strength which is an explanation of Figure 14 has been revised.

Page 2: [62] Commented **Admin** **1/16/2022 9:09:00 PM**

Responded but not done as per the response

Page 2: [63] Commented	Asus	1/21/2022 8:56:00 PM

This point has been revised as per Reviewer's request in Round 1 that the paragraphs have been moved to Section 1 (Introduction).

Page 2: [64] Commented	Admin	1/16/2022 9:12:00 PM

Responded but the response seems to be thrown on the face of the reviewer just like that and no ethics are found in the authors response. The details given in the responses were gone through by the reviewer without going through them this comment was not given earlier.

Page 2: [65] Commented	Asus	1/21/2022 8:57:00 PM

This points have been responded and revise as per Reviewer's request with strong argument dan obvious explanation in Round 1, which were deliver with full ethical manner. There had been already clear explanation of technical results of the research.

Page 2: [66] Commented	Asus	1/21/2022 9:00:00 PM

As our response in Round 1, there are several studies of long-term durability of concrete in sea water had been conducted by parameter of compressive strength as reported by [3–6]. As mentioned above, the Rebound Hammer test and compressive strength tests of core drilled specimens are reliable approach to evaluate the existing concrete element in field.

BUKTI KORESPONDENSI
REVIEW ROUND 3

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Manuscript Information Overview

Manuscript ID	**sustainability-1541735**
Status	English correction done
Acceptance Certificate	Download Acceptance Certificate (PDF) (/acceptance/certificate/displayFile/5121375a91ba46f317b40f1867f75701)
Article type	Article
Title	Long-term Durability of Bio-Polymer Modified Concrete in Tidal Flooding Prone Area: A Challenge of Sustainable Concrete Materials
Journal	*Sustainability* (https://www.mdpi.com/journal/sustainability)
Abstract	The need for durable concrete in marine environments such as areas prone to tidal flooding is important due to its ability to deteriorate the structures. This led to the design of a durable and strong Polymer-Modified Concrete (PMC) using natural or bio-polymer modified concrete. However, the use of biopolymer-modified concrete is very limited. Therefore, this research developed a bio-polymer modified concrete using Gracilaria Sp., Moringa oleifera, and honey for column retrofitting. The research aimed to retrofit and improve the compressive strength and durability of broken columns submerged by tidal flooding by applying bio-polymer modified concrete with Gracilaria Sp., Moringa oleifera, and honey. A field application of column retrofitting was conducted in areas prone to tidal flooding. The retrofitted columns performance was observed for 14 months and validated by non-destructive and destructive tests. The result showed that the compressive strength of the retrofitted column achieved 32.37 MPa, which is a 92.34% increase compared to the baseline. This research provides answers to the challenge of concrete materials sustainability by promoting bio-polymer modified concrete that significantly increased its performance and long-term durability using Gracilaria Sp., Moringa oleifera, and honey.
Keywords	durability; bio-polymer; concrete; tidal flooding sustainable.
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Editor Decision

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Comments	Extensive editing of English language and style required
Decision Date	24 January 2022

Review Report

Reviewer 1	Review Report (Round 1) (/user/manuscripts/review/23444067?report=16713168)
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Title: Long-term Durability of Bio-Polymer Modified Concrete in Tidal Flooding Prone Area: A Challenge of Sustainable Concrete Materials

Authors: Rr. M. I. Retno Susilorini * , Iskhaq Iskandar , Budi Santosa

Abstract: The need for durable concrete in marine environments such as areas prone to tidal flooding is important due to its ability to deteriorate the structures. This led to the design of a durable and strong Polymer-Modified Concrete (PMC) using natural or bio-polymer modified concrete. However, the use of biopolymer-modified concrete is very limited. Therefore, this research developed a bio-polymer modified concrete using Gracilaria Sp., Moringa oleifera, and honey for column retrofitting. The research aimed to retrofit and improve the compressive strength and durability of broken columns submerged by tidal flooding by applying bio-polymer modified concrete with Gracilaria Sp., Moringa oleifera, and honey. A field application of column retrofitting was conducted in areas prone to tidal flooding. The retrofitted columns performance was observed for 14 months and validated by non-destructive and destructive tests. The result showed that the compressive strength of the retrofitted column achieved 32.37 MPa, which is a 92.34% increase compared to the baseline. This research provides answers to the challenge of concrete materials sustainability by promoting bio-polymer modified concrete that significantly increased its performance and long-term durability using Gracilaria Sp., Moringa oleifera, and honey.

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I agree with the authors' responses on the ethics of authors, reviewers and editors. However, I still found some of the responses were not responded to and I could not find the right responses. But as authors speak justifications that those comments are done already. One simple example, I asked to change the bulletin points to give the sub-sectional numbers but it was not given now also. Authors mentioned that the revised manuscript should compare with the original manuscript. For the information to authors, we are also academicians and as a reviewer we used to compare the comments given and responses by comparing the original and the revised manuscript. But when the contraction takes place every time we get frustrated and it is not possible to compare all the revised versions. Therefore, due to respect to the author's justifications we assuming that all the original comments are properly addressed in the revised manuscript.

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Long-term Durability of Bio-Polymer Modified Concrete in Tidal Flooding Prone Area: A Challenge of Sustainable Concrete Materials

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Abstract: The need for durable concrete in marine environments such as areas prone to tidal flooding is important due to its ability to deteriorate the structures. This led to the design of a durable and strong Polymer-Modified Concrete (PMC) using natural or bio-polymer modified concrete. However, the use of biopolymer-modified concrete is very limited. Therefore, this research developed a bio-polymer modified concrete using *Gracilaria Sp*., *Moringa oleifera*, and honey for column retrofitting. The research aimed to retrofit and improve the compressive strength and durability of broken columns submerged by tidal flooding by applying bio-polymer modified concrete with *Gracilaria Sp*., *Moringa oleifera*, and honey. A field application of column retrofitting was conducted in areas prone to tidal flooding. The retrofitted columns performance was observed for 14 months and validated by non-destructive and destructive tests. The result showed that the compressive strength of the retrofitted column achieved 32.37 MPa, which is a 92.34% increase compared to the baseline. This research provides answers to the challenge of concrete materials sustainability by promoting bio-polymer modified concrete that significantly increased its performance and long-term durability using *Gracilaria Sp*., *Moringa oleifera*, and honey.

Keywords: durability; bio-polymer; concrete; tidal flooding sustainable.

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1. Introduction

The deterioration of concrete structures caused by tidal flooding is one of the major causes of coastal infrastructure damage. Therefore, it is important to ensure concrete structures' durability in an aggressive environment, such as areas prone to tidal flooding. Some of the major causes of concrete deterioration are chemical attack of seawater constituents during the hydration process of cement, alkali-aggregate expansion, crystallization pressure of salts, frost action in cold climates, and corrosion of reinforced steel embedded in concrete structures. Others include physical erosion, such as wave and floating objects contacted to the concrete structures, as well as the carbonic acid attack that leaches away the calcium from hydrated cement [1,2]. Hence, it is necessary to ensure that concrete materials have good performance and durability.

Several research have reported the durability of concrete structures in the marine environment, including long-term investigation of concrete performance exposed to seawater [3–6]. Furthermore, concrete mixed with seawater achieved a good mechanical properties performance even though it was slightly lower than those using plain water [7–9]. It is also reported to provide a more resistant product against deterioration and

higher compressive strength at an early age. Preliminary reasearch also conveyed the improved durability and bond strength of concrete structures in the marine environment was achieved due to the development of Polymer-Modified Concrete (PMC) by mixing a polymer material into Portland Cement [10]. According to [11-12], thermoplastics, such as epoxy resins, elastomers or rubbers, natural polymers cellulose, lignin proteins, latex, re-dispersible polymer powder, water-soluble powder, liquid resins, SF (Silica Fume), RHA (Rice Husk Ash), and SF with nano-silica were used in PMC. However, research on the utilization of natural or bio-polymer modified concrete and mortar are still very rare irrespective of the advantages such as increased compressive strength and durability [13–17].

This research aims to implement column retrofitting in tidal flooding areas with bio-polymer modified concrete using *Gracilaria Sp*., *Moringa oleifera*, and honey. It was conducted by field application of columns retrofitting in areas prone to tidal flooding for 14 months and validated by non-destructive and destructive tests. The result showed that the bio-polymer modified concrete using *Gracilaria Sp*., *Moringa oleifera*, and honey increased concrete columns' performance and long-term durability.

2. Materials and Methods

This research was conducted by field application as well as non-destructive and destructive tests in sites prone to tidal flooding. The methods and stages are outlined in subsequent sub-sections.

- **On-site column retrofitting and control column construction**

  Two broken columns were retrofitted in the site, and a control column was constructed, as shown in Table 1. Each specimen identity was represented by one column.

Table 1: Detail of Column Experiment

No	Specimen Identity	Status	Mix Composition
1	K1	retrofitted column	Mix I
2	K3	retrofitted column	Mix III
3	K	control column	Mix-Normal

The column retrofitting and construction was carried out by grouting it with bio-polymer modified concrete. Furthermore, *Gracilaria Sp.* powder, an agar-agar product sold in the marketplace, *Moringa oleifera* powder from its seeds and honey were added to the mixture, as shown in Figure 1 and Table 2. The concrete mix composition of Mix I and Mix III were implemented in producing concrete bricks [16]. All concrete columns were designed for compressive strength of $f'_c = 30$ MPa with a dimension of 15 cm x 15 cm x 100 cm as shown in Figure 5. The concrete mixture was calculated by Indonesian National Standard for Procedure of Concrete Mixing Design (SNI 03-2834-2000). However, bio-polymers did not add the Mix-Normal process shown in Table 4.

Figure 1: The materials used in columns production as bio-polymers modified concrete: (a) and (b) *Gracilaria Sp.* powder which agar-agar product sold in marketplace; (c) raw *Moringa oleifera* seeds with skin; (d) raw *Moringa oleifera* seeds without skin; and (e) honey which is also honey product sold in the marketplace.

- **Non-destructive test for retrofitted and control columns**

This stage was conducted on-site, which led to the construction of the control columns after the broken sections were retrofitted. The Rebound Hammer test was carried out as a non-destructive test to analyze the columns compressive strength with Matest 2H1Q17. All columns were tested at 7, 14, and 28 days, while some were retested at 12, 13, and 14 months with mix K3, which contains Moringa oleifera and mix-normal.

The non-destructive procedure used in this test followed ASTM C 805 - Standard Test Method for Rebound Number of Hardened Concrete, as shown in Figure 2. Several shootings were applied to the clean and flat surfaces of zone A, B, and C. Each zone was shot ten times, as shown by Figure 3.

Figure 2: Hammer Test Matest 2H1Q17 used in this research as non-destructive test equipment

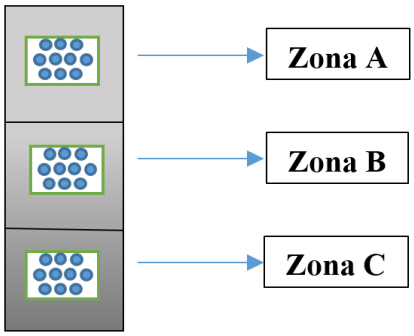

Figure 3: The zones for shooting at column surface for Rebound Hammer Test

The Rebound Value was read by the equipment and then corrected for inclination as indicated in Table 3. After the corrected Rebound Value was calculated as R, the concrete (W_m) strength that referred to the cubes was calculated in accordance with the age, as shown in Table 4.

Table 3: Correction of the Test Hammer Indications for Non-Horizontal Impacts (Manual Book Hammer Test Matest 2H1Q17)

Rebound Value Rα	Correction for inclination angle α			
	Upwards		Downwards	
	+90°	+45°	-45 °	-90 °
10			2.4	3.2
20	-5.4	-3.5	2.5	3.4
30	-4.7	-3.1	2.3	3.1
40	-3.9	-2.6	2	2.7
50	-3.1	-2.1	1.6	2.2
60	-2.3	-1.6	1.3	1.7

Table 4: Cube Compressive Strength (W, in kg/cm^2) as a function of the Rebound Number R Type N

R	Age of Concrete			
	14 to 56 days		7 days	
	W_m	W_{min}	W_m	Wmin
20	101	54	121	74
21	113	64	132	83
22	126	75	145	94
23	139	86	157	104
24	152	98	169	115
25	166	110	183	127
26	180	122	196	138
27	195	135	210	150
28	210	149	225	164
29	225	163	239	177
30	241	178	254	191
31	257	193	269	205
32	274	209	285	220

33	291	225	300	234
34	307	240	315	248
35	324	256	331	263
36	342	273	348	279
37	360	290	365	295
38	370	307	381	311
39	395	324	398	327
40	413	341	416	344
41	432	359	434	361
42	450	377	451	378
43	469	395	470	396
44	488	414	488	414
45	507	432	507	432
46	526	450	526	451
47	546	470	546	570
48	565	489	565	489
49	584	508	584	508
50	604	527	604	527
51	623	546	623	546
52	643	565	643	565
53	663	584	663	584
54	683	603	683	603
55	703	622	703	622

- **Destructive test for retrofitted and control columns**

After the Rebound Hammer test, the inner concrete's compressive strength was conducted using the Core Drill method. This technique was purposed to obtain compressive strength of the drilled core of concrete using the ASTM C 42/C 42M – 04 and SNI 03-2492-2002 Standard test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete. A versatile diamond drilling system with a diameter of 3 mm and a HILTI DD 150-U machine was also used, as shown in Figure 4. The Core Drill method was applied only to columns K3 at 14 months. The samples were drilled from the inner columns at points A, B, and C, as shown in Figure 5. The drilled concrete cylinder with a diameter and height of 70 mm and 140 mm used the ASTM code to test for compressive strength. This is in addition to the use of Computer Control Servo Hydraulic Concrete Compression Testing Machine and Hung-Ta serial HT 8391PC to obtain compressive strength of concrete cylinder as shown in Figure 6.

Figure 4: The Core Drill method using HILTI DD 150-U machine with versatile diamond drilling

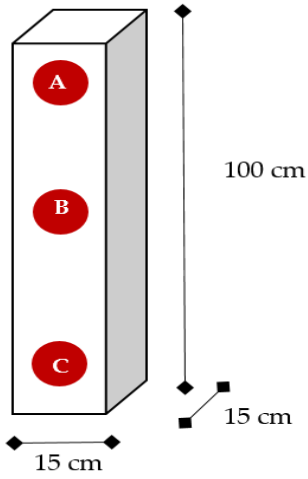

Figure 5: Column dimension and The zones A, B, C, for drilling concrete cores

Calculation of compressive test followed the expression of Equation (1).

$$\sigma = \{\left(\frac{P}{A}\right) . f_{l/d} . f_{dia} . f_d\} \quad (1)$$

where σ is characteristic compressive strength (MPa), P is compressive load (N), A is compressive area (mm2), l is the height of sample (mm), d is the diameter of the sample (mm), $f_{l/d}$ is correction factor of core diameter, and f_d is correction factor of damage caused by drilling. The correction factor of core diameter referred to ASTM C 42/C 42M – 04 and ACI 214.4R-03, while the correction factor of damage caused by drilling is referred to ACI 214.4R-03.

Figure 6: The Computer Control Servo Hydraulic Concrete Compression Testing Machine, Hung-Ta serial HT 8391PC

3. Results

3.1. On-site column retrofitting and construction

This research retrofitted 2 broken columns marked by a red circle, as shown in Figure 7-(a). Those two columns were used to pin the broken masonry wall and observed that the concrete's cover, as well as most parts of the columns were peeled off while the steel reinforcement was corroded. After some months, almost half of the left column collapsed, as shown by Figure 7-(b).

Figure 7: The broken columns which were retrofitted by applying bio-polymer modified concrete, (a) Situation at the time the left column still existed, and (b) Situation in the next few months after the left column had almost collapsed.

Figure 8-(a) shows that the first step in column retrofitting is conducted by peeling the cover of old concrete and unnecessary debris and applying the formwork of 1 m from the base floor. The next step of the activities was grouting the column with bio-polymer modified concrete consisting of *Gracilaria, Sp*., *Moringa oleifera*, and honey. After the retrofitted column stiffness increased, it was wrapped by jute sack, and curing was applied for about a week by watering it as shown in Figure 8-(b).

(a)

(b)

Figure 8: The column retrofitting activities: (a) Peeling, formwork, grouting with bio-polymer modified concrete consisting of Gracilaria, Sp., Moringa oleifera, and honey; (b) Curing by watering the column for a week.

Figure 9 shows a control column constructed in conjunction with columns retrofitting. The procedure included: mixing the concrete materials consisting of cement, split, sand, and water referred to Mix Normal as shown in Table 2. This is in addition to conducting steel reinforcement and framework curing.

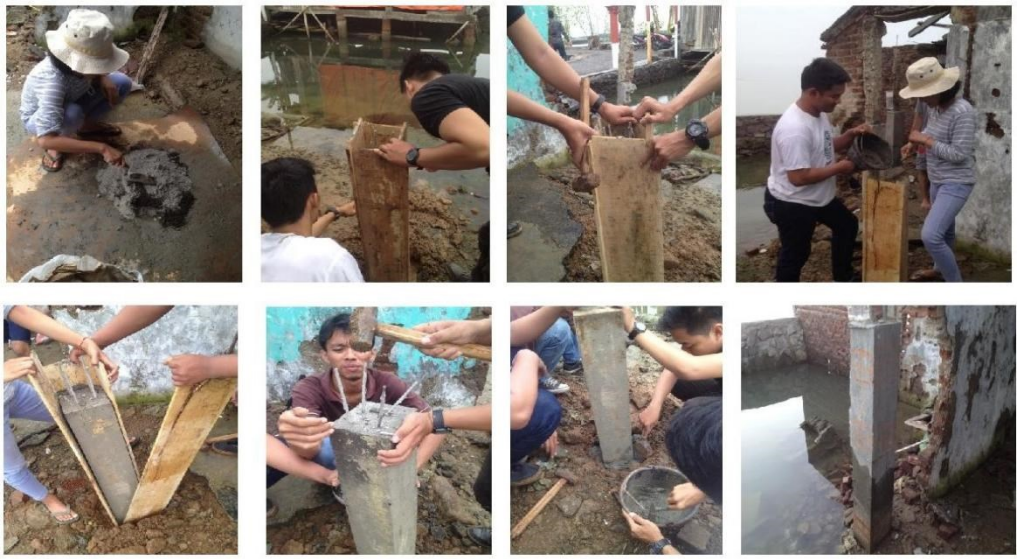

Figure 9: Construction of control column.

3.2. Non-destructive test for retrofitted and control columns

The non-destructive test examined the retrofitted and control columns to investigate their compressive strength. A Rebound Hammer Test was also used by shooting at the necessary points (A, B, C) in the house submerged by tidal flooding at 28 days, as shown in Figures 10-12. A year later, the retrofitted and control columns were tested at 12, 13, and 14 months as shown by Figures 11 and 12.

Figure 10: Rebound Hammer Test that was conducted to retrofitted columns at 7, 14, and 28 days

Figure 11: Rebound Hammer Test that was conducted to retrofitted columns at 12, 13, and 14 months

Figure 12: Rebound Hammer Test that was conducted to control column at 14 months

198 The baseline of the Rebound Hammer Test was conducted by shooting the old broken
199 column at points A, B, C to obtain the baseline of compressive strength before column
200 retrofitting procedures, as shown in Figures 13 and 14. It was found that the baseline
201 compressive strength of the old broken columns was 17.3 MPa, 18.63 MPa, and 16.6 MPa
202 at points A, B, and C.
203

Figure 13: The Rebound Hammer Test was column at conducted at the points that marked by red circles

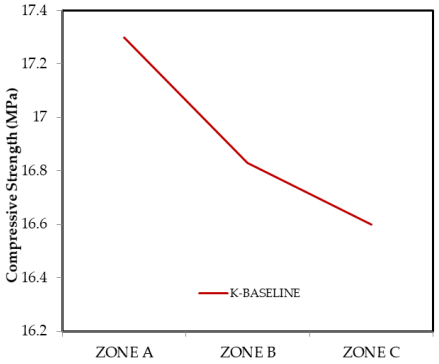

Figure 14: Compressive strength of old broken column that become baseline value

204
205 The Rebound Hammer Test result observed that the retrofitted column of K1
206 performed lower compressive strength to K3 at point A, which was higher at B and C
207 within 7, 14, and 28 days as indicated in Figure 15. Furthermore, a very high compressive
208 strength value was obtained at point B within 14 months compared to the lower value in
209 the retrofitted column, as shown in Figure 16. The research also found that the
210 compressive strength of K1 at point C was decreased at all ages, as shown in Figure 17.
211 Rebound Hammer Test results also noted that at 14 months, the compressive strength
212 values of retrofitted and control columns decreased, as shown in Figure 18.
213

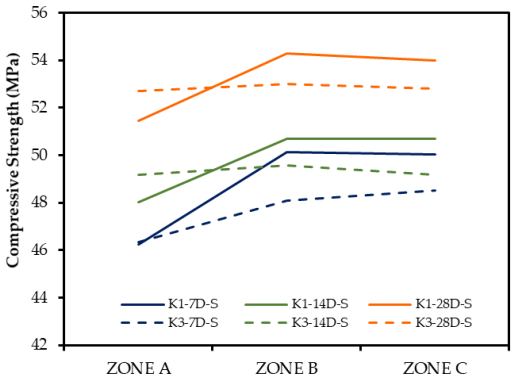

Figure 15: Compressive strength of retrofitted columns of K1 and K3 at 7, 14, 28 days

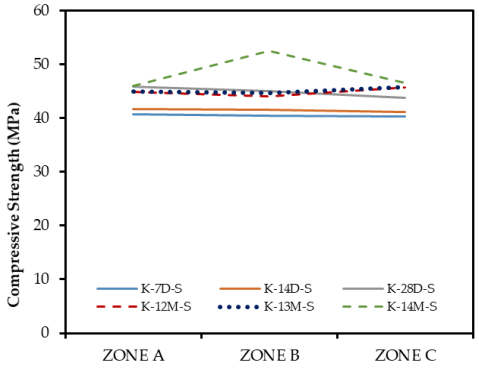

Figure 16: Compressive strength of control column at 7, 14, 28 days, and also 12, 13, 14 months

214

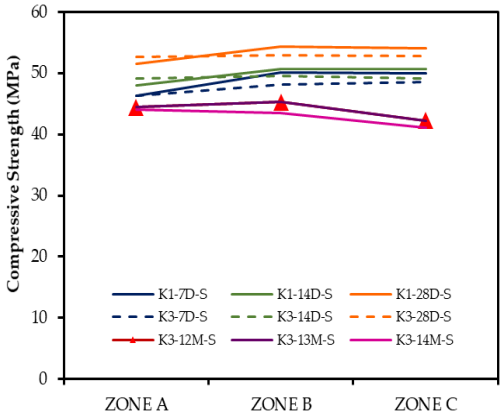

Figure 17: Compressive strength of retrofitted columns of K1 at 7, 14, 28 days, and K3 column at 12, 13, 14 months

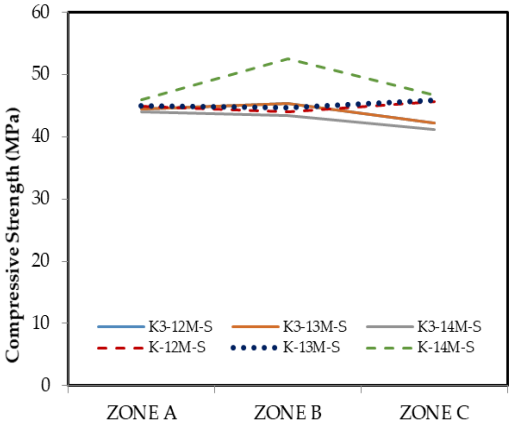

Figure 18: Compressive strength of control

3.3. Destructive Test for column specimens

The research applied a Destructive Test to investigate the compressive strength of retrofitted and control columns by the Core Drill method. Figures 19 and 20 describe the Core Drill implementation process needed to obtain the core's concrete sample using concrete cylinders. Figure 21 illustrates that the retrofitted column of K3 has stable compressive strength at all points (A, B, C) with 30 MPa. Point B has a slightly higher compressive strength value, which did not occur on the control column. The research found that the compressive strength at point A was very high (52.44 MPa) and low (42.76 MPa and 45.98 MPa) at points B and C.

Figure 19: Core Drill method of retrofitted and control columns conducted to obtain samples used for the compressive strength test.

Figure 20: A drilled concrete cylinder tested for compressive stress

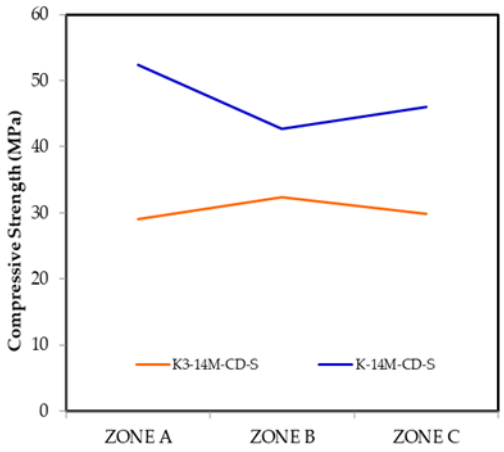

Figure 21: Compressive strength of drilled concrete cylinders of retrofitted and control columns at 14 month

This research found that the destructive test result of the compressive strength at 14 months has the ability to control column surface by Rebound Hammer Test (K-14M-RH-S). The values were higher than the retrofitted column (K3-14M-RH-S), especially in the middle of point B. However, the retrofitted column has shown the averaged compressive strength along with the column height (at points A, B, and C), as shown in Figure 22. The inner columns compressive strength of the Core Drill Test (K-14M-CD-S and K3-14M-CD-S) had lower results than Rebound Hammer Test. The baseline value of the compressive test of the column before it was retrofitted (K-Baseline) was the lowest (16.91 MPa) compared to the test results of Rebound Hammer and Core Drill. Figure 23 illustrates an increase in compressive strength at point B of the retrofitted column of Core Drill Test (K3-14M-CD-S) was 92.34% higher (32.37 MPa to 16.83 MPa) at point B than K-Baseline.

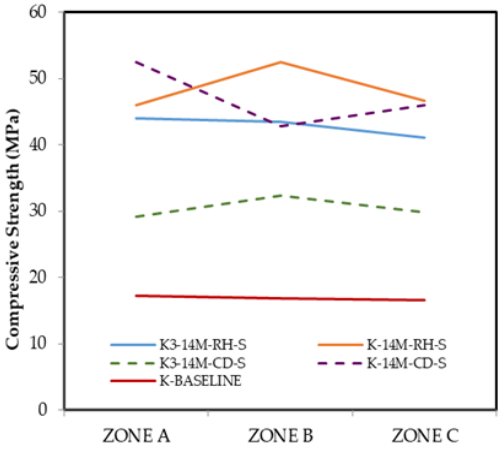

Figure 22: Compressive strength of retrofitted and control columns were obtained from Rebound Hammer Test and Core Drill method

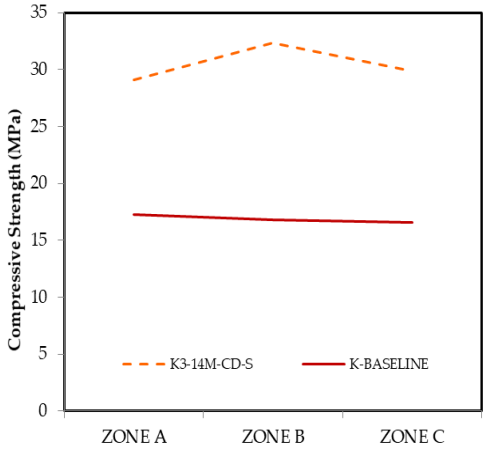

Figure 23. Compressive strength of baseline column was obtained from Core Drill method

4. Discussion

One of the most effective ways to increase concrete durability and bond strength in areas prone to tidal flooding is using PMC (Polymer Modified Concrete) [10]. Research by [11] found that the application of Styrene-Butadiene Rubber (SBR) latex into PMC and fiber-reinforced polymers (FRP) increased the concrete compressive strength by 72% and 86.64%, respectively. The experiment conducted by [12] on the addition of SF, RHA, and SF with nano-silica into concrete as polymer proved an increase in the compressive strength of the PMC by 82.9 MPa.

Subsequently, concrete durability in tidal-prone areas plays an important role in achieving sustainable concrete. According to research conducted by [4], Indonesia's climate has relative humidity ranging from 70-90%. The corrosion in carbonated concrete has become a serious problem in concrete sustainability in the marine environment and areas prone to tidal flooding. Therefore, concretes designed with a life span of 50 years when subjected to a marine environment, such as BS 6349-1, need to be stronger and durable with compressive strength of 25-40 MPa [4]. Previous research reported the retrofitting of concrete structure elements using polymer-modified concrete bonding with adhesive agents [14], premixed mortar additive [13], and concrete-bricks production with a mix of K1 and K3 [16], as shown in Table 1. It was found that the columns designed with premixed mortar additive as polymer achieved compressive strength at age 28 days of 60.69 MPa. The compressive strength was 34.87% higher than the control (45 MPa). It was also reported that the compressive strength of the center of brick-wall surface tested by

Rebound Hammer and Core drill had a compressive strength of 42.3 MPa [13] and 58.60 MPa at 14 months [16].

Research on the use of natural or bio-polymer to mix concrete, such as PMC is still rare, especially when applied to areas prone to tidal flooding. In this research, the innovation of biopolymer modified concrete using *Gracilaria Sp*., *Moringa oleifera*, and honey were applied to the old-broken columns retrofitting to get a more durable and resistant concrete structure. The field application results and column tests found that the compressive strength of the retrofitted column achieved 32.37 MPa, increasing 92.34% compared to the baseline.

All columns in the research were submerged by tidal flooding intensively for 14 months because the aggressive environment contributes to the concrete's structure degradation. Research by [3] reported that concrete compressive strength with ordinary, normal Portland Cement exposed to the marine environment for 20 years is likely to significantly drop in the 10th year from approximately 50 MPa to 30 MPa. Hence, it confirmed that seawater has the ability to attack the performance of concrete by catastrophic damage. The columns retrofitting biopolymer, which modified concrete using *Gracilaria Sp*., *Moringa oleifera*, and honey, increased its compressive strength by 100% from the baseline after 14 months, as shown in Figure 23. Therefore, the concrete structure with the addition of *Gracilaria Sp*., *Moringa oleifera*, and honey has strong and durable characteristics to be used in aggressive environments such as areas prone to tidal flooding.

5. Conclusions

In conclusion, it is necessary to develop concrete materials that are strong and durable in a marine environment prone to trial flooding. This research proved that the bio-polymer modified concrete that used *Gracilaria Sp*., *Moringa oleifera*, and honey significantly increased concrete columns' performance and long-term durability. The findings also showed that the compressive strength of the retrofitted column achieved 32.37 MPa, a 92.34% increase compared to the baseline. Therefore, the challenges of getting sustainable concrete materials for areas prone to tidal flooding can be fulfilled by using bio-polymer modified concrete with *Gracilaria Sp*., *Moringa oleifera*, and honey.

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References

1. Akshat Dimri; Jay Kr. Varshney; V. K. Verma; Sandeep Gupta A Review on Strength of Concrete in Seawater. *Int. J. Eng. Res.* **2015**, *V4*, 844–847, doi:10.17577/ijertv4is030890.
2. Chandrasekaran, S.; Jain, A. *Materials for Ocean Structures*; 2016; ISBN 9781315366692.
3. Fukute, T.; Hamada, H. A Study on the Durability of Concrete Exposed in Marine Environment for 20 Years. *Rep. Port Harb. Institute, Minist. Transp. Japan* **1993**, *51*, 251–272.

4. Irmawaty, R.; Hamada, H.; Witanto, H. Durability Design for Indonesian Climate. In Proceedings of the Proceedings of the 2nd International Seminar on Infrastructure Development In Cluster Island Eastern Part of Indonesia (ISID 2014); Balikpapan, Indonesia2014.
5. Nanukuttan, S. V; Basheer, P.A.M.; McCarter, W.J.; Tang, L.; Holmes, N.; Chrisp, T.M.; Starrs, G.; Magee, B. The performance of concrete exposed to marine environments: Predictive modelling and use of laboratory/on site test methods. *Constr. Build. Mater.* **2015**, *93*, 831–840, doi:https://doi.org/10.1016/j.conbuildmat.2015.05.083.
6. Khanzadeh-Moradllo, M.; Meshkini, M.H.; Eslamdoost, E.; Sadati, S.; Shekarchi, M. Effect of Wet Curing Duration on Long-Term Performance of Concrete in Tidal Zone of Marine Environment. *Int. J. Concr. Struct. Mater.* **2015**, *9*, 487–498, doi:10.1007/s40069-015-0118-3.
7. Younis, A.; Ebead, U.; Suraneni, P.; Nanni, A. Fresh and hardened properties of seawater-mixed concrete. *Constr. Build. Mater.* **2018**, *190*, 276–286, doi:10.1016/J.CONBUILDMAT.2018.09.126.
8. Susilorini, M.. R.; W, K.R.D.; Wibowo, T. The Performance of Early-Age Concrete with Seawater Curing. *J. Coast. Dev.* **2013**, *8*, 89–95.
9. Guo, Q.; Chen, L.; Zhao, H.; Admilson, J.; Zhang, W. The Effect of Mixing and Curing Sea Water on Concrete Strength at Different Ages. *MATEC Web Conf.* **2018**, *142*, 02004, doi:10.1051/matecconf/201814202004.
10. ACI Committee 548 *Report on Polymer-Modified Concrete*; 2009;
11. Bothra, S.R.; Ghugal, Y.M. Polymer-Modified Concrete: Review. *Int. J. Res. Eng. Technol.* **2015**, *04*, 845–848, doi:10.15623/ijret.2015.0404146.
12. Alhazmi, H.; Shah, S.A.R.; Anwar, M.K.; Raza, A.; Ullah, M.K.; Iqbal, F. Utilization of Polymer Concrete Composites for a Circular Economy: A Comparative Review for Assessment of Recycling and Waste Utilization. *Polym. 2021, Vol. 13, Page 2135* **2021**, *13*, 2135, doi:10.3390/POLYM13132135.
13. Retno Susilorini, M.I.; William, S.S.; Rianto; Kartikowati, S.; Setiawan, M.H.; Ludfie Hadrian, P.; Kurniawan, E. Masonry Walls Retrofitting with Eco-Concrete Bricks in Tidal Flooding Prone Area. *Int. J. Eng. Res. Technol.* **2020**, *13*, 560–569.
14. Susilorini, R.M.I.R.; Rejeki, V.G.S.; Santosa, B.; Caresta, F.D.; Putro, M.S. Polymer modified mortar with bonding adhesive agent for column repairing in tidal flooding prone area. *AIP Conf. Proc.* **2018**, *1977*, doi:10.1063/1.5042969.
15. Retno Susilorini, M.I.; Suryanto, R.; Pramana, Y. Carbohydrate polymers for green multi-purpose mortar. *Int. J. Eng. Res. Technol.* **2020**, *13*, 580–585.
16. Susilorini, R.M.I.R.; Suwarno, D.; Santosa, B.; Putra, L.H.; Kurniawan, E. Rebound Hammer Test result of old repaired masonry wall using premixed mortar additive in tidal flooding prone area. *AIP Conf. Proc.* **2018**, *1977*, 1–6, doi:10.1063/1.5042982.
17. Susilorini, R.M.I.R.; Santosa, B.; Rejeki, V.G.S.; Riangsari, M.F.D.; Hananta, Y.D. The increase of compressive strength of natural polymer-modified concrete with Moringa oleifera.; 2017.

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Abstract	The need for durable concrete in marine environments such as areas prone to tidal flooding is important due to its ability to deteriorate the structures. This led to the design of a durable and strong Polymer-Modified Concrete (PMC) using natural or bio-polymer modified concrete. However, the use of biopolymer-modified concrete is very limited. Therefore, this research developed a bio-polymer modified concrete using Gracilaria Sp., Moringa oleifera, and honey for column retrofitting. The research aimed to retrofit and improve the compressive strength and durability of broken columns submerged by tidal flooding by applying bio-polymer modified concrete with Gracilaria Sp., Moringa oleifera, and honey. A field application of column retrofitting was conducted in areas prone to tidal flooding. The retrofitted columns performance was observed for 14 months and validated by non-destructive and destructive tests. The result showed that the compressive strength of the retrofitted column achieved 32.37 MPa, which is a 92.34% increase compared to the baseline. This research provides answers to the challenge of concrete materials sustainability by promoting bio-polymer modified concrete that significantly increased its performance and long-term durability using Gracilaria Sp., Moringa oleifera, and honey.
Keywords	durability; bio-polymer; concrete; tidal flooding sustainable.
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Long-Term Durability of Bio-Polymer Modified Concrete in Tidal Flooding Prone Area: A Challenge of Sustainable Concrete Materials

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Abstract: The need for durable concrete in marine environments such as areas prone to tidal flooding is important due to its ability to deteriorate the structures. This led to the design of a durable and strong Polymer-Modified Concrete (PMC) using natural or bio-polymer modified concrete. However, the use of biopolymer-modified concrete is very limited. Therefore, this research developed a bio-polymer modified concrete using *Gracilaria* sp., *Moringa oleifera*, and honey (GMH) for column retrofitting. The research aimed to retrofit and improve the compressive strength and durability of broken columns submerged by tidal flooding by applying bio-polymer modified concrete with GMH. A field application of column retrofitting was conducted in areas prone to tidal flooding. The retrofitted columns performance was observed for 14 months and validated by non-destructive and destructive tests. The result showed that the compressive strength of the retrofitted column achieved 32.37 MPa, which is a 92.34% increase compared to the baseline. This research provides answers to the challenge of concrete materials sustainability by promoting bio-polymer modified concrete that significantly increased its performance and long-term durability using GMH.

Keywords: durability; bio-polymer; concrete; tidal flooding; sustainability

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1. Introduction

The deterioration of concrete structures caused by tidal flooding is one of the major causes of coastal infrastructure damage. Therefore, it is important to ensure concrete structures' durability in an aggressive environment, such as areas prone to tidal flooding. Some of the major causes of concrete deterioration are chemical attack of seawater constituents during the hydration process of cement, alkali-aggregate expansion, crystallization pressure of salts, frost action in cold climates, and corrosion of reinforced steel embedded in concrete structures. Others include physical erosion, such as wave and floating objects contacted to the concrete structures, as well as the carbonic acid attack that leaches away the calcium from hydrated cement [1,2]. Hence, it is necessary to ensure that concrete materials have good performance and durability.

Several research have reported the durability of concrete structures in the marine environment, including long-term investigation of concrete performance exposed to seawater [3–6]. Furthermore, concrete mixed with seawater achieved a good mechanical properties performance even though it was slightly lower than those using plain water [7–9]. It is also reported to provide a more resistant product against deterioration and higher compressive strength at an early age. Preliminary reasearch also conveyed the improved durability and bond strength of concrete structures in the marine environment was achieved due to the development of Polymer-Modified Concrete (PMC) by mixing

a polymer material into Portland Cement [10–13]. According to [11,12], thermoplastics, such as epoxy resins, elastomers or rubbers, natural polymers cellulose, lignin proteins, latex, re-dispersible polymer powder, water-soluble powder, liquid resins, SF (Silica Fume), RHA (Rice Husk Ash), and SF with nano-silica were used in PMC. There were also several studies reported the advantage of PMC for marine environment i.e., [14–19]. However, research on the utilization of natural or bio-polymer modified concrete and mortar are still very rare irrespective of the advantages such as increased compressive strength and durability [20–24].

This research aims to implement column retrofitting in tidal flooding areas with bio-polymer modified concrete using *Gracilaria* sp., *Moringa oleifera*, and honey (GMH). It was conducted by field application of columns retrofitting in areas prone to tidal flooding for 14 months and validated by non-destructive and destructive tests. The result showed that the bio-polymer modified concrete using GMH increased concrete columns' performance and long-term durability.

2. Materials and Methods

This research was conducted by field application as well as non-destructive and destructive tests in sites prone to tidal flooding. The methods and stages are outlined in subsequent sub-sections.

- **On-site column retrofitting and control column construction**

Two broken columns were retrofitted in the site, and a control column was constructed, as shown in Table 1. Each specimen identity was represented by one column.

The column retrofitting and construction was carried out by grouting it with bio-polymer modified concrete. Furthermore, *Gracilaria* sp. powder, an agar-agar product sold in the marketplace, *Moringa oleifera* powder from its seeds and honey were added to the mixture, as shown in Figure 1, Tables 2 and 3. The concrete mix composition of Mix I and Mix III were implemented in producing concrete bricks [23]. All concrete columns were designed for compressive strength of f'_c = 30 MPa with a dimension of 15 cm × 15 cm × 100 cm. The concrete mixture was calculated by Indonesian National Standard for Procedure of Concrete Mixing Design (SNI 03-2834-2000). However, bio-polymers did not add the Mix-Normal process shown in Table 2.

Table 1. Detail of Column Retrofitting and Construction.

No	Specimen Code	Status	Mix Composition
1	K1 *	retrofitted column	Mix I *
2	K3 *	retrofitted column	Mix III *
3	K	control column	Mix-Normal

* the mix composition and specimen code referred to author's previous study of [23].

Table 2. Mix composition of bio-polymer.

Mix Composition	Specimen Code	*Gracilaria* sp.	Honey	*Moringa Oleifera*
		% of Cement Weight		
Mix I *	K1 *	0.05	0.03	0
Mix III *	K3 *	0.025	0	0.075
Mix-Normal	K	—	—	—

* the mix composition and specimen code referred to author's previous study of [23].

Table 3. Mix composition of concrete for 1 column production.

Cement	Sand	Crushed Stone	Water	Bio-Polymer
(kg)	(kg)	(kg)	(l)	(% of Cement Weight)
8	8	8	3.6	see Table 1

Figure 1. The materials used in columns production as bio-polymers modified concrete: (**a**,**b**) *Gracilaria* sp. Powder, which is an agar-agar product sold in marketplace; (**c**) raw *Moringa oleifera* seeds with skin; (**d**) raw *Moringa oleifera* seeds without skin; and (**e**) honey which is also honey product sold in the marketplace.

- **Non-destructive test for retrofitted and control columns**

This stage was conducted on-site, which led to the construction of the control columns after the broken sections were retrofitted. The Rebound Hammer test was carried out as a non-destructive test to analyze the columns compressive strength with Matest 2H1Q17. All columns were tested at 7, 14, and 28 days, while some were retested at 12, 13, and 14 months with mix K3, which contains *Moringa oleifera* and mix-normal.

The non-destructive procedure used in this test followed ASTM C 805-Standard Test Method for Rebound Number of Hardened Concrete, as shown in Figure 2. Several shootings were applied to the clean and flat surfaces of zone A, B, and C. Each zone was shot ten times, as shown by Figure 3.

Figure 2. Hammer Test Matest 2H1Q17 used in this research as non-destructive test equipment.

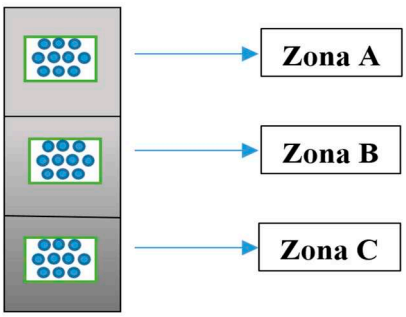

Figure 3. The zones for shooting at column surface for Rebound Hammer Test.

The Rebound Value was read by the equipment and then corrected for inclination as indicated in Table 4. After the corrected Rebound Value was calculated as R, the concrete (W_m) strength that referred to the cubes was calculated in accordance with the age, as shown in Table 5.

Table 4. Correction of the Test Hammer Indications for Non-Horizontal Impacts (Manual Book Hammer Test Matest 2H1Q17).

Rebound Value Rα	Correction for Inclination Angle α			
	Upwards		Downwards	
	+90°	+45°	−45°	−90°
10			2.4	3.2
20	−5.4	−3.5	2.5	3.4
30	−4.7	−3.1	2.3	3.1
40	−3.9	−2.6	2	2.7
50	−3.1	−2.1	1.6	2.2
60	−2.3	−1.6	1.3	1.7

Table 5. Cube Compressive Strength (W, in kg/cm^2) as a function of the Rebound Number R Type N.

R	Age of Concrete			
	14 to 56 Days		7 Days	
	W_m	W_{min}	W_m	W_{min}
20	101	54	121	74
21	113	64	132	83
22	126	75	145	94
23	139	86	157	104
24	152	98	169	115
25	166	110	183	127
26	180	122	196	138
27	195	135	210	150
28	210	149	225	164
29	225	163	239	177
30	241	178	254	191
31	257	193	269	205
32	274	209	285	220
33	291	225	300	234
34	307	240	315	248
35	324	256	331	263
36	342	273	348	279
37	360	290	365	295
38	370	307	381	311
39	395	324	398	327
40	413	341	416	344
41	432	359	434	361
42	450	377	451	378
43	469	395	470	396
44	488	414	488	414
45	507	432	507	432
46	526	450	526	451
47	546	470	546	570
48	565	489	565	489
49	584	508	584	508
50	604	527	604	527
51	623	546	623	546
52	643	565	643	565
53	663	584	663	584
54	683	603	683	603
55	703	622	703	622

- **Destructive test for retrofitted and control columns**

After the Rebound Hammer test, the inner concrete's compressive strength was obtained using the Core Drill method. This technique was purposed to obtain compressive strength of the drilled core of concrete using the ASTM C 42/C 42M–04 and SNI 03-2492-2002 Standard test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete. A versatile diamond drilling system with a diameter of 3 mm and a HILTI DD 150-U machine was also used to obtain the core of concrete specimens. The Core Drill method was applied only to columns K3 at 14 months. The samples were drilled from the inner columns at points A, B, and C, as shown in Figure 4. The drilled concrete cylinder with a diameter and height of 70 mm and 140 mm used the ASTM code to test for compressive strength. This is in addition to the use of Computer Control Servo Hydraulic Concrete Compression Testing Machine and Hung-Ta serial HT 8391PC to obtain compressive strength of concrete cylinder as shown in Figure 5.

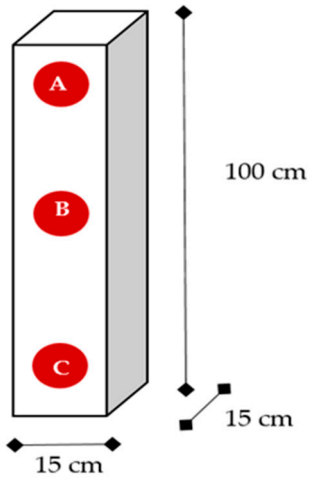

Figure 4. Column dimension and using HILTI DD 150-U machine.

Figure 5. The Computer Control Servo Hydraulic Concrete Compression Testing Machine, Hung-Ta serial HT 8391PC.

The zones A, B, and C are for drilling concrete cores with versatile diamond drilling. Calculation of compressive test followed the expression of Equation (1).

$$\sigma = \left\{ \left(\frac{P}{A} \right) \cdot f_{\frac{l}{d}} \cdot f_{dia} \cdot f_d \right\} \quad (1)$$

where σ is characteristic compressive strength (MPa), P is compressive load (N), A is compressive area (mm^2), l is the height of sample (mm), d is the diameter of the sample (mm), $f_{\frac{l}{d}}$ is

correction factor of core diameter, and f_d is correction factor of damage caused by drilling. The correction factor of core diameter referred to as ASTM C 42/C 42M–04 and ACI 214.4R-03, while the correction factor of damage caused by drilling is referred to as ACI 214.4R-03.

3. Results

3.1. On-Site Column Retrofitting and Construction

This research retrofitted two broken columns marked by red rectangles, as shown in Figure 6a. Those two columns were used to pin the broken masonry wall and observed that the concrete's cover as well as most parts of the columns were peeled off, while the steel reinforcement was corroded. After some months, almost half of the left column collapsed, as shown by Figure 6b.

(**a**) (**b**)

Figure 6. The broken columns which were retrofitted by applying bio-polymer modified concrete, (**a**) Situation at the time the left column still existed, and (**b**) Situation in the next few months after the left column had almost collapsed.

Figure 7a shows that the first step in column retrofitting is conducted by peeling the cover of old concrete and unnecessary debris and applying the formwork of 1 m from the base floor. The next step of the activities was grouting the column with bio-polymer modified concrete consisting of *Gracilaria* sp., *Moringa oleifera*, and honey. After the retrofitted column stiffness increased, it was wrapped by jute sack, and curing was applied for about a week by watering it, as shown in Figure 7b.

Figure 8 shows a control column constructed in conjunction with columns retrofitting. The procedure included: mixing the concrete materials consisting of cement, split (crushed stone), sand, and water referred to as Mix-Normal. This is in addition to conducting steel reinforcement and framework curing.

3.2. Non-Destructive Test for Retrofitted and Control Columns

The non-destructive test examined the retrofitted and control columns to investigate their compressive strength. A Rebound Hammer Test was also used by shooting at the necessary points (A, B, C) in the house submerged by tidal flooding at 28 days, as shown in Figures 9–11. A year later, the retrofitted and control columns were tested at 12, 13, and 14 months as shown by Figures 10 and 11.

(**a**)

(**b**)

Figure 7. The column retrofitting activities: (**a**) Peeling, formwork, grouting with bio-polymer modified concrete consisting of *Gracilaria* sp., *Moringa oleifera*, and honey (GMH); (**b**) Curing by watering the column for a week.

The baseline of the Rebound Hammer Test was conducted by shooting the old broken column at points A, B, C to obtain the baseline of compressive strength before column retrofitting procedures, as shown in Figures 12 and 13. It was found that the baseline compressive strength of the old broken columns was 17.3 MPa, 18.63 MPa, and 16.6 MPa at points A, B, and C, respectively.

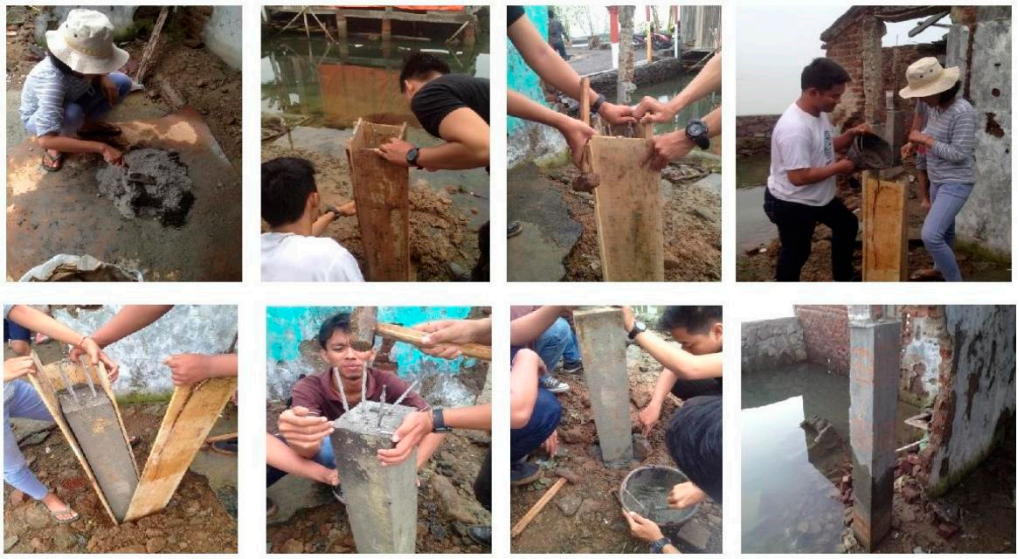

Figure 8. Construction of control column.

Figure 9. Rebound Hammer Test that was conducted on the retrofitted columns at 7, 14, and 28 days.

Figure 10. Rebound Hammer Test that was conducted on the retrofitted columns at 12, 13, and 14 months.

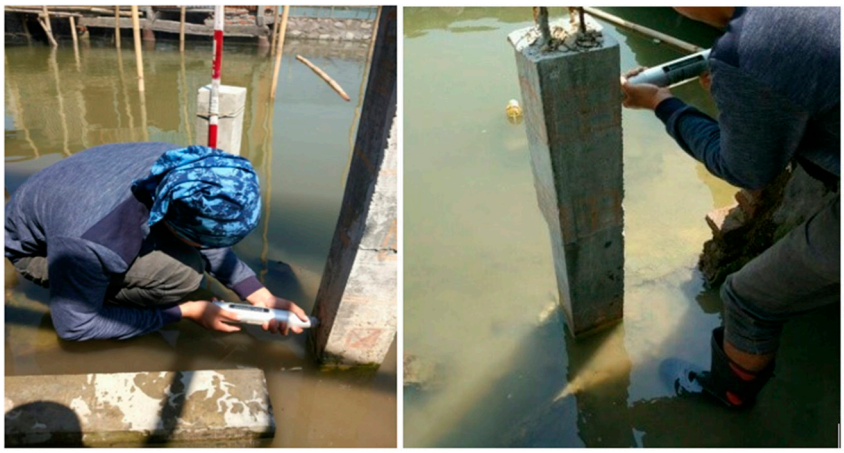

Figure 11. Rebound Hammer Test that was conducted on the control column at 14 months.

Figure 12. The Rebound Hammer Test was conducted on the points marked by red circles.

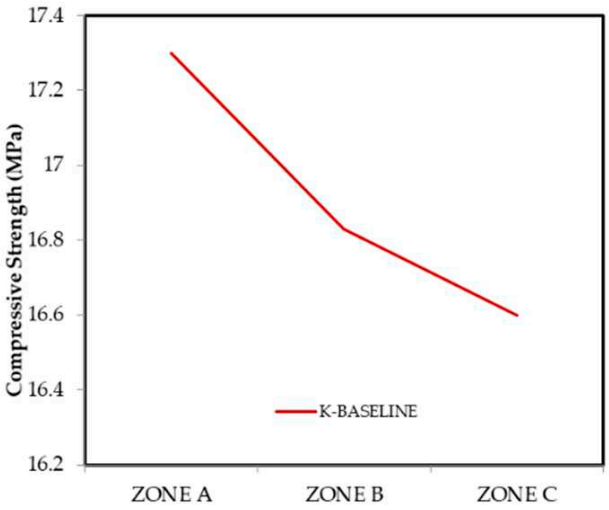

Figure 13. Compressive strength of the old broken column that became the baseline value.

The Rebound Hammer Test result observed that the retrofitted column of K1 had lower compressive strength compared to K3 at point A, but was higher at B and C at 7, 14, and 28 days as indicated in Figure 14. Furthermore, a very high compressive strength value was obtained at point B within 14 months compared to the lower value in the retrofitted

column, as shown in Figure 15. The research also found that the compressive strength of K1 at point C was decreased at all ages, as shown in Figure 16. Rebound Hammer Test results also noted that at 14 months, the compressive strength values of retrofitted and control columns decreased, as shown in Figure 17.

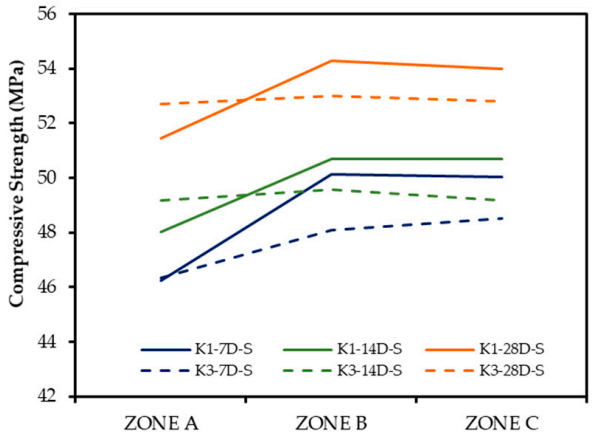

Figure 14. Compressive strength of retrofitted columns of K1 and K3 at 7, 14, 28 days.

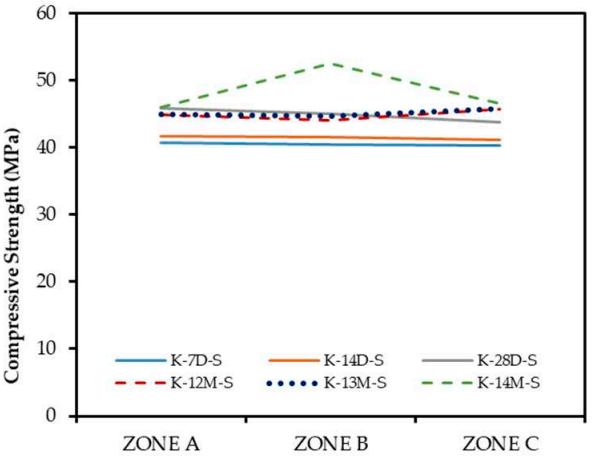

Figure 15. Compressive strength of control column at 7, 14, 28 days, and at 12, 13, 14 months.

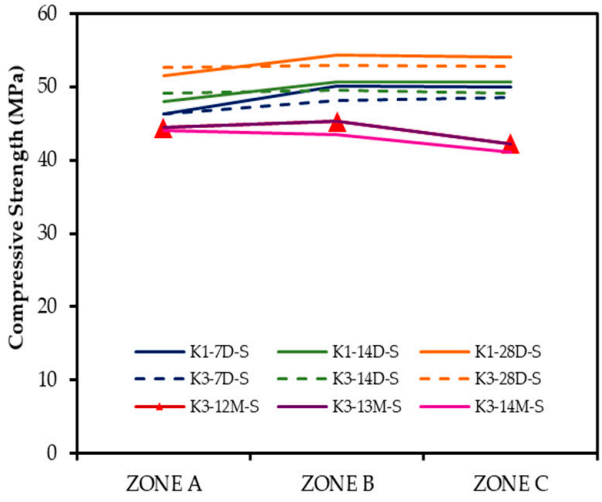

Figure 16. Compressive strength of retrofitted columns of K1 at 7, 14, 28 days, and K3 column at 12, 13, 14 months.

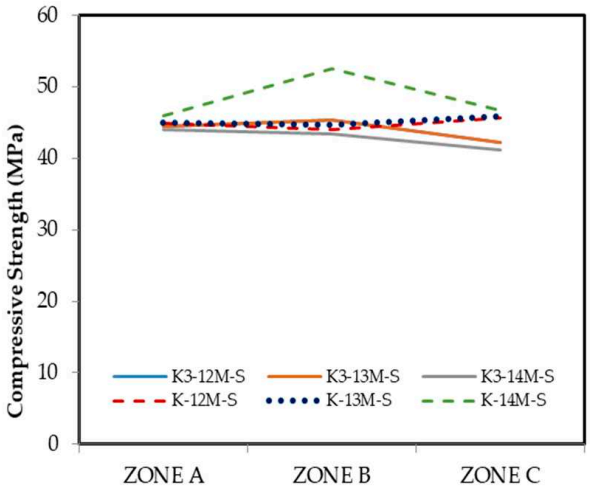

Figure 17. Compressive strength of control.

3.3. Destructive Test for Column Specimens

The research applied a Destructive Test to investigate the compressive strength of retrofitted and control columns by the Core Drill method. Figures 18 and 19 describe the Core Drill implementation process needed to obtain the core's concrete sample using concrete cylinders. Figure 20 illustrates that the retrofitted column of K3 has stable compressive strength at all points (A, B, C) with 30 MPa. Point B has a slightly higher compressive strength value, which did not occur on the control column. The research found that the compressive strength at point A was very high (52.44 MPa) but low at points B and C (42.76 MPa and 45.98 MPa).

Figure 18. Core Drill method of retrofitted and control columns conducted to obtain samples used for the compressive strength test.

Figure 19. A drilled concrete cylinder tested for compressive stress.

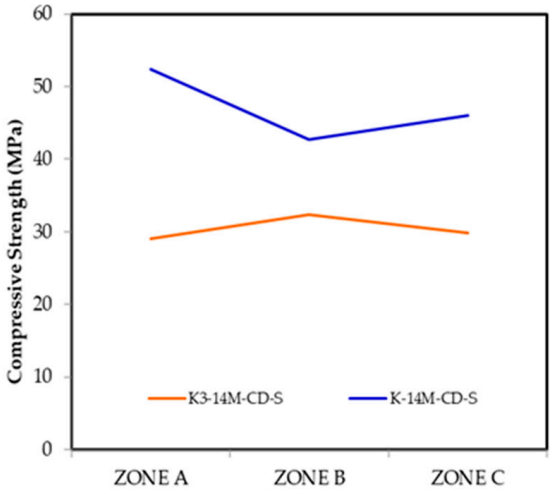

Figure 20. Compressive strength of drilled concrete cylinders of retrofitted and control columns at 14 month.

This research found that the destructive test result of the compressive strength at 14 months has the ability to control column surface by Rebound Hammer Test (K-14M-RH-S). The values were higher than the retrofitted column (K3-14M-RH-S), especially in the middle of point B. However, the retrofitted column has shown average compressive strength along with the column height (at points A, B, and C), as shown in Figure 21. The inner columns compressive strength of the Core Drill Test (K-14M-CD-S and K3-14M-CD-S) had lower results than Rebound Hammer Test. The baseline value of the compressive test of the column before it was retrofitted (K-Baseline) was the lowest (16.91 MPa) compared to the test results of Rebound Hammer and Core Drill. Figure 22 illustrates an increase in compressive strength at point B of the retrofitted column of Core Drill Test (K3-14M-CD-S), where it was was 92.34% higher (32.37 MPa to 16.83 MPa) at point B than at K-Baseline.

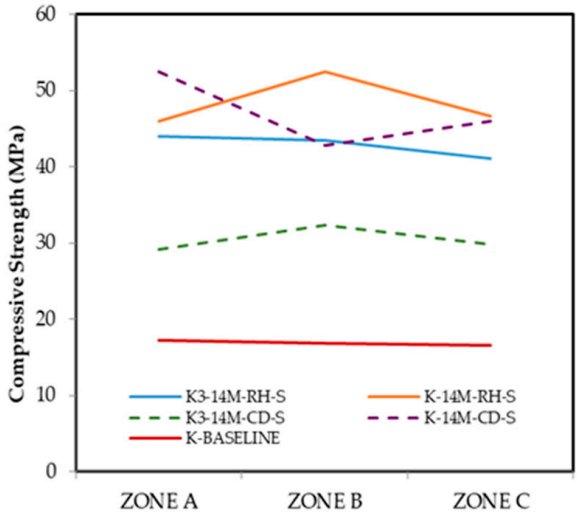

Figure 21. Compressive strength of retrofitted and control columns were obtained from Rebound Hammer Test and Core Drill method.

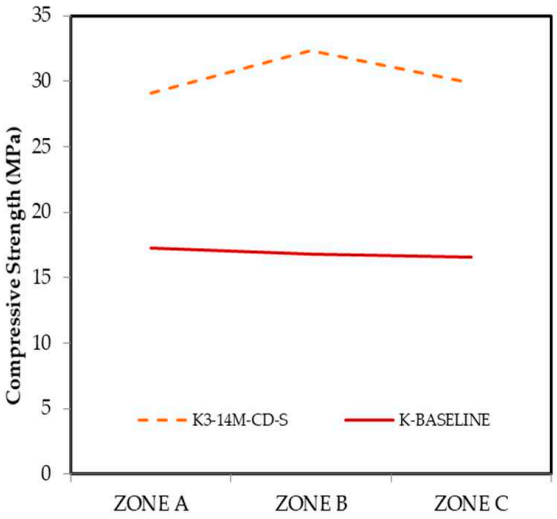

Figure 22. Compressive strength of baseline column was obtained from Core Drill method.

4. Discussion

One of the most effective ways to increase concrete durability and bond strength in areas prone to tidal flooding is using PMC (Polymer Modified Concrete) [10]. Research by [11] found that the application of Styrene-Butadiene Rubber (SBR) latex into PMC and fiber-reinforced polymers (FRP) increased the concrete compressive strength by 72% and 86.64%, respectively. The experiment conducted by [13] on the addition of SF, RHA, and SF with nano-silica into concrete as polymer proved an increase in the compressive strength of the PMC by 82.9 MPa.

Subsequently, concrete durability in tidal-prone areas plays an important role in achieving sustainable concrete. According to research conducted by [4], Indonesia's climate has relative humidity ranging from 70% to 90%. The corrosion in carbonated concrete has become a serious problem in concrete sustainability in the marine environment and areas prone to tidal flooding. Therefore, concretes designed with a life span of 50 years when subjected to a marine environment, such as BS 6349-1, need to be stronger and durable with compressive strength of 25–40 MPa [4]. Previous research reported the retrofitting of concrete structure elements using polymer-modified concrete bonding with adhesive agents [21], premixed mortar additive [20], and concrete-bricks production with a mix of K1 and K3 [23]. It was found that the columns designed with premixed mortar additive

as polymer achieved compressive strength at age 28 days of 60.69 MPa. The compressive strength was 34.87% higher than the control (45 MPa). It was also reported that the compressive strength of the center of brick-wall surface tested by Rebound Hammer and Core drill had a compressive strength of 42.3 MPa [20] and 58.60 MPa at 14 months [23].

Research on the use of natural or bio-polymer to mix concrete, such as PMC is still rare, especially when applied to areas prone to tidal flooding. In this research, the innovation of biopolymer modified concrete using GMH were applied to the old-broken columns retrofitting to get a more durable and resistant concrete structure. The field application results and column tests found that the compressive strength of the retrofitted column achieved 32.37 MPa, increasing 92.34% compared to the baseline.

All columns in the research were submerged by tidal flooding intensively for 14 months because the aggressive environment contributes to the concrete's structure degradation. Research by [3] reported that concrete compressive strength with ordinary, normal Portland Cement exposed to the marine environment for 20 years is likely to significantly drop in the 10th year from approximately 50 MPa to 30 MPa.

5. Conclusions

In conclusion, it is necessary to develop concrete materials that are strong and durable in a marine environment prone to trial flooding. This research proved that the bio-polymer modified concrete using GMH significantly increased concrete columns' performance and long-term durability. The findings also showed that the compressive strength of the retrofitted column achieved 32.37 MPa, a 92.34% increase compared to the baseline. Therefore, the challenges of getting sustainable concrete materials for areas prone to tidal flooding can be fulfilled by using bio-polymer modified concrete with *Gracilaria* sp., *Moringa oleifera*, and honey (GMH).

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References

1. Dimri, A.; Varshney, J.K.; Verma, V.K.; Gupta, S. A Review on Strength of Concrete in Seawater. *Int. J. Eng. Res.* **2015**, *4*, 844–847. [CrossRef]
2. Chandrasekaran, S.; Jain, A. *Materials for Ocean Structures*, 1st ed.; CRC Press, Taylor & Francis Group: London, UK, 2016; pp. 129–131. [CrossRef]
3. Fukute, T.; Hamada, H. A Study on the Durability of Concrete Exposed in Marine Environment for 20 Years. *Doboku Gakkai Ronbunshu* **1992**, *442*, 43–52. [CrossRef]
4. Irmawaty, R.; Hamada, H.; Witanto, H. Durability Design for Indonesian Climate. In Proceedings of the 2nd International Seminar on Infrastructure Development in Cluster Island Eastern Part of Indonesia (ISID 2014), Balikpapan, Indonesia, 3–4 June 2014.

5. Nanukuttan, S.V.; Basheer, P.A.M.; McCarter, W.J.; Tang, L.; Holmes, N.; Chrisp, T.M.; Starrs, G.; Magee, B. The performance of concrete exposed to marine environments: Predictive modelling and use of laboratory/on site test methods. *Constr. Build. Mater.* **2015**, *93*, 831–840. [CrossRef]
6. Khanzadeh-Moradllo, M.; Meshkini, M.H.; Eslamdoost, E.; Sadati, S.; Shekarchi, M. Effect of Wet Curing Duration on Long-Term Performance of Concrete in Tidal Zone of Marine Environment. *Int. J. Concr. Struct. Mater.* **2015**, *9*, 487–498. [CrossRef]
7. Younis, A.; Ebead, U.; Suraneni, P.; Nanni, A. Fresh and hardened properties of seawater-mixed concrete. *Constr. Build. Mater.* **2018**, *190*, 276–286. [CrossRef]
8. Susilorini, M.R. The Performance of Early-Age Concrete with Seawater Curing. *J. Coast. Dev.* **2013**, *8*, 89–95.
9. Guo, Q.; Chen, L.; Zhao, H.; Admilson, J.; Zhang, W. The Effect of Mixing and Curing Sea Water on Concrete Strength at Different Ages. *MATEC Web Conf.* **2018**, *142*, 02004. [CrossRef]
10. ACI Committee 548 Report on Polymer-Modified Concrete. American Concrete Institute. 2009. Available online: https://www.concrete.org/Portals/0/Files/PDF/Previews/548309web.pdf (accessed on 10 December 2021).
11. Bothra, S.R.; Ghugal, Y.M. Polymer-Modified Concrete: Review. *Int. J. Res. Eng. Technol.* **2015**, *4*, 845–848. [CrossRef]
12. Hirde, S.K.; Dudhal, O.S. Review on Polymer Modified Concrete And Its Application To Concrete Structures. *Int. J. Eng. Res.* **2016**, *5*, 766–769.
13. Alhazmi, H.; Shah, S.A.R.; Anwar, M.K.; Raza, A.; Ullah, M.K.; Iqbal, F. Utilization of Polymer Concrete Composites for a Circular Economy: A Comparative Review for Assessment of Recycling and Waste Utilization. *Polymers* **2021**, *13*, 2135. [CrossRef] [PubMed]
14. Zhao, C.; Jia, X.; Yi, Z.; Li, H.; Peng, Y. Mechanical performance of single-graded copolymer-modified pervious concrete in a corrosive environment. *Materials* **2021**, *14*, 7304. [CrossRef] [PubMed]
15. Madhani, B.; Palson, P. Comparative Study of Corrosion Resistance of Polymer Modified Concrete and Concrete with Corrosion Inhibiting Agent. International journal of engineering research and technology, 5.Comparative Study of Corrosion Resistance of Polymer Modified Concrete and Concrete with Corrosion Inhibiting Agent. *Int. J. Eng. Res.* **2016**, *5*, 314–319. [CrossRef]
16. Seyed Farhad Nabavi, B. Performance of Polymer-Concrete Composites in Service Life of Maritime Structures. Ph.D. Thesis, University of Technology, Sydney, Australia, December 2014.
17. Binti Noruzman, A.H. Performance of Polymer Modified Concrete Incorporating Polyvinyl Acetate Waste. Ph.D. Thesis, Universiti Teknologi Malaysia, Johor, Malaysia, August 2019.
18. Wang, K.; Liu, Z.; Wang, Z.; Yang, W. Study on polymer modified cement-based coating with healing effect on rusty carbon steel. *Int. J. Corros.* **2014**, *2014*, 628191. [CrossRef]
19. Kantharia, M.; Mishra, P.K.; Trivedi, M.K.; Gogoi, R. Effect of chemical exposure on mechanical strength of polymer mortar. *Int. J. Recent Technol. Eng.* **2019**, *7*, 944–948.
20. Retno Susilorini, M.I.; William, S.S.; Rianto; Kartikowati, S.; Setiawan, M.H.; Ludfie Hardian, P.; Kurniawan, E. Masonry Walls Retrofitting with Eco-Concrete Bricks in Tidal Flooding Prone Area. *Int. J. Eng. Res. Technol.* **2020**, *13*, 560–569. [CrossRef]
21. Susilorini, R.M.I.R.; Rejeki, V.G.S.; Santosa, B.; Caresta, F.D.; Putro, M.S. Polymer modified mortar with bonding adhesive agent for column repairing in tidal flooding prone area. *AIP Conf. Proc.* **2018**, *1977*, 030049. [CrossRef]
22. Retno Susilorini, M.I.; Suryanto, R.; Pramana, Y. Carbohydrate polymers for green multi-purpose mortar. *Int. J. Eng. Res. Technol.* **2020**, *13*, 580–585. [CrossRef]
23. Susilorini, R.M.I.R.; Suwarno, D.; Santosa, B.; Putra, L.H.; Kurniawan, E. Rebound Hammer Test result of old repaired masonry wall using premixed mortar additive in tidal flooding prone area. *AIP Conf. Proc.* **2018**, *1977*, 040012. [CrossRef]
24. Susilorini, R.M.I.R.; Santosa, B.; Rejeki, V.G.S.; Riangsari, M.F.D.; Hananta, Y.D. The increase of compressive strength of natural polymer modified concrete with *Moringa oleifera*. *AIP Conf. Proc.* **2017**, *1818*, 020059. [CrossRef]