From: Editorial Office
Sent: 11 February 2021 23:50
To: Yulian Arifin
Cc: Eka Agustina; Fransius Andhi; Setianto Samingan Agus
Subject: [Infrastructures] Manuscript ID: infrastructures-1127055 - Submission Received

Dear Dr. Arifin,

Thank you very much for uploading the following manuscript to the MDPI submission system. One of our editors will be in touch with you soon.

Journal name: Infrastructures
Manuscript ID: infrastructures-1127055
Type of manuscript: Article
Title: The Role of Additives in Soil-Cement Subjected to Wetting-Drying Cycles
Authors: Yulian Firmana Arifin *, Eka Agustina, Fransius Andhi, Setianto Samingan Agus
Received: 11 February 2021
E-mails: y.arifin@ulm.ac.id, eagustina17875@gmail.com, andhi.bzp@gmail.com, samingan.agus@mottmac.com

You can follow progress of your manuscript at the following link (login required):
https://susy.mdpi.com/user/manuscripts/review_info/7814d2bc5ceece8180bc7c53e58e8ee7

The following points were confirmed during submission:

1. Infrastructures is an open access journal with publishing fees of 1400 CHF for an accepted paper (see https://www.mdpi.com/about/apc/ for details). This manuscript, if accepted, will be published under an open access Creative Commons CC BY license (https://creativecommons.org/licenses/by/4.0/), and I agree to pay the Article Processing Charges as described on the journal webpage (https://www.mdpi.com/journal/infrastructures/apc). See https://www.mdpi.com/about/openaccess for more information about open access publishing.

Please note that you may be entitled to a discount if you have previously received a discount code or if your institute is participating in the MDPI Institutional Open Access Program (IOAP), for more information see https://www.mdpi.com/about/ioap. If you have been granted any other special discounts for your submission, please contact the Infrastructures editorial office.

2. I understand that:

a. If previously published material is reproduced in my manuscript, I will provide proof that I have obtained the necessary copyright permission. (Please refer to the Rights & Permissions website: https://www.mdpi.com/authors/rights).

b. My manuscript is submitted on the understanding that it has not been published in or submitted to another peer-reviewed journal. Exceptions to this rule are papers containing material disclosed at conferences. I confirm that I will inform the journal editorial office if this is the case for my manuscript. I confirm that all authors are familiar with and agree with submission of the contents of the manuscript. The journal editorial office reserves the right to contact all authors to confirm this in case of doubt. I will provide email addresses for all authors and an institutional e-mail address for at least one of the co-authors, and specify the name, address and e-mail for invoicing purposes.

If you have any questions, please do not hesitate to contact the Infrastructures editorial office at infrastructures@mdpi.com

Kind regards,

Infrastructures Editorial Office
St. Alban-Anlage 66, 4052 Basel, Switzerland
E-Mail: infrastructures@mdpi.com
Tel. +41 61 683 77 34
Fax: +41 61 302 89 18

*** This is an automatically generated email ***

From: Madalina Buzatu
Sent: 15 February 2021 16:03
To: Yulian Arifin
Cc: Madalina Buzatu; Eka Agustina; Fransius Andhi; Setianto Samingan Agus; Infrastructures Editorial Office
Subject: [Infrastructures] Manuscript ID: infrastructures-1127055 - Assistant Editor Assigned

Dear Dr. Arifin,

Your manuscript has been assigned to Madalina Buzatu for further processing who will act as a point of contact for any questions related to your paper.

Journal: Infrastructures
Manuscript ID: infrastructures-1127055
Title: The Role of Additives in Soil-Cement Subjected to Wetting-Drying Cycles
Authors: Yulian Firmana Arifin *, Eka Agustina , Fransius Andhi , Setianto Samingan Agus

Received: 11 February 2021
E-mails: y.arifin@ulm.ac.id, eagustina17875@gmail.com, andhi.bzp@gmail.com, samingan.agus@mottmac.com

You can find it here:
https://susy.mdpi.com/user/manuscripts/review_info/7814d2bc5ceece8180bc7c53e58e8ee7

Best regards,
Ms. Madalina Buzatu
Assistant Editor
Email: buzatu@mdpi.com
MDPI Open Access Publishing Romania
Str Avram Iancu 454, 407280 Floresti, Cluj, Romania
Infrastructures Editorial Office
E-mail: infrastructures@mdpi.com
http://www.mdpi.com/journal/infrastructures/
/Geomatics/ is Recruiting Editors
https://www.mdpi.com/journal/geomatics/announcements/2226

Journal	Infrastructures (https://www.mdpi.com/journal/infrastructures) (ISSN 2412-3811)
Manuscript ID	infrastructures-1127055
Type	Article
Number of Pages	16
Title	The Role of Additives in Soil-Cement Subjected to Wetting-Drying Cycles
Authors	Yulian Firmana Arifin * , Eka Agustina , Fransius Andhi , Setianto Samingan Agus

Abstract

This study aims to explore the use of additives in soil-cement mixtures, that have undergone a drying-wetting cycle. The two types of soil used include granitic and lateritic, which are widely used in road base construction in Katingan area, Central Kalimantan, Indonesia. The cement used was the ordinary Portland type I, while the additive utilized was for commercial purposes, and predominantly containing CaCl2. This research was conducted by testing the optimum cement content for each soil, to determine the shear strength according to the Indonesian standards (i.e., minimum UCS of 2400 kPa). The shear strength of the granitic and lateritic soils were deduced to be 5.5% and 5% on a dry weight basis, respectively. The utilization of 0.8% additive resulted in a 0.5% reduction of the optimum cement content of granite-like soil. The results showed that the optimum additive content, for granite soil was higher than those without supplement, while for the lateritic, no changes occurred. However, the advantage of using supplements was more pronounced in the samples when subjected to wetting-drying cycles. Also, at the highest additive level, the moisture content and soil-cement loss during wetting, is always smaller than those with no supplements.

Author's Reply to the Review Report (Reviewer 1)

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?e9a1de4761e1496f).

* Author's Notes to Reviewer

File Edit View Insert Format Tools Table Help

Paragraph

P 0 WORDS

Word / PDF Choose File No file chosen

Submit or Save as draft (submit later)

Review Report Form

Open Review
(x) I would not like to sign my review report
( ) I would like to sign my review report

English language and style
( ) Extensive editing of English language and style required
( ) Moderate English changes required
(x) English language and style are fine/minor spell check required
( ) I don't feel qualified to judge about the English language and style

	Yes	Can be improved	Must be improved	Not applicable
Does the introduction provide sufficient background and include all relevant references?	( )	( )	(x)	( )
Is the research design appropriate?	(x)	( )	( )	( )
Are the methods adequately described?	( )	(x)	( )	( )
Are the results clearly presented?	(x)	( )	( )	( )
Are the conclusions supported by the results?	( )	( )	(x)	( )

Comments and Suggestions for Authors

The manuscript is suitable for publication in this journal, however some points must be improved and adjusted for its acceptance and publication:

a) The introduction is insufficient in terms of recent citations and appropriate to the theme. The application of soil-cement involves several characteristics that must be detailed, including works addressing the testing of wetting and drying cycles, I suggest reading and inserting the following works: The durability of soil-cement columns in high sulphate environments; Environmental Durability of Soil-Cement Block Incorporated with Ornamental Stone Waste; Engineering characteristics of compressed earth blocks stabilized with cement and fly ash; Durability of soil-Cement blocks with the incorporation of limestone residues from the processing of marble; Mechanical Properties and Durability of Deep Soil-Cement Column Reinforced by Jute and PVA Fiber; Soil-cement brick with cassava wastewater.

b) The description of the materials is insufficient, the authors must redo the approach, including the description of the wetting and drying cycles;

c) The authors indicate a series of soil characterization results in the methodology section, I suggest switching to the results section, if these are results obtained by the authors;

d) The conclusion is insufficient and does not adequately support the possible results and concussions, a total reformulation is necessary.

Submission Date	11 February 2021
Date of this review	17 Feb 2021 05:34:43

Journal	Infrastructures (https://www.mdpi.com/journal/infrastructures) (ISSN 2412-3811)
Manuscript ID	infrastructures-1127055
Type	Article
Number of Pages	16
Title	The Role of Additives in Soil-Cement Subjected to Wetting-Drying Cycles

Authors: Yulian Firmana Arifin * , Eka Agustina , Fransius Andhi , Setianto Samingan Agus

Abstract: This study aims to explore the use of additives in soil-cement mixtures, that have undergone a drying-wetting cycle. The two types of soil used include granitic and lateritic, which are widely used in road base construction in Katingan area, Central Kalimantan, Indonesia. The cement used was the ordinary Portland type I, while the additive utilized was for commercial purposes, and predominantly containing CaCl2. This research was conducted by testing the optimum cement content for each soil, to determine the shear strength according to the Indonesian standards (i.e., minimum UCS of 2400 kPa). The shear strength of the granitic and lateritic soils were deduced to be 5.5% and 5% on a dry weight basis, respectively. The utilization of 0.8% additive resulted in a 0.5% reduction of the optimum cement content of granite-like soil. The results showed that the optimum additive content, for granite soil was higher than those without supplement, while for the lateritic, no changes occurred. However, the advantage of using supplements was more pronounced in the samples when subjected to wetting-drying cycles. Also, at the highest additive level, the moisture content and soil-cement loss during wetting, is always smaller than those with no supplements.

Author's Reply to the Review Report (Reviewer 2)

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?e9a1de4761e1496f).

* Author's Notes to Reviewer

File Edit View Insert Format Tools Table Help

Paragraph

P 0 WORDS

Word / PDF Choose File No file chosen

Submit or Save as draft (submit later)

Review Report Form

Open Review

(x) I would not like to sign my review report
( ) I would like to sign my review report

English language and style

(x) Extensive editing of English language and style required
( ) Moderate English changes required
( ) English language and style are fine/minor spell check required
( ) I don't feel qualified to judge about the English language and style

	Yes	Can be improved	Must be improved	Not applicable
Does the introduction provide sufficient background and include all relevant references?	( )	( )	(x)	( )
Is the research design appropriate?	(x)	( )	( )	( )
Are the methods adequately described?	( )	(x)	( )	( )
Are the results clearly presented?	( )	( )	(x)	( )
Are the conclusions supported by the results?	( )	(x)	( )	( )

Comments and Suggestions for Authors

The English spelling and grammar in the paper need to be improved substantially. There are so many errors that is difficult to understand much of the paper. Other comments follow:

1. Introduction: The authors should refer to the authors of references when discussing the literature, rather than just the citation itself.
2. Introduction: The specific objective of the additive used in the paper is not clear. Is it expected to improve strength, reduce cost, improve wet/dry behavior? There is not a clear objective in the introduction.

3. Table 2 and 4: Why don't the XRF compositions include oxygen?
4. Line 138-179: These sections may be better in the results section.
5. Table 6: Please define all symbols in the table.
6. Line 230: "50 mm" Is there a typo in the unit?

Submission Date	11 February 2021
Date of this review	18 Feb 2021 06:20:45

Dear Editor and Reviewers,

Thank you for the fast response and comments concerning our manuscript entitled “The Role of Additives in Soil-Cement Subjected to Wetting-Drying Cycles”. These comments are all valuable and helpful for improving our manuscript.

According to the reviewers’ comments, we have tried our best to improve the manuscript to meet the journal's requirements. The responses to the reviewers are attached below.

Best regards, Y.F. Arifin

Reviewer’s general comment:

The English spelling and grammar in the paper need to be improved substantially. There are so many errors that is difficult to understand much of paper.

Author's response,

The English of the revised manuscript has been improved and check by a professional English editing. We do thank the reviewer for the valuable comment to improve the quality of the manuscript.

Reviewer’s comments point1:

The introduction is insufficient in terms of recent citations and appropriate to the theme. The application of soil-cement involves several characteristics that must be detailed, including works addressing the testing of wetting and drying cycles, I suggest reading and inserting the following works: The durability of soil-cement columns in high sulphate environments; Environmental Durability of Soil-Cement Block Incorporated with Ornamental Stone Waste; Engineering characteristics of compressed earth blocks stabilized with cement and fly ash; Durability of soil-Cement blocks with the incorporation of limestone residues from the processing of marble; Mechanical Properties and Durability of Deep Soil-Cement Column Reinforced by Jute and PVA Fiber; Soil-cement brick with cassava wastewater.

Author's response point1:

We do thank the reviewer for conscientious review. The introduction section has been modified as suggested by the reviewer in line 85-101. We have added five suggested references. Meanwhile, for one more reference we do not have access to the journal (i.e., Mechanical Properties and Durability of Deep Soil-Cement Column Reinforced by Jute and PVA Fiber). Also, the material used in the literature is fiber as we have not included it in this article.

Reviewer’s comments point 2:

The description of the materials is insufficient, the authors must redo the approach, including the description of the wetting and drying cycles.

Author's response point 2:

The description of the materials and the wetting-drying cycles has been added in the revised manuscript in line 129-133 and line 173-186, respectively, as suggested. We do thank the reviewer for the comment that improve the quality of the manuscript.

Reviewer's comments point 3:

The authors indicate a series of soil characterization results in the methodology section, I suggest switching to the results section, if these are results obtained by the authors

Author's response point 3:

We agree the suggestion of the reviewer, the sections of line 138-179 (the original manuscript) have been moved in the results section as shown on the revised manuscript in line 201-219.

Reviewer's comments point 4:

The conclusion is insufficient and does not adequately support the possible results and concussions, a total reformulation is necessary

Author's response point 4:

The conclusion has been reformulated based on the main research finding in line 410-425. We are grateful for the comments from the reviewer.

Dear Editor and Reviewers,

Thank you for the fast response and comments concerning our manuscript entitled “The Role of Additives in Soil-Cement Subjected to Wetting-Drying Cycles”. These comments are all valuable and helpful for improving our manuscript.

According to the reviewers’ comments, we have tried our best to improve the manuscript to meet the journal's requirements. The responses to the reviewers are attached below.

Best regards, Y.F. Arifin

Reviewer’s comments point1:

Introduction: The authors should refer to the authors of references when discussing the literature, rather than just the citation itself.

Author's response point1:

We do thank the reviewer for conscientious review. We already rewrite introduction in line 32-45. Furthermore, we also add more references regarding the effect of wetting-drying cycles on the soil-cement mixture in line 85-101.

Reviewer’s comments point 2:

Introduction: The specific objective of the additive used in the paper is not clear. Is it expected to improve strength, reduce cost, improve wet/dry behavior? There is not a clear objective in the introduction.

Author's response point 2:

The objective in introduction has been revised. The additive was proposed to improve the wet/dry behavior. The sentences have been modified in the revised manuscript in line 102-115.

Reviewer’s comments point 3:

Table 2 and 4: Why don't the XRF compositions include oxygen?

Author's response point 3:

As rightfully stated by the reviewer, the XRF should be possible to include the detection of oxygen element; however, here the light element of oxygen could not be detected in the analysis due to the limitation of XRF equipment's type. We do apologize for this equipment's limitation and thank the reviewer for the remarkable comment.

Reviewer’s comments point 4:

Line 138-179: These sections may be better in the results section.

Author's response point 4:

We agree the reviewer for the suggestion. The sentences have been moved in the section of results in line 201-219.

Reviewer’s comments point 5:

Table 6: Please define all symbols in the table.

Author's response point 5:

The symbols have been defined now in Table 6 in the revised manuscript. The description is also mentioned in line 186-194. This addition is consistent with all symbols used in the text.

Reviewer’s comments point 6:

Line 230: "50 mm" Is there a typo in the unit?

Author's response point 6:

As rightfully stated by the reviewer, there is typo in the unit that should be 50 µm (micro meter). The revised unit can be found in lines 267 and 331. We do thank the reviewer for the correction.

infrastructures

MDPI

Article

The Role of Additives in Soil-Cement Subjected to Wetting-Drying Cycles

Yulian Firmana Arifin [1,*], Eka Agustina [2] , Fransius Andhi [2] and Setianto Samingan Agus [3]

[1] Civil Engineering Study Program, University of Lambung Mangkurat, Jl. A. Yani km 35 Banjarbaru 70714, Indonesia; y.arifin@ulm.ac.id
[2] Public Works, Spatial Planning, and Transportation Office, Katingan Regency, Jl. Katamso/Jl. A.H. Nasution, Kasongan, Indonesia; eagustina17875@gmail.com, andhi.bzp@gmail.com
[3] Mott MacDonald Pte. Ltd., Singapore; samingan.agus@mottmac.com
* Correspondence: y.arifin@ulm.ac.id; Tel.: +625114773858

Abstract: This study aimed to explore the use of additives in soil-cement mixtures that have undergone a drying-wetting cycle. Two types of soil used included granitic and lateritic, which are widely used in road base construction in Katingan area, Central Kalimantan, Indonesia. The cement used was the ordinary Portland type I, while the additive utilized was for commercial purposes, and predominantly contained $CaCl_2$. This research was conducted by testing the optimum cement content for each soil to determine the shear strength according to the Indonesian standards (i.e., minimum UCS of 2400 kPa). The optimum cement content of the granitic and lateritic soils were deduced to be 5.5% and 5% on a dry weight basis, respectively. The utilization of 0.8% additive resulted in a 0.5% reduction of the optimum cement content of granite-like soil. The results showed that the optimum additive content for granite soil was higher than that of without supplement, while for the lateritic, no changes occurred. The advantage of using supplements, however, was more pronounced in the samples when subjected to wetting-drying cycles. Also, at the optimum additive level, the moisture content and soil-cement loss during wetting, was always lower than those without supplements.

Keywords: lateritic soil, granitic soil, additive, soil stabilization, soil-cement

Citation: Lastname, F.; Lastname, F.; Lastname, F. Title. *Infrastructures* **2021**, *6*, x. https://doi.org/10.3390/xxxxx

Academic Editor: Firstname Lastname
Received: date
Accepted: date
Published: date

1. Introduction

Central Kalimantan is a province in Indonesia, which is famous for its vast swampy areas; thus, it is difficult to source granular material for road foundation. Therefore, soil-cement base is mostly used as an alternative.

The reliability and performance of this mixture have been widely studied [1–12]. Sunitsakul et al. [1] reported that the shear strength of a mixture is strongly affected by the water-cement ratio and independent of its dry density. However, the dry density of the compacted mix shall be higher than 95% of the maximum dry density of the modified Proctor compaction as one of the criteria for the road base application [1]. Moreover, the percentage of cement is directly proportional to the shear strength of the soil-cement base [2,7,13]. This is because, with the increase in cement, the amount of calcium silicate hydrate (C-S-H), calcium aluminum hydrate (C-A-H), and calcium hydroxide ($Ca(OH)_2$) produced by the mixture's reaction also rises [4,11]. Also, a soil-cement shear strength increases with higher curing time [2,3,5,7,11]. Da et al. [2] reported that a mixture soaked in a higher pH groundwater produced greater strength than those immersed in distilled water. This corresponds with the increase in sample pH with an higher percentage of cement [5]. It can be concluded that the ability to resist stress by the mix is influenced by several factors, such as water-cement ratio, density, curing time, salt content in the soil, and environmental conditions, namely water and pH.

Furthermore, the addition of cement also improves the compaction behavior of a mixture in the case of fine-grained soils [7]. The compression index decreases, and the coefficient of consolidation increases with higher cement content. It has also been found that the soil pores become smaller, and the structure behaves more robustly with it thus increasing percentage [7]. The presence of Mg^{2+}, SO_4^{2+}, and Cl^- ions are discovered in soils with high salt content [11], which resulted in the reduction of calcium silicate hydrate (C-S-H) and aluminum hydrate (C-A-H) bonds. Consequently, the strength of soil-cement mixture also reduced. Besides its application in road construction, this mixture is also used for other purposes, such as grouting and foundation [6,9].

To improve the strength attainment, soil and cement are normally mixed with some additional components, which are either solid or liquid from natural or artificial ingredients. This addition always leads the physical or chemical changes in the mixture. The use of additives to increase the shear strength of soil-cement mixture started in the late 1950s, where the researcher [14] used 29 additives, such as dispersants, synthetic resins, waterproofing agents, salts, and alkalis. The addition of 0.5-1.0% supplements, such as sodium carbonate, sodium hydroxide, sodium sulfate, and potassium permanganate significantly increased the soil-cement shear strength by 150% [14]. However, adding more substance beyond this did not result in a significant improvement, and partly resulted in strength reduction, as seen in a case, where potassium hydroxide, calcium chloride, and sodium chloride were used.

Using different types of additives, such as acid, enzymatic solution, and calcium lignosulfonate, Blanck et al. [15] obtained some distinct results of compaction, UCS, swelling, permeability, and surface tension tests for various concentrations. At high proportions of calcium lignosulfonate, the shear strength of the soil-cement mix was lower than that of at low concentrations. Lime and rice husk ash were also used as additives to increase soil's resistant level. Lin et al. [16] added nano-silicon dioxide to the sewage sludge ash-cement mixture to improve its plasticity, shear strength, compression, swelling, and permeability behavior. Adding 2% of this compound to samples at the optimum moisture content produced the highest compressive strength. Aryal et al. [17] used polypropylene fiber to improve the performance of a mix in terms of its wetting-drying and freezing-thawing behavior. It was found out that the soil with 10% cement and 0.5% fiber was able to withstand wetting-drying up to 12 cycles based on its percentage loss. Organic fiber such as jute was also used to increase ductility [18]. Garbage, i.e., ceramic waste and marble dust were combined with little amount of cement (i.e., 2%) to produce a sub-base material for rural and highway [19]. For different purposes, superplasticizers additives were also used to improve the mixture's performance in grouting work to increase soil injectability and shear strength [20]. It was observed that the mix exhibited a different behavior dependent upon the soil type, additive and its percentage. Therefore, the soil-cement mix and the supplements were first tested according to its conditions and designation [14].

A number of researchers have studied the durability of soil-cement mixtures with additives subjected to wetting-drying cycles [21–24]. França et al. [23] observed the addition of 30% limestone to the soil-cement mixture reduced water absorption and increased its compressive strength. Calcite and gibbsite-rich limestone have also been used in the granite waste-cement mixture. As a result, the sample's strength of 60% waste with 5% limestone met the requirements after experiencing wetting-drying cycles for 90 days [21]. De Souza and Lucena [24] replaced water with cassava wastewater, containing calcium and potassium predominantly in making brick soil-cement. After seven days of wetting-drying cycles, the strength, water absorption, and loss of mass of the sample met the established criteria. These results demonstrated the successful use of additives rich in calcium on soil-cement affected by wetting-drying cycles. The importance of the calcium content in the soil-cement mixture was also reported by Van Ngoc et al. [25]. Deep and rapid damage to soil-cement due to calcium leaching was found in samples submerged in high seawater concentrations [25]. Apart from calcium, the fly ash that contains much silica was also announced to reduce mass loss due to wetting-drying processes with a sample retention strength of 51-88% [22]. However, generally, the mixtures are used for brick. In this case, brushing was not carried out in the wetting-drying test [24].

This article discusses about the reliability of two types of soil, which are predominantly granular material (i.e., granitic and lateritic soils), that have been mixed with cement and commercial additives with respect to their behavior in wetting-drying cycles. These two were chosen because they are widely available in Katingan where it is not easy to find materials that meet the road base requirements. The most common method is to use a soil-cement mixture from the local soil. This method is more affordable than ordering selected materials from other regions. However, it is often encountered in the location, i.e., the high rainfall and tides, causing the road to be submerged in several places. Therefore, the soil-cement base was degraded, as shown on the Tumbang Lahang-Tumbang Samba-Tumbang Kaman road section, Katingan Regency, Central Kalimantan (Figure 1 (a). it was in contrasts with the soil-cement conditions that were not submerged, as shown in Figure 1 (b). This study aimed to find a solution to the problem by mixing an additive rich in calcium into the soil-cement. It is expected to improve the soil-cement mixture's performance against drying-wetting cycles, as shown by the reduced water absorption and loss of mass.

(a) **(b)**

Figure 1. The appearance of soil-cement as a base (a) undergo wetting-drying cycles, and (b) non submerged road

2. Materials and Methods

2.1. Materials

One of the materials used was a granitic soil taken from Hampalit, Katingan Hilir, in Central Kalimantan. The deposits at the location are shown in Figure 2. Another material was a lateritic soil from Tumbang Kaman, about 100km to the North of the district capital of Katingan, Kasongan, Central Kalimantan. This soil is a type used in the road application as shown in Figure 1. The basic and engineering properties of the two soils are summarized in Table 1. The two samples almost had the same composition, which predominantly was sand. Both were classified as silty sand (SM) under the USCS classification system [26]. The chemical composition of the granitic and lateritic soils used were determined using X-ray fluorescence (XRF) tests as summarized in Table 2. Although the two samples were classified into the same soil type, the chemical composition of the soil was different. The lateritic soil predominantly contained Si and Fe, while the granitic majorly comprised Si and Ti. The presence of Si can increase the soil cement's strength by forming C-S-H in the mixture [27].

The type used in the study was an ordinary Portland cement type I with a specific gravity of 3.15. Using the X-ray fluorescence (XRF) test, its chemical contents, as summarized in Table 3, were obtained. The results were compatible with the Portland cement content, which consists of major oxides (i.e., CaO, SiO_2, Al_2O_3, and Fe_2O_3) and minor oxides (i.e., MgO, SO_3, and some alkali oxides (K_2O and Na_2O)) [28].

Table 1. Engineering properties of soils.

Properties	Granitic	Lateritic
Specific gravity	2.64	2.64
Water content (%)	2.4	4.3
Gravel (%)	0.00	1.19
Sand (%)	77.76	69.46
Silt (%)	7.74	0.9
Clay (%)	14.5	28.56
Liquid limit (%)	-	28.59
Plastic limit (%)	-	22.74
Plasticity Index (%)	-	5.85
Soil Classification (USCS)	Silty sand	Silty sand
Unconfined compression strength (c_u) (kN/m^2)	-	26.8
Maximum dry density (kN/m^3)[1]	16.33	17.73
Optimum moisture content (%)[1]	12.5	14.3

[1] Modified Proctor compaction test.

Table 2. Chemical composition of soils.

Composition	Granitic [1]	Lateritic [1]
Al	1.77	15
Si	83.12	29
Ca	0.02	0.89
Ti	10.75	2.28
Fe	1.18	46.3
Ni	0.00	3.93

[1] obtained from the X-ray Fluorescence test (XRF)

Table 3. Chemical composition of cement used.

Compounds	Percentage [1]
CaO	67.28
SiO_2	18.68
Al_2O_3	4.30
Fe_2O_3	4.54
MgO	1.10
Alkali ($K_2O + Na_2O$)	1.71
SO_3	1.28

[1] obtained from the X-ray Fluorescence test (XRF)

Figure 2. Granitic soil deposits in Hampalit village, Central Kalimantan

The additive used was a commercial type, which was in the form of powder with chemical contents shown in Table 4, mainly including chlorine (Cl), calcium (Ca), and potassium (K).

Table 4. Chemical composition of additive used.

Compositions	Percentage [1]
Cl	55.7
K	4.47
Ca	37.6
Fe	0.18
Ni	0.964
Cu	0.092

[1] obtained from the X-ray Fluorescence test (XRF).

2.2. Methods and Procedures

Each soil density was achieved by compacting the samples by following the Modified Proctor Standard to obtain its optimum moisture content of the lateritic and granitic samples at 14.3% and 12.5% respectively with a maximum dry density of 17.73 kN/m3 and 16.33 kN/m3, respectively, as shown in Table 1.

Unconfined compression strength (UCS) was carried out on each sample at its optimum moisture content and maximum dry density with various cement percentages of 4%, 4.5%, 5%, 5.5%, and 6% on a dry weight basis based on SNI03-6887-2002 [29], which was similar to ASTM D-1633-2000 [30]. This test is commonly used to determine the effect of cement on the soil [1–3][5–8][10][11][14–16][18].

Based on the Indonesian standard (SNI03-3438 1994) [31], the optimum cement content is at UCS of 2200 kPa. However, following the latest and more specific standard, the general specification of the highway of the country, is considered to be at UCS of 2000-2400kPa [32]. It should be noted that the required soil shear strength for road application differs from a country to another country. Antunes et al. [5] compared the strength required by several countries. Table 5 shows the required mechanical specifications compared to those used in Indonesia; however, in this study, the maximum value was used (i.e., 2400 kPa).

Table 5. Laboratory UCS required for soil-cement mixture.

Layer	U.S. Army Corps for Engineer*)	German[5]	Portuguese[5]	Southern African[5]	Indonesia [31]	Indonesia [32]
Base	≥ 5.17 MPa for 7 days curing time	≥7.0 MPa for 28 days curing time	Non-specified	1.5≤UCS≤3.0 MPa for 7 days curing time	2.2 MPa for 7 days curing time	2.0≤UCS≤2.4 MPa for 7 days curing time
Sub base Layer	≥ 1.72 MPa for 7 days curing time	≥ 0.5 MPa for 28 days curing time	0.8≤UCS≤1.0 MPa for 28 days curing time	0.75≤UCS≤1.5 MPa for 7 days curing time	0.6 MPa for 7 days curing time	Non-specified

The wetting-drying test was carried out based on the Indonesian standard (SNI 6427 2012) [33]. The soil material passing a No. 4 (4.75-mm) Sieve was used. Two samples were used in the wetting-drying test. One was used for any changes in absorption (i.e., Specimen No. 1), and the other was for soil loss (i.e., Specimen No. 2). After compaction, the samples were stored in a humid place and protected from free water for seven days. Specimen No. 1 was weighed and measured in dimensions after storage at the end of day 7. Then, the samples were immersed in water at room temperature for 5 hours. Specimen No. 1 was then again weighed and measured. Both specimens were placed in an oven at

71°C for 42 hours. Then, sample No. 1 was weighed and measured in its dimensions. For Sample No. 2, two firm strokes were given on all areas with the wire scratch brush. It took approximately 18-20 vertical firm strokes to cover the specimen's sides twice and four strokes on each end. Then, the weight was weighed. Both samples were re-immersed, and the same procedure was continued for 12 cycles. At the end of the cycle, the samples were placed in an oven at 110°C for 24 hours to determine the dry weight. This method is similar to ASTM standards [34]. After 12 cycles, UCS tests were performed to obtain the residual shear strength of each sample. Table 6 presents the summary of the initial conditions of the tested samples. GC and LC refer to granitic and lateritic soils, respectively. The next two numbers indicate the cement and additive content. An additional denotation is given at the end of the sample numbering in Table 6, namely "1" for the volume and moisture change measurements, and "2" is for the soil-cement loss measurement.

Table 6. Initial condition of wetting-drying samples.

Soil	Sample Code	γ_d	w (%)	Cement (%)	Additive (%)
Granitic	GC-5-0-1	16.33	12.5	5	0
Granitic	GC-5-0-2	16.33	12.5	5	0
Granitic	GC-5-0.8-1	16.33	12.5	5	0.8
Granitic	GC-5-0.8-2	16.33	12.5	5	0.8
Lateritic	LC-5-0-1	17.73	14.3	5	0
Lateritic	LC-5-0-2	17.73	14.3	5	0
Lateritic	LC-5-2-1	17.73	14.3	5	2.0
Lateritic	LC-5-2-2	17.73	14.3	5	2.0
Lateritic	LC-5-5-1	17.73	14.3	5	5.0
Lateritic	LC-5-5-2	17.73	14.3	5	5.0
Lateritic	LC-5-9-1	17.73	14.3	5	9.0
Lateritic	LC-5-9-2	17.73	14.3	5	9.0
Lateritic	LC-5-14-1	17.73	14.3	5	14.0
Lateritic	LC-5-14-2	17.73	14.3	5	14.0

Two tests were carried out to determine the microscopic samples and chemical components before and after mixing with additives and the wetting-drying processes. The two tests were field-emission scanning electron microscopy (FESEM) and energy-dispersive X-ray spectroscopy (EDAX). Other researchers investigating the soil-cement mix also used these two methods.

3. Results

3.1. Optimum Additive and Soil-Cement Content

Figure 3 shows the results of the UCS granitic and lateritic soils. This graph shows that the optimum cement content for both was 5.5% and 5.0%, respectively.

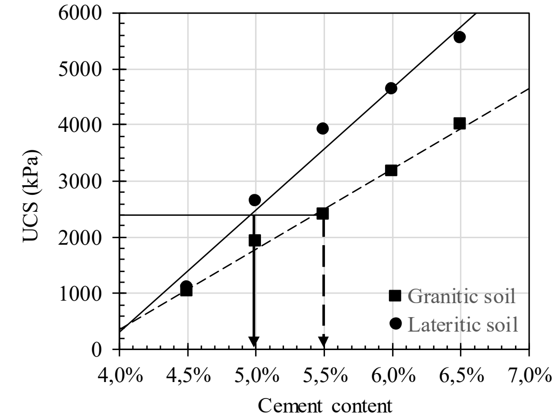


Figure 3. Optimum cement content determination.

The additive content in the mixtures was determined using a trial test by mixing an added component with varying concentrations from 2% to 14% of the soil-cement sample. In the determination of cement content, the optimum additive also known as its percentage produced the sample's UCS of 2400 kPa. Its variation with the additive content is shown in Figures 4 (a) and 4 (b) for the granitic and lateritic soils, respectively. For the granitic soil, lower cement contents (i.e., 4.5% and 5%) with the addition of the same percentage of supplements were assessed. It was found that its UCS was still below 2400 kPa. As shown in Figure 4 (a), the optimum additive content was 0.8% and 6% for 5% cement content. The lower additive content (i.e. 0.8%) was selected and used for further blending. However, for the lateritic soil (Figure 4 (b), 2% of the percentage addition of the additive was chosen because it gave the required strength (2400kPa). Although the UCS was almost the same as soil-cement mix without additives, its effect on the wetting-drying cycles was easily discernible.

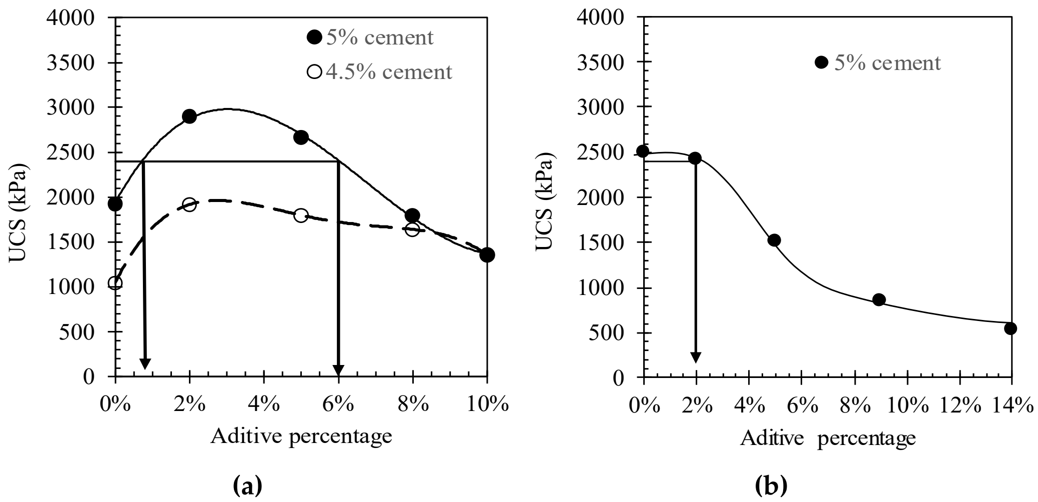
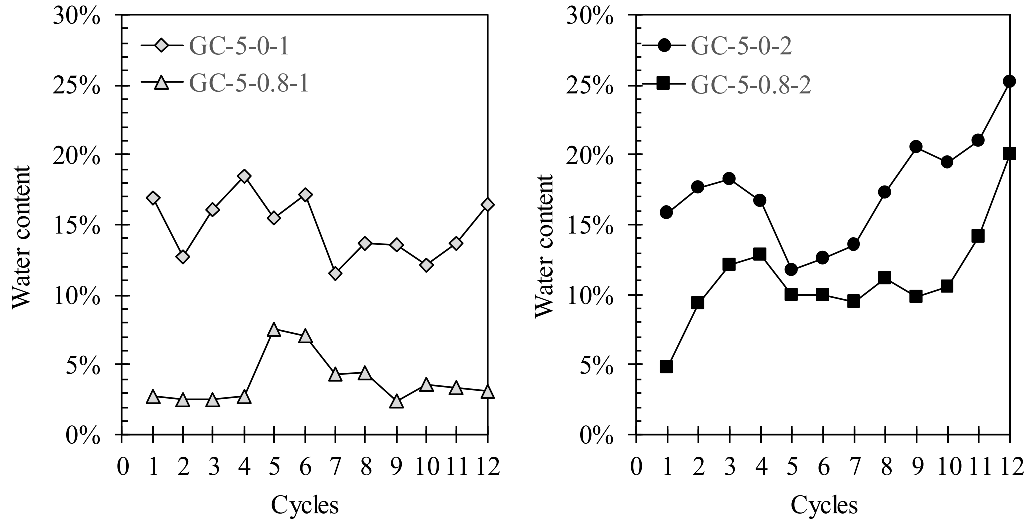


Figure 4. Determination of additives percentage in the mixture (a) granite soil, and (b) lateritic soil.

3.2. Granitic Soil

Figure 5 shows the change in water content during the 12 cycles of the wetting-drying process for the granitic soil. As shown in Figure 5 (a), the moisture content of the soil-cement sample after wetting varied with an average of 3.9% for the samples mixed with 0.8% additive, and 14.8% for the samples without it. The addition of 0.8% supplement reduced the amount of water absorbed by the sample 3.8 times. Meanwhile, for the brushed samples (Figure 5 (b), the water increased with high number of the wetting-drying cycles, which was observed after the 6th cycle. The sample's water content without additive increased from 16% in the first cycle to 25% in the 12th cycle (or equal to an increase of 1.6 folds). Moreover, with supplement it also increased from 4.8% to 20% (or about 4.2 times). Nevertheless, samples' water content with additive was still lower than those without.

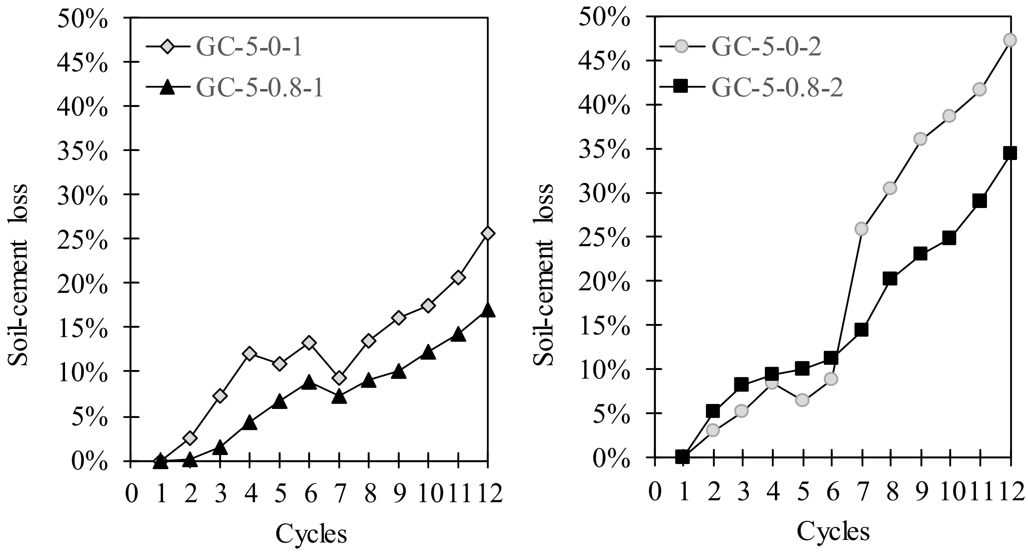


(a) **(b)**

Figure 5. Water content alteration throughout the wetting-drying cycles (a) volume and moisture change specimens, and (b) soil-cement loss specimens.

One of the important conclusions on the soil-cement samples that have undergone the wetting-drying processes is with respect to the soil-cement loss, which is defined as the ratio of original calculated sample's oven-dried weight minus its final corrected (ASTM D559 1996) [34]. Simply, it is the dry unit weight of the sample per cycle divided by the initial dry density of the sample. In this paper, the soil-cement loss was shown not only in the brushed samples but also when being soaked (i.e., volume and moisture change specifications). Figure 6 shows the results where (a) shows that for the soil-cement samples without additive, the mixture started losing weight in the second cycle, while those with supplement in the third cycle. At the end of test (i.e. in the 12th cycle, the soil-cement sample without additive exhibited weight loss of 25% and 17%. The loss for the samples with supplement was 8% less than those without. This was more significant in the sample that was intended for the investigation (Figure 6 (b). The soil-cement loss commenced from the second cycle and increased until the last phase. At the end of the test, the soil-cement loss of the samples without additive was 47% or 14% greater than those with supplement (i.e., 34%). The addition of this substances reduced the soil-cement loss due to the wetting-drying cycles.

Upon completion of these cycles, the samples were tested for their strength (UCS). Sample GC-5-0-2 was not examined for being broken before testing. Figure 7 depicts the results of the UCS tests on these specimens. Before the wetting-drying cycles, the samples with additives (GC-5-0.8) had UCS of 2400 kPa and after the process, it dropped to 1049 kPa for Sample 1 (i.e., for volume and moisture change measurement) and 678 kPa for 2 (i.e., the specimen for the soil-cement loss measurement). The smallest UCS was observed in the sample without additive (i.e., 441 kPa). It could be concluded that the wetting-drying process also decreased the strength of the mixture. Those with the additives were twice as stronger than those without at the end of the cycles.



(a) **(b)**

Figure 6. Soil-cement loss throughout the wetting-drying cycles (a) volume and moisture change specimens, and (b) soil-cement loss specimens.

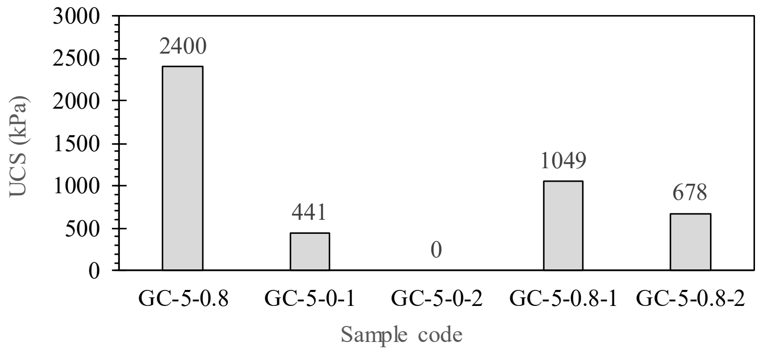
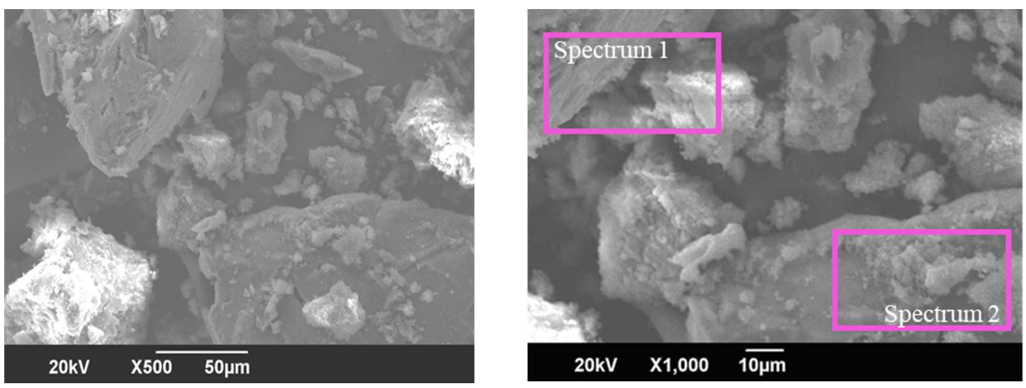


Figure 7. Unconfined compression strength of granitic-cement samples.

Figures 8-10 shows the SEM results of the granitic soil samples (Figure 8), the granitic-cement mix specimen (Figure 9), and the soil-cement mix with 0.8% additive (Figure 10). It was clearly observed in Figures 8(a) and 8(b) that the granitic soil consisted of sand grains and silt particles with irregular shapes and varying sizes, which were even smaller than 50μm. Also, the grains did not appear to bind to one another.



(a) **(b)**

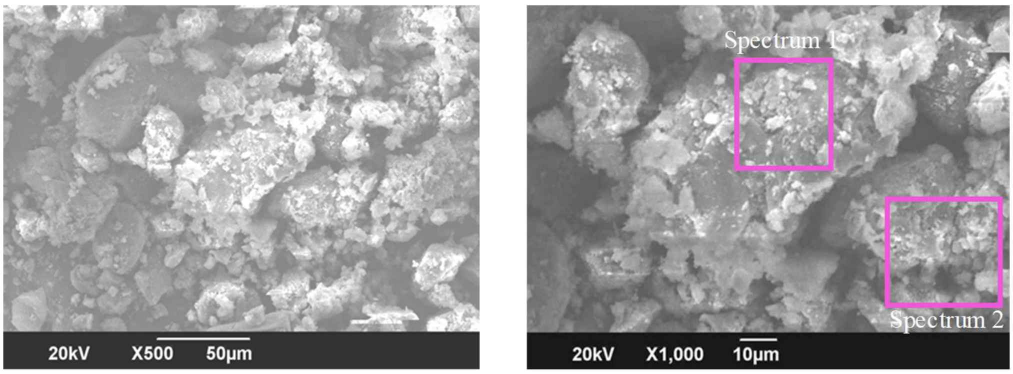
Figure 8. SEM Pictures of granitic soil (a) 500× magnification, and (b) 1000× magnification.

Table 7 presents the average chemical contents of this type of soil extracted with EDX in Spectrum 1 and 2 (Figure 8) showed the dominance of Si and Ti, which confirmed the chemical content results from XRF as shown in Table 2. The addition of cement was observed to produce bonding between the grains, and more compact and smaller pores, as shown in Figure 9. The presence of cement, rich in CaO was observed from the increase in Ca element at the area where the EDX test was carried out (Figure 9), and the results are shown in Table 7. The Ca content increased to 6.64% that was not previously found in the granitic soil.

Table 7. Initial condition of wetting-drying samples.

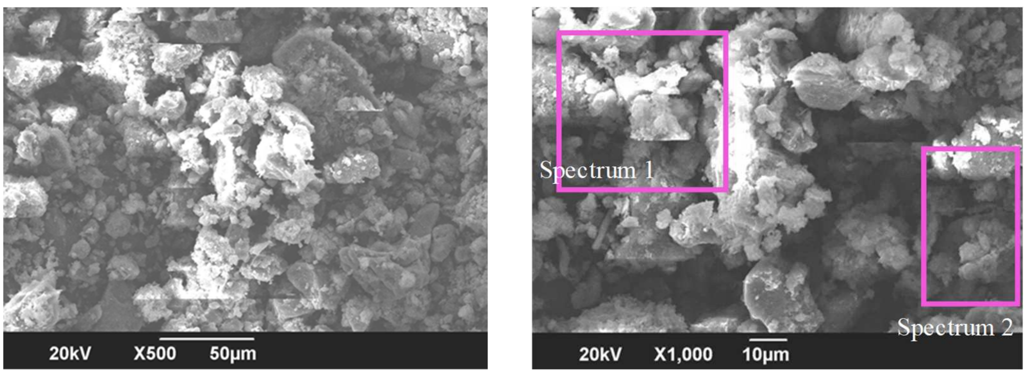
Element	Granitic Soil (Figure 8)	GC-5-0-1 (Figure 9)	GC-5-0.8-1 (Figure 10)
Si (%)	91.95	88.82	77.06
Al (%)	1.93	1.28	6.39
Ca (%)	0.095	6.64	15.2
Ti (%)	6.73	1.41	1.69

The addition of 0.8% additive resulted in more compact clusters with smaller visible pores as shown in Figures 10 (a) and 10 (b). In Table 7, the Ca content increased to 15.2% due to high content of $CaCl_2$ in the supplement. The presence of this chemical also increased Ti content due to the reduced mobilization of Ti in the soil by $CaCl_2$ [35,36].



(a) **(b)**

Figure 9. SEM Pictures of GC-5-0-1 sample (a) 500× magnification, and (b) 1000× magnification.



(a) **(b)**

Figure 10. SEM Pictures of GC-5-0.8-1 sample (a) 500× magnification, and (b) 1000×.

Other elements appeared to have little effects; therefore, the influence of additive was not easily recognizable on the different samples' chemical elements taken in Spectrums 1 and 2 (Figure 10). However, the average Ca content increased in the specimen, and the SEM results clearly showed differences in the physical conditions in the samples with additive.

3.3. Lateritic Soil

Figures 11(a) and 11(b) show the moisture content of the lateritic-cement samples that were subjected to wetting-drying cycles for volume and moisture changes, and soil-cement loss specimens, respectively. The LC-5-14-1 sample (i.e., that with 14% additive) was not tested after the second cycle because it collapsed. Meanwhile, the average water content of the samples LC-5-0-1, LC-5-2-1, LC-5-5-1, and LC-5-9-1 were 9.9%, 2.8%, 9.8%, and 10.5%, respectively. Specimens with 2% additive showed the smallest moisture content. However, for brushed samples, the volume varied but did not increase. This is different from the ones in the granitic-cement sample, which increased after wetting-drying cycles. The average moisture content of the sample was 11.7%, 5.7%, 12.1%, and 12.9% for LC-5-0-2, LC-5-2-2, LC-5-5-2, and LC-5-9-2 respectively. Meanwhile, the water content of the LC-5-14-2 sample was not tested because it collapsed after the second cycle.

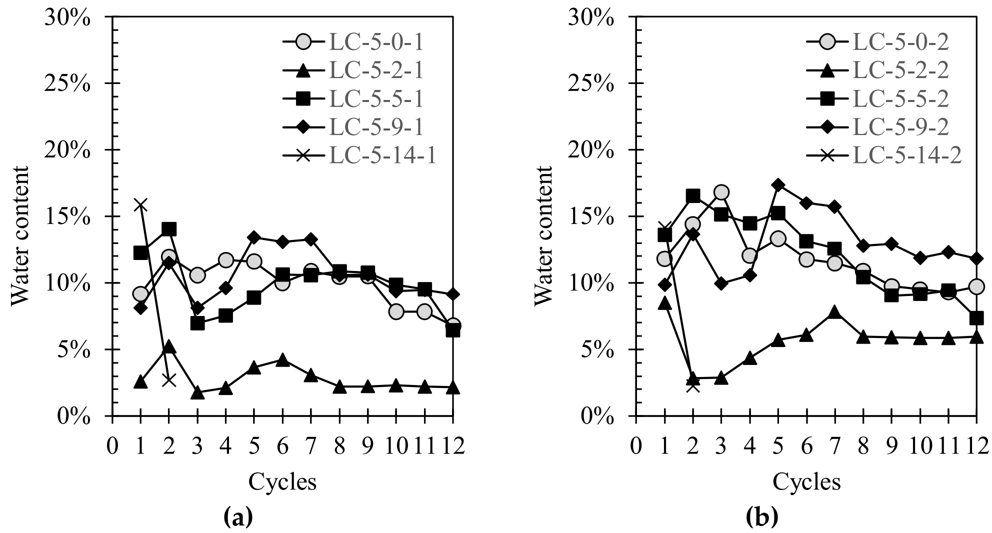
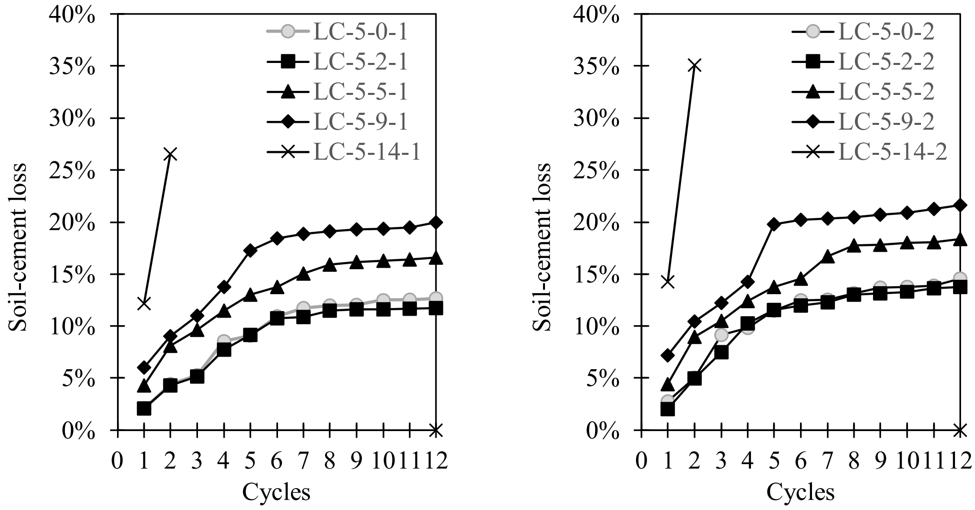


Figure 11. Water content alteration throughout the wetting-drying cycles (a) volume and moisture change specimens, and (b) soil-cement loss specimens.

Figures 12(a) and 12(b) show a soil-cement loss for volume and moisture change specimens. As observed in Figure 12(a), the increase in property started from the first cycle to the fifth. Moreover, the sample tended not to lose weight. At the end of the cycle, the soil-cement loss samples LC-5-0-2-1, LC-5-2-1, LC-5-5-1, and LC-5-9-1 were 12.6%, 11.7%, 16.6, and 20%, respectively. Similar behavior was observed in specimens where the sample lost significant weight started from cycle 1 to 5. After this, the increase in sample tonnage loss was not that great. At the end of the wetting-drying cycles, the soil-cement loss samples LC-5-0-2, LC-5-2-2, LC-5-5-2, and LC-5-9-2 were 14.5%, 13.7%, 18.4%, and 21.6%, respectively. These results indicated that the sample experiencing the least weight loss was that with the addition of 2% additive (i.e., LC-5-2) for both tests, as shown in Figure 13. The addition of more than 2% supplement resulted in an increase in soil-cement loss.



(a) **(b)**

Figure 12. Soil-cement loss throughout the wetting-drying cycles (a) volume and moisture change specimens, and (b) soil-cement loss specimens.

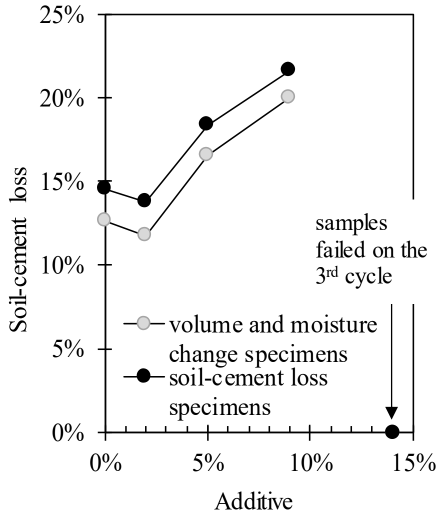


Figure 13. Soil-cement loss as a function of additive content of lateritic soil

After the wetting-drying test, the samples were examined using UCS, and as shown in Figure 14, the results were compared with UCS specimens before the wetting-drying test. As observed in Figure 14, this process did not significantly affect the sample UCS either with or without additives. There was no discernible difference between the two. Moreover, the higher the percentage of the additive, the lower the UCS value. These results indicated that the addition of supplements does not always result in a positive trend. Investigations needed to be carried out for each type of soil and additives used. Moreover, these results were in accordance with previous findings reported by those literature [3,14].

Figure 15 shows SEM photos of samples of lateritic soil (Figure 15 (a), soil-cement (Figure 15 (b), and soil-cement-additive mixtures (Figure 15 (c) -15 (f). Figure 15 (a) shows compacted lateritic soil grains with large pores. The granular size varies even less than 50μm. The chemical content test was carried out with EDX on Spectrum 1 with the composition shown in Table 8. In the sample, Al, Si, and Fe were the dominant elements according to the XRF test (Table 2). After adding cement, the specimen was observed to be denser with closed pores, as shown in Figure 15(b). Like the granitic soil sample, cement added to the quantity of Ca, which increased from 0.21% to 4.11% in the EDX test results (Table 8).

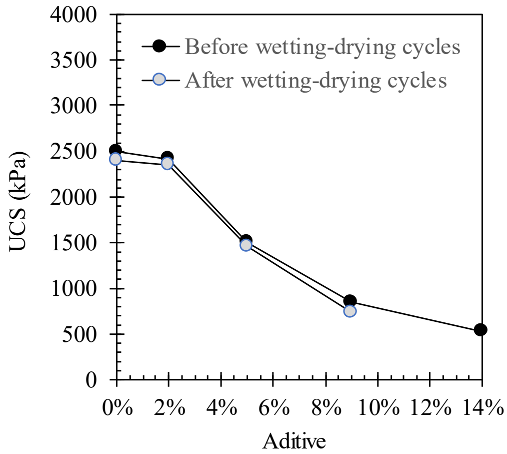
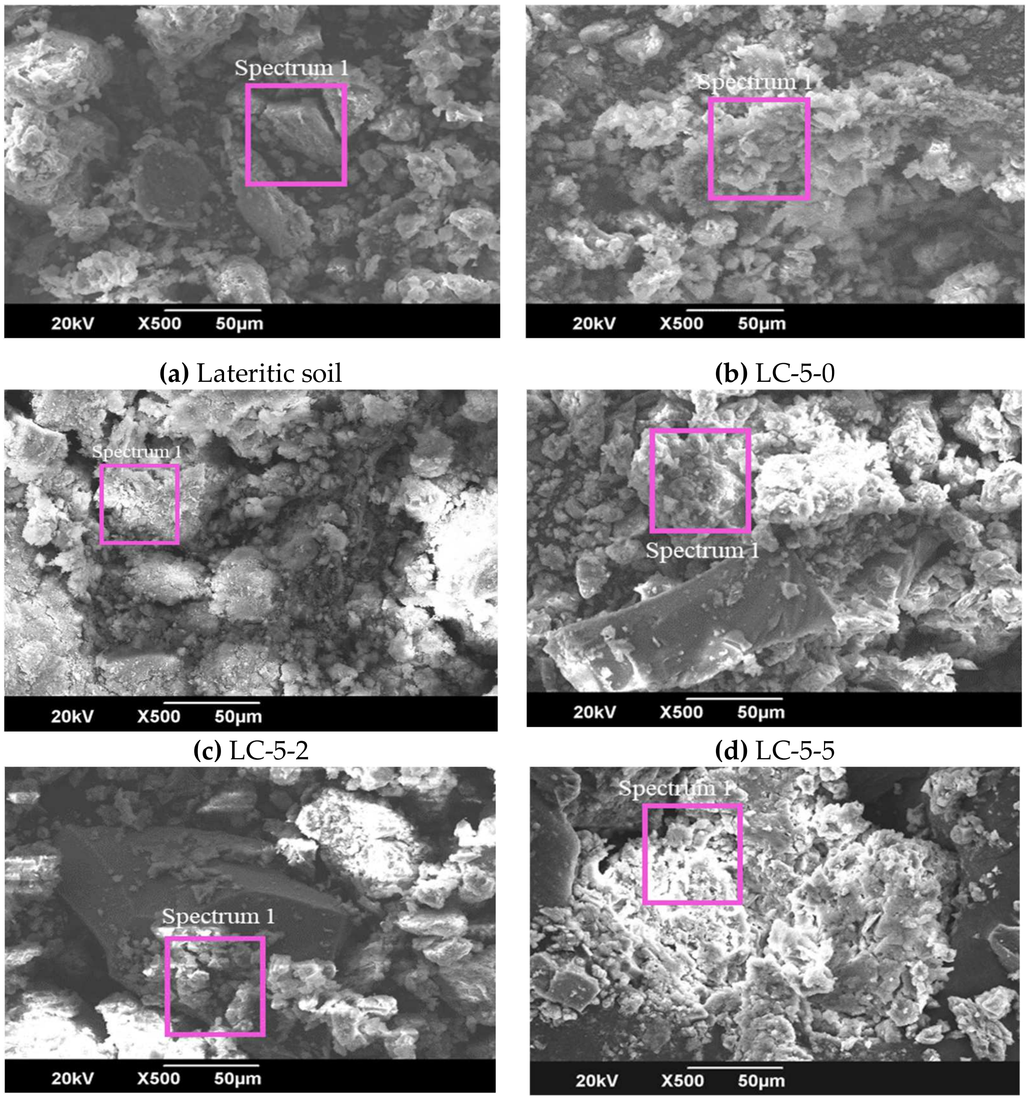


Figure 14. UCS as a function additive content before and after wetting-drying cycles of lateritic soil



(a) Lateritic soil **(b)** LC-5-0

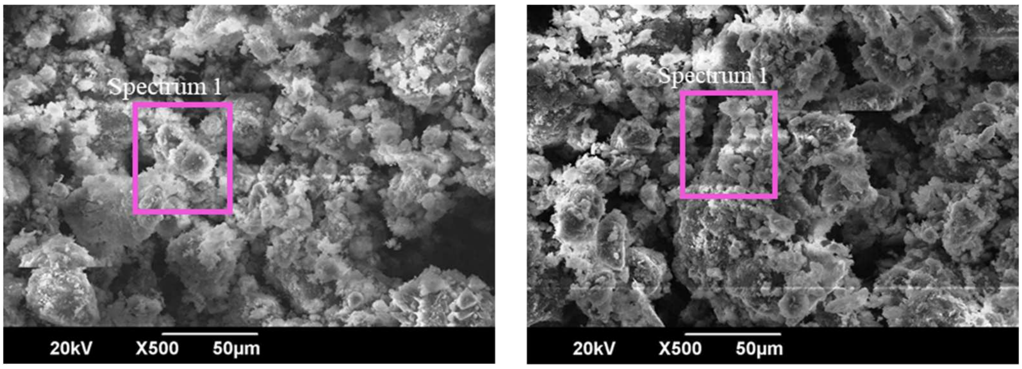
(c) LC-5-2 **(d)** LC-5-5

(e) LC-5-9 **(f)** LC-5-14

Figure 15. SEM photos samples lateritic-cement-additive before wetting-drying cycles

The addition of 2% additive resulted in a denser sample with a yet smaller pores. The soil grains were also invisible in this condition (Figure 15 (c). However, excessive supplements caused the cement clusters to reappear; the pores were also clearly visible (Figure 15 (d) -15 (f). The bond between cement and soil grains were no longer visible at the additive percentage of 9% and 14% (Figures 15 (e) and 15 (f). From the EDX results (Table 8), it was observed that the addition of 2% additives resulted in an increase in Ca, reduction in the Fe, and unchanged content of Si and Al. The addition of Ca, which was supposed to increase the shear strength of the sample, did not occur because of the Fe content reduction. Goldberg [37] reported that iron oxide in clays has a beneficial effect on soil physical properties, increases its stability and dispersion. Reduced iron oxide content resulted in reduced soil shear strength [38]. When the additive was more than 2%, this resulted in a significant increase in Ca, with the Fe content not much changing, while Si and Al decreased. Although, iron oxide, aluminum oxide content stabilizes clay soils by decreasing clay dispersion, water uptake, and increasing micro-aggregation [37], Fe, Al, and Si's reduced content resulted in reduced soil shear strength [38]. Therefore, it was concluded that additives with high $CaCl_2$ content are not suitable for stabilizing lateritic soils with high Fe content.

Figure 16 shows SEM photos of samples LC-5-0-1 and LC-5-2-1 after the wetting-drying process. It was observed that the two samples showed almost the same conditions where the cement clusters with small pores were visible. The two specimens' chemical content showed that the Al content was slightly increased, and Si remained constant after wetting-drying cycles (Table 8). Meanwhile, the Ca quantity increased due to reduced Fe content in the soil.



(a) LC-5-0-1 After wetting-drying cycles **(b)** LC-5-2-1 After wetting-drying cycles

Figure 16. SEM photos samples lateritic-cement-additive after wetting-drying cycles.

Table 8. Chemical elements lateritic-cement-additive mixtures.

Element	**Before wetting-drying process**						**After wetting-drying**	
	Lateritic Figure 15(a)	LC-5-0 Figure 15(b)	LC-5-2 Figure 15(c)	LC-5-5 Figure 15(d)	LC-5-9 Figure 15(e)	LC-5-14 Figure 15(f)	LC-5-0-1 Figure 16(a)	LC-5-2-1 Figure 16(b)
Al (%)	31.37	30.48	34.41	28.16	30.42	26.68	32.62	36.08
Si (%)	45.14	42.99	45.1	40.87	40.54	35.37	42.00	44.83
Ca (%)	0.21	4.11	4.67	9.66	13.74	22.95	9.00	7.50
Fe (%)	19.39	17.65	13.45	9.70	10.92	9.84	10.75	7.71

4. Discussions

The effect of wetting-drying on soil-cement is rarely examined; therefore, information on reducing its effect is also limited. One of the efforts that have been made is to add polypropylene fiber [17]. However, in this study, additives rich in Ca^{2+} and Cl^- (Table

4) were used. The addition of $CaCl_2$ to cement is generally used to stimulate in addition to increase the strength [14,39,40]. The dosage used is also varied for different soil types. It was observed that the optimum additive used which were 0.8% and 2%, corresponded to UCS 2400 kPa based on the required soil-cement strength standards [32]. The effect of adding additives higher than the optimum percentage was also different for the two soils. For lateritic soils, the supplements of more than 2% resulted in a reduction in UCS. While, for granitic-cement, the maximum UCS 3000 kPa was obtained at an additive content of 3% (Figure 4). This result allowed a reduction in the amount of cement in the mixture, which was initially obtained by 5.5% (Figure 3). By adding a 0.8% additive, the required cement was only 5% (Figure 4). This was due to Si and Al's high content in granitic soil, allowing the formation of more C-S-H and C-A-H. Both compounds play a major role in increasing soil-cement strength [4,11].

The indications of reduced strength due to excess $CaCl_2$ have been submitted by among researchers [39,40] as a consequence of the formation of $3CaO.Al_2O_3.CaCl_2.10H_2O$, due to the presence of Cl^- preventing the formation of C-S-H and C-A-H [4,11]. This effect occurs not only in short-term but also in long-term strength [4]. Moreover, the Si and Al content of the two samples tested were different, which resulted in a different effect. The low content of Si and Al in lateritic soils resulted in limited C-S-H, and C-A-H formation. The addition of Cl- further reduced their production. SEM results proved that the addition of a Cl-rich additive resulted in a granular shape, which increased with the addition of the additive (Figures 15(d)-15(f)). This is an evidence of the formation of $3CaO.Al_2O_3.CaCl_2.10H_2O$ based on observations made by Xiong et al. [11]. Temperature has also been reported to influence soil-cement [40]. UCS increased when the sample was carried out at 2-21^oC; while, the opposite effect occurred when mixing was carried out above 50^oC. In this study, the temperature effect on the increase and reduction in soil-cement-additive strength was neglected because all tests were carried out at room temperatures between 25°C-30°C.

Moreover, the discussion of adding additives to soil-cement does not only consider strength but also the amount of water absorbed by the water and loss of weight, mainly due to wetting-drying cycles. The addition of supplements at the optimum percentage (i.e., 0.8% for granitic soils and 2% for lateritic soils) reduced the amount of water absorbed, represented by the sample's low water content as shown in Figures 5 and 11. The addition of additives resulted in flocculated and clustered structures as shown in Figures 10(a), 10(b), and 15(c), which increased with higher C-S-H and C-A-H formed [10]. The pores became smaller and denser. Consequently, the water absorbed by the sample when submerged was reduced. The increased strength resulted in weight loss due to soil-cement particles' release with less additive rather than no supplement (Figures 6 and 12). Also, the specimens' strength with additives tested after the wetting-drying cycle was more remarkable than those without (Figure 7).

5. Conclusions

The test results of wetting-drying cycles on soil-cement with additives have been presented and analyzed. Based on the highest compressive strength, the optimum additive contents for the granitic-cement and lateritic-cement mixtures obtained were 0.8% and 2%, respectively. The utilization of additives increased the resistance of the soil-cement mixture in the wetting-drying cycles.

The addition of a 0.8% supplement to the granitic soil-cement reduced the amount of water absorbed by the sample 3.8 times. The soil-cement loss of the samples without additive was found 14% greater than those with supplement. For the same soil, the wetting-drying process also decreased the strength of the mixtures. Those with the additives were twice stronger than those without at the end of the cycles.

For Lateritic soil, the specimens with 2% additive showed the smallest moisture content for both volume change, and soil lost test. Meanwhile, the mass lost due to wetting-drying process on these soils with additives was slightly smaller than those without additives. This result was also seen in the residual strength measured after the wetting-drying test. The effect additive was different from the granitic soil. The chemical content of the soil used affected the success of using additives.

Author Contributions: Conceptualization, Y.F.A.; methodology, Y.F.A.; investigation, E.A. and F.A.; writing—original draft preparation, Y.F.A.; writing—review and editing, Y.F.A. and S.S.A.; visualization, E.A. and F.A. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding

Data Availability Statement:

Acknowledgments:

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

References

1. Sunitsakul, J.; Sawatparnich, A.; Sawangsuriya, A. Prediction of Unconfined Compressive Strength of Soil-Cement at 7 Days. *Geotech. Geol. Eng.* **2012**, *30*, 263–268, doi:10.1007/s10706-011-9460-7.
2. Da, C.; Yingdi, L.; Chaohua, J.; Xingguo, F. The Mechanical Properties of Coastal Soil Treated with Cement. **2013**, 1155–1160, doi:10.1007/s11595-013-0836-9.
3. Wang, F.; Ping, X.; Zhou, J.; Kang, T. Effects of crumb rubber on the frost resistance of cement-soil. *Constr. Build. Mater.* **2019**, *223*, 120–132, doi:10.1016/j.conbuildmat.2019.06.208.
4. Xing, H.; Yang, X.; Xu, C.; Ye, G. Strength characteristics and mechanisms of salt-rich soil-cement. *Eng. Geol.* **2009**, *103*, 33–38, doi:10.1016/j.enggeo.2008.07.011.
5. Antunes, V.; Simão, N.; Freire, A.C. A Soil-Cement Formulation for Road Pavement Base and Sub Base Layers : a Case Study. **2017**.
6. Fan, J.; Wang, D.; Qian, D. Journal of Rock Mechanics and Geotechnical Engineering Soil-cement mixture properties and design considerations for reinforced excavation. *J. Rock Mech. Geotech. Eng.* **2018**, *10*, 791–797, doi:10.1016/j.jrmge.2018.03.004.
7. Mengue, E.; Mroueh, H.; Lancelot, L.; Medjo, R. Evaluation of the Compressibility and Compressive Strength of a Compacted Cement Treated Laterite Soil for Road Application. *Geotech. Geol. Eng.* **2018**, doi:10.1007/s10706-018-0576-x.
8. Pongsivasathit, S.; Horpibulsuk, S.; Piyaphipat, S. Case Studies in Construction Materials Assessment of mechanical properties of cement stabilized soils. *Case Stud. Constr. Mater.* **2019**, *11*, e00301, doi:10.1016/j.cscm.2019.e00301.
9. Khosravi, M.; Boulanger, R.W.; Wilson, D.W.; Olgun, C.G. ScienceDirect Stress transfer from rocking shallow foundations on soil-cement reinforced clay. *Soils Found.* **2019**, *59*, 966–981, doi:10.1016/j.sandf.2019.04.003.
10. Tyagi, A.; Xiao, H.; Chin, K.; Lee, F. Model for predicting the unit weight of cement-treated soils. *Soils Found.* **2019**, *59*, 1921–1932, doi:10.1016/j.sandf.2019.09.002.
11. Xiong, F.; Xing, H.; Li, H. Experimental study on the effects of multiple corrosive ion coexistence on soil-cement characteristics. *Soils Found.* **2019**, *59*, 398–406, doi:10.1016/j.sandf.2018.12.001.
12. Zidan, A.F. Strength and Consolidation Characteristics for Cement Stabilized Cohesive Soil Considering Consistency Index. *Geotech. Geol. Eng.* **2020**, *6*, doi:10.1007/s10706-020-01367-6.
13. Pongsivasathit, S.; Horpibulsuk, S.; Piyaphipat, S. Assessment of mechanical properties of cement stabilized soils. *Case Stud. Constr. Mater.* **2019**, *11*, e00301, doi:10.1016/j.cscm.2019.e00301.
14. Lambe, T.W.; Moh, Z.-C. Improvement of strength of soil-cement with additives. *Highw. Res. Board Bull.* **1958**, 38–47.
15. Blanck, G.; Cuisinier, O.; Masrouri, F. Soil treatment with organic non-traditional additives for the improvement of earthworks. *Acta Geotech.* **2014**, *9*, 1111–1122, doi:10.1007/s11440-013-0251-6.
16. Lin, D.F.; Luo, H.L.; Hsiao, D.H.; Chen, C.T.; Cai, M. Du Enhancing soft subgrade soil with a sewage sludge ash/cement

mixture and nano-silicon dioxide. *Environ. Earth Sci.* **2016**, *75*, doi:10.1007/s12665-016-5432-9.

17. Aryal, S.; Kolay, P.K. Long-Term Durability of Ordinary Portland Cement and Polypropylene Fibre Stabilized Kaolin Soil Using Wetting–Drying and Freezing–Thawing Test. *Int. J. Geosynth. Gr. Eng.* **2020**, *6*, doi:10.1007/s40891-020-0191-9.
18. Tajdini, M.; Hajialilue Bonab, M.; Golmohamadi, S. An Experimental Investigation on Effect of Adding Natural and Synthetic Fibres on Mechanical and Behavioural Parameters of Soil–Cement Materials. *Int. J. Civ. Eng.* **2018**, *16*, 353–370, doi:10.1007/s40999-016-0118-y.
19. Deboucha, S.; Aissa Mamoune, S. mohammed; Sail, Y.; Ziani, H. Effects of Ceramic Waste, Marble Dust, and Cement in Pavement Sub-base Layer. *Geotech. Geol. Eng.* **2020**, *38*, 3331–3340, doi:10.1007/s10706-020-01211-x.
20. Anagnostopoulos, C.A.; Chrysanidis, T.; Anagnostopoulou, M. Experimental data of cement grouting in coarse soils with different superplasticisers. *Data Br.* **2020**, *30*, 105612, doi:10.1016/j.dib.2020.105612.
21. Carvalho, A.; de Castro Xavier, G.; Alexandre, J.; Pedroti, L.G.; de Azevedo, A.R.G.; Vieira, C.M.F.; Monteiro, S.N. Environmental durability of soil-cement block incorporated with ornamental stone waste. *Mater. Sci. Forum* **2014**, *798–799*, 548–553, doi:10.4028/www.scientific.net/MSF.798-799.548.
22. Elahi, T.E.; Shahriar, A.R.; Islam, M.S. Engineering characteristics of compressed earth blocks stabilized with cement and fly ash. *Constr. Build. Mater.* **2021**, *277*, 122367, doi:10.1016/j.conbuildmat.2021.122367.
23. França, B.R.; Azevedo, A.R.G.; Monteiro, S.N.; Da Costa, F.; Filho, G.; Marvila, M.T.; Alexandre, J.; Zanelato, E.B. Durability of soil-Cement blocks with the incorporation of limestone residues from the processing of marble. *Mater. Res.* **2018**, *21*, doi:10.1590/1980-5373-MR-2017-1118.
24. de Souza, J.M.; Lucena, L. de F.L. Soil-Cement Brick with Cassava Wastewater. In *Use of cassava wastewater and scheelite residues in ceramic formulations*; Acchar, W., da Silva, V.M., Eds.; 2021; p. 116 ISBN 9783030587819.
25. Van Ngoc, P.; Turner, B.; Huang, J.; Kelly, R. Experimental study on the durability of soil-cement columns in coastal areas. *Geotech. Eng.* **2017**, *48*, 138–143.
26. ASTMD2487 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System). *ASTM Int. West Conshohocken, PA* **2006**, 1–5, doi:10.1520/D2487-11.
27. Kirgiz, M.S. Effects of blended-cement paste chemical composition changes on some strength gains of blended-mortars. *Sci. World J.* **2014**, *2014*, doi:10.1155/2014/625350.
28. Bediako, M.; Amankwah, E.O. Analysis of chemical composition of Portland cement in Ghana: A key to understand the behavior of cement. *Adv. Mater. Sci. Eng.* **2015**, *2015*, doi:10.1155/2015/349401.
29. SNI03-6887-2002 Metode Pengujian Kuat Tekan Bebas Campuran Tanah Semen. *Natl. Stand. Agency Indones.* **2002**, 1–12.
30. ASTMD1633-00 Standard Test Methods for Compressive Strength of Molded Soil-Cement Cylinders. *ASTM Int. West Conshohocken, PA, USA,* **2000**, 1–4.
31. SNI03-3438-1994 Tata cara pembuatan rencana stabilisasi tanah dengan semen portland. *Natl. Stand. Agency Indones.* **1994**, 1–15.
32. DGH *General Specifications for Road and Bridge Construction Works*; 2018th ed.; Directorate General of Highway, Ministry of Public Work and Housing, 2018;
33. SNI-6427-2012 Test methods for wetting and drying test of compacted soil-cement mixtures. *Natl. Stand. Agency Indones.* **2012**, 1–25.
34. ASTMD559 Standard Test Methods for Wetting and Drying Compacted Soil-Cement Mixtures. *Am. Soc. Test. Mater.* **1996**, 1–6.
35. Cai, L.; He, L.; Peng, S.; Li, M.; Tong, M. Influence of titanium dioxide nanoparticles on the transport and deposition of microplastics in quartz sand. *Environ. Pollut.* **2019**, *253*, 351–357, doi:10.1016/j.envpol.2019.07.006.
36. Tan, W.; Peralta-Videa, J.R.; Gardea-Torresdey, J.L. Interaction of titanium dioxide nanoparticles with soil components and

plants: Current knowledge and future research needs-a critical review. *Environ. Sci. Nano* **2018**, *5*, 257–278, doi:10.1039/c7en00985b.

37. Goldberg, S. Interaction of aluminum and iron oxides and clay minerals and their effect on soil physical properties: A review. *Commun. Soil Sci. Plant Anal.* **1985**, *20*, 1181–1207, doi:https://doi.org/10.1080/00103629009368144.
38. Yong, R.N.; Sethi, A.J.; Booy, E.; Dascal, O. Basic characterization and effect of some chemicals on a clay from outardes 2. *Eng. Geol.* **1979**, *14*, 83–107, doi:10.1016/0013-7952(79)90079-6.
39. Bowers, B.B.; Daniels, J.L.; Anderson, J.B. Field considerations for calcium chloride modification of soil-cement. *J. Mater. Civ. Eng.* **2014**, *26*, 65–70, doi:10.1061/(ASCE)MT.1943-5533.0000780.
40. Bowers, B.F.; Daniels, J.L.; Lei, S.; Deblasis, N.J. Additives for Soil-Cement Stabilization. In *Pavement and Geotechnical Engineering for Transportation*; Huang, B., Bowers, B.F., Mei, G.-X., Luo, S.-H., Zhang, Z., Eds.; ASCE, 2013; pp. 68–75 ISBN 9780784412817.

infrastructures MDPI

Article

The Role of Additives in Soil-Cement Subjected to Wetting-Drying Cycles

Yulian Firmana Arifin [1,*], Eka Agustina [2] , Fransius Andhi [2] and Setianto Samingan Agus [3]

[1] Civil Engineering Study Program, University of Lambung Mangkurat, Jl. A. Yani km 35 Banjarbaru 70714, Indonesia; y.arifin@ulm.ac.id
[2] Public Works, Spatial Planning, and Transportation Office, Katingan Regency, Jl. Katamso/Jl. A.H. Nasution, Kasongan, Indonesia; eagustina17875@gmail.com, andhi.bzp@gmail.com
[3] Mott MacDonald Pte. Ltd., Singapore; samingan.agus@mottmac.com
* Correspondence: y.arifin@ulm.ac.id; Tel.: +625114773858

Abstract: This study aimed to explore the use of additives in soil-cement mixtures that have undergone a drying-wetting cycle. Two types of soil used included granitic and lateritic, which are widely used in road base construction in Katingan area, Central Kalimantan, Indonesia. The cement used was the ordinary Portland type I, while the additive utilized was for commercial purposes, and predominantly contained $CaCl_2$. This research was conducted by testing the optimum cement content for each soil to determine the shear strength according to the Indonesian standards (i.e., minimum UCS of 2400 kPa). The optimum cement content of the granitic and lateritic soils were deduced to be 5.5% and 5% on a dry weight basis, respectively. The utilization of 0.8% additive resulted in a 0.5% reduction of the optimum cement content of granite-like soil. The results showed that the optimum additive content for granite soil was higher than that of without supplement, while for the lateritic, no changes occurred. The advantage of using supplements, however, was more pronounced in the samples when subjected to wetting-drying cycles. Also, at the optimum additive level, the moisture content and soil-cement loss during wetting, was always lower than those without supplements.

Keywords: lateritic soil, granitic soil, additive, soil stabilization, soil-cement

Citation: Lastname, F.; Lastname, F.; Lastname, F. Title. *Infrastructures* **2021**, *6*, x. https://doi.org/10.3390/xxxxx

Academic Editor: Firstname Lastname

Received: date

Accepted: date

Published: date

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

1. Introduction

Central Kalimantan is a province in Indonesia, which is famous for its vast swampy areas; thus, it is difficult to source granular material for road foundation. Therefore, soil-cement base is mostly used as an alternative.

The reliability and performance of this mixture have been widely studied [1–12]. Sunitsakul et al. [1] reported that the shear strength of a mixture is strongly affected by the water-cement ratio and independent of its dry density. However, the dry density of the compacted mix shall be higher than 95% of the maximum dry density of the modified Proctor compaction as one of the criteria for the road base application [1]. Moreover, the percentage of cement is directly proportional to the shear strength of the soil-cement base [2,7,13]. This is because, with the increase in cement, the amount of calcium silicate hydrate (C-S-H), calcium aluminum hydrate (C-A-H), and calcium hydroxide ($Ca(OH)_2$) produced by the mixture's reaction also rises [4,11]. Also, a soil-cement shear strength increases with higher curing time [2,3,5,7,11]. Da et al. [2] reported that a mixture soaked in a higher pH groundwater produced greater strength than those immersed in distilled water. This corresponds with the increase in sample pH with an higher percentage of cement [5]. It can be concluded that the ability to resist stress by the mix is influenced by several factors, such as water-cement ratio, density, curing time, salt content in the soil, and environmental conditions, namely water and pH.

Deleted: s
Deleted: ,
Deleted: The two
Deleted: ing
Deleted: ,
Deleted: ,
Deleted: those
Deleted: However, the
Deleted:
Deleted: is
Deleted: smaller
Deleted: no
Deleted: ,
Deleted: making
Deleted: had
Commented [MDP1]: Make the author citation form, not just include literature.
Deleted: mixure
Deleted: ,

Furthermore, the addition of cement also improves the compaction behavior of a mixture in the case of fine-grained soils [7]. The compression index decreases, and the coefficient of consolidation increases with higher cement content. It has also been found that the soil pores become smaller, and the structure behaves more robustly with it thus increasing percentage [7]. The presence of Mg^{2+}, SO_4^{2+}, and Cl^- ions are discovered in soils with high salt content [11], which resulted in the reduction of calcium silicate hydrate (C-S-H) and aluminum hydrate (C-A-H) bonds. Consequently, the strength of soil-cement mixture also reduced. Besides its application in road construction, this mixture is also used for other purposes, such as grouting and foundation [6,9].

To improve the strength attainment, soil and cement are normally mixed with some additional components, which are either solid or liquid from natural or artificial ingredients. This addition always leads the physical or chemical changes in the mixture. The use of additives to increase the shear strength of soil-cement mixture started in the late 1950s, where the researcher [14] used 29 additives, such as dispersants, synthetic resins, waterproofing agents, salts, and alkalis. The addition of 0.5-1.0% supplements, such as sodium carbonate, sodium hydroxide, sodium sulfate, and potassium permanganate significantly increased the soil-cement shear strength by 150% [14]. However, adding more substance beyond this did not result in a significant improvement, and partly resulted in strength reduction, as seen in a case, where potassium hydroxide, calcium chloride, and sodium chloride were used.

Using different types of additives, such as acid, enzymatic solution, and calcium lignosulfonate, Blanck et al. [15] obtained some distinct results of compaction, UCS, swelling, permeability, and surface tension tests for various concentrations. At high proportions of calcium lignosulfonate, the shear strength of the soil-cement mix was lower than that of at low concentrations. Lime and rice husk ash were also used as additives to increase soil's resistant level. Lin et al. [16] added nano-silicon dioxide to the sewage sludge ash-cement mixture to improve its plasticity, shear strength, compression, swelling, and permeability behavior. Adding 2% of this compound to samples at the optimum moisture content produced the highest compressive strength. Aryal et al. [17] used polypropylene fiber to improve the performance of a mix in terms of its wetting-drying and freezing-thawing behavior. It was found out that the soil with 10% cement and 0.5% fiber was able to withstand wetting-drying up to 12 cycles based on its percentage loss. Organic fiber such as jute was also used to increase ductility [18]. Garbage, i.e., ceramic waste and marble dust were combined with little amount of cement (i.e., 2%) to produce a sub-base material for rural and highway [19]. For different purposes, superplasticizers additives were also used to improve the mixture's performance in grouting work to increase soil injectability and shear strength [20]. It was observed that the mix exhibited a different behavior dependent upon the soil type, additive and its percentage. Therefore, the soil-cement mix and the supplements were first tested according to its conditions and designation [14].

A number of researchers have studied the durability of soil-cement mixtures with additives subjected to wetting-drying cycles [21–24]. França et al. [23] observed the addition of 30% limestone to the soil-cement mixture reduced water absorption and increased its compressive strength. Calcite and gibbsite-rich limestone have also been used in the granite waste-cement mixture. As a result, the sample's strength of 60% waste with 5% limestone met the requirements after experiencing wetting-drying cycles for 90 days [21]. De Souza and Lucena [24] replaced water with cassava wastewater, containing calcium and potassium predominantly in making brick soil-cement. After seven days of wetting-drying cycles, the strength, water absorption, and loss of mass of the sample met the established criteria. These results demonstrated the successful use of additives rich in calcium on soil-cement affected by wetting-drying cycles. The importance of the calcium content in the soil-cement mixture was also reported by Van Ngoc et al. [25]. Deep and rapid damage to soil-cement due to calcium leaching was found in samples submerged in high seawater concentrations [25]. Apart from calcium, the fly ash that contains much sil-

Deleted: behaviour
Deleted: mixure
Deleted: mixure
Deleted: In order
Deleted: t
Deleted: ,
Deleted: The
Deleted: due to this addition are always physical or chemical
Deleted: ,
Deleted: example was
Deleted: the
Deleted: enzimatic
Formatted: Font: 10 pt
Formatted: Font: 10 pt
Deleted: behaviour
Deleted: discovered
Deleted: addictives
Deleted: ing on
Deleted: The
Deleted: has been studied by several researchers …
Formatted: Font: 10 pt
Deleted: is
Deleted: which contains
Deleted: lots of

ica was also announced to reduce mass loss due to wetting-drying processes with a sample retention strength of 51-88% [22]. However, generally, the mixtures are used for brick. In this case, brushing was not carried out in the wetting-drying test [24].

This article discusses about the reliability of two types of soil, which are predominantly granular material (i.e., granitic and lateritic soils), that have been mixed with cement and commercial additives with respect to their behavior in wetting-drying cycles. These two were chosen because they are widely available in Katingan where it is not easy to find materials that meet the road base requirements. The most common method is to use a soil-cement mixture from the local soil. This method is more affordable than ordering selected materials from other regions. However, it is often encountered in the location, i.e., the high rainfall and tides, causing the road to be submerged in several places. Therefore, the soil-cement base was degraded, as shown on the Tumbang Lahang-Tumbang Samba-Tumbang Kaman road section, Katingan Regency, Central Kalimantan (Figure 1 (a). it was in contrasts with the soil-cement conditions that were not submerged, as shown in Figure 1 (b). This study aimed to find a solution to the problem by mixing an additive rich in calcium into the soil-cement. It is expected to improve the soil-cement mixture's performance against drying-wetting cycles, as shown by the reduced water absorption and loss of mass.

(a) **(b)**

Figure 1. The appearance of soil-cement as a base (a) undergo wetting-drying cycles, and (b) non submerged road

2. Materials and Methods

2.1. Materials

One of the materials used was a granitic soil taken from Hampalit, Katingan Hilir, in Central Kalimantan. The deposits at the location are shown in Figure 2. Another material was a lateritic soil from Tumbang Kaman, about 100km to the North of the district capital of Katingan, Kasongan, Central Kalimantan. This soil is a type used in the road application as shown in Figure 1. The basic and engineering properties of the two soils are summarized in Table 1. The two samples almost had the same composition, which predominantly was sand. Both were classified as silty sand (SM) under the USCS classification system [26]. The chemical composition of the granitic and lateritic soils used were determined using X-ray fluorescence (XRF) tests as summarized in Table 2. Although the two samples were classified into the same soil type, the chemical composition of the soil was different. The lateritic soil predominantly contained Si and Fe, while the granitic majorly comprised Si and Ti. The presence of Si can increase the soil cement's strength by forming C-S-H in the mixture [27].

The type used in the study was an ordinary Portland cement type I with a specific gravity of 3.15. Using the X-ray fluorescence (XRF) test, its chemical contents, as summarized in Table 3, were obtained. The results were compatible with the Portland cement content, which consists of major oxides (i.e., CaO, SiO_2, Al_2O_3, and Fe_2O_3) and minor oxides (i.e., MgO, SO_3, and some alkali oxides (K_2O and Na_2O)) [28].

Deleted: (de Souza & Lucena, 2021)
Deleted: ,
Deleted: behaviour
Deleted: dryng
Deleted: .
Deleted: I
Deleted: in this area
Deleted: cheaper
Deleted: In
Deleted: s
Deleted: The other
Deleted: the
Deleted: was s
Deleted: and are
Deleted: of
Deleted:
Deleted: and are summarized in Table 3

Table 1. Engineering properties of soils.

Properties	Granitic	Lateritic
Specific gravity	2.64	2.64
Water content (%)	2.4	4.3
Gravel (%)	0.00	1.19
Sand (%)	77.76	69.46
Silt (%)	7.74	0.9
Clay (%)	14.5	28.56
Liquid limit (%)	-	28.59
Plastic limit (%)	-	22.74
Plasticity Index (%)	-	5.85
Soil Classification (USCS)	Silty sand	Silty sand
Unconfined compression strength (c_u) (kN/m^2)	-	26.8
Maximum dry density (kN/m^3)[1]	16.33	17.73
Optimum moisture content (%)[1]	12.5	14.3

[1] Modified Proctor compaction test.

Deleted: Maksimum

Table 2. Chemical composition of soils.

Composition	Granitic [1]	Lateritic [1]
Al	1.77	15
Si	83.12	29
Ca	0.02	0.89
Ti	10.75	2.28
Fe	1.18	46.3
Ni	0.00	3.93

[1] obtained from the X-ray Fluorescence test (XRF)

Table 3. Chemical composition of cement used.

Compounds	Percentage [1]
CaO	67.28
SiO_2	18.68
Al_2O_3	4.30
Fe_2O_3	4.54
MgO	1.10
Alkali ($K_2O + Na_2O$)	1.71
SO_3	1.28

[1] obtained from the X-ray Fluorescence test (XRF)

Figure 2. Granitic soil deposits in Hampalit village, Central Kalimantan

The additive used was a commercial type, which was in the form of powder with chemical contents shown in Table 4, mainly including chlorine (Cl), calcium (Ca), and potassium (K).

Deleted: form

Deleted:

Table 4. Chemical composition of additive used.

Compositions	Percentage [1]
Cl	55.7
K	4.47
Ca	37.6
Fe	0.18
Ni	0.964
Cu	0.092

[1] obtained from the X-ray Fluorescence test (XRF).

2.2. Methods and Procedures

Each soil density was achieved by compacting the samples by following the Modified Proctor Standard to obtain its optimum moisture content of the lateritic and granitic samples at 14.3% and 12.5% respectively, with a maximum dry density of 17.73 kN/m3 and 16.33 kN/m3, respectively, as shown in Table 1.

Deleted: .

Deleted: With

Unconfined compression strength (UCS) was carried out on each sample at its optimum moisture content and maximum dry density with various cement percentages of 4%, 4.5%, 5%, 5.5%, and 6% on a dry weight basis based on SNI03-6887-2002 [29], which was similar to ASTM D-1633-2000 [30]. This test is commonly used to determine the effect of cement on the soil [1–3][5–8][10][11][14–16][18].

Based on the Indonesian standard (SNI03-3438 1994) [31], the optimum cement content is at UCS of 2200 kPa. However, following the latest and more specific standard, the general specification of the highway of the country, is considered to be at UCS of 2000-2400kPa [32]. It should be noted that the required soil shear strength for road application differs from a country to another country. Antunes et al. [5] compared the strength required by several countries. Table 5 shows the required mechanical specifications compared to those used in Indonesia; however, in this study, the maximum value was used (i.e., 2400 kPa).

Deleted: ,

Table 5. Laboratory UCS required for soil-cement mixture.

Layer	U.S. Army Corps for Engineer*)	German[5]	Portuguese[5]	Southern African[5]	Indonesia [31]	Indonesia [32]
Base	≥ 5.17 MPa for 7 days curing time	≥7.0 MPa for 28 days curing time	Non-specified	1.5≤UCS≤3.0 MPa for 7 days curing time	2.2 MPa for 7 days curing time	2.0≤UCS≤2.4 MPa for 7 days curing time
Sub base Layer	≥ 1.72 MPa for 7 days curing time	≥ 0.5 MPa for 28 days curing time	0.8≤UCS≤1.0 MPa for 28 days curing time	0.75≤UCS≤1.5 MPa for 7 days curing time	0.6 MPa for 7 days curing time	Non-specified

The wetting-drying test was carried out based on the Indonesian standard (SNI 6427 2012) [33]. The soil material passing a No. 4 (4.75-mm) Sieve was used. Two samples were used in the wetting-drying test. One was used for any changes in absorption (i.e., Specimen No. 1), and the other was for soil loss (i.e., Specimen No. 2). After compaction, the samples were stored in a humid place and protected from free water for seven days. Specimen No. 1 was weighed and measured in dimensions after storage at the end of day 7. Then, the samples were immersed in water at room temperature for 5 hours. Specimen No. 1 was then again weighed and measured. Both specimens were placed in an oven at

Deleted: is

Deleted: again

71°C for 42 hours. Then, sample No. 1 was weighed and measured in its dimensions. For Sample No. 2, two firm strokes were given on all areas with the wire scratch brush. It took approximately 18-20 vertical firm strokes to cover the specimen's sides twice and four strokes on each end. Then, the weight was weighed. Both samples were re-immersed, and the same procedure was continued for 12 cycles. At the end of the cycle, the samples were placed in an oven at 110°C for 24 hours to determine the dry weight. This method is similar to ASTM standards [34]. After 12 cycles, UCS tests were performed to obtain the residual shear strength of each sample. Table 6 presents the summary of the initial conditions of the tested samples. GC and LC refer to granitic and lateritic soils, respectively. The next two numbers indicate the cement and additive content. An additional denotation is given at the end of the sample numbering in Table 6, namely "1" for the volume and moisture change measurements, and "2" is for the soil-cement loss measurement.

Table 6. Initial condition of wetting-drying samples.

Soil	Sample Code	γ_d	w (%)	Cement (%)	Additive (%)
Granitic	GC-5-0-1	16.33	12.5	5	0
Granitic	GC-5-0-2	16.33	12.5	5	0
Granitic	GC-5-0.8-1	16.33	12.5	5	0.8
Granitic	GC-5-0.8-2	16.33	12.5	5	0.8
Lateritic	LC-5-0-1	17.73	14.3	5	0
Lateritic	LC-5-0-2	17.73	14.3	5	0
Lateritic	LC-5-2-1	17.73	14.3	5	2.0
Lateritic	LC-5-2-2	17.73	14.3	5	2.0
Lateritic	LC-5-5-1	17.73	14.3	5	5.0
Lateritic	LC-5-5-2	17.73	14.3	5	5.0
Lateritic	LC-5-9-1	17.73	14.3	5	9.0
Lateritic	LC-5-9-2	17.73	14.3	5	9.0
Lateritic	LC-5-14-1	17.73	14.3	5	14.0
Lateritic	LC-5-14-2	17.73	14.3	5	14.0

Two tests were carried out to determine the microscopic samples and chemical components before and after mixing with additives and the wetting-drying processes. The two tests were field-emission scanning electron microscopy (FESEM) and energy-dispersive X-ray spectroscopy (EDAX). Other researchers investigating the soil-cement mix also used these two methods.

3. Results

3.1. Optimum Additive and Soil-Cement Content

Figure 3 shows the results of the UCS granitic and lateritic soils. This graph shows that the optimum cement content for both was 5.5% and 5.0%, respectively.

Deleted: o

Deleted: is

Deleted: takes

Deleted: o

Deleted: The

Deleted: are summarized in Table 6

Deleted: The

Deleted: are shown in Figure 3

Deleted: which were

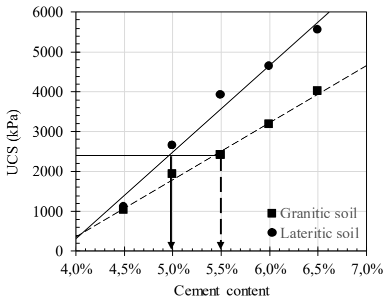


Figure 3. Optimum cement content determination.

Deleted: ditermination

The additive content in the mixtures was determined using a trial test by mixing an added component with varying concentrations from 2% to 14% of the soil-cement sample. In the determination of cement content, the optimum additive also known as its percentage produced the sample's UCS of 2400 kPa. Its variation with the additive content is shown in Figures 4 (a) and 4 (b) for the granitic and lateritic soils, respectively. For the granitic soil, lower cement contents (i.e., 4.5% and 5%) with the addition of the same percentage of supplements were assessed. It was found that its UCS was still below 2400 kPa. As shown in Figure 4 (a), the optimum additive content was 0.8% and 6% for 5% cement content. The lower additive content (i.e. 0.8%) was selected and used for further blending. However, for the lateritic soil (Figure 4 (b), 2% of the percentage addition of the additive was chosen because it gave the required strength (2400kPa). Although the UCS was almost the same as soil-cement mix without additives, its effect on the wetting-drying cycles was easily discernible.

Deleted: discovered

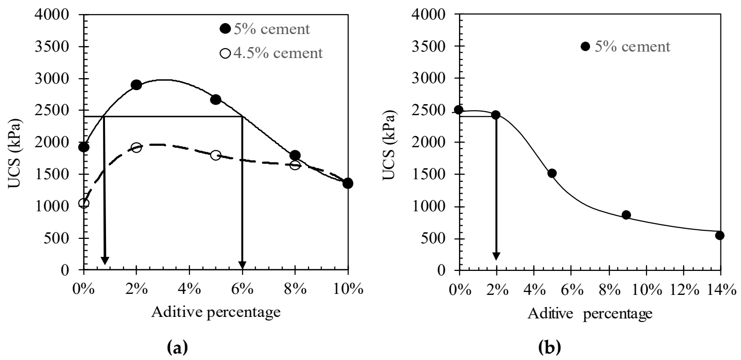


Figure 4. Determination of additives percentage in the mixture (a) granite soil, and (b) lateritic soil.

3.2. Granitic Soil

Figure 5 shows the change in water content during the 12 cycles of the wetting-drying process for the granitic soil. As shown in Figure 5 (a), the moisture content of the soil-cement sample after wetting varied with an average of 3.9% for the samples mixed with 0.8% additive, and 14.8% for the samples without it. The addition of 0.8% supplement reduced the amount of water absorbed by the sample 3.8 times. Meanwhile, for the brushed samples (Figure 5 (b), the water increased with high number of the wetting-drying cycles, which was observed after the 6th cycle. The sample's water content without

Deleted: ,

Formatted: Superscript

Deleted: th

additive increased from 16% in the first cycle to 25% in the 12^{th} cycle (or equal to an increase of 1.6 folds). Moreover, with supplement it also increased from 4.8% to 20% (or about 4.2 times). Nevertheless, samples' water content with additive was still lower than those without.

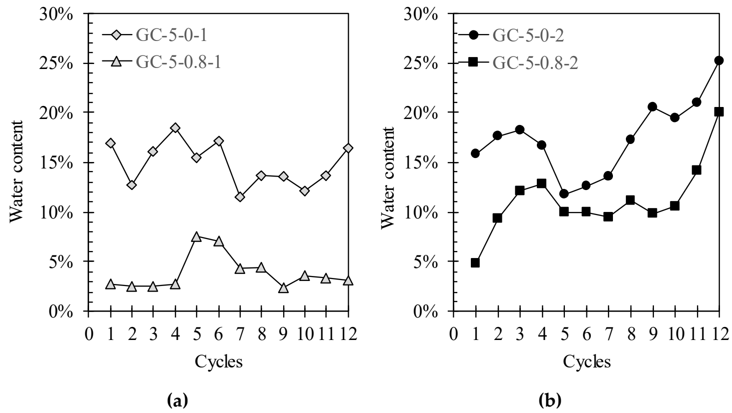
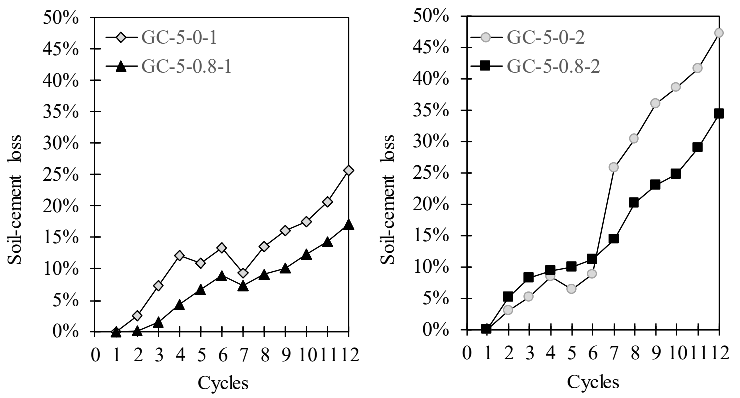


Figure 5. Water content alteration throughout the wetting-drying cycles (a) volume and moisture change specimens, and (b) soil-cement loss specimens.

One of the important conclusions on the soil-cement samples that have undergone the wetting-drying processes is with respect to the soil-cement loss, which is defined as the ratio of original calculated sample's oven-dried weight minus its final corrected (ASTM D559 1996) [34]. Simply, it is the dry unit weight of the sample per cycle divided by the initial dry density of the sample. In this paper, the soil-cement loss was shown not only in the brushed samples but also when being soaked (i.e., volume and moisture change specifications). Figure 6 shows the results where (a) shows that for the soil-cement samples without additive, the mixture started losing weight in the second cycle, while those with supplement in the third cycle. At the end of test (i.e. in the 12^{th} cycle, the soil-cement sample without additive exhibited weight loss of 25% and 17%. The loss for the samples with supplement was 8% less than those without. This was more significant in the sample that was intended for the investigation (Figure 6 (b). The soil-cement loss commenced from the second cycle and increased until the last phase. At the end of the test, the soil-cement loss of the samples without additive was 47% or 14% greater than those with supplement (i.e., 34%). The addition of this substances reduced the soil-cement loss due to the wetting-drying cycles.

Upon completion of these cycles, the samples were tested for their strength (UCS). Sample GC-5-0-2 was not examined for being broken before testing. Figure 7 depicts the results of the UCS tests on these specimens. Before the wetting-drying cycles, the samples with additives (GC-5-0.8) had UCS of 2400 kPa and after the process, it dropped to 1049 kPa for Sample 1 (i.e., for volume and moisture change measurement) and 678 kPa for 2 (i.e., the specimen for the soil-cement loss measurement). The smallest UCS was observed in the sample without additive (i.e., 441 kPa). It could be concluded that the wetting-drying process also decreased the strength of the mixture. Those with the additives were twice as stronger than those without at the end of the cycles.

Deleted: th
Formatted: Superscript
Deleted: d
Deleted: .
Deleted: W
Deleted: Or s
Deleted:
Deleted: The
Deleted: are presented in Figure 6.
Deleted: W
Deleted: ed
Formatted: Superscript
Deleted: th
Deleted: because it was
Deleted: However,
Deleted:
Deleted: the
Deleted: are shown in Figure 7
Deleted: . A
Deleted: was
Deleted: ,



(a) **(b)**

Figure 6. Soil-cement loss throughout the wetting-drying cycles (a) volume and moisture change specimens, and (b) soil-cement loss specimens.

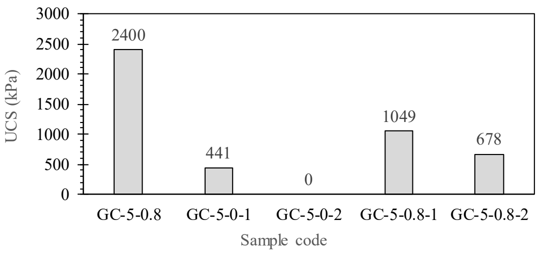
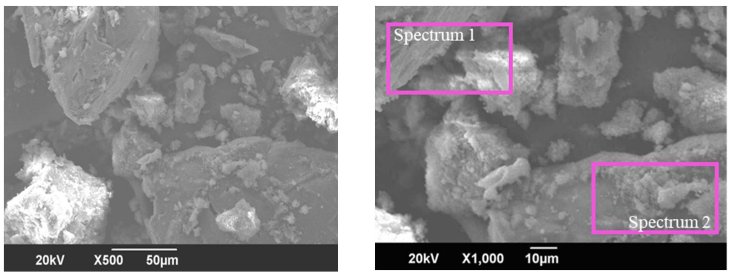


Figure 7. Unconfined compression strength of granitic-cement samples.

Figures 8-10 shows the SEM results of the granitic soil samples (Figure 8), the granitic-cement mix specimen (Figure 9), and the soil-cement mix with 0.8% additive (Figure 10). It was clearly observed in Figures 8(a) and 8(b) that the granitic soil consisted of sand grains and silt particles with irregular shapes and varying sizes, which were even smaller than 50μm. Also, the grains did not appear to bind to one another.

Deleted: clearly



(a) **(b)**

Figure 8. SEM Pictures of granitic soil (a) 500× magnification, and (b) 1000× magnification.

Table 7 presents the average chemical contents of this type of soil extracted with EDX in Spectrum 1 and 2 (Figure 8) showed the dominance of Si and Ti, which confirmed the chemical content results from XRF as shown in Table 2. The addition of cement was observed to produce bonding between the grains, and more compact and smaller pores, as shown in Figure 9. The presence of cement, rich in CaO was observed from the increase in Ca element at the area where the EDX test was carried out (Figure 9), and the results are shown in Table 7. The Ca content increased to 6.64% that was not previously found in the granitic soil.

Deleted: .

Deleted: W

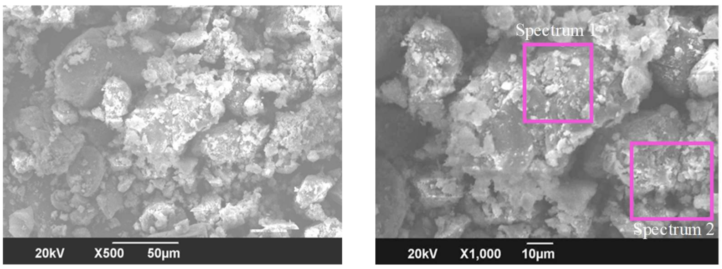
Deleted: which is

Table 7. Initial condition of wetting-drying samples.

Element	Granitic Soil (Figure 8)	GC-5-0-1 (Figure 9)	GC-5-0.8-1 (Figure 10)
Si (%)	91.95	88.82	77.06
Al (%)	1.93	1.28	6.39
Ca (%)	0.095	6.64	15.2
Ti (%)	6.73	1.41	1.69

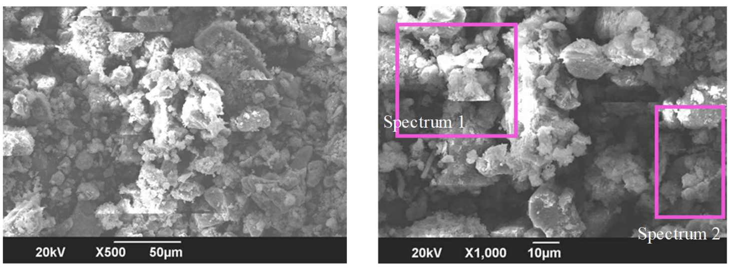
The addition of 0.8% additive resulted in more compact clusters with smaller visible pores as shown in Figures 10 (a) and 10 (b). In Table 7, the Ca content increased to 15.2% due to high content of $CaCl_2$ in the supplement. The presence of this chemical also increased Ti content due to the reduced mobilization of Ti in the soil by $CaCl_2$ [35,36].

Deleted: . This was



(a) **(b)**

Figure 9. SEM Pictures of GC-5-0-1 sample (a) 500× magnification, and (b) 1000× magnification.



(a) **(b)**

Figure 10. SEM Pictures of GC-5-0.8-1 sample (a) 500× magnification, and (b) 1000×.

Other elements appeared to have little effects; therefore, the influence of additive was not easily recognizable on the different samples' chemical elements taken in Spectrums 1 and 2 (Figure 10). However, the average Ca content increased in the specimen, and the SEM results clearly showed differences in the physical conditions in the samples with additive.

Deleted: ,
Deleted: were
Deleted: recognisable

3.3. Lateritic Soil

Figures 11(a) and 11(b) show the moisture content of the lateritic-cement samples that were subjected to wetting-drying cycles for volume and moisture changes, and soil-cement loss specimens, respectively. The LC-5-14-1 sample (i.e., that with 14% additive) was not tested after the second cycle because it collapsed. Meanwhile, the average water content of the samples LC-5-0-1, LC-5-2-1, LC-5-5-1, and LC-5-9-1 were 9.9%, 2.8%, 9.8%, and 10.5%, respectively. Specimens with 2% additive showed the smallest moisture content. However, for brushed samples, the volume varied but did not increase. This is different from the ones in the granitic-cement sample, which increased after wetting-drying cycles. The average moisture content of the sample was 11.7%, 5.7%, 12.1%, and 12.9% for LC-5-0-2, LC-5-2-2, LC-5-5-2, and LC-5-9-2 respectively. Meanwhile, the water content of the LC-5-14-2 sample was not tested because it collapsed after the second cycle.

Deleted:
Deleted: that of

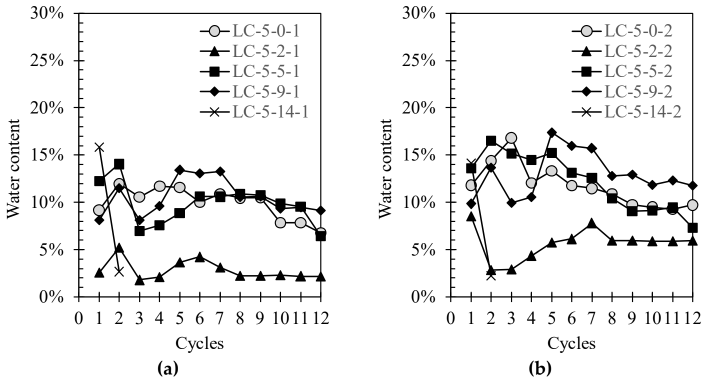


Figure 11. Water content alteration throughout the wetting-drying cycles (a) volume and moisture change specimens, and (b) soil-cement loss specimens.

Figures 12(a) and 12(b) show a soil-cement loss for volume and moisture change specimens. As observed in Figure 12(a), the increase in property started from the first cycle to the fifth. Moreover, the sample tended not to lose weight. At the end of the cycle, the soil-cement loss samples LC-5-0-2-1, LC-5-2-1, LC-5-5-1, and LC-5-9-1 were 12.6%, 11.7%, 16.6, and 20%, respectively. Similar behavior was observed in specimens where the sample lost significant weight started from cycle 1 to 5. After this, the increase in sample tonnage loss was not that great. At the end of the wetting-drying cycles, the soil-cement loss samples LC-5-0-2, LC-5-2-2, LC-5-5-2, and LC-5-9-2 were 14.5%, 13.7%, 18.4%, and 21.6%, respectively. These results indicated that the sample experiencing the least weight loss was that with the addition of 2% additive (i.e., LC-5-2) for both tests, as shown in Figure 13. The addition of more than 2% supplement resulted in an increase in soil-cement loss.

Deleted: this
Deleted: increase
Deleted: ing
Deleted: s
Deleted: ing
Deleted: that experienced

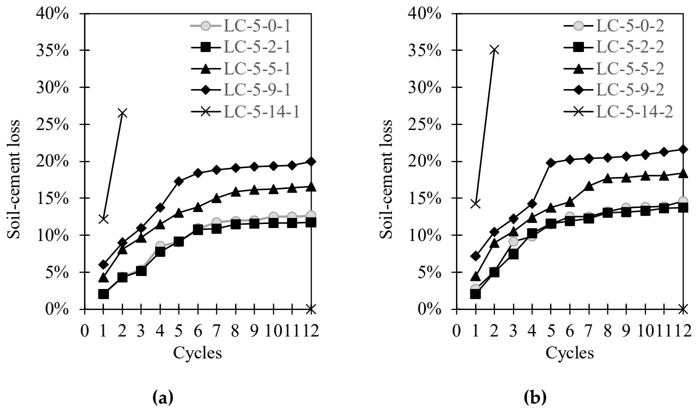


Figure 12. Soil-cement loss throughout the wetting-drying cycles (a) volume and moisture change specimens, and (b) soil-cement loss specimens.

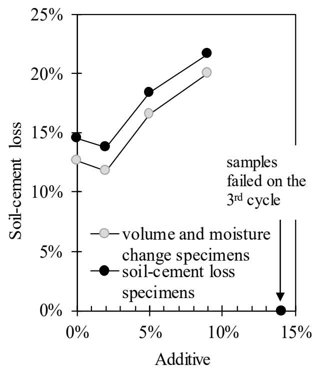


Figure 13. Soil-cement loss as a function of additive content of lateritic soil

After the wetting-drying test, the samples were examined using UCS, and as shown in Figure 14, the results were compared with UCS specimens before the wetting-drying test. As observed in Figure 14, this process did not significantly affect the sample UCS either with or without additives. There was no discernible difference between the two. Moreover, the higher the percentage of the additive, the lower the UCS value. These results indicated that the addition of supplements does not always result in a positive trend. Investigations needed to be carried out for each type of soil and additives used. Moreover, these results were in accordance with previous findings reported by those literature [3,14].

Figure 15 shows SEM photos of samples of lateritic soil (Figure 15 (a), soil-cement (Figure 15 (b), and soil-cement-additive mixtures (Figure 15 (c) -15 (f). Figure 15 (a) shows compacted lateritic soil grains with large pores. The granular size varies even less than 50µm. The chemical content test was carried out with EDX on Spectrum 1 with the composition shown in Table 8. In the sample, Al, Si, and Fe were the dominant elements according to the XRF test (Table 2). After adding cement, the specimen was observed to be denser with closed pores, as shown in Figure 15(b). Like the granitic soil sample, cement

Deleted: is shown in Figure 14, which

Deleted: or not

Deleted: to be

Deleted: The

Deleted: in the sample were Al, Si, and Fe added to the quantity of Ca, which increased from 0.21% to 4.11% in the EDX test results (Table 8).

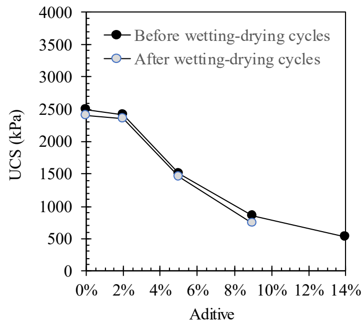
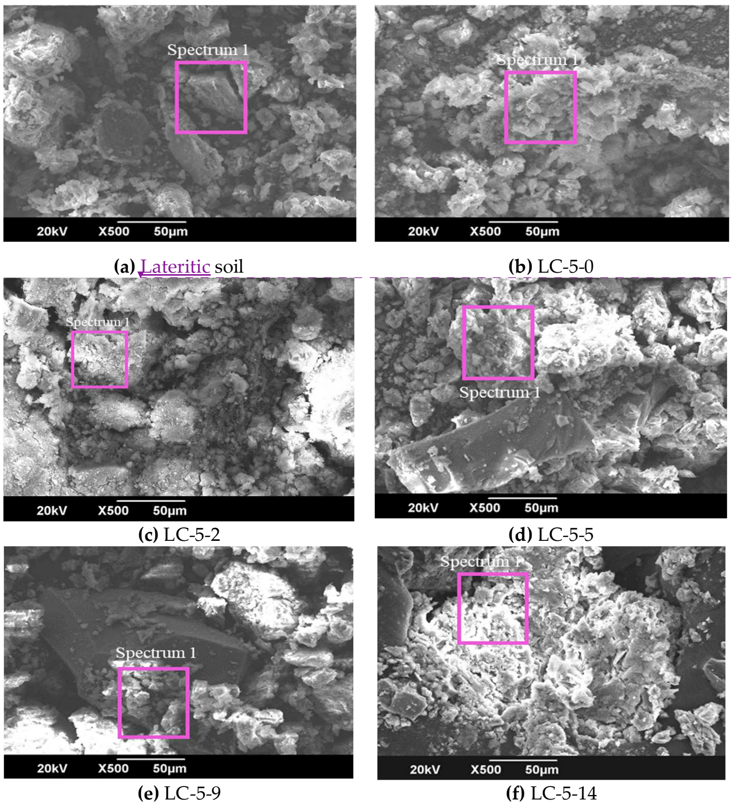


Figure 14. UCS as a function additive content before and after wetting-drying cycles of lateritic soil

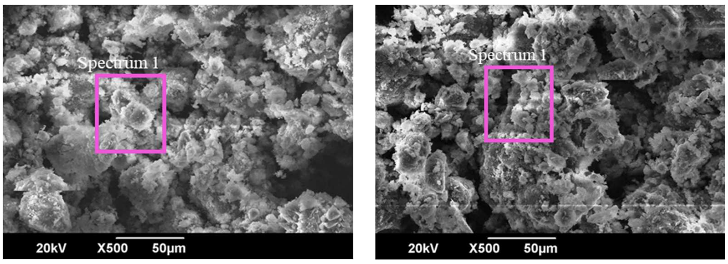


Deleted: Leteritic

Figure 15. SEM photos samples lateritic-cement-additive before wetting-drying cycles

The addition of 2% additive resulted in a denser sample with a yet smaller pores. The soil grains were also invisible in this condition (Figure 15 (c). However, excessive supplements caused the cement clusters to reappear, the pores were also clearly visible (Figure 15 (d) -15 (f). The bond between cement and soil grains were no longer visible at the additive percentage of 9% and 14% (Figures 15 (e) and 15 (f). From the EDX results (Table 8), it was observed that the addition of 2% additives resulted in an increase in Ca, reduction in the Fe, and unchanged content of Si and Al. The addition of Ca, which was supposed to increase the shear strength of the sample, did not occur because of the Fe content reduction. Goldberg [37] reported that iron oxide in clays has a beneficial effect on soil physical properties, increases its stability and dispersion. Reduced iron oxide content resulted in reduced soil shear strength [38]. When the additive was more than 2%, this resulted in a significant increase in Ca, with the Fe content not much changing, while Si and Al decreased. Although, iron oxide, aluminum oxide content stabilizes clay soils by decreasing clay dispersion, water uptake, and increasing micro-aggregation [37], Fe, Al, and Si's reduced content resulted in reduced soil shear strength [38]. Therefore, it was concluded that additives with high $CaCl_2$ content are not suitable for stabilizing lateritic soils with high Fe content.

Figure 16 shows SEM photos of samples LC-5-0-1 and LC-5-2-1 after the wetting-drying process. It was observed that the two samples showed almost the same conditions where the cement clusters with small pores were visible. The two specimens' chemical content showed that the Al content was slightly increased, and Si remained constant after wetting-drying cycles (Table 8). Meanwhile, the Ca quantity increased due to reduced Fe content in the soil.



(a) LC-5-0-1 After wetting-drying cycles **(b)** LC-5-2-1 After wetting-drying cycles

Figure 16. SEM photos samples lateritic-cement-additive after wetting-drying cycles.

Table 8. Chemical elements lateritic-cement-additive mixtures.

Element	**Before wetting-drying process**						**After wetting-drying**	
	Lateritic Figure 15(a)	LC-5-0 Figure 15(b)	LC-5-2 Figure 15(c)	LC-5-5 Figure 15(d)	LC-5-9 Figure 15(e)	LC-5-14 Figure 15(f)	LC-5-0-1 Figure 16(a)	LC-5-2-1 Figure 16(b)
Al (%)	31.37	30.48	34.41	28.16	30.42	26.68	32.62	36.08
Si (%)	45.14	42.99	45.1	40.87	40.54	35.37	42.00	44.83
Ca (%)	0.21	4.11	4.67	9.66	13.74	22.95	9.00	7.50
Fe (%)	19.39	17.65	13.45	9.70	10.92	9.84	10.75	7.71

4. Discussions

The effect of wetting-drying on soil-cement is rarely examined; therefore, information on reducing its effect is also limited. One of the efforts that have been made is to add polypropylene fiber [17]. However, in this study, additives rich in Ca^{2+} and Cl^- (Table

Deleted: not
Deleted: again
Deleted: the
Deleted: content remained
Deleted: much
Deleted: the
Deleted: .
Deleted: ,

4) were used. The addition of $CaCl_2$ to cement is generally used to stimulate in addition to increase the strength [14,39,40]. The dosage used is also varied for different soil types. It was observed that the optimum additive used which were 0.8% and 2%, corresponded to UCS 2400 kPa based on the required soil-cement strength standards [32]. The effect of adding additives higher than the optimum percentage was also different for the two soils. For lateritic soils, the supplements of more than 2% resulted in a reduction in UCS. While, for granitic-cement, the maximum UCS 3000 kPa was obtained at an additive content of 3% (Figure 4). This result allowed a reduction in the amount of cement in the mixture, which was initially obtained by 5.5% (Figure 3). By adding a 0.8% additive, the required cement was only 5% (Figure 4). This was due to Si and Al's high content in granitic soil, allowing the formation of more C-S-H and C-A-H. Both compounds play a major role in increasing soil-cement strength [4,11].

The indications of reduced strength due to excess $CaCl_2$ have been submitted by among researchers [39,40] as a consequence of the formation of $3CaO.Al_2O_3.CaCl_2.10H_2O$, due to the presence of Cl^- preventing the formation of C-S-H and C-A-H [4,11]. This effect occurs not only in short-term but also in long-term strength [4]. Moreover, the Si and Al content of the two samples tested were different, which resulted in a different effect. The low content of Si and Al in lateritic soils resulted in limited C-S-H, and C-A-H formation. The addition of Cl- further reduced their production. SEM results proved that the addition of a Cl-rich additive resulted in a granular shape, which increased with the addition of the additive (Figures 15(d)-15(f)). This is an evidence of the formation of $3CaO.Al_2O_3.CaCl_2.10H_2O$ based on observations made by Xiong et al. [11]. Temperature has also been reported to influence soil-cement [40]. UCS increased when the sample was carried out at 2-21°C; while, the opposite effect occurred when mixing was carried out above 50°C. In this study, the temperature effect on the increase and reduction in soil-cement-additive strength was neglected because all tests were carried out at room temperatures between 25°C-30°C.

Moreover, the discussion of adding additives to soil-cement does not only consider strength but also the amount of water absorbed by the water and loss of weight, mainly due to wetting-drying cycles. The addition of supplements at the optimum percentage (i.e., 0.8% for granitic soils and 2% for lateritic soils) reduced the amount of water absorbed, represented by the sample's low water content as shown in Figures 5 and 11. The addition of additives resulted in flocculated and clustered structures as shown in Figures 10(a), 10(b), and 15(c), which increased with higher C-S-H and C-A-H formed [10]. The pores became smaller and denser. Consequently, the water absorbed by the sample when submerged was reduced. The increased strength resulted in weight loss due to soil-cement particles' release with less additive rather than no supplement (Figures 6 and 12). Also, the specimens' strength with additives tested after the wetting-drying cycle was more remarkable than those without (Figure 7).

5. Conclusions

The test results of wetting-drying cycles on soil-cement with additives have been presented and analyzed. Based on the highest compressive strength, the optimum additive contents for the granitic-cement and lateritic-cement mixtures obtained were 0.8% and 2%, respectively. The utilization of additives increased the resistance of the soil-cement mixture in the wetting-drying cycles.

The addition of a 0.8% supplement to the granitic soil-cement reduced the amount of water absorbed by the sample 3.8 times. The soil-cement loss of the samples without additive was found 14% greater than those with supplement. For the same soil, the wetting-drying process also decreased the strength of the mixtures. Those with the additives were twice stronger than those without at the end of the cycles.

For Lateritic soil, the specimens with 2% additive showed the smallest moisture content for both volume change, and soil lost test. Meanwhile, the mass lost due to wetting-

Deleted: ing
Deleted: itself
Deleted: was
Deleted:
Deleted: Meanw
Deleted: s
Deleted: is
Deleted: which allows
Deleted: I
Deleted: . Which is
Deleted: t
Formatted: Superscript
Deleted: , that
Deleted: ed
Deleted:
Deleted: s
Deleted: is curred
Formatted: Superscript
Deleted: , meanwhile,
Deleted: s
Deleted: is
Formatted: Superscript
Deleted: s
Deleted: that was
Deleted: which was
Deleted: s

drying process on these soils with additives was slightly smaller than those without additives. This result was also seen in the residual strength measured after the wetting-drying test. The effect additive was different from the granitic soil. The chemical content of the soil used affected the success of using additives.

Deleted: is

Deleted: dring

Author Contributions: Conceptualization, Y.F.A.; methodology, Y.F.A.; investigation, E.A. and F.A.; writing—original draft preparation, Y.F.A.; writing—review and editing, Y.F.A. and S.S.A.; visualization, E.A. and F.A. All authors have read and agreed to the published version of the manuscript.

Deleted: . ;

Funding: This research received no external funding

Data Availability Statement:

Acknowledgments:

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

References

1. Sunitsakul, J.; Sawatparnich, A.; Sawangsuriya, A. Prediction of Unconfined Compressive Strength of Soil-Cement at 7 Days. *Geotech. Geol. Eng.* **2012**, *30*, 263–268, doi:10.1007/s10706-011-9460-7.
2. Da, C.; Yingdi, L.; Chaohua, J.; Xingguo, F. The Mechanical Properties of Coastal Soil Treated with Cement. **2013**, 1155–1160, doi:10.1007/s11595-013-0836-9.
3. Wang, F.; Ping, X.; Zhou, J.; Kang, T. Effects of crumb rubber on the frost resistance of cement-soil. *Constr. Build. Mater.* **2019**, *223*, 120–132, doi:10.1016/j.conbuildmat.2019.06.208.
4. Xing, H.; Yang, X.; Xu, C.; Ye, G. Strength characteristics and mechanisms of salt-rich soil-cement. *Eng. Geol.* **2009**, *103*, 33–38, doi:10.1016/j.enggeo.2008.07.011.
5. Antunes, V.; Simão, N.; Freire, A.C. A Soil-Cement Formulation for Road Pavement Base and Sub Base Layers : a Case Study. **2017**.
6. Fan, J.; Wang, D.; Qian, D. Journal of Rock Mechanics and Geotechnical Engineering Soil-cement mixture properties and design considerations for reinforced excavation. *J. Rock Mech. Geotech. Eng.* **2018**, *10*, 791–797, doi:10.1016/j.jrmge.2018.03.004.
7. Mengue, E.; Mroueh, H.; Lancelot, L.; Medjo, R. Evaluation of the Compressibility and Compressive Strength of a Compacted Cement Treated Laterite Soil for Road Application. *Geotech. Geol. Eng.* **2018**, doi:10.1007/s10706-018-0576-x.
8. Pongsivasathit, S.; Horpibulsuk, S.; Piyaphipat, S. Case Studies in Construction Materials Assessment of mechanical properties of cement stabilized soils. *Case Stud. Constr. Mater.* **2019**, *11*, e00301, doi:10.1016/j.cscm.2019.e00301.
9. Khosravi, M.; Boulanger, R.W.; Wilson, D.W.; Olgun, C.G. ScienceDirect Stress transfer from rocking shallow foundations on soil-cement reinforced clay. *Soils Found.* **2019**, *59*, 966–981, doi:10.1016/j.sandf.2019.04.003.
10. Tyagi, A.; Xiao, H.; Chin, K.; Lee, F. Model for predicting the unit weight of cement-treated soils. *Soils Found.* **2019**, *59*, 1921–1932, doi:10.1016/j.sandf.2019.09.002.
11. Xiong, F.; Xing, H.; Li, H. Experimental study on the effects of multiple corrosive ion coexistence on soil-cement characteristics. *Soils Found.* **2019**, *59*, 398–406, doi:10.1016/j.sandf.2018.12.001.
12. Zidan, A.F. Strength and Consolidation Characteristics for Cement Stabilized Cohesive Soil Considering Consistency Index. *Geotech. Geol. Eng.* **2020**, *6*, doi:10.1007/s10706-020-01367-6.
13. Pongsivasathit, S.; Horpibulsuk, S.; Piyaphipat, S. Assessment of mechanical properties of cement stabilized soils. *Case Stud. Constr. Mater.* **2019**, *11*, e00301, doi:10.1016/j.cscm.2019.e00301.
14. Lambe, T.W.; Moh, Z.-C. Improvement of strength of soil-cement with additives. *Highw. Res. Board Bull.* **1958**, 38–47.
15. Blanck, G.; Cuisinier, O.; Masrouri, F. Soil treatment with organic non-traditional additives for the improvement of earthworks. *Acta Geotech.* **2014**, *9*, 1111–1122, doi:10.1007/s11440-013-0251-6.
16. Lin, D.F.; Luo, H.L.; Hsiao, D.H.; Chen, C.T.; Cai, M. Du Enhancing soft subgrade soil with a sewage sludge ash/cement

mixture and nano-silicon dioxide. *Environ. Earth Sci.* **2016**, *75*, doi:10.1007/s12665-016-5432-9.
17. Aryal, S.; Kolay, P.K. Long-Term Durability of Ordinary Portland Cement and Polypropylene Fibre Stabilized Kaolin Soil Using Wetting–Drying and Freezing–Thawing Test. *Int. J. Geosynth. Gr. Eng.* **2020**, *6*, doi:10.1007/s40891-020-0191-9.
18. Tajdini, M.; Hajialilue Bonab, M.; Golmohamadi, S. An Experimental Investigation on Effect of Adding Natural and Synthetic Fibres on Mechanical and Behavioural Parameters of Soil–Cement Materials. *Int. J. Civ. Eng.* **2018**, *16*, 353–370, doi:10.1007/s40999-016-0118-y.
19. Deboucha, S.; Aissa Mamoune, S. mohammed; Sail, Y.; Ziani, H. Effects of Ceramic Waste, Marble Dust, and Cement in Pavement Sub-base Layer. *Geotech. Geol. Eng.* **2020**, *38*, 3331–3340, doi:10.1007/s10706-020-01211-x.
20. Anagnostopoulos, C.A.; Chrysanidis, T.; Anagnostopoulou, M. Experimental data of cement grouting in coarse soils with different superplasticisers. *Data Br.* **2020**, *30*, 105612, doi:10.1016/j.dib.2020.105612.
21. Carvalho, A.; de Castro Xavier, G.; Alexandre, J.; Pedroti, L.G.; de Azevedo, A.R.G.; Vieira, C.M.F.; Monteiro, S.N. Environmental durability of soil-cement block incorporated with ornamental stone waste. *Mater. Sci. Forum* **2014**, *798–799*, 548–553, doi:10.4028/www.scientific.net/MSF.798-799.548.
22. Elahi, T.E.; Shahriar, A.R.; Islam, M.S. Engineering characteristics of compressed earth blocks stabilized with cement and fly ash. *Constr. Build. Mater.* **2021**, *277*, 122367, doi:10.1016/j.conbuildmat.2021.122367.
23. França, B.R.; Azevedo, A.R.G.; Monteiro, S.N.; Da Costa, F.; Filho, G.; Marvila, M.T.; Alexandre, J.; Zanelato, E.B. Durability of soil-Cement blocks with the incorporation of limestone residues from the processing of marble. *Mater. Res.* **2018**, *21*, doi:10.1590/1980-5373-MR-2017-1118.
24. de Souza, J.M.; Lucena, L. de F.L. Soil-Cement Brick with Cassava Wastewater. In *Use of cassava wastewater and scheelite residues in ceramic formulations*; Acchar, W., da Silva, V.M., Eds.; 2021; p. 116 ISBN 9783030587819.
25. Van Ngoc, P.; Turner, B.; Huang, J.; Kelly, R. Experimental study on the durability of soil-cement columns in coastal areas. *Geotech. Eng.* **2017**, *48*, 138–143.
26. ASTMD2487 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System). *ASTM Int. West Conshohocken, PA* **2006**, 1–5, doi:10.1520/D2487-11.
27. Kirgiz, M.S. Effects of blended-cement paste chemical composition changes on some strength gains of blended-mortars. *Sci. World J.* **2014**, *2014*, doi:10.1155/2014/625350.
28. Bediako, M.; Amankwah, E.O. Analysis of chemical composition of Portland cement in Ghana: A key to understand the behavior of cement. *Adv. Mater. Sci. Eng.* **2015**, *2015*, doi:10.1155/2015/349401.
29. SNI03-6887-2002 Metode Pengujian Kuat Tekan Bebas Campuran Tanah Semen. *Natl. Stand. Agency Indones.* **2002**, 1–12.
30. ASTMD1633-00 Standard Test Methods for Compressive Strength of Molded Soil-Cement Cylinders. *ASTM Int. West Conshohocken, PA, USA,* **2000**, 1–4.
31. SNI03-3438-1994 Tata cara pembuatan rencana stabilisasi tanah dengan semen portland. *Natl. Stand. Agency Indones.* **1994**, 1–15.
32. DGH *General Specifications for Road and Bridge Construction Works*; 2018th ed.; Directorate General of Highway, Ministry of Public Work and Housing, 2018;
33. SNI-6427-2012 Test methods for wetting and drying test of compacted soil-cement mixtures. *Natl. Stand. Agency Indones.* **2012**, 1–25.
34. ASTMD559 Standard Test Methods for Wetting and Drying Compacted Soil-Cement Mixtures. *Am. Soc. Test. Mater.* **1996**, 1–6.
35. Cai, L.; He, L.; Peng, S.; Li, M.; Tong, M. Influence of titanium dioxide nanoparticles on the transport and deposition of microplastics in quartz sand. *Environ. Pollut.* **2019**, *253*, 351–357, doi:10.1016/j.envpol.2019.07.006.
36. Tan, W.; Peralta-Videa, J.R.; Gardea-Torresdey, J.L. Interaction of titanium dioxide nanoparticles with soil components and

plants: Current knowledge and future research needs-a critical review. *Environ. Sci. Nano* **2018**, *5*, 257–278, doi:10.1039/c7en00985b.

37. Goldberg, S. Interaction of aluminum and iron oxides and clay minerals and their effect on soil physical properties: A review. *Commun. Soil Sci. Plant Anal.* **1985**, *20*, 1181–1207, doi:https://doi.org/10.1080/00103629009368144.
38. Yong, R.N.; Sethi, A.J.; Booy, E.; Dascal, O. Basic characterization and effect of some chemicals on a clay from outardes 2. *Eng. Geol.* **1979**, *14*, 83–107, doi:10.1016/0013-7952(79)90079-6.
39. Bowers, B.B.; Daniels, J.L.; Anderson, J.B. Field considerations for calcium chloride modification of soil-cement. *J. Mater. Civ. Eng.* **2014**, *26*, 65–70, doi:10.1061/(ASCE)MT.1943-5533.0000780.
40. Bowers, B.F.; Daniels, J.L.; Lei, S.; Deblasis, N.J. Additives for Soil-Cement Stabilization. In *Pavement and Geotechnical Engineering for Transportation*; Huang, B., Bowers, B.F., Mei, G.-X., Luo, S.-H., Zhang, Z., Eds.; ASCE, 2013; pp. 68–75 ISBN 9780784412817.

infrastructures

MDPI

Article

The Role of Additives in Soil–Cement Subjected to Wetting–Drying Cycles

Yulian Firmana Arifin [1,*], Eka Agustina [2], Fransius Andhi [2] and Setianto Samingan Agus [3]

[1] Civil Engineering Study Program, University of Lambung Mangkurat, Jl. A. Yani km 35 Banjarbaru 70714, Indonesia; y.arifin@ulm.ac.id
[2] Civil Engineering Master Program, University of Lambung Mangkurat, Jl. Brigjen. H. Hasan Basri Banjarmasin 70123, Indonesia; h2a512011@mhs.ulm.ac.id, h2a512012@mhs.ulm.ac.id
[3] Mott MacDonald Pte. Ltd., Singapore; samingan.agus@mottmac.com
* Correspondence: y.arifin@ulm.ac.id; Tel.: +625114773858

Abstract: This study aimed to explore the use of additives in soil–cement mixtures that have undergone a wetting–drying cycle. Two types of soil were used, granitic and lateritic, which are widely used in road base construction in the Katingan area, Central Kalimantan, Indonesia. The cement used was the ordinary Portland type I, while the additive utilized was for commercial purposes, and predominantly contained $CaCl_2$. This research was conducted by testing the optimum cement content for each soil to determine the shear strength according to Indonesian standards (i.e., minimum UCS of 2400 kPa). The optimum cement contents of granitic and lateritic soils were deduced to be 5.5% and 5% on a dry weight basis, respectively. The utilization of 0.8% additive resulted in a 0.5% reduction of the optimum cement content of granite-like soil. The results showed that the optimum additive content for granitic soil was higher than that without supplementation, while for lateritic, no changes occurred. The advantage of using supplements, however, was more pronounced in the samples when they had been subjected to wetting–drying cycles. Additionally, at the optimum additive level, the moisture content and soil–cement loss during wetting was always lower than without supplements.

Keywords: lateritic soil; granitic soil; additive; soil stabilization; soil–cement

Citation: Lastname, F.; Lastname, F.; Lastname, F. Title. *Infrastructures* **2021**, *6*, x. https://doi.org/10.3390/xxxxx

Academic Editor: Firstname Lastname

Received: date

Accepted: date

Published: date

1. Introduction

Central Kalimantan is a province in Indonesia which is famous for its vast swampy areas; thus, it is difficult to source granular material for road foundations. Therefore, a soil–cement base is often used as an alternative.

The reliability and performance of this mixture have been widely studied [1–12]. Sunitsakul et al. [1] reported that the shear strength of a mixture is strongly affected by the water–cement ratio independent of its dry density. The dry density of the compacted mix should be higher than 95% of the maximum dry density of the modified Proctor compaction, as one of the criteria for road base application [1]. In addition, the percentage of cement is directly proportional to the shear strength of the soil–cement base [2,7,13]. This is because, with the increase in cement, the amount of calcium silicate hydrate (C-S-H), calcium aluminum hydrate (C-A-H), and calcium hydroxide ($Ca(OH)_2$) produced by the mixture's reaction also increases [4,11]. Additionally, the soil–cement shear strength increases with curing time [2,3,5,7,11]. Da et al. [2] reported that a mixture soaked in a higher pH groundwater produced greater strength than those immersed in distilled water. This corresponds with the increase in sample pH with a higher percentage of cement [5]. It can be concluded that the ability to resist stress by the mix is influenced by several factors, such as the water–cement ratio, density, curing time, salt content in the soil, and environmental conditions, particularly water and pH.

Commented [AK1]: Please confirm throughout.
Deleted: -…ement Subjected to Wetting–- ... [1]
Deleted: -…ement mixtures that have undergone a drying- ... [2]
Deleted: included…granitic and lateritic, which are widely used in road base construction in the Katingan area, Central Kalimantan, Indonesia. The cement used was the ordinary Portland type I, while the additive utilized was for commercial purposes, and predominantly contained $CaCl_2$. This research was conducted by testing the optimum cement content for each soil to determine the shear strength according to the…Indonesian standards minimum UCS of 2400 kPa). The optimum cement contents of the…granitic and lateritic soils were deduced to be 5.5% and 5% on a dry weight basis, respectively. The utilization of 0.8% additive resulted in a 0.5% reduction of the optimum cement content of granite-like soil. The results showed that the optimum additive c ... [3]
Deleted: -
Deleted: lso
Deleted: -
Deleted: ,…was always lower than th ... [4]
Deleted: ,…granitic soil;,…additive;, ... [5]
Deleted: -
Deleted: ,
Deleted: -
Deleted: mostly
Deleted: -
Deleted: and
Deleted: However, …t ... [6]
Deleted: hall…be higher than 95% of ... [7]
Deleted: Moreover…n addition, the ... [8]
Deleted: rises…[4,11]. Additionallys ... [9]
Deleted: -
Deleted: h higher…curing time [2,3, ... [10]
Deleted: -
Deleted: , …articularlynamely ... [11]

The addition of cement also improves the compaction behavior of a mixture in the case of fine-grained soils [7]. The compression index decreases, and the coefficient of consolidation increases, with a higher cement content. It has also been found that the soil pores become smaller, and the structure behaves more robustly with an increasing percentage [7]. Mg^{2+}, SO_4^{2+}, and Cl^- ions have been discovered in soils with high salt content [11], resulting in the reduction of calcium silicate hydrate (C-S-H) and aluminum hydrate (C-A-H) bonds. Consequently, the strength of the soil–cement mixture is reduced in this case. In addition to its application in road construction, this mixture is also used for other purposes, such as grouting and foundations [6,9].

To improve the strength attainment, soil and cement are normally mixed with some additional components, which are either solid or liquid natural or artificial ingredients. This addition always leads physical or chemical changes in the mixture. The use of additives to increase the shear strength of the soil–cement mixture started in the late 1950s; the researcher [14] used 29 additives, such as dispersants, synthetic resins, waterproofing agents, salts, and alkalis. The addition of 0.5–1.0% supplements, such as sodium carbonate, sodium hydroxide, sodium sulfate, and potassium permanganate, significantly increased the soil–cement shear strength by 150% [14]. Adding more substances beyond this did not result in a significant improvement, and partly resulted in strength reduction, as seen in a case where potassium hydroxide, calcium chloride, and sodium chloride were used.

Using different types of additives, such as acids, enzymatic solutions, and calcium lignosulfonate, Blanck et al. [15] obtained distinct compaction, UCS, swelling, permeability, and surface tension tests for various concentrations. At high proportions of calcium lignosulfonate, the shear strength of the soil–cement mix was lower than that at low concentrations. Lime and rice husk ash were also used as additives to increase the soil's resistance level. Lin et al. [16] added nano-silicon dioxide to a sewage sludge ash–cement mixture to improve its plasticity, shear strength, compression, swelling, and permeability behavior. Adding 2% of this compound to samples at the optimum moisture content produced the highest compressive strength. Aryal et al. [17] used polypropylene fiber to improve the performance of a mix in terms of its wetting–drying and freezing–thawing behavior. It was found out that the soil with 10% cement and 0.5% fiber was able to withstand wetting–drying for up to 12 cycles, based on its percentage loss. Organic fiber such as jute was also used to increase ductility [18]. Garbage, such as ceramic waste and marble dust, were combined with a small amount of cement (i.e., 2%) to produce a sub-base material for rural roads and highways [19]. For different purposes, superplasticizer additives were also used to improve the mixture's performance in grouting, to increase soil injectability and shear strength [20]. It was observed that the mix exhibited different behavior dependent upon the soil type, additive, and its percentage. Therefore, the soil–cement mix and the supplements were first tested according to conditions and designation [14].

Researchers have studied the durability of soil–cement mixtures with additives subjected to wetting–drying cycles [21–24]. França et al. [23] observed the addition of 30% limestone to a soil–cement mixture reduced water absorption and increased its compressive strength. Calcite and gibbsite-rich limestone have also been used in granite waste–cement mixtures. The sample with 60% waste and 5% limestone met the requirements for strength after experiencing wetting–drying cycles for 90 days [21]. De Souza and Lucena [24] replaced water with cassava wastewater, containing calcium and potassium, when making brick soil–cement. After seven days of wetting–drying cycles, the strength, water absorption, and loss of mass of the sample met the established criteria. These results have demonstrated the successful use of additives rich in calcium on soil–cement affected by wetting–drying cycles. The importance of the calcium content in the soil–cement mixture was also reported by Van Ngoc et al. [25]. Deep and rapid damage to soil–cement due to calcium leaching was found in samples submerged in high seawater concentrations [25]. Apart from calcium, fly ash, which contains silica, was also found to reduce mass loss due to wetting–drying processes, with a sample retention strength of 51–88% [22]. Generally,

Deleted: Furthermore, …t ... [12]
Deleted: it thus…increasing percentage [7]. The presence of …g²⁺, SO₄²⁺, and Cl⁻ ions have beenare…discovered in soils high salt content [11], which…result ... [13]
Deleted: -
Deleted: also
Deleted: Besides
Deleted: from…natural or artificial ingredients. This addition always leads th ... [14]
Deleted: -
Deleted: , where…the researcher [14] used 29 additives, such as dispersants, synthetic resins, waterproofing agents, salts, and alkalis. The addition of 0.5–- ... [15]
Deleted: -…ement shear strength by 150% [14]. However, …a ... [16]
Deleted: ,
Deleted: some …istinct results of ... [17]
Deleted: -
Deleted: of…at low concentrations. Lime and rice husk ash were also used as ... [18]
Deleted: -…ement mixture to impro ... [19]
Deleted: i.e.,…ceramic waste and m ... [20]
Deleted: -
Deleted: its
Deleted: A number of …r…searcher ... [21]
Deleted: the
Deleted: -
Deleted: the
Deleted: -
Deleted: As a result, t…e sample's ... [22]
Deleted: -
Deleted: predominantly in
Deleted: -…ement. After seven days ... [23]
Deleted: the…fly ash, whichh that. ... [24]
Deleted: -
Deleted: -
Deleted: However,…Gg ... [25]

the mixtures are used for brick. In this case, brushing was not carried out in the wetting–drying test [24].

This article discusses the reliability of two types of soil of predominantly granular material (i.e., granitic and lateritic soils), that have been mixed with cement and commercial additives, with respect to their behavior in wetting–drying cycles. They were chosen because they are widely available in Katingan, where it is not easy to find materials that meet the road base requirements. The most common method is to use a soil–cement mixture from the local soil. This method is more affordable than ordering materials from other regions. High rainfall and tides are often encountered in this location, causing the road to be submerged in several places. Therefore, the soil–cement base becomes degraded, as shown on the Tumbang Lahang-Tumbang Samba-Tumbang Kaman road section, Katingan Regency, Central Kalimantan, as indicated by the arrow in Figure 1a. This is in contrast with the soil–cement conditions where the road was not submerged, as shown in Figure 1b. No visible damage appears to the surface of the soil–cement in the figure. In this study, we aimed to find a solution to the problem by mixing an additive rich in calcium into the soil–cement. This was expected to improve the soil–cement mixture's performance against drying–wetting cycles, as shown by the reduced water absorption and loss of mass.

(a) **(b)**

Figure 1. The appearance of soil–cement as a base (**a**) undergoing wetting–drying cycles, and (**b**) non-submerged road.

2. Materials and Methods

2.1. Materials

One of the materials used was a granitic soil taken from Hampalit, Katingan Hilir, in Central Kalimantan. The deposits at the location are shown in Figure 2. Another material was a lateritic soil from Tumbang Kaman, about 100 km to the north of the district capital of Katingan, Kasongan, Central Kalimantan. This soil is a type used in road applications, as shown in Figure 1. The basic and engineering properties of the two soils are summarized in Table 1. The two samples had almost the same composition, which predominantly was sand. Both were classified as silty sand (SM) under the USCS classification system [26]. The chemical composition of the granitic and lateritic soils were determined using X-ray fluorescence (XRF) tests, as summarized in Table 2. Although the two samples were classified into the same soil type, the chemical composition of the soils was different. The lateritic soil predominantly contained Si and Fe, while the granitic was largely comprised of Si and Ti. The presence of Si can increase the soil cement's strength by forming C-S-H in the mixture [27].

The cement type used in the study was an ordinary Portland cement type I, with a specific gravity of 3.15. Using the X-ray fluorescence (XRF) test, its chemical contents, as summarized in Table 3, were obtained. The results were comparable with the Portland cement content, which consists of major oxides (i.e., CaO, SiO_2, Al_2O_3, and Fe_2O_3) and minor oxides (i.e., MgO, SO_3, and some alkali oxides (K_2O and Na_2O)) [28].

Deleted: -
Deleted: about…the reliability of two types of soil , which are ... [26]
Deleted: -
Deleted: se two
Deleted: -
Deleted: selected
Deleted: However, …h ... [27]
Deleted: it is…often encountered in thise…location, i.e., the high rainfall and tides… ... [28]
Deleted: -
Deleted: was…degraded, as shown on the Tumbang Lahang-Tumbang Samba-Tumbang Kaman road section, Katingan Regency, Central Kalimantan, as indicated by the arrow in Figure 1 ... [29]
Deleted: (…) ... [30]
Deleted: it…iwa… in contrasts ... [31]
Deleted: -
Deleted: that were…not submerged, as shown in Figure 1 (... [32]
Deleted: (…)… No visible damage appears to the surface of the soil–cement in the figure. In tT…is study, we aimed to find a solution to the problem by mixing an additive rich in calcium into the soil–- ... [33]
Deleted: It…wai ... [34]
Deleted: -…ement mixture's performance against drying–- ... [35]
Commented [AK2]: Add an explanation for the arrow.
Deleted: -
Deleted: -
Formatted: Font: Bold
Formatted: Font: Bold
Deleted:
Deleted: N…rth of the district capital of Katingan, Kasongan, Central Kalima ... [36]
Deleted: tible

Table 1. Engineering properties of the soils.

Properties	Granitic	Lateritic
Specific gravity	2.64	2.64
Water content (%)	2.4	4.3
Gravel (%)	0.00	1.19
Sand (%)	77.76	69.46
Silt (%)	7.74	0.9
Clay (%)	14.5	28.56
Liquid limit (%)	-	28.59
Plastic limit (%)	-	22.74
Plasticity index (%)	-	5.85
Soil Classification (USCS)	Silty sand	Silty sand
Unconfined compression strength (c_u) (kN/m^2)	-	26.8
Maximum dry density (kN/m^3)[1]	16.33	17.73
Optimum moisture content (%)[1]	12.5	14.3

[1] Modified Proctor compaction test.

Table 2. Chemical composition of soils.

Composition	Granitic [1]	Lateritic [1]
Al	1.77	15
Si	83.12	29
Ca	0.02	0.89
Ti	10.75	2.28
Fe	1.18	46.3
Ni	0.00	3.93

[1] obtained from the X-ray fluorescence test (XRF)

Table 3. Chemical composition of the cement

Compounds	Percentage [1]
CaO	67.28
SiO_2	18.68
Al_2O_3	4.30
Fe_2O_3	4.54
MgO	1.10
Alkali ($K_2O + Na_2O$)	1.71
SO_3	1.28

[1] obtained from the X-ray fluorescence test (XRF)

(a) (b)

Figure 2. (a) Granitic soil, and (b) Granitic soil deposits in Hampalit village, Central Kalimantan.

Deleted: I

Deleted: F

Deleted: used

Deleted: F

Commented [AK3]: Add a,b to the subfigures and describe them both.

The additive used was a commercial type, which was in the form of a powder. The chemical contents are shown in Table 4, and mainly included chlorine (Cl), calcium (Ca), and potassium (K).

Table 4. Chemical composition of the additive.

Compositions	Percentage [1]
Cl	55.7
K	4.47
Ca	37.6
Fe	0.18
Ni	0.964
Cu	0.092

[1] obtained from the X-ray fluorescence test (XRF).

2.2. Methods and Procedures

Each soil density was achieved by compacting the samples by following the Modified Proctor Standard to obtain the optimum moisture content of the lateritic and granitic samples, which were 14.3% and 12.5%, respectively, with a maximum dry density of 17.73 kN/m^3 and 16.33 kN/m^3, respectively, as shown in Table 1.

Unconfined compression strength (UCS) tests were carried out on each sample at its optimum moisture content and maximum dry density, with various cement percentages of 4%, 4.5%, 5%, 5.5%, and 6% on a dry weight basis based on SNI03-6887-2002 [29], which was similar to ASTM D-1633-2000 [30]. This test is commonly used to determine the effect of cement on the soil [1–3,5–8,10–11,14–16,18].

Based on the Indonesian standard (SNI03-3438 1994) [31], the optimum cement content is at a UCS of 2200 kPa. Following the latest and more specific standard, the general specification for highways, a UCS of 2000–2400 kPa is required [32]. It should be noted that the required soil shear strength for road applications differs from country to country. Antunes et al. [5] compared the strength required by several countries. Table 5 shows the required mechanical specifications compared to those used in Indonesia; however, in this study, the maximum value was used (i.e., 2400 kPa).

Table 5. Laboratory UCS required for soil–cement mixtures.

Layer	U.S. Army Corps for Engineer [5]	German [5]	Portuguese [5]	Southern African [5]	Indonesia [31]	Indonesia [32]
Base	≥5.17 MPa for 7 days curing time	≥7.0 MPa for 28 days curing time	Non-specified	1.5 ≤ UCS ≤ 3.0 MPa for 7 days curing time	2.2 MPa for 7 days curing time	2.0 ≤ UCS ≤ 2.4 MPa for 7 days curing time
Sub-base Layer	≥1.72 MPa for 7 days curing time	≥0.5 MPa for 28 days curing time	0.8 ≤ UCS ≤ 1.0 MPa for 28 days curing time	0.75 ≤ UCS ≤ 1.5 MPa for 7 days curing time	0.6 MPa for 7 days curing time	Non-specified

The wetting–drying test was carried out based on the Indonesian standard (SNI 6427 2012) [33]. A No. 4 (4.75 mm) sieve was used. Two samples were used in the wetting–drying test. One was used for any changes in absorption (i.e., Specimen No. 1), and the other was for soil loss (i.e., Specimen No. 2). After compaction, the samples were stored in a humid place and protected from free water for seven days. Specimen No. 1 was weighed and measured in dimensions after storage at the end of day 7. Then, the samples were immersed in water at room temperature for 5 hours. Specimen No. 1 was again

Deleted: with
Deleted: ing
Deleted: used
Deleted: F
Deleted: its
Deleted: at
Formatted: Superscript
Formatted: Superscript
Deleted: as
Commented [AK4]: Please combine these.
Deleted: However,
Deleted: f
Deleted: of the
Deleted: of the country
Deleted: is considered to be at
Deleted: -
Deleted: a
Deleted: another
Deleted: -
Commented [AK5]: Add an explanation for this symbol
Deleted:
Deleted:
Deleted:
Deleted:
Deleted:
Deleted:
Deleted: -
Deleted: The soil material passing a
Deleted: -
Deleted: S
Deleted: -
Deleted: then

weighed and measured. Both specimens were placed in an oven at 71 °C for 42 hours. Then, sample No. 1 was weighed and measured in its dimensions. For Sample No. 2, two firm strokes were given on all areas with the wire scratch brush. It took approximately 18–20 vertical firm strokes to cover the specimen's sides twice, and four strokes on each end. Then, it was weighed. Both samples were re-immersed, and the same procedure was continued for 12 cycles. At the end of the cycle, the samples were placed in an oven at 110 °C for 24 hours to determine the dry weight. This method is similar to the ASTM standard [34]. After 12 cycles, UCS tests were performed to obtain the residual shear strength of each sample. Table 6 presents a summary of the initial conditions of the tested samples. GC and LC refer to granitic and lateritic soils, respectively. The next two numbers indicate the cement and additive content. An additional denotation is given at the end of the sample numbering in Table 6, namely "1" for the volume and moisture change measurements, and "2" is for the soil–cement loss measurements.

Table 6. Initial conditions of the wetting–drying samples.

Soil	Sample Code	γ_d	w (%)	Cement (%)	Additive (%)
Granitic	GC-5-0-1	16.33	12.5	5	0
Granitic	GC-5-0-2	16.33	12.5	5	0
Granitic	GC-5-0.8-1	16.33	12.5	5	0.8
Granitic	GC-5-0.8-2	16.33	12.5	5	0.8
Lateritic	LC-5-0-1	17.73	14.3	5	0
Lateritic	LC-5-0-2	17.73	14.3	5	0
Lateritic	LC-5-2-1	17.73	14.3	5	2.0
Lateritic	LC-5-2-2	17.73	14.3	5	2.0
Lateritic	LC-5-5-1	17.73	14.3	5	5.0
Lateritic	LC-5-5-2	17.73	14.3	5	5.0
Lateritic	LC-5-9-1	17.73	14.3	5	9.0
Lateritic	LC-5-9-2	17.73	14.3	5	9.0
Lateritic	LC-5-14-1	17.73	14.3	5	14.0
Lateritic	LC-5-14-2	17.73	14.3	5	14.0

Two tests were carried out to determine the microscopic samples and chemical components before and after mixing with additives and the wetting–drying processes. The two tests were field-emission scanning electron microscopy (FESEM) and energy-dispersive X-ray spectroscopy (EDAX). Other researchers investigating soil–cement mixes have also used these two methods.

3. Results

3.1. Optimum Additive and Soil–Cement Content

Figure 3 shows the results of the UCS granitic and lateritic soils. This graph shows that the optimum cement content for both was 5.5% and 5.0%, respectively. The additive content in the mixtures was determined using a trial test by mixing an added component with varying concentrations from 2% to 14% of the soil–cement sample. In the determination of the cement content, the optimum additive percentage produced a sample UCS of 2400 kPa. Its variation with the additive content is shown in Figure 4a and 4b for the granitic and lateritic soils, respectively. For the granitic soil, lower cement contents (i.e., 4.5% and 5%), with the addition of the same percentage of supplements, were assessed. It was found that the UCS was still below 2400 kPa. As shown in Figure 4a, the optimum additive content was 0.8% and 6% for 5% cement content. A lower additive content (i.e., 0.8%) was selected and used for further blending. For the lateritic soil (Figure 4b), 2% of the additive

Deleted: -
Deleted: the weight was
Deleted: s
Deleted: the
Commented [AK6]: I recommend adding this as a footnote to the table.
Deleted: -
Deleted: -
Deleted: -
Deleted: the
Deleted: -
Deleted: -
Deleted: -
Deleted: also known as its
Deleted: the
Deleted: 's
Deleted: s
Deleted:
Deleted: (
Deleted:)
Deleted:
Deleted: (
Deleted:)
Deleted: its
Deleted:
Deleted: (
Deleted:)
Deleted: The
Deleted: However,
Deleted: f
Deleted:
Deleted: (
Deleted:)
Deleted: of the percentage addition

was chosen because it gave the required strength (2400 kPa). Although the UCS was almost the same as for the soil-cement mix without additives, its effect on the wetting-drying cycles was easily discernible.

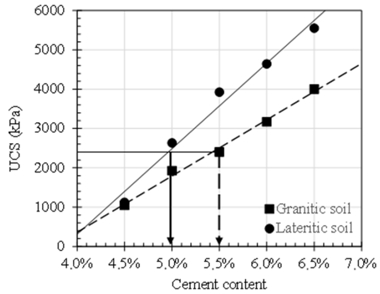
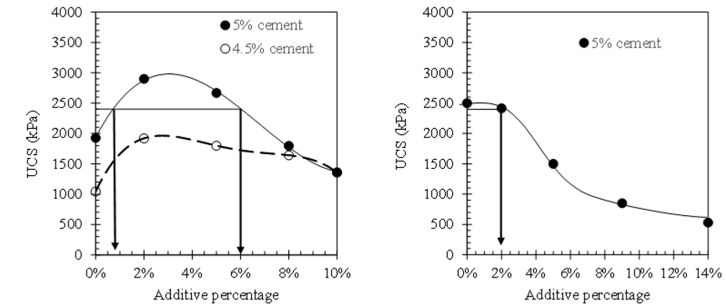


Figure 3. Optimum cement content determination.



(a) **(b)**

Figure 4. Determination of additive percentage in the mixture. (**a**) Granitic soil, and (**b**) lateritic soil.

3.2. Granitic Soil

Figure 5 shows the change in water content during the 12 cycles of the wetting-drying process for granitic soil. As shown in Figure 5a, the moisture content of the soil-cement sample after wetting varied by an average of 3.9% for the samples mixed with 0.8% additive, and 14.8% for the samples without it. The addition of 0.8% supplement reduced the amount of water absorbed by the sample by 3.8 times. Meanwhile, for the brushed samples (Figure 5b), the water increased with the number of wetting-drying cycles, which was observed after the sixth cycle. The sample's water content without additive increased from 16% in the first cycle to 25% in the 12th cycle (a 1.6-fold increase). In addition, with the supplements, it also increased from 4.8% to 20% (or about 4.2 times); nevertheless, the sample water content with additives was still lower than without.

An important conclusion with regards to soil-cement samples that have undergone wetting-drying processes is with respect to the soil-cement loss, which is defined as the ratio of the original calculated sample's oven-dried weight minus its final corrected weight (ASTM D559 1996) [34]. Simply, it is the dry unit weight of the sample per cycle divided by the initial dry density of the sample. Here, the soil-cement loss was shown not only in the brushed samples, but also during soaking (i.e., volume and moisture change

Deleted: -…ement mix without additives, its effect on the wetting–- ... [37]
Commented [AK7]: Change the comma a decimal point.
Commented [AK8]: Additive is spelled wrong.
Deleted: s
Deleted: g
Formatted: Font: Bold
Formatted: Font: Bold
Deleted: -
Deleted: the …ranitic soil. As shown in Figure 5 (... [38]
Deleted: (…)… the moisture content of the soil–-… ... [39]
Deleted: with…an average of 3.9% for the samples mixed with 0.8% additive, and 14.8% for the samples without it. The addition of 0.8% supplement reduced the amount of water absorbed by the sample by 3.8 times. Meanwhile, for the brushed samples (Figure 5 ... [40]
Deleted: (…) ... [41]
Deleted: high…number of the ... [42]
Deleted: -
Deleted: 6th
Deleted: or… equal to an increase o ... [43]
Deleted:
Deleted: s
Deleted: Moreover…n addition, with the supplements, it also increased from 4.8% to 20% (or about 4.2 times);….nN ... [44]
Formatted: Not Superscript/Subscript
Deleted: s'…water content with additives was still lower than those ... [45]
Deleted: s
Deleted: on…to the ... [46]
Deleted: -
Deleted: the
Deleted: -…rying processes is with r ... [47]
Deleted: when being…soakinged ... [48]

specifications). Figure 6a shows that for the soil–cement samples without additives the mixture started losing weight in the second cycle, while for those with supplements this occurred in the third cycle. At the end of the test (i.e., after the 12th cycle), the soil–cement samples without additives exhibited a weight loss of 25% and 17%. The loss for the samples with supplements was 8% less than those without. This was more significant in the sample that was intended for investigation (Figure 6b). The soil–cement loss commenced from the second cycle and increased until the last phase. At the end of the test, the soil–cement loss of the samples without additives was 47%, or 14% greater than those with supplements (i.e., 34%). The addition of these substances reduced the soil–cement loss due to the wetting–drying cycles.

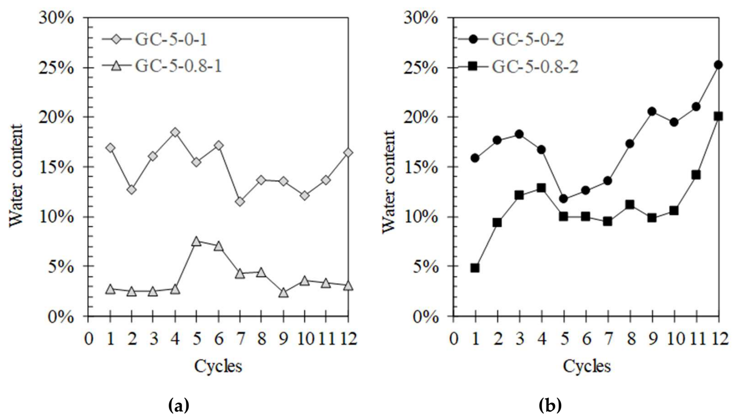


Figure 5. Water content alteration throughout the wetting–drying cycles. (**a**) Volume and moisture change specimens, and (**b**) soil–cement loss specimens.

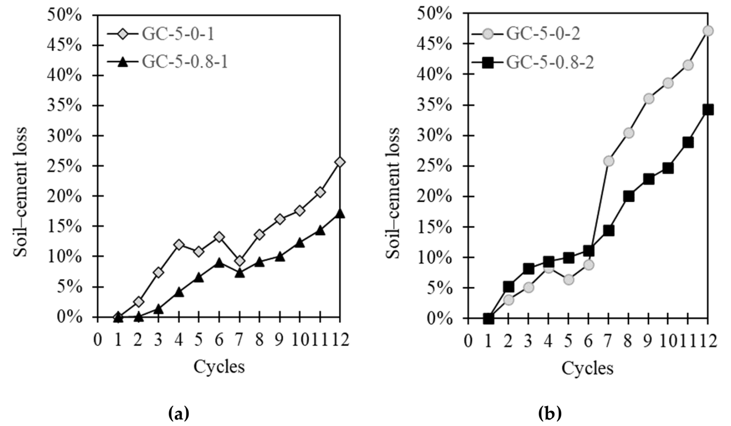


Figure 6. Soil–cement loss throughout the wetting–drying cycles. (**a**) Volume and moisture change specimens, and (**b**) soil–cement loss specimens.

Upon completion of these cycles, the samples were tested for their strength (UCS). Sample GC-5-0-2 was not examined due to being broken before testing. Figure 7 depicts

Deleted: shows the results; where (
Deleted:)
Deleted: -
Deleted: ,
Deleted: . in
Deleted: -
Formatted: Not Superscript/Subscript
Deleted: the
Deleted:
Deleted: (
Deleted:)
Deleted: -
Deleted: -
Deleted: is
Deleted: -
Deleted: -
Deleted: -
Deleted: v
Formatted: Font: Bold
Deleted: -
Deleted: One of the important
Formatted: Font: Bold
Commented [AK9]: Please update soil-cement to soil–cement.
Deleted: -
Deleted: -
Deleted: v
Formatted: Font: Bold
Deleted: -
Formatted: Font: Bold
Deleted: for

the results of the UCS tests on these specimens. Before the wetting–drying cycles, the samples with additives (GC-5-0.8) had a UCS of 2400 kPa, and after the process, it dropped to 1049 kPa for Sample 1 (i.e., for the volume and moisture change measurement) and 678 kPa for Sample 2 (i.e., the specimen for the soil–cement loss measurement). The smallest UCS was observed in the sample without additives (i.e., 441 kPa). It could be concluded that the wetting–drying process decreased the strength of the mixture. Those with additives were twice as strong as those without at the end of the cycles.

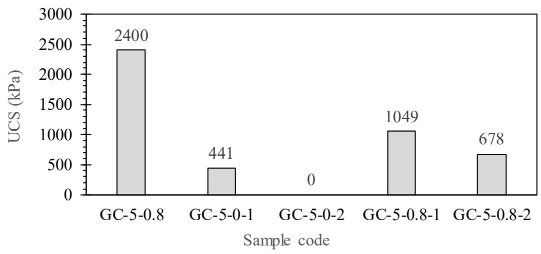
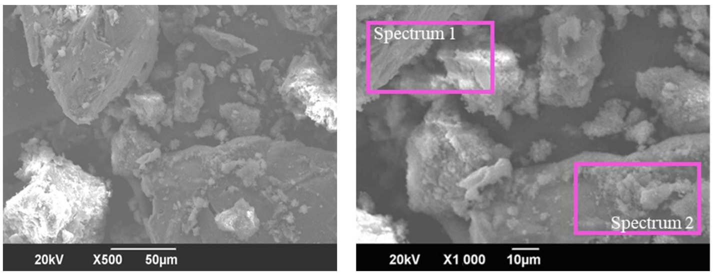


Figure 7. Unconfined compression strength of the granitic–cement samples.

Figures 8–10 show the SEM results of the granitic soil samples (Figure 8), the granitic–cement mix specimen (Figure 9), and the soil–cement mix with 0.8% additives (Figure 10). It can be clearly observed in Figure 8a,b that the granitic soil consisted of sand grains and silt particles with irregular shapes and varying sizes, which were smaller than 50 µm. The grains did not appear to bind to one another.



(a) **(b)**

Figure 8. SEM Pictures of granitic soil at (**a**) 500× magnification and (**b**) 1000× magnification.

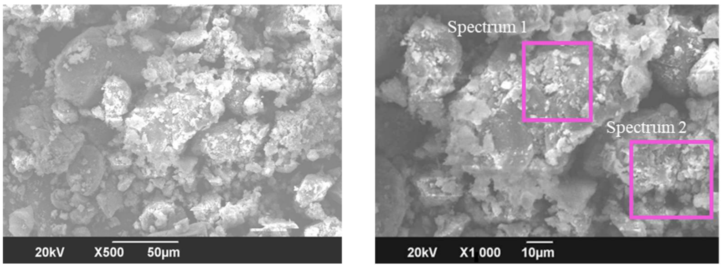
Table 7 presents the average chemical contents of this type of soil, extracted with EDX in Spectrums 1 and 2 (Figure 8). This showed the dominance of Si and Ti, confirming the chemical content results from XRF, as shown in Table 2. The addition of cement was observed to produce bonding between the grains, and more compact and smaller pores, as shown in Figure 9. The presence of cement, rich in CaO, was observed from the increase in Ca element at the area where the EDX test was carried out (Figure 9), and the results are shown in Table 7. The Ca content increased to 6.64%.

The addition of 0.8% additive resulted in more compact clusters with smaller visible pores, as shown in Figure 10a,b. In Table 7, the Ca content increased to 15.2% due to a high content of $CaCl_2$ in the supplement. The presence of this chemical also increased the Ti content due to reduced mobilization of Ti in the soil by $CaCl_2$ [35,36].

Deleted: -
Deleted: -
Deleted: -
Deleted: also
Deleted: the
Deleted: er
Deleted: than
Deleted: -
Deleted: -
Deleted: s
Deleted: -
Deleted: -
Deleted: was
Deleted: s
Deleted: (
Deleted:)
Deleted: and 8(
Deleted:)
Deleted: even
Deleted: Also,
Deleted: t
Commented [AK10]: Change 1,000 to 1000.
Deleted: ,
Formatted: Font: Bold
Formatted: Font: Bold
Deleted: , which
Deleted: ed
Deleted: that was not previously found in the granitic soil
Deleted: s
Deleted:
Deleted: (
Deleted:) and
Deleted: 10
Deleted: (
Deleted:)
Deleted: the

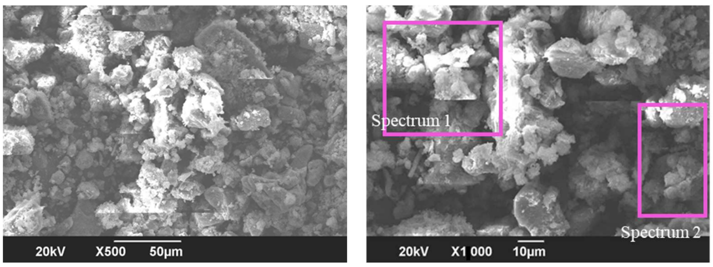
Table 7. Initial condition of the wetting drying samples.

Element	Granitic Soil (Figure 8)	GC-5-0-1 (Figure 9)	GC-5-0.8-1 (Figure 10)
Si (%)	91.95	88.82	77.06
Al (%)	1.93	1.28	6.39
Ca (%)	0.095	6.64	15.2
Ti (%)	6.73	1.41	1.69



(a) **(b)**

Figure 9. SEM pictures of the GC-5-0-1 sample at (**a**) 500× magnification and (**b**) 1000× magnification.



(a) **(b)**

Figure 10. SEM pictures of the GC-5-0.8-1 sample at (**a**) 500× magnification and (**b**) 1000× magnification.

Other elements appeared to have little effect; therefore, the influence of additives was not easily recognizable on the different samples' chemical elements, taken in Spectrums 1 and 2 (Figure 10). The average Ca content increased in the specimens, and the SEM results clearly showed differences in the physical conditions of the samples with additives.

3.3. Lateritic Soil

Figure 11a,b show the moisture content of the lateritic cement samples that were subjected to wetting drying cycles for volume and moisture changes, and soil cement loss specimens, respectively. The LC-5-14-1 sample (i.e., that with 14% additives) was not tested after the second cycle because it collapsed. The average water content of the samples LC-5-0-1, LC-5-2-1, LC-5-5-1, and LC-5-9-1 were 9.9%, 2.8%, 9.8%, and 10.5%, respectively. Specimens with 2% additives showed the lowest moisture content. For brushed

Deleted: -

Commented [AK11]: It is hard to read the white text on the image. Change 1,000 to 1000.

Deleted: P

Deleted: ,

Formatted: Font: Bold

Formatted: Font: Bold

Commented [AK12]: Change 1,000 to 1000

Deleted: P

Deleted: ,

Formatted: Font: Bold

Formatted: Font: Bold

Deleted: .

Deleted: s

Deleted: However,

Deleted: t

Deleted: in

Deleted: s

Deleted: (

Deleted:) and

Deleted: 11

Deleted: (

Deleted:)

Deleted: s

Deleted: -

Deleted: -

Deleted: -

Deleted: Meanwhile, t

Deleted: small

Deleted: However,

Deleted: f

samples, the volume varied but did not increase. This was different from the granitic–cement samples, which showed increased volume after wetting–drying cycles. The average moisture content of the samples were 11.7%, 5.7%, 12.1%, and 12.9% for LC-5-0-2, LC-5-2-2, LC-5-5-2, and LC-5-9-2, respectively. The water content of the LC-5-14-2 sample was not tested because it collapsed after the second cycle.

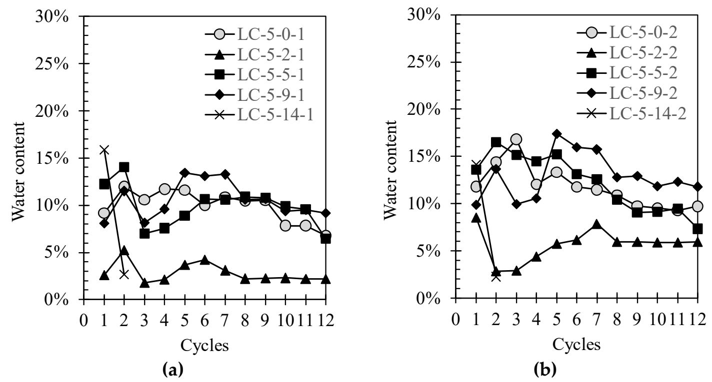


Figure 11. Water content alterations throughout the wetting–drying cycles: (**a**) volume and moisture change specimens, and (**b**) soil–cement loss specimens.

Figure 12a,b show soil–cement loss for volume and moisture change specimens. As observed in Figure 12a, the increase in this property occurred from the first cycle to the fifth. In addition, the sample tended not to lose weight. At the end of the cycle, the soil–cement loss samples LC-5-0-2-1, LC-5-2-1, LC-5-5-1, and LC-5-9-1 were 12.6%, 11.7%, 16.6, and 20%, respectively. Similar behavior was observed in specimens where the sample lost significant weight from cycles 1 to 5. After this, the increase in sample tonnage loss was not that great. At the end of the wetting–drying cycles, the soil–cement loss samples LC-5-0-2, LC-5-2-2, LC-5-5-2, and LC-5-9-2 were 14.5%, 13.7%, 18.4%, and 21.6%, respectively. These results indicated that the sample experiencing the least weight loss was that with the addition of 2% additives (i.e., LC-5-2) for both tests, as shown in Figure 13. The addition of more than 2% supplements resulted in an increase in soil–cement loss.

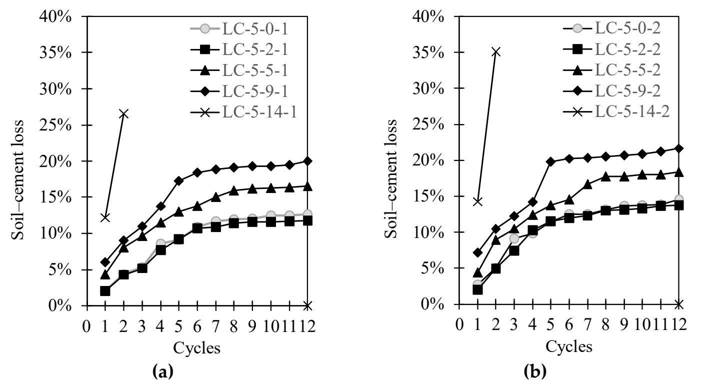


Figure 12. Soil–cement loss throughout the wetting–drying cycles: (**a**) volume and moisture change specimens, and (**b**) soil–cement loss specimens.

Deleted: is
Deleted: ones in the
Deleted: -
Deleted: -
Deleted: as
Deleted: Meanwhile, t
Deleted: -
Deleted: ;
Formatted ... [49]
Deleted: -
Formatted ... [50]
Deleted: s
Deleted: (
Deleted:) and
Deleted: 12
Deleted: (b
Deleted:)
Deleted: s
Deleted: a
Deleted: -
Deleted: (
Deleted:)
Deleted: start
Deleted: Moreover
Deleted: -
Deleted: started
Deleted: -
Deleted: -
Deleted: -
Commented [AK13]: Change soil-cement to ... [51]
Deleted: -
Deleted: -
Deleted: ;
Formatted ... [52]
Deleted: ,
Deleted: -
Formatted ... [53]

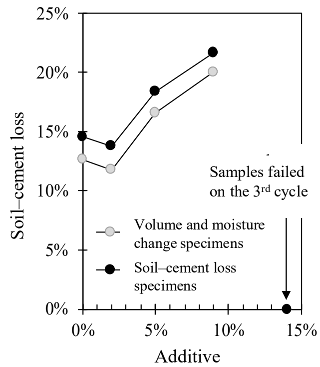


Figure 13. Soil–cement loss as a function of the additive content of lateritic soil.

After the wetting–drying test, the samples were examined using UCS, and as shown in Figure 14, the results were compared with UCS specimens before the wetting–drying tests. As observed in Figure 14, this process did not significantly affect the sample UCS, either with or without additives. There was no discernible difference between the two. In addition, the higher the percentage of the additives, the lower the UCS value. These results indicated that the addition of supplements does not always result in a positive trend. Investigations needed to be carried out for each type of soil, and the additives used. These results were in accordance with previous findings [3,14].

Figure 15 shows SEM photos of samples of lateritic soil (Figure 15a), soil–cement (Figure 15b), and soil–cement–additive mixtures (Figure 15c–f). Figure 15a shows compacted lateritic soil grains with large pores. The granular size varies by even less than 50 µm. The chemical content test was carried out with EDX on Spectrum 1 with the composition shown in Table 8. In the sample, Al, Si, and Fe were the dominant elements, according to the XRF test (Table 2). After adding cement, the specimen was observed to be denser with closed pores, as shown in Figure 15b. Like the granitic soil sample, cement added to the quantity of Ca, which increased from 0.21% to 4.11% in the EDX test results (Table 8).

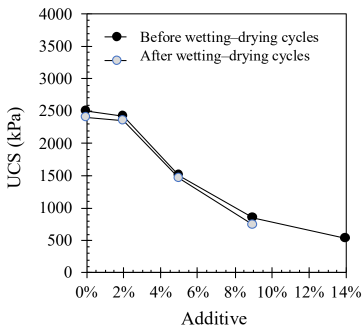


Figure 14. UCS as a function of additive content before and after wetting–drying cycles of lateritic soil.

Commented [AK14]: update soil–cement. Remove the superscript from 3rd.

Deleted: -

Deleted: -

Deleted: -

Deleted: Moreover

Deleted: the

Deleted: Moreover,

Deleted: t

Deleted: reported in theby those literature

Deleted:

Deleted: (

Deleted:)

Deleted: -

Deleted:

Deleted: (

Deleted:)

Deleted: -

Deleted: -

Deleted:

Deleted: (

Deleted:)

Deleted: -15

Deleted: (

Deleted:)

Deleted:

Deleted: (

Deleted:)

Deleted: (

Deleted:)

Commented [AK15]: change to wetting–drying. Additive spelled wrong.

Deleted: -

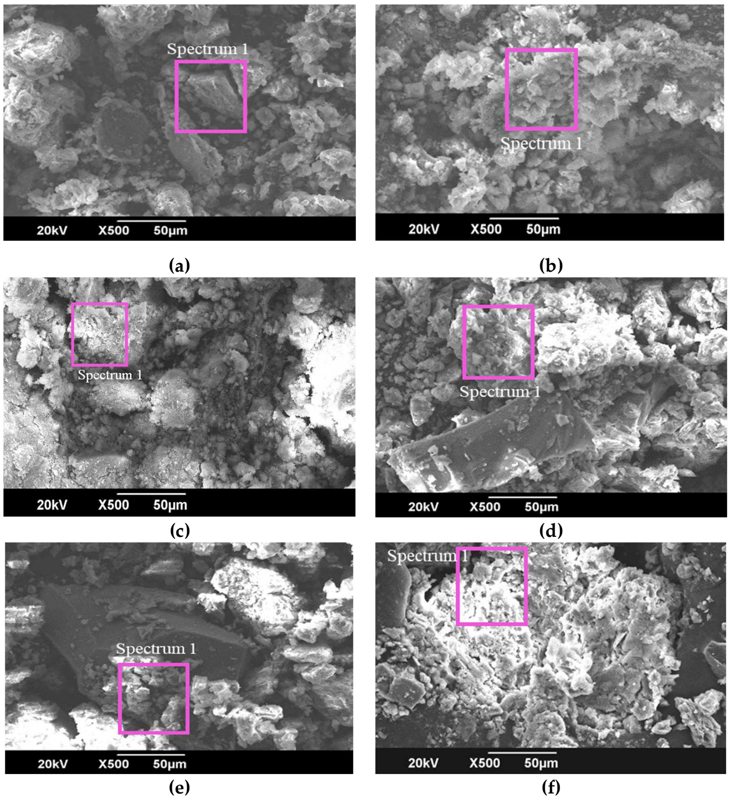


Figure 15. SEM photos of samples of lateritic–cement–additive before wetting–drying cycles (a) Lateritic soil, (b) LC-5-0, (c) LC-5-2, (d) LC-5-5, (e) LC-5-9, and (f) LC-5-14

The addition of 2% additive resulted in a denser sample with even smaller pores. The soil grains were also invisible in this condition (Figure 15c). Excessive supplements caused the cement clusters to reappear; the pores were also clearly visible in this case (Figure 15d–f). The bonds between the cement and soil grains were no longer visible at the additive percentages of 9% and 14% (Figure 15e,f). From the EDX results (Table 8), it was observed that the addition of 2% additives resulted in an increase in Ca, reduction in Fe, and unchanged contents of Si and Al. The addition of Ca, which was supposed to increase the shear strength of the sample, did not occur because of the Fe content reduction. Goldberg [37] reported that iron oxide in clays has a beneficial effect on soil physical properties, increasing its stability and dispersion. Reduced iron oxide content resulted in reduced soil shear strength [38]. When the additive was more than 2%, this resulted in a significant increase in Ca, with the Fe content not changing much, while Si and Al decreased. Iron oxide and aluminum oxide stabilize clay soils by decreasing clay dispersion and water uptake, and increasing micro-aggregation [37], however Fe, Al, and Si's reduced content resulted in reduced soil shear strength [38]. Therefore, it was concluded that additives with high $CaCl_2$ content are not suitable for stabilizing lateritic soils with high Fe content.

Figure 16 shows SEM photos of samples LC-5-0-1 and LC-5-2-1 after the wetting–drying process. It was observed that the two samples showed almost the same conditions;

Commented [AK16]: Please describe all subfigures seperately. The white text is hard to read in some subfigures.

Deleted: s

Deleted: -

Deleted: -

Deleted: -

Deleted: a

Deleted: yet

Deleted:

Deleted: (

Deleted:)

Deleted: However,

Deleted: e

Deleted:

Deleted: (

Deleted:)

Deleted: -15

Deleted: (

Deleted:)

Deleted: s

Deleted:

Deleted: (

Deleted:) and

Deleted: 15

Deleted: (

Deleted:)

Deleted: the

Deleted: es

Deleted: t much

Deleted: Although, i

Deleted: ,

Deleted: content

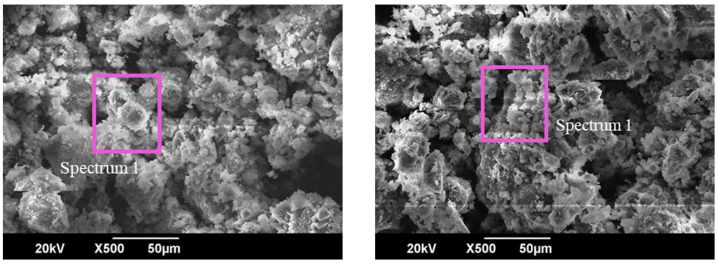
Deleted: s

Deleted: ,

Deleted: -

Deleted: where the

cement clusters with small pores were visible. The two specimens' chemical contents showed that the Al content was slightly increased, and Si remained constant after wetting–drying cycles (Table 8). Meanwhile, the Ca quantity increased due to reduced Fe content in the soil.



(a) **(b)**

Figure 16. SEM photos of samples of lateritic–cement–additive after wetting–drying cycles (a) LC-5-0-1 After wetting–drying cycles, and (b) LC-5-2-1 After wetting–drying cycles

Table 8. Chemical elements of lateritic–cement–additive mixtures.

Element	**Before wetting–drying process**						**After wetting–drying**	
	Lateritic Figure 15a	LC-5-0 Figure 15b	LC-5-2 Figure 15c	LC-5-5 Figure 15d	LC-5-9 Figure 15e	LC-5-14 Figure 15f	LC-5-0-1 Figure 16a	LC-5-2-1 Figure 16b
Al (%)	31.37	30.48	34.41	28.16	30.42	26.68	32.62	36.08
Si (%)	45.14	42.99	45.1	40.87	40.54	35.37	42.00	44.83
Ca (%)	0.21	4.11	4.67	9.66	13.74	22.95	9.00	7.50
Fe (%)	19.39	17.65	13.45	9.70	10.92	9.84	10.75	7.71

4. Discussion

The effect of wetting–drying on soil–cement has rarely been examined; therefore, information on reducing its effects is also limited. One strategy is to add polypropylene fiber [17]. In this study, additives rich in Ca^{2+} and Cl^- (Table 4) were used. The addition of $CaCl_2$ to cement is generally used to increase the strength [14,39,40]. The dosage used also varies for different soil types. It was observed that the optimum additive amounts were 0.8% and 2%, corresponding to UCS 2400 kPa, based on the required soil–cement strength standards [32]. The effect of adding more additives than the optimum percentage was also different for the two soils. For lateritic soils, more than 2% supplements resulted in a reduction in the UCS. For granitic–cement, the maximum UCS of 3000 kPa was obtained at an additive content of 3% (Figure 4). This result allowed a reduction in the amount of cement in the mixture, initially of 5.5% (Figure 3). When adding 0.8% additives, the required cement was only 5% (Figure 4). This was due to Si and Al's high content in granitic soil, allowing the formation of more C-S-H and C-A-H. Both compounds play a major role in increasing soil–cement strength [4,11].

Indications of reduced strength due to excess $CaCl_2$ have been submitted by many researchers [39,40] as a consequence of the formation of $3CaO.Al_2O_3.CaCl_2.10H_2O$, due to the presence of Cl^- preventing the formation of C-S-H and C-A-H [4,11]. This effect occurs not only in short-term, but also in long-term strength [4]. The Si and Al content of the two samples tested were different, which resulted in a different effect. The low content of Si and Al in lateritic soils resulted in limited C-S-H and C-A-H formation. The addition of Cl- further reduced their production. SEM results proved that the addition of a Cl-rich

Deleted: -

Commented [AK17]: Move the subfigure description to the main description. The white text is hard to read.

Deleted: s

Deleted: -…ement–-…dditive after wetting–-drying cycles (a) LC-5-0-1 After wetting–-drying cycles, and (b) LC-5-2-1 After wetting–-… ... [54]

Deleted: -…ement– ... [55]

Deleted: -

Deleted: -

Deleted: (…) ... [56]

Deleted: (…) ... [57]

Deleted: (…) ... [58]

Deleted: (…) ... [59]

Deleted: (…) ... [60]

Deleted: (…) ... [61]

Deleted: (…) ... [62]

Deleted: (…) ... [63]

Deleted: s

Deleted: -…rying on soil–- ... [64]

Deleted: is…rarely been examined; therefore, information on reducing its effects is also limited. One strategyof the efforts that have been made ... [65]

Deleted: However, …i ... [66]

Deleted: stimulate in addition to…increase the strength [14,39,40]. The dosage used is …lso variesd…for different soil types. It was observed that the optin ... [67]

Deleted: -

Deleted: higher …han the optimum ... [68]

Deleted: -

Deleted: which was…initially of ol ... [69]

Deleted: -

Deleted: The i…dications of reduce ... [70]

Deleted: Moreover, …t ... [71]

Deleted: ,

additive resulted in a granular shape, which increased with the addition of the additive (Figure 15d–f). This is evidence of the formation of $3CaO.Al_2O_3.CaCl_2.10H_2O$ based on observations made by Xiong et al. [11]. Temperature has also been reported to influence soil–cement [40]. The UCS increased when the sample was kept at 2–21 °C, while the opposite effect occurred when mixing was carried out above 50 °C. In this study, the temperature effect on the increase and reduction in soil–cement–additive strength was neglected, because all tests were carried out at room temperature (between 25–30 °C).

In addition, the discussion around adding additives to soil–cement does not only consider strength, but also the amount of water absorbed and loss of weight due to wetting–drying cycles. The addition of supplements at the optimum percentage (i.e., 0.8% for granitic soils and 2% for lateritic soils) reduced the amount of water absorbed, represented by the samples' low water content, as shown in Figures 5 and 11. The addition of additives resulted in flocculated and clustered structures, as shown in Figures 10a,b and 15c, which increased with higher C-S-H and C-A-H formation [10]. The pores became smaller and denser. Consequently, the water absorbed by the sample when submerged was reduced. The increased strength resulted in weight loss due to soil–cement particle release with less additives, rather than no supplements (Figures 6 and 12). Additionally, the specimens' strength with additives, tested after the wetting–drying cycles, was better than those without (Figure 7).

5. Conclusions

The test results of the impact of wetting–drying cycles on soil–cement with additives have been presented and analyzed. Based on the highest compressive strength, the optimum additive contents for the granitic–cement and lateritic–cement mixtures obtained were 0.8% and 2%, respectively. The utilization of additives increased the resistance of the soil–cement mixture in the wetting–drying cycles.

The addition of 0.8% supplements to the granitic soil–cement reduced the amount of water absorbed by the sample by 3.8 times. The soil–cement loss of the samples without additives was 14% greater than those with supplements. For the same soil, the wetting–drying process also decreased the strength of the mixtures. Those with additives were twice as strong than those without at the end of the cycles.

For lateritic soil, the specimens with 2% additive showed the smallest moisture content for both volume change and the soil loss test. Meanwhile, the mass lost due to the wetting–drying process on these soils with additives was slightly smaller than for those without additives. This result was also seen in the residual strength measured after the wetting–drying test. The effect additive was different to that for granitic soil. The chemical content of the soil used affected the success of the additives.

Author Contributions: Conceptualization, Y.F.A.; methodology, Y.F.A.; investigation, E.A. and F.A.; writing—original draft preparation, Y.F.A.; writing—review and editing, Y.F.A. and S.S.A.; visualization, E.A. and F.A. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding

Data Availability Statement:

Acknowledgments:

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

References

1. Sunitsakul, J.; Sawatparnich, A.; Sawangsuriya, A. Prediction of Unconfined Compressive Strength of Soil-Cement at 7 Days. *Geotech. Geol. Eng.* **2012**, *30*, 263–268, doi:10.1007/s10706-011-9460-7.
2. Da, C.; Yingdi, L.; Chaohua, J.; Xingguo, F. The Mechanical Properties of Coastal Soil Treated with Cement. **2013**, 1155–1160,

Deleted: s
Deleted: (…) ... [72]
Deleted: -15
Deleted: (…) ... [73]
Deleted: an
Deleted: -
Deleted: carried out…at 2–- ... [74]
Deleted: º
Deleted: ; …hile, ... [75]
Deleted: º…. In this study, the temperature effect on the increase and reduction ... [76]
Deleted: s…(between 25–°C- ... [77]
Deleted: Moreover
Deleted: of
Deleted: -
Deleted: by the water…and loss of ... [78]
Deleted: -
Deleted: '
Deleted: s…10(…)… and ... [79]
Deleted: , 10
Deleted: (…) ... [80]
Deleted: ,
Deleted: (…) ... [81]
Deleted: ed
Deleted: -
Deleted: s'…release with less additi ... [82]
Deleted: -
Deleted: more remarkable
Deleted: -…rying cycles on soil-–… ... [83]
Deleted: a… ... [84]
Deleted: -…ement reduced the amo ... [85]
Deleted: found
Deleted: -
Deleted: the…additives were twice ... [86]
Deleted: L…teritic soil, the specime ... [87]
Deleted: -…rying process on these s ... [88]
Deleted: from the…granitic soil. The ... [89]

doi:10.1007/s11595-013-0836-9.

3. Wang, F.; Ping, X.; Zhou, J.; Kang, T. Effects of crumb rubber on the frost resistance of cement-soil. *Constr. Build. Mater.* **2019**, *223*, 120–132, doi:10.1016/j.conbuildmat.2019.06.208.
4. Xing, H.; Yang, X.; Xu, C.; Ye, G. Strength characteristics and mechanisms of salt-rich soil-cement. *Eng. Geol.* **2009**, *103*, 33–38, doi:10.1016/j.enggeo.2008.07.011.
5. Antunes, V.; Simão, N.; Freire, A.C. A Soil-Cement Formulation for Road Pavement Base and Sub Base Layers : a Case Study. **2017**.
6. Fan, J.; Wang, D.; Qian, D. Journal of Rock Mechanics and Geotechnical Engineering Soil-cement mixture properties and design considerations for reinforced excavation. *J. Rock Mech. Geotech. Eng.* **2018**, *10*, 791–797, doi:10.1016/j.jrmge.2018.03.004.
7. Mengue, E.; Mroueh, H.; Lancelot, L.; Medjo, R. Evaluation of the Compressibility and Compressive Strength of a Compacted Cement Treated Laterite Soil for Road Application. *Geotech. Geol. Eng.* **2018**, doi:10.1007/s10706-018-0576-x.
8. Pongsivasathit, S.; Horpibulsuk, S.; Piyaphipat, S. Case Studies in Construction Materials Assessment of mechanical properties of cement stabilized soils. *Case Stud. Constr. Mater.* **2019**, *11*, e00301, doi:10.1016/j.cscm.2019.e00301.
9. Khosravi, M.; Boulanger, R.W.; Wilson, D.W.; Olgun, C.G. ScienceDirect Stress transfer from rocking shallow foundations on soil-cement reinforced clay. *Soils Found.* **2019**, *59*, 966–981, doi:10.1016/j.sandf.2019.04.003.
10. Tyagi, A.; Xiao, H.; Chin, K.; Lee, F. Model for predicting the unit weight of cement-treated soils. *Soils Found.* **2019**, *59*, 1921–1932, doi:10.1016/j.sandf.2019.09.002.
11. Xiong, F.; Xing, H.; Li, H. Experimental study on the effects of multiple corrosive ion coexistence on soil-cement characteristics. *Soils Found.* **2019**, *59*, 398–406, doi:10.1016/j.sandf.2018.12.001.
12. Zidan, A.F. Strength and Consolidation Characteristics for Cement Stabilized Cohesive Soil Considering Consistency Index. *Geotech. Geol. Eng.* **2020**, *6*, doi:10.1007/s10706-020-01367-6.
13. Pongsivasathit, S.; Horpibulsuk, S.; Piyaphipat, S. Assessment of mechanical properties of cement stabilized soils. *Case Stud. Constr. Mater.* **2019**, *11*, e00301, doi:10.1016/j.cscm.2019.e00301.
14. Lambe, T.W.; Moh, Z.-C. Improvement of strength of soil-cement with additives. *Highw. Res. Board Bull.* **1958**, 38–47.
15. Blanck, G.; Cuisinier, O.; Masrouri, F. Soil treatment with organic non-traditional additives for the improvement of earthworks. *Acta Geotech.* **2014**, *9*, 1111–1122, doi:10.1007/s11440-013-0251-6.
16. Lin, D.F.; Luo, H.L.; Hsiao, D.H.; Chen, C.T.; Cai, M. Du Enhancing soft subgrade soil with a sewage sludge ash/cement mixture and nano-silicon dioxide. *Environ. Earth Sci.* **2016**, *75*, doi:10.1007/s12665-016-5432-9.
17. Aryal, S.; Kolay, P.K. Long-Term Durability of Ordinary Portland Cement and Polypropylene Fibre Stabilized Kaolin Soil Using Wetting–Drying and Freezing–Thawing Test. *Int. J. Geosynth. Gr. Eng.* **2020**, *6*, doi:10.1007/s40891-020-0191-9.
18. Tajdini, M.; Hajialilue Bonab, M.; Golmohamadi, S. An Experimental Investigation on Effect of Adding Natural and Synthetic Fibres on Mechanical and Behavioural Parameters of Soil–Cement Materials. *Int. J. Civ. Eng.* **2018**, *16*, 353–370, doi:10.1007/s40999-016-0118-y.
19. Deboucha, S.; Aissa Mamoune, S. mohammed; Sail, Y.; Ziani, H. Effects of Ceramic Waste, Marble Dust, and Cement in Pavement Sub-base Layer. *Geotech. Geol. Eng.* **2020**, *38*, 3331–3340, doi:10.1007/s10706-020-01211-x.
20. Anagnostopoulos, C.A.; Chrysanidis, T.; Anagnostopoulou, M. Experimental data of cement grouting in coarse soils with different superplasticisers. *Data Br.* **2020**, *30*, 105612, doi:10.1016/j.dib.2020.105612.
21. Carvalho, A.; de Castro Xavier, G.; Alexandre, J.; Pedroti, L.G.; de Azevedo, A.R.G.; Vieira, C.M.F.; Monteiro, S.N. Environmental durability of soil-cement block incorporated with ornamental stone waste. *Mater. Sci. Forum* **2014**, *798–799*, 548–553, doi:10.4028/www.scientific.net/MSF.798-799.548.
22. Elahi, T.E.; Shahriar, A.R.; Islam, M.S. Engineering characteristics of compressed earth blocks stabilized with cement and fly ash. *Constr. Build. Mater.* **2021**, *277*, 122367, doi:10.1016/j.conbuildmat.2021.122367.

23. França, B.R.; Azevedo, A.R.G.; Monteiro, S.N.; Da Costa, F.; Filho, G.; Marvila, M.T.; Alexandre, J.; Zanelato, E.B. Durability of soil-Cement blocks with the incorporation of limestone residues from the processing of marble. *Mater. Res.* **2018**, *21*, doi:10.1590/1980-5373-MR-2017-1118.
24. de Souza, J.M.; Lucena, L. de F.L. Soil-Cement Brick with Cassava Wastewater. In *Use of cassava wastewater and scheelite residues in ceramic formulations*; Acchar, W., da Silva, V.M., Eds.; 2021; p. 116 ISBN 9783030587819.
25. Van Ngoc, P.; Turner, B.; Huang, J.; Kelly, R. Experimental study on the durability of soil-cement columns in coastal areas. *Geotech. Eng.* **2017**, *48*, 138–143.
26. ASTMD2487 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System). *ASTM Int. West Conshohocken, PA* **2006**, 1–5, doi:10.1520/D2487-11.
27. Kirgiz, M.S. Effects of blended-cement paste chemical composition changes on some strength gains of blended-mortars. *Sci. World J.* **2014**, *2014*, doi:10.1155/2014/625350.
28. Bediako, M.; Amankwah, E.O. Analysis of chemical composition of Portland cement in Ghana: A key to understand the behavior of cement. *Adv. Mater. Sci. Eng.* **2015**, *2015*, doi:10.1155/2015/349401.
29. SNI03-6887-2002 Metode Pengujian Kuat Tekan Bebas Campuran Tanah Semen. *Natl. Stand. Agency Indones.* **2002**, 1–12.
30. ASTMD1633-00 Standard Test Methods for Compressive Strength of Molded Soil-Cement Cylinders. *ASTM Int. West Conshohocken, PA, USA,* **2000**, 1–4.
31. SNI03-3438-1994 Tata cara pembuatan rencana stabilisasi tanah dengan semen portland. *Natl. Stand. Agency Indones.* **1994**, 1–15.
32. DGH *General Specifications for Road and Bridge Construction Works*; 2018th ed.; Directorate General of Highway, Ministry of Public Work and Housing, 2018;
33. SNI-6427-2012 Test methods for wetting and drying test of compacted soil-cement mixtures. *Natl. Stand. Agency Indones.* **2012**, 1–25.
34. ASTMD559 Standard Test Methods for Wetting and Drying Compacted Soil-Cement Mixtures. *Am. Soc. Test. Mater.* **1996**, 1–6.
35. Cai, L.; He, L.; Peng, S.; Li, M.; Tong, M. Influence of titanium dioxide nanoparticles on the transport and deposition of microplastics in quartz sand. *Environ. Pollut.* **2019**, *253*, 351–357, doi:10.1016/j.envpol.2019.07.006.
36. Tan, W.; Peralta-Videa, J.R.; Gardea-Torresdey, J.L. Interaction of titanium dioxide nanoparticles with soil components and plants: Current knowledge and future research needs-a critical review. *Environ. Sci. Nano* **2018**, *5*, 257–278, doi:10.1039/c7en00985b.
37. Goldberg, S. Interaction of aluminum and iron oxides and clay minerals and their effect on soil physical properties: A review. *Commun. Soil Sci. Plant Anal.* **1985**, *20*, 1181–1207, doi:https://doi.org/10.1080/00103629009368144.
38. Yong, R.N.; Sethi, A.J.; Booy, E.; Dascal, O. Basic characterization and effect of some chemicals on a clay from outardes 2. *Eng. Geol.* **1979**, *14*, 83–107, doi:10.1016/0013-7952(79)90079-6.
39. Bowers, B.B.; Daniels, J.L.; Anderson, J.B. Field considerations for calcium chloride modification of soil-cement. *J. Mater. Civ. Eng.* **2014**, *26*, 65–70, doi:10.1061/(ASCE)MT.1943-5533.0000780.
40. Bowers, B.F.; Daniels, J.L.; Lei, S.; Deblasis, N.J. Additives for Soil-Cement Stabilization. In *Pavement and Geotechnical Engineering for Transportation*; Huang, B., Bowers, B.F., Mei, G.-X., Luo, S.-H., Zhang, Z., Eds.; ASCE, 2013; pp. 68–75 ISBN 9780784412817.

Page 1: [1] Deleted Alexis Korb 09/03/2021 12:50:00

Page 1: [1] Deleted Alexis Korb 09/03/2021 12:50:00

Page 1: [2] Deleted Alexis Korb 09/03/2021 12:50:00

Page 1: [2] Deleted Alexis Korb 09/03/2021 12:50:00

Page 1: [3] Deleted Kayla Mackie 07/03/2021 18:39:00

Page 1: [3] Deleted Kayla Mackie 07/03/2021 18:39:00

Page 1: [3] Deleted Kayla Mackie 07/03/2021 18:39:00

Page 1: [3] Deleted Kayla Mackie 07/03/2021 18:39:00

Page 1: [3] Deleted Kayla Mackie 07/03/2021 18:39:00

Page 1: [4] Deleted Kayla Mackie 07/03/2021 18:41:00

Page 1: [4] Deleted Kayla Mackie 07/03/2021 18:41:00

Page 1: [5] Deleted Kayla Mackie 07/03/2021 18:41:00

Page 1: [5] Deleted Kayla Mackie 07/03/2021 18:41:00

Page 1: [5] Deleted Kayla Mackie 07/03/2021 18:41:00

Page 1: [5] Deleted Kayla Mackie 07/03/2021 18:41:00

Page 1: [6] Deleted Alexis Korb 09/03/2021 12:55:00

Page 1: [6] Deleted Alexis Korb 09/03/2021 12:55:00

Page 1: [7] Deleted Kayla Mackie 07/03/2021 18:42:00

Page 1: [7] Deleted Kayla Mackie 07/03/2021 18:42:00

Page 1: [8] Deleted Alexis Korb 09/03/2021 12:55:00

Page 1: [8] Deleted Alexis Korb 09/03/2021 12:55:00

Page 1: [9] Deleted Kayla Mackie 07/03/2021 18:42:00

Page 1: [9] Deleted Kayla Mackie 07/03/2021 18:42:00

Page 1: [9] Deleted Kayla Mackie 07/03/2021 18:42:00

Page 1: [10] Deleted Kayla Mackie 07/03/2021 18:42:00

Page 1: [10] Deleted Kayla Mackie 07/03/2021 18:42:00

Page 1: [11] Deleted Kayla Mackie 07/03/2021 18:43:00

Page 1: [11] Deleted Kayla Mackie 07/03/2021 18:43:00

Page 2: [12] Deleted Alexis Korb 09/03/2021 12:56:00

Page 2: [12] Deleted Alexis Korb 09/03/2021 12:56:00

Page 2: [13] Deleted Kayla Mackie 07/03/2021 18:44:00

Page 2: [13] Deleted Kayla Mackie 07/03/2021 18:44:00

Page 2: [13] Deleted Kayla Mackie 07/03/2021 18:44:00

Page 2: [13] Deleted Kayla Mackie 07/03/2021 18:44:00

Page 2: [13] Deleted Kayla Mackie 07/03/2021 18:44:00

Page 2: [14] Deleted Kayla Mackie 07/03/2021 18:52:00

Page 2: [14] Deleted Kayla Mackie 07/03/2021 18:52:00

Page 2: [15] Deleted Kayla Mackie 07/03/2021 18:52:00

Page 2: [15] Deleted Kayla Mackie 07/03/2021 18:52:00

Page 2: [16] Deleted Alexis Korb 09/03/2021 13:30:00

Page 2: [16] Deleted Alexis Korb 09/03/2021 13:30:00

Page 2: [16] Deleted Alexis Korb 09/03/2021 13:30:00

Page 2: [17] Deleted Kayla Mackie 07/03/2021 19:03:00

Page 2: [17] Deleted Kayla Mackie 07/03/2021 19:03:00

Page 2: [18] Deleted Kayla Mackie 07/03/2021 19:03:00

Page 2: [18] Deleted Kayla Mackie 07/03/2021 19:03:00

Page 2: [18] Deleted Kayla Mackie 07/03/2021 19:03:00

Page 2: [19] Deleted Alexis Korb 09/03/2021 12:57:00

Page 2: [19] Deleted Alexis Korb 09/03/2021 12:57:00

Page 2: [19] Deleted Alexis Korb 09/03/2021 12:57:00

Page 2: [19] Deleted Alexis Korb 09/03/2021 12:57:00

Page 2: [20] Deleted Kayla Mackie 07/03/2021 19:04:00

Page 2: [20] Deleted Kayla Mackie 07/03/2021 19:04:00

Page 2: [20] Deleted Kayla Mackie 07/03/2021 19:04:00

Page 2: [20] Deleted Kayla Mackie 07/03/2021 19:04:00

Page 2: [20] Deleted Kayla Mackie 07/03/2021 19:04:00

Page 2: [21] Deleted Alexis Korb 09/03/2021 12:59:00

Page 2: [21] Deleted Alexis Korb 09/03/2021 12:59:00

Page 2: [21] Deleted Alexis Korb 09/03/2021 12:59:00

Page 2: [21] Deleted Alexis Korb 09/03/2021 12:59:00

Page 2: [22] Deleted Kayla Mackie 07/03/2021 19:06:00

Page 2: [22] Deleted Kayla Mackie 07/03/2021 19:06:00

Page 2: [22] Deleted Kayla Mackie 07/03/2021 19:06:00

Page 2: [22] Deleted Kayla Mackie 07/03/2021 19:06:00

Page 2: [23] Deleted Alexis Korb 09/03/2021 12:59:00

Page 2: [23] Deleted Alexis Korb 09/03/2021 12:59:00

Page 2: [23] Deleted Alexis Korb 09/03/2021 12:59:00

Page 2: [23] Deleted Alexis Korb 09/03/2021 12:59:00

Page 2: [23] Deleted Alexis Korb 09/03/2021 12:59:00

Page 2: [23] Deleted Alexis Korb 09/03/2021 12:59:00

Page 2: [24] Deleted Kayla Mackie 07/03/2021 19:07:00

Page 2: [24] Deleted Kayla Mackie 07/03/2021 19:07:00

Page 2: [24] Deleted Kayla Mackie 07/03/2021 19:07:00

Page 2: [24] Deleted Kayla Mackie 07/03/2021 19:07:00

Page 2: [25] Deleted Alexis Korb 09/03/2021 13:00:00

Page 2: [25] Deleted Alexis Korb 09/03/2021 13:00:00

Page 3: [26] Deleted Kayla Mackie 07/03/2021 19:07:00

Page 3: [26] Deleted Kayla Mackie 07/03/2021 19:07:00

Page 3: [27] Deleted Alexis Korb 09/03/2021 13:01:00

Page 3: [27] Deleted Alexis Korb 09/03/2021 13:01:00

Page 3: [28] Deleted Kayla Mackie 07/03/2021 19:17:00

Page 3: [28] Deleted Kayla Mackie 07/03/2021 19:17:00

Page 3: [28] Deleted Kayla Mackie 07/03/2021 19:17:00

Page 3: [29] Deleted Kayla Mackie 07/03/2021 19:17:00

Page 3: [29] Deleted Kayla Mackie 07/03/2021 19:17:00

Page 3: [30] Deleted Alexis Korb 09/03/2021 13:01:00

Page 3: [30] Deleted Alexis Korb 09/03/2021 13:01:00

Page 3: [31] Deleted Kayla Mackie 07/03/2021 19:18:00

Page 3: [31] Deleted Kayla Mackie 07/03/2021 19:18:00

Page 3: [31] Deleted Kayla Mackie 07/03/2021 19:18:00

Page 3: [32] Deleted Kayla Mackie 07/03/2021 19:18:00

Page 3: [32] Deleted Kayla Mackie 07/03/2021 19:18:00

Page 3: [33] Deleted Alexis Korb 09/03/2021 13:01:00

Page 3: [33] Deleted Alexis Korb 09/03/2021 13:01:00

Page 3: [33] Deleted Alexis Korb 09/03/2021 13:01:00

Page 3: [33] Deleted Alexis Korb 09/03/2021 13:01:00

Page 3: [34] Deleted Kayla Mackie 07/03/2021 19:18:00

Page 3: [34] Deleted Kayla Mackie 07/03/2021 19:18:00

Page 3: [35] Deleted Alexis Korb 09/03/2021 13:01:00

Page 3: [35] Deleted Alexis Korb 09/03/2021 13:01:00

Page 3: [36] Deleted Kayla Mackie 07/03/2021 19:19:00

Page 3: [36] Deleted Kayla Mackie 07/03/2021 19:19:00

Page 3: [36] Deleted Kayla Mackie 07/03/2021 19:19:00

Page 3: [36] Deleted Kayla Mackie 07/03/2021 19:19:00

Page 3: [36] Deleted Kayla Mackie 07/03/2021 19:19:00

Page 7: [37] Deleted Alexis Korb 09/03/2021 13:11:00

Page 7: [37] Deleted Alexis Korb 09/03/2021 13:11:00

Page 7: [38] Deleted Kayla Mackie 07/03/2021 20:14:00

Page 7: [38] Deleted Kayla Mackie 07/03/2021 20:14:00

Page 7: [39] Deleted Alexis Korb 09/03/2021 13:12:00

Page 7: [39] Deleted Alexis Korb 09/03/2021 13:12:00

Page 7: [39] Deleted Alexis Korb 09/03/2021 13:12:00

Page 7: [40] Deleted Kayla Mackie 07/03/2021 20:14:00

Page 7: [40] Deleted Kayla Mackie 07/03/2021 20:14:00

Page 7: [41] Deleted Alexis Korb 09/03/2021 13:12:00

Page 7: [41] Deleted Alexis Korb 09/03/2021 13:12:00

Page 7: [42] Deleted Kayla Mackie 07/03/2021 20:14:00

Page 7: [42] Deleted Kayla Mackie 07/03/2021 20:14:00

Page 7: [43] Deleted Kayla Mackie 07/03/2021 20:15:00

Page 7: [43] Deleted Kayla Mackie 07/03/2021 20:15:00

Page 7: [44] Deleted Alexis Korb 09/03/2021 13:12:00

Page 7: [44] Deleted Alexis Korb 09/03/2021 13:12:00

Page 7: [44] Deleted Alexis Korb 09/03/2021 13:12:00

Page 7: [45] Deleted Kayla Mackie 07/03/2021 20:15:00

Page 7: [45] Deleted Kayla Mackie 07/03/2021 20:15:00

Page 7: [46] Deleted Kayla Mackie 07/03/2021 20:16:00

Page 7: [46] Deleted Kayla Mackie 07/03/2021 20:16:00

Page 7: [47] Deleted Alexis Korb 09/03/2021 13:13:00

Page 7: [47] Deleted Alexis Korb 09/03/2021 13:13:00

Page 7: [47] Deleted Alexis Korb 09/03/2021 13:13:00

Page 7: [47] Deleted Alexis Korb 09/03/2021 13:13:00

Page 7: [48] Deleted Kayla Mackie 07/03/2021 20:17:00

Page 7: [48] Deleted Kayla Mackie 07/03/2021 20:17:00

Page 11: [49] Formatted **Kayla Mackie** **08/03/2021 18:21:00**

Font: Bold

Page 11: [50] Formatted **Kayla Mackie** **08/03/2021 18:21:00**

Font: Bold

Page 11: [51] Commented [AK13] **Alexis Korb** **09/03/2021 13:21:00**

Change soil-cement to soil–cement.

Page 11: [52] Formatted **Kayla Mackie** **08/03/2021 18:23:00**

Font: Bold

Page 11: [53] Formatted **Kayla Mackie** **08/03/2021 18:23:00**

Font: Bold

Page 14: [54] Deleted **Alexis Korb** **09/03/2021 13:26:00**

Page 14: [54] Deleted **Alexis Korb** **09/03/2021 13:26:00**

Page 14: [54] Deleted **Alexis Korb** **09/03/2021 13:26:00**

Page 14: [54] Deleted **Alexis Korb** **09/03/2021 13:26:00**

Page 14: [54] Deleted **Alexis Korb** **09/03/2021 13:26:00**

Page 14: [55] Deleted **Alexis Korb** **09/03/2021 13:26:00**

Page 14: [55] Deleted **Alexis Korb** **09/03/2021 13:26:00**

Page 14: [56] Deleted **Alexis Korb** **09/03/2021 13:26:00**

Page 14: [56] Deleted Alexis Korb 09/03/2021 13:26:00

Page 14: [57] Deleted Alexis Korb 09/03/2021 13:26:00

Page 14: [57] Deleted Alexis Korb 09/03/2021 13:26:00

Page 14: [58] Deleted Alexis Korb 09/03/2021 13:26:00

Page 14: [58] Deleted Alexis Korb 09/03/2021 13:26:00

Page 14: [59] Deleted Alexis Korb 09/03/2021 13:26:00

Page 14: [59] Deleted Alexis Korb 09/03/2021 13:26:00

Page 14: [60] Deleted Alexis Korb 09/03/2021 13:26:00

Page 14: [60] Deleted Alexis Korb 09/03/2021 13:26:00

Page 14: [61] Deleted Alexis Korb 09/03/2021 13:26:00

Page 14: [61] Deleted Alexis Korb 09/03/2021 13:26:00

Page 14: [62] Deleted Alexis Korb 09/03/2021 13:26:00

Page 14: [62] Deleted Alexis Korb 09/03/2021 13:26:00

Page 14: [63] Deleted Alexis Korb 09/03/2021 13:26:00

Page 14: [63] Deleted Alexis Korb 09/03/2021 13:26:00

Page 14: [64] Deleted Alexis Korb 09/03/2021 13:26:00

Page 14: [64] Deleted Alexis Korb 09/03/2021 13:26:00

Page 14: [65] Deleted Kayla Mackie 08/03/2021 18:46:00

Page 14: [65] Deleted Kayla Mackie 08/03/2021 18:46:00

Page 14: [66] Deleted Alexis Korb 09/03/2021 13:26:00

Page 14: [66] Deleted Alexis Korb 09/03/2021 13:26:00

Page 14: [67] Deleted Kayla Mackie 08/03/2021 18:47:00

Page 14: [67] Deleted Kayla Mackie 08/03/2021 18:47:00

Page 14: [67] Deleted Kayla Mackie 08/03/2021 18:47:00

Page 14: [67] Deleted Kayla Mackie 08/03/2021 18:47:00

Page 14: [67] Deleted Kayla Mackie 08/03/2021 18:47:00

Page 14: [67] Deleted Kayla Mackie 08/03/2021 18:47:00

Page 14: [68] Deleted Kayla Mackie 08/03/2021 18:47:00

Page 14: [68] Deleted Kayla Mackie 08/03/2021 18:47:00

Page 14: [68] Deleted Kayla Mackie 08/03/2021 18:47:00

Page 14: [68] Deleted Kayla Mackie 08/03/2021 18:47:00

Page 14: [69] Deleted Kayla Mackie 08/03/2021 18:48:00

Page 14: [69] Deleted Kayla Mackie 08/03/2021 18:48:00

Page 14: [69] Deleted Kayla Mackie 08/03/2021 18:48:00

Page 14: [69] Deleted Kayla Mackie 08/03/2021 18:48:00

Page 14: [70] Deleted Kayla Mackie 08/03/2021 19:04:00

Page 14: [70] Deleted Kayla Mackie 08/03/2021 19:04:00

Page 14: [71] Deleted Alexis Korb 09/03/2021 13:34:00

Page 14: [71] Deleted Alexis Korb 09/03/2021 13:34:00

Page 15: [72] Deleted Alexis Korb 09/03/2021 13:27:00

Page 15: [72] Deleted Alexis Korb 09/03/2021 13:27:00

Page 15: [73] Deleted Alexis Korb 09/03/2021 13:27:00

Page 15: [73] Deleted Alexis Korb 09/03/2021 13:27:00

Page 15: [74] Deleted Kayla Mackie 08/03/2021 19:05:00

Page 15: [74] Deleted Kayla Mackie 08/03/2021 19:05:00

Page 15: [75] Deleted Kayla Mackie 08/03/2021 19:06:00

Page 15: [75] Deleted Kayla Mackie 08/03/2021 19:06:00

Page 15: [76] Deleted Alexis Korb 09/03/2021 13:27:00

Page 15: [76] Deleted Alexis Korb 09/03/2021 13:27:00

Page 15: [76] Deleted Alexis Korb 09/03/2021 13:27:00

Page 15: [77] Deleted Kayla Mackie 08/03/2021 19:06:00

Page 15: [77] Deleted Kayla Mackie 08/03/2021 19:06:00

Page 15: [78] Deleted Kayla Mackie 08/03/2021 19:07:00

Page 15: [78] Deleted Kayla Mackie 08/03/2021 19:07:00

Page 15: [79] Deleted Alexis Korb 09/03/2021 13:28:00

Page 15: [79] Deleted Alexis Korb 09/03/2021 13:28:00

Page 15: [79] Deleted Alexis Korb 09/03/2021 13:28:00

Page 15: [79] Deleted Alexis Korb 09/03/2021 13:28:00

Page 15: [80] Deleted Alexis Korb 09/03/2021 13:28:00

Page 15: [80] Deleted Alexis Korb 09/03/2021 13:28:00

Page 15: [81] Deleted Alexis Korb 09/03/2021 13:28:00

Page 15: [81] Deleted Alexis Korb 09/03/2021 13:28:00

Page 15: [82] Deleted Kayla Mackie 08/03/2021 19:09:00

Page 15: [82] Deleted Kayla Mackie 08/03/2021 19:09:00

Page 15: [83] Deleted Alexis Korb 09/03/2021 13:28:00

Page 15: [83] Deleted Alexis Korb 09/03/2021 13:28:00

Page 15: [83] Deleted Alexis Korb 09/03/2021 13:28:00

Page 15: [83] Deleted Alexis Korb 09/03/2021 13:28:00

Page 15: [83] Deleted Alexis Korb 09/03/2021 13:28:00

Page 15: [83] Deleted Alexis Korb 09/03/2021 13:28:00

Page 15: [83] Deleted Alexis Korb 09/03/2021 13:28:00

Page 15: [84] Deleted Kayla Mackie 08/03/2021 19:10:00

Page 15: [84] Deleted Kayla Mackie 08/03/2021 19:10:00

Page 15: [85] Deleted Alexis Korb 09/03/2021 13:29:00

Page 15: [85] Deleted Alexis Korb 09/03/2021 13:29:00

Page 15: [86] Deleted Kayla Mackie 08/03/2021 19:10:00

Page 15: [86] Deleted Kayla Mackie 08/03/2021 19:10:00

Page 15: [87] Deleted Kayla Mackie 08/03/2021 19:11:00

Page 15: [87] Deleted Kayla Mackie 08/03/2021 19:11:00

Page 15: [87] Deleted Kayla Mackie 08/03/2021 19:11:00

Page 15: [88] Deleted Alexis Korb 09/03/2021 13:29:00

Page 15: [88] Deleted Alexis Korb 09/03/2021 13:29:00

Page 15: [89] Deleted Kayla Mackie 08/03/2021 19:11:00

Page 15: [89] Deleted Kayla Mackie 08/03/2021 19:11:00

From: y.arifin@ulm.ac.id
Sent: 26 February 2021 20:21
To: Infrastructures
Subject: RE: [Infrastructures] Manuscript ID: infrastructures-1127055 - Major Revisions

Dear Ms. Sharon Fan,
I will do my best. I try to finish next Friday.

Best regards, Arifin

Sent from Mail for Windows 10

From: Infrastructures
Sent: 26 February 2021 17:04
To: y.arifin@ulm.ac.id
Cc: Madalina Buzatu
Subject: Re: [Infrastructures] Manuscript ID: infrastructures-1127055 - Major Revisions

Dear Dr. Arifin,

Thank you for your email and information. You are fully understood. Could you please finish revision by next Friday (5th March)?

Kind Regards
Ms. Sharon Fan
On 2/26/2021 4:55 PM, y.arifin@ulm.ac.id wrote:

> Dear Ms. Sharon Fan,
> Thank you for the information regarding my article. The reviewers have provided very constructive inputs to increase the value of my articles. I have started revising. Nevertheless, I may need more time because I have to discuss the revision with all the authors. I try to finish in not too long from the time given by the editor.
> Thank you for your cooperation.
>
> Best regards,
>
> Arifin
>
> Sent from Mail for Windows 10
>
> ---
>
> **From:** Infrastructures Editorial Office
> **Sent:** 20 February 2021 9:28
> **To:** Yulian Arifin
> **Cc:** Eka Agustina; Fransius Andhi; Setianto Samingan Agus; Infrastructures Editorial Office; Madalina Buzatu
> **Subject:** [Infrastructures] Manuscript ID: infrastructures-1127055 - Major Revisions
>
> Dear Dr. Arifin,

Thank you for submitting the following manuscript to Infrastructures:

Manuscript ID: infrastructures-1127055
Type of manuscript: Article
Title: The Role of Additives in Soil-Cement Subjected to Wetting-Drying Cycles
Authors: Yulian Firmana Arifin *, Eka Agustina, Fransius Andhi, Setianto Samingan Agus
Received: 11 February 2021
E-mails: y.arifin@ulm.ac.id, eagustina17875@gmail.com, andhi.bzp@gmail.com, samingan.agus@mottmac.com

It has been reviewed by experts in the field and we request that you make major revisions before it is processed further. Please find your manuscript and the review reports at the following link:
https://susy.mdpi.com/user/manuscripts/resubmit/7814d2bc5ceece8180bc7c53e58e8ee7

Your co-authors can also view this link if they have an account in our submission system using the e-mail address in this message.

Please revise the manuscript according to the reviewers' comments and upload the revised file within 10 days. Use the version of your manuscript found at the above link for your revisions, as the editorial office may have made formatting changes to your original submission. Any revisions should be clearly highlighted, for example using the "Track Changes" function in Microsoft Word, so that changes are easily visible to the editors and reviewers. Please provide a cover letter to explain point-by-point the details of the revisions in the manuscript and your responses to the reviewers' comments. Please include in your rebuttal if you found it impossible to address certain comments. The revised version will be inspected by the editors and reviewers. Please detail the revisions that have been made, citing the line number and exact change, so that the editor can check the changes expeditiously. Simple statements like 'done' or 'revised as requested' will not be accepted unless the change is simply a typographical error.

Please carefully read the guidelines outlined in the 'Instructions for Authors' on the journal website https://www.mdpi.com/journal/infrastructures/instructions and ensure that your manuscript resubmission adheres to these guidelines. In particular, please ensure that abbreviations have been defined in parentheses the first time they appear in the abstract, main text, and in figure or table captions; citations within the text are in the correct format; references at the end of the text are in the correct format; figures and/or tables are placed at appropriate positions within the text and are of suitable quality; tables are prepared in MS Word table format, not as images; and permission has been obtained and there are no copyright issues.

We suggest that you use a professional English editing service or have your manuscript checked by a native English speaking colleague. If you use some English editing service, please provide us the English Editing certificate.

If you have the paper edited by your native English speaking colleague, please send us an email to explain and copy your colleague in.

Regarding the English editing service, we can suggest AJE (https://www.aje.com/en).

Do not hesitate to contact us if you have any questions regarding the revision of your manuscript or if you need more time. We look forward to hearing from you soon.

Kind regards,

Ms. Sharon Fan
Managing Editor, MDPI
No. 21 Cuijingbeili, Tongzhou District, Beijing, China
Skype: live:sharon.fan_2
Infrastructures (www.mdpi.com/journal/infrastructures)
Remote Sensing (www.mdpi.com/journal/remotesensing)

From: y.arifin@ulm.ac.id
Sent: 06 March 2021 23:47
To: buzatu@mdpi.com
Subject: RE: [Infrastructures] Manuscript ID: infrastructures-1127055 - Minor Revisions (Due Date 8 March 2021)

Dear Ms. Madalina Buzatu,
Thank you for your email. I sent the manuscript to MDPI English editing service. I need three days longer than the date you requested. The manuscript will be ready on March 11, 2021, based on an MDPI English Editing email.
Thank you for your consideration.

Best regards, Arifin

Sent from Mail for Windows 10

From: Infrastructures Editorial Office
Sent: 05 March 2021 21:56
To: Yulian Arifin
Cc: Eka Agustina; Fransius Andhi; Setianto Samingan Agus; Infrastructures Editorial Office
Subject: [Infrastructures] Manuscript ID: infrastructures-1127055 - Minor Revisions (Due Date 8 March 2021)

Dear Dr. Arifin,

Thank you for submitting your manuscript:

Manuscript ID: infrastructures-1127055
Type of manuscript: Article
Title: The Role of Additives in Soil-Cement Subjected to Wetting-Drying Cycles
Authors: Yulian Firmana Arifin *, Eka Agustina, Fransius Andhi, Setianto Samingan Agus
Received: 11 February 2021
E-mails: y.arifin@ulm.ac.id, eagustina17875@gmail.com, andhi.bzp@gmail.com, samingan.agus@mottmac.com

It has been reviewed by experts in the field and we request that you make minor revisions before it is processed further. Please find your manuscript and the review reports at the following link:
https://susy.mdpi.com/user/manuscripts/resubmit/7814d2bc5ceece8180bc7c53e58e8ee7

Please check carefully the Academic Editor's notes and revise accordingly.

Your co-authors can also view this link if they have an account in our submission system using the e-mail address in this message.

Please revise the manuscript according to the reviewers' comments and upload the revised file by 8 March 2021. Use the version of your manuscript found at the above link for your revisions, as the editorial office may have made formatting changes to your original submission. Any revisions should be clearly highlighted, for example using the "Track Changes" function in Microsoft Word, so that they are easily visible to the editors and reviewers. Please provide a short cover letter detailing any changes, for the benefit of the editors and reviewers. Please detail the revisions that have been made, citing the line number and exact change, so that the editor can check the changes expeditiously. Simple statements like ‘done’ or ‘revised as requested’ will not be accepted unless the change is simply a typographical error.

If the reviewers have suggested that your manuscript should undergo extensive English editing, please have the English in the manuscript thoroughly checked and edited for language and form. Alternatively, MDPI provides an English editing service checking grammar, spelling, punctuation and some improvement of style where necessary for an additional charge (extensive re-writing is not included), see details at https://www.mdpi.com/authors/english.

Do not hesitate to contact us if you have any questions regarding the revision of your manuscript or if you need more time. We look forward to hearing from you soon.

Kind regards,
Ms. Madalina Buzatu
Assistant Editor
Email: buzatu@mdpi.com
MDPI Open Access Publishing Romania
Str Avram Iancu 454, 407280 Floresti, Cluj, Romania
Infrastructures Editorial Office
E-mail: infrastructures@mdpi.com
http://www.mdpi.com/journal/infrastructures/

From: Ms. Madalina Buzatu
Sent: 10 March 2021 17:26
To: y.arifin@ulm.ac.id
Cc: infrastructures@mdpi.com
Subject: [Infrastructures] Manuscript ID: infrastructures-1127055 - Institutional Email Received

Dear Dr. Arifin,

Thank you very much for your reply. We will update the email addresses in our system.

Thank you for your understanding.

We are looking forward for your revised version of the manuscript.

Kind regards,

Ms. Madalina Buzatu
Assistant Editor
Email: buzatu@mdpi.com
MDPI OPEN ACCESS PUBLISHING ROMANIA SRL
Str Avram Iancu 454, Floresti, Cluj, Romania
www.mdpi.com
/Geomatics/ is Recruiting Editors
https://www.mdpi.com/journal/geomatics/announcements/2226

Remote Sensing 2020 Best Cover Awards Open for Vote (Vote deadline: 20 February 2021)

Voting link: https://www.surveymonkey.com/r/MRYTHLQ

Twitter Link: https://twitter.com/RemoteSens_MDPI/status/1351063826628816898

On 3/10/2021 10:32 AM, y.arifin@ulm.ac.id wrote:
> Dear Ms. Madalina Buzatu,
>
> We decided to change both Mr. Fransius Andhi and Mrs. Eka Agustina's
> institution to be the University of Lambung Mangkurat. They are our
> students in Master Program who also work as a government employee.
>
>

>
> Mrs. Eka Agustina; email: h2a512011@mhs.ulm.ac.id
>
> Mr. Fransius Andhi; email: h2a512012@mhs.ulm.ac.id
>
>
>
> Institution:
>
> Civil Engineering Master Program, University of Lambung Mangkurat, Indonesia
>
>
>
> Thank you for your consideration.
>
>
>
> Best regards, Arifin
>
>
>
>
>
> Sent from Mail <https://go.microsoft.com/fwlink/?LinkId=550986> for
> Windows 10
>
>
>
> *From: *Ms. Madalina Buzatu <mailto:buzatu@mdpi.com>
> *Sent: *10 March 2021 14:26
> *To: *y.arifin@ulm.ac.id <mailto:y.arifin@ulm.ac.id>
> *Cc: *infrastructures@mdpi.com <mailto:infrastructures@mdpi.com>
> *Subject: *[Infrastructures] Manuscript ID: infrastructures-1127055 -
> Institutional Email
>
>
>
> Dear Dr. Arifin,
>
>
>
> Thank you for your email. As per our guidelines, all authors' email
>
> addresses should be institutional emails
>
> (https://www.mdpi.com/journal/remotesensing/instructions).
>
>
>
> If he/she does not have one, could you please send us an institutional
>

> confirm (an official screenshot with brief information is also fine), or
>
> a CV and publication list of the author?
>
>
>
> We are looking forward to hearing from you.
>
>
>
> Kind regards,
>
>
>
> Ms. Madalina Buzatu
>
> Assistant Editor
>
> Email: buzatu@mdpi.com
>
> MDPI OPEN ACCESS PUBLISHING ROMANIA SRL
>
> Str Avram Iancu 454, Floresti, Cluj, Romania
>
> www.mdpi.com
>

>
> The information contained in this message is confidential and intended
>
> solely for the use of the individual or entity to whom they are
>
> addressed. If you have received this message in error, please notify me
>
> and delete this message from your system. You may not copy this message
>
> in its entirety or in part, or disclose its contents to anyone.
>
>
>
> On 3/10/2021 3:37 AM, y.arifin@ulm.ac.id wrote:
>
>> Dear Ms. Madalina Buzatu
>
>>
>
>> Mr. Andhy and Mrs. Eka Agustina do not have an official email from their
>
>> office. It is rare for a small office to have its email. For Dr. Agus,
>
>> his email of samingan.agus@mottmac.com
>
>> <mailto:samingan.agus@mottmac.com> is an official email from his office
>
>> in Singapore (i.e., Mott MacDonald Pte. Ltd., Singapore).
>
>>
>
>>
>
>>
>
>> Best regards, Arifin
>
>>
>
>>
>
>>
>
>> Sent from Mail <https://go.microsoft.com/fwlink/?LinkId=550986> for
>
>> Windows 10
>
>>
>
>>
>

>>
>
>> *From: *Ms. Madalina Buzatu <mailto:buzatu@mdpi.com>
>
>> *Sent: *08 March 2021 16:36
>
>> *To: *y.arifin@ulm.ac.id <mailto:y.arifin@ulm.ac.id>
>
>> *Cc: *infrastructures@mdpi.com <mailto:infrastructures@mdpi.com>;
>
>> eagustina17875@gmail.com <mailto:eagustina17875@gmail.com>;
>
>> andhi.bzp@gmail.com <mailto:andhi.bzp@gmail.com>;
>
>> samingan.agus@mottmac.com <mailto:samingan.agus@mottmac.com>
>
>> *Subject: *[Infrastructures] Manuscript ID: infrastructures-1127055 -
>
>> Revision New Deadline - 13 March 2021 and Institutional Email Needed
>
>>
>
>>
>
>>
>
>> Dear Dr. Arifin,
>
>>
>
>>
>
>>
>
>> Thank you for your email and please apologize the misunderstanding caused.
>
>>
>
>>
>
>>
>
>> You are well understood. Normally we give 5 days for minor revision but
>
>>
>
>> we would like to give you an extension.
>
>>
>
>>

>
>>
>
>> Please try to revise and resubmit by the new due date, 13 March 2021.
>
>>
>
>>
>
>>
>
>> It would help to process your paper without any delay.
>
>>
>
>>
>
>>
>
>> Hope you could understand and cooperate.
>
>>
>
>>
>
>>
>
>> Also, we would like to kindly ask you to replace the following email
>
>>
>
>> addresses: eagustina17875@gmail.com, andhi.bzp@gmail.com,
>
>>
>
>> samingan.agus@mottmac.com with institutional email address, as
>
>>
>
>> institutional email addresses are more formal in the scientific
>
>>
>
>> publishing and correspondence. Send us the new email addresses via this
>
>>
>
>> email within two days. We will help update it in system.
>
>>
>

>>
>
>>
>
>> We are looking forward to hearing from you!
>
>>
>
>>
>
>>
>
>> Kind regards,
>
>>
>
>>
>
>>
>
>> Ms. Madalina Buzatu
>
>>
>
>> Assistant Editor
>
>>
>
>> Email: buzatu@mdpi.com
>
>>
>
>> MDPI OPEN ACCESS PUBLISHING ROMANIA SRL
>
>>
>
>> Str Avram Iancu 454, Floresti, Cluj, Romania
>
>>
>
>> www.mdpi.com
>
>>
>
>> /Geomatics/ is Recruiting Editors
>
>>
>
>> https://www.mdpi.com/journal/geomatics/announcements/2226
>
>>

>
>>
>
>>
>
>> Remote Sensing 2020 Best Cover Awards Open for Vote (Vote deadline: 20
>
>>
>
>> February 2021)
>
>>
>
>>
>
>>
>
>> Voting link: https://www.surveymonkey.com/r/MRYTHLQ
>
>>
>
>>
>
>>
>
>> Twitter Link:
> https://twitter.com/RemoteSens_MDPI/status/1351063826628816898
>
>>
>
>>
>
>>
>
>> Disclaimer: MDPI recognizes the importance of data privacy and
>
>>
>
>> protection. We treat personal data in line with the General Data
>
>>
>
>> Protection Regulation (GDPR) and with what the community expects of us.
>
>>
>
>> The information contained in this message is confidential and intended
>
>>
>
>> solely for the use of the individual or entity to whom they are

>
>>
>
>> addressed. If you have received this message in error, please notify me
>
>>
>
>> and delete this message from your system. You may not copy this message
>
>>
>
>> in its entirety or in part, or disclose its contents to anyone.
>
>>
>
>>
>
>>
>
>>
>
>>
>
>>
>
>>
>
>>
>
>>
>
>>
>
>>
>
>>
>
>>
>
>>
>
>>
>
>> On 3/8/2021 9:49 AM, y.arifin@ulm.ac.id wrote:
>
>>
>
>>> Dear Ms. Madalina Buzatu
>
>>
>

>>>
>
>>
>
>>> Thank you for your email. I replied to your email two days ago. I asked
>
>>
>
>>> for additional time because MDPI English Service needs time until 11
>
>>
>
>>> March 2021 to finish the English correction.
>
>>
>
>>>
>
>>
>
>>> Thank you for your consideration.
>
>>
>
>>>
>
>>
>
>>> Best regards,
>
>>
>
>>>
>
>>
>
>>>
>
>>
>
>>>
>
>>
>
>>> Arifin
>
>>
>
>>>
>
>>

>
>>>
>
>>
>
>>>
>
>>
>
>>> Sent from Mail <https://go.microsoft.com/fwlink/?LinkId=550986> for
>
>>
>
>>> Windows 10
>
>>
>
>>>
>
>>
>
>>>
>
>>
>
>>>
>
>>
>
>>> *From: *Infrastructures Editorial Office
> <mailto:infrastructures@mdpi.com>
>
>>
>
>>> *Sent: *08 March 2021 15:39
>
>>
>
>>> *To: *Yulian Arifin <mailto:y.arifin@ulm.ac.id>
>
>>
>
>>> *Cc: *Eka Agustina <mailto:eagustina17875@gmail.com>; Fransius Andhi
>
>>
>
>>> <mailto:andhi.bzp@gmail.com>; Setianto Samingan Agus
>
>>
>
>>> <mailto:samingan.agus@mottmac.com>; Infrastructures Editorial Office

>
>>
>
>>> <mailto:infrastructures@mdpi.com>
>
>>
>
>>> *Subject: *[Infrastructures] Manuscript ID: infrastructures-1127055 -
>
>>
>
>>> Revision Reminder (Due Date Today - 8 March 2021)
>
>>
>
>>>
>
>>
>
>>>
>
>>
>
>>>
>
>>
>
>>> Dear Dr. Arifin,
>
>>
>
>>>
>
>>
>
>>>
>
>>
>
>>>
>
>>
>
>>> We sent a revision request for the following manuscript on 5 March 2021.
>
>>
>
>>>
>
>>
>

>>>
>
>>
>
>>>
>
>>
>
>>> Manuscript ID: infrastructures-1127055
>
>>
>
>>>
>
>>
>
>>> Type of manuscript: Article
>
>>
>
>>>
>
>>
>
>>> Title: The Role of Additives in Soil-Cement Subjected to Wetting-Drying
>
>>
>
>>> Cycles
>
>>
>
>>>
>
>>
>
>>> Authors: Yulian Firmana Arifin *, Eka Agustina, Fransius Andhi, Setianto
>
>>
>
>>>
>
>>
>
>>> Samingan Agus
>
>>
>
>>>
>
>>

>
>>> Received: 11 February 2021
>
>>
>
>>>
>
>>
>
>>> E-mails: y.arifin@ulm.ac.id, eagustina17875@gmail.com,
>
>> andhi.bzp@gmail.com,
>
>>
>
>>>
>
>>
>
>>> samingan.agus@mottmac.com
>
>>
>
>>>
>
>>
>
>>>
>
>>
>
>>>
>
>>
>
>>>
>
>>
>
>>>
>
>>
>
>>> May we kindly ask you to update us on the progress of your revisions? If
>
>>
>
>>> you
>
>>
>

>>>
>
>>
>
>>> have finished your revisions, please upload the revised version together
>
>>
>
>>> with
>
>>
>
>>>
>
>>
>
>>> your responses to the reviewers as soon as possible.
>
>>
>
>>>
>
>>
>
>>>
>
>>
>
>>>
>
>>
>
>>> You can find your manuscript and review reports at this link:
>
>>
>
>>>
>
>>
>
>>>
>
>>
> https://susy.mdpi.com/user/manuscripts/resubmit/7814d2bc5ceece8180bc7c53e58e8ee7
>
>>
>
>>>
>
>>
>

>>>
>
>>
>
>>>
>
>>
>
>>> Thank you in advance for your kind cooperation and we look forward to
>
>>
>
>>> hearing
>
>>
>
>>>
>
>>
>
>>> from you soon.
>
>>
>
>>>
>
>>
>
>>>
>
>>
>
>>>
>
>>
>
>>> Kind regards,
>
>>
>
>>>
>
>>
>
>>> Ms. Madalina Buzatu
>
>>
>
>>>
>
>>

>
>>> Assistant Editor
>
>>
>
>>>
>
>>
>
>>> Email: buzatu@mdpi.com
>
>>
>
>>>
>
>>
>
>>> MDPI Open Access Publishing Romania
>
>>
>
>>>
>
>>
>
>>> Str Avram Iancu 454, 407280 Floresti, Cluj, Romania
>
>>
>
>>>
>
>>
>
>>> Infrastructures Editorial Office
>
>>
>
>>>
>
>>
>
>>> E-mail: infrastructures@mdpi.com
>
>>
>
>>>
>
>>
>
>>> http://www.mdpi.com/journal/infrastructures/
>

>>
>
>>>
>
>>
>
>>> /Geomatics/ is Recruiting Editors
>
>>
>
>>>
>
>>
>
>>> https://www.mdpi.com/journal/geomatics/announcements/2226
>
>>
>
>>>
>
>>
>
>>>
>
>>
>
>>>
>
>>
>
>>> Remote Sensing 2020 Best Cover Awards Open for Vote (Vote deadline: 20
>
>>
>
>>>
>
>>
>
>>> February 2021)
>
>>
>
>>>
>
>>
>
>>>
>
>>
>
>>>

>
>>
>
>>> Voting link: https://www.surveymonkey.com/r/MRYTHLQ
>
>>
>
>>>
>
>>
>
>>>
>
>>
>
>>>
>
>>
>
>>> Twitter Link:
>
>> https://twitter.com/RemoteSens_MDPI/status/1351063826628816898
>
>>
>
>>>
>
>>
>
>>>
>
>>
>
>>>
>
>>
>
>>> Disclaimer: MDPI recognizes the importance of data privacy and
>
>>
>
>>> protection. We
>
>>
>
>>>
>
>>
>
>>> treat personal data in line with the General Data Protection Regulation
>

>>
>
>>>
>
>>
>
>>> (GDPR) and with what the community expects of us. The information
>
>> contained
>
>>
>
>>>
>
>>
>
>>> in this message is confidential and intended solely for the use of the
>
>>
>
>>>
>
>>
>
>>> individual or entity to whom they are addressed. If you have received
> this
>
>>
>
>>>
>
>>
>
>>> message in error, please notify me and delete this message from your
>
>>
>
>>> system.
>
>>
>
>>>
>
>>
>
>>> You may not copy this message in its entirety or in part, or disclose its
>
>>
>
>>>
>

>>
>
>>> contents to anyone.
>
>>
>
>>>
>
>>
>
>>>
>
>>
>
>>>
>
>>
>
>>
>
>>
>
>
>

From: Ms. Madalina Buzatu
Sent: 11 March 2021 16:57
To: y.arifin@ulm.ac.id
Cc: infrastructures@mdpi.com; h2a512011@mhs.ulm.ac.id; h2a512012@mhs.ulm.ac.id; samingan.agus@mottmac.com
Subject: [Infrastructures] Manuscript ID: infrastructures-1127055 - Revision Reminder (Due Date 13 March 2021)

Dear Dr. Arifin,

A kind reminder that we are waiting on your revised manuscript of which request was sent on 5 March 2021.

Manuscript ID: infrastructures-1127055
Type of manuscript: Article
Title: The Role of Additives in Soil-Cement Subjected to Wetting-Drying Cycles
Authors: Yulian Firmana Arifin *, Eka Agustina, Fransius Andhi, Setianto Samingan Agus
Received: 11 February 2021
E-mails: y.arifin@ulm.ac.id, eagustina17875@gmail.com, andhi.bzp@gmail.com, samingan.agus@mottmac.com

May we kindly ask you to update us on the progress of your revisions? If you have finished your revisions, please upload the revised version together with your responses to the reviewers as soon as possible.

You can find your manuscript and review reports at this link:

https://susy.mdpi.com/user/manuscripts/resubmit/7814d2bc5ceece8180bc7c53e58e8ee7

Thank you in advance for your kind cooperation and we look forward to hearing from you soon.

Kind regards,

Ms. Madalina Buzatu
Assistant Editor
Email: buzatu@mdpi.com
MDPI OPEN ACCESS PUBLISHING ROMANIA SRL
Str Avram Iancu 454, Floresti, Cluj, Romania
www.mdpi.com
/Geomatics/ is Recruiting Editors
https://www.mdpi.com/journal/geomatics/announcements/2226

Remote Sensing 2020 Best Cover Awards Open for Vote (Vote deadline: 20 February 2021)

Voting link: https://www.surveymonkey.com/r/MRYTHLQ

Twitter Link: https://twitter.com/RemoteSens_MDPI/status/1351063826628816898

From: Submission System
Sent: 12 March 2021 9:03
To: Yulian Arifin
Cc: Eka Agustina; Fransius Andhi; Setianto Samingan Agus
Subject: [Infrastructures] Manuscript ID: infrastructures-1127055 - Manuscript Resubmitted

Dear Dr. Arifin,

Thank you very much for resubmitting the modified version of the following manuscript:

Manuscript ID: infrastructures-1127055
Type of manuscript: Article
Title: The Role of Additives in Soil-Cement Subjected to Wetting-Drying Cycles
Authors: Yulian Firmana Arifin *, Eka Agustina, Fransius Andhi, Setianto Samingan Agus
Received: 11 February 2021
E-mails: y.arifin@ulm.ac.id, h2a512011@mhs.ulm.ac.id, h2a512012@mhs.ulm.ac.id, samingan.agus@mottmac.com

https://susy.mdpi.com/user/manuscripts/review_info/7814d2bc5ceece8180bc7c53e58e8ee7

A member of the editorial office will be in touch with you soon regarding progress of the manuscript.

Kind regards,

MDPI

--
Infrastructures Editorial Office
Postfach, CH-4020 Basel, Switzerland
Office: St. Alban-Anlage 66, CH-4052 Basel
Tel. +41 61 683 77 34 (office)
Fax +41 61 302 89 18 (office)
E-mail: infrastructures@mdpi.com
https://www.mdpi.com/journal/infrastructures/

From: MDPI Billing
Sent: 17 March 2021 21:35
To: Yulian Firmana Arifin
Cc: Madalina Buzatu; Billing Dpt; Infrastructures Editorial Office
Subject: [Infrastructures] Manuscript ID: infrastructures-1127055 - APC Invoice

Dear Dr. Arifin,

Please find attached the invoice for your recently accepted paper. Follow this link to adjust the currency, change the address, or add comments, as necessary:
https://susy.mdpi.com/user/manuscript/7814d2bc5ceece8180bc7c53e58e8ee7/invoice/1064630.

For immediate payment by credit card, visit https://payment.mdpi.com/1064630.

If you would like to use a different method of payment, click here:
https://www.mdpi.com/about/payment. Please include the invoice ID (infrastructures-1127055) as reference in any transaction.

APC invoice amount: 1400.00 CHF
Manuscript ID: infrastructures-1127055
Type of manuscript: Article
Title: The Role of Additives in Soil-Cement Subjected to Wetting-Drying Cycles
Authors: Yulian Firmana Arifin *, Eka Agustina, Fransius Andhi, Setianto Samingan Agus
Received: 11 February 2021
E-mails: y.arifin@ulm.ac.id, h2a512011@mhs.ulm.ac.id, h2a512012@mhs.ulm.ac.id, samingan.agus@mottmac.com

We will publish your accepted paper in open access format immediately upon receipt of the article processing charge (APC) and completion of the editing process.

If you encounter any problems revising the invoice or cannot access the link, please contact invoices@mdpi.com

Thank you very much for your support of open access publishing.

Kind regards,
MDPI Billing Team

MDPI
St. Alban-Anlage 66
4052 Basel, Switzerland
Tel. +41 61 683 77 35; Fax +41 61 302 89 18
E-mail Accounting: billing@mdpi.com
http://www.mdpi.com/
https://www.mdpi.com/about/apc_faq

From: y.arifin@ulm.ac.id
Sent: 18 March 2021 0:20
To: Infrastructures Editorial Office
Subject: RE: [Infrastructures] Manuscript ID: infrastructures-1127055 - Accepted for Publication

Dear Ms. Madalina Buzatu,
I appreciate your email. I'm glad to hear our paper was approved. The bill has already been paid. I'm excited to find out more about the next step.

Best regards, Arifin

Sent from Mail for Windows 10

From: Infrastructures Editorial Office
Sent: 17 March 2021 21:32
To: Yulian Arifin
Cc: Eka Agustina; Fransius Andhi; Setianto Samingan Agus; Infrastructures Editorial Office
Subject: [Infrastructures] Manuscript ID: infrastructures-1127055 - Accepted for Publication

Dear Dr. Arifin,

We are pleased to inform you that the following paper has been officially accepted for publication:

Manuscript ID: infrastructures-1127055
Type of manuscript: Article
Title: The Role of Additives in Soil-Cement Subjected to Wetting-Drying Cycles
Authors: Yulian Firmana Arifin *, Eka Agustina, Fransius Andhi, Setianto Samingan Agus
Received: 11 February 2021
E-mails: y.arifin@ulm.ac.id, h2a512011@mhs.ulm.ac.id, h2a512012@mhs.ulm.ac.id, samingan.agus@mottmac.com

https://susy.mdpi.com/user/manuscripts/review_info/7814d2bc5ceece8180bc7c53e58e8ee7

We will now make the final preparations for publication, then return the manuscript to you for your approval.

If, however, extensive English edits are required to your manuscript, we will need to return the paper requesting improvements throughout.

We encourage you to set up your profile at SciProfiles.com, MDPI's researcher network platform. Articles you publish with MDPI will be linked to your SciProfiles page, where colleagues and peers will be able to see all of your publications, citations, as well as your other academic contributions.

We also invite you to contribute to Encyclopedia (https://encyclopedia.pub), a scholarly platform providing accurate information about the latest research results. You can adapt parts of your paper to provide valuable reference information for others in the field.

Kind regards,
Ms. Madalina Buzatu
Assistant Editor
Email: buzatu@mdpi.com
MDPI Open Access Publishing Romania
Str Avram Iancu 454, 407280 Floresti, Cluj, Romania
Infrastructures Editorial Office
E-mail: infrastructures@mdpi.com
http://www.mdpi.com/journal/infrastructures/

From: Ms. Madalina Buzatu
Sent: 18 March 2021 19:24
To: y.arifin@ulm.ac.id
Cc: Infrastructures
Subject: [Infrastructures] Manuscript ID: infrastructures-1127055 - Payment Confirmation

Dear Dr. Arifin,

Thank you very much for your email. I am writing you to confirm that the APC payment was received and we will further process your manuscript by making the final preparations for publication, then return the manuscript to you for your approval.

Please do not hesitate to contact me if you have any questions.

Kind regards,

Ms. Madalina Buzatu
Assistant Editor
Email: buzatu@mdpi.com
MDPI OPEN ACCESS PUBLISHING ROMANIA SRL
Str Avram Iancu 454, Floresti, Cluj, Romania
www.mdpi.com

> Subject: RE: [Infrastructures] Manuscript ID: infrastructures-1127055 -
> Accepted for Publication
> Date: Thu, 18 Mar 2021 00:20:04 +0800
> From: y.arifin@ulm.ac.id
> To: Infrastructures Editorial Office <infrastructures@mdpi.com>
>
>

From: y.arifin@ulm.ac.id
Sent: 19 March 2021 19:27
To: Infrastructures Editorial Office
Subject: RE: [Infrastructures] Manuscript ID: infrastructures-1127055 - Final Proofreading Before Publication

Dear Ms. Madalina Buzatu,
Thank you for your email. I have already sent the revised version of our paper. I also want to confirm that we would like to use the Open Review option.
We look forward to hearing to the next move.

Best regards, Arifin

Sent from Mail for Windows 10

From: Madalina Buzatu
Sent: 18 March 2021 21:32
To: Yulian Arifin
Cc: Infrastructures Editorial Office; Eka Agustina; Fransius Andhi; Setianto Samingan Agus
Subject: [Infrastructures] Manuscript ID: infrastructures-1127055 - Final Proofreading Before Publication

Dear Dr. Arifin,

We invite you to proofread your manuscript to ensure that this is the final version that can be published and confirm that you will require no further changes from hereon:

Manuscript ID: infrastructures-1127055
Type of manuscript: Article
Title: The Role of Additives in Soil-Cement Subjected to Wetting-Drying Cycles
Authors: Yulian Firmana Arifin *, Eka Agustina, Fransius Andhi, Setianto Samingan Agus
Received: 11 February 2021
E-mails: y.arifin@ulm.ac.id, h2a512011@mhs.ulm.ac.id, h2a512012@mhs.ulm.ac.id, samingan.agus@mottmac.com

Please read the following instructions carefully before proofreading:

1) Download the manuscript from the link provided at the end of this message and upload the final proofed version at the same link within 24 hours (1 working day). If you experience any difficulties, please contact the Infrastructures Editorial Office.

2) Please use Microsoft Word's built-in track changes function to highlight any changes you make, or send a comprehensive list of changes in a separate document. Note that this is the *last chance* to make textual changes to the manuscript. Some style and formatting changes may have been made by the production team, please do not revert these changes.

3) All authors must agree to the final version. Check carefully that authors' names and affiliations are correct, and that funding sources are correctly acknowledged. Incorrect author names or affiliations are picked up by indexing databases, such as the Web of Science or PubMed, and can be difficult to correct.

After proofreading, final production will be carried out. Note that changes to the position of figures and tables may occur during the final steps. Changes can be made to a paper published online only at the discretion of the Editorial Office. In this case, a separate Correction or Addendum will be published and we reserve the right to charge 50 CHF per Correction (including changes to author names or affiliations).
Please confirm whether you would like to use the Open Review option, where the review reports and authors' response are published alongside your paper. Reviewers can also choose to identify themselves along with the published paper. We encourage authors to take advantage of this option as proof of the rigorous peer review process used to publish your research. However, we will not publish the review reports without your explicit approval.

Please download the final version of your paper for proofreading here:

https://susy.mdpi.com/user/manuscripts/proof/file/7814d2bc5ceece8180bc7c53e58e8ee7

and upload here:

https://susy.mdpi.com/user/manuscripts/resubmit/7814d2bc5ceece8180bc7c53e58e8ee7

Supplementary and other additional files can be found at the second link. We look forward to hearing from you soon.

Kind regards,

Ms. Madalina Buzatu
Assistant Editor
Email: buzatu@mdpi.com
MDPI Open Access Publishing Romania
Str Avram Iancu 454, 407280 Floresti, Cluj, Romania
Infrastructures Editorial Office
E-mail: infrastructures@mdpi.com
http://www.mdpi.com/journal/infrastructures/

From: y.arifin@ulm.ac.id
Sent: 22 March 2021 13:18
To: Madalina Buzatu; Infrastructures Editorial Office
Subject: RE: [Infrastructures] Manuscript ID: infrastructures-1127055 - Your paper is not ready for publication

Dear Ms. Sharon Fan,
Sorry for the delay in responding to your email. If required, I will respond to the comments. I received notification via email that the article had been published.

1. As for affiliation 1 and 2, we need to add a comma before city. It should be as following. is it okay?
Jl. A. Yani km 35, Banjarbaru 70714, Indonesia ....Yes
Jl. Brigjen. H. Hasan Basri, Banjarmasin 70123, Indonesia ....Yes
2. Please add Zip Code for affiliation "Mott MacDonald Pte. Ltd., Singapore" .... 189721.
3. Please provide institutional email of Dr. Setianto Samingan Agus ....The email available is official email
4. Please let me know if you need to add section "Data Availability Statement". In this section, please provide details regarding where data sup-porting reported results can be found, including links to publicly archived datasets analyzed or generated during the study. Please refer to suggested Data Availability Statements in section “MDPI Research Data Policies” at https://www.mdpi.com/ethics. You might choose to exclude this statement if the study did not report any data. .... I can not access to the link. I choose to exclude this statement.

Best regards, Arifin

Sent from Mail for Windows 10

From: Infrastructures Editorial Office
Sent: 20 March 2021 10:45
To: Yulian Arifin
Cc: Infrastructures Editorial Office; Eka Agustina; Fransius Andhi; Setianto Samingan Agus; Madalina Buzatu
Subject: [Infrastructures] Manuscript ID: infrastructures-1127055 - Your paper is not ready for publication

Dear Dr. Arifin,

Your paper is still not ready for publication. Please find following comments.
1. As for affiliation 1 and 2, we need to add a comma before city. It should be as following. is it okay?
Jl. A. Yani km 35, Banjarbaru 70714, Indonesia
Jl. Brigjen. H. Hasan Basri, Banjarmasin 70123, Indonesia
2. Please add Zip Code for affiliation "Mott MacDonald Pte. Ltd., Singapore"
3. Please provide institutional email of Dr. Setianto Samingan Agus
4. Please let me know if you need to add section "Data Availability Statement". In this section, please provide details regarding where data

sup-porting reported results can be found, including links to publicly archived datasets analyzed or generated during the study. Please refer to suggested Data Availability Statements in section “MDPI Research Data Policies” at https://www.mdpi.com/ethics. You might choose to exclude this statement if the study did not report any data.

Once we confirm the above issues, we will publish this paper as soon as possible.

I look forward to hearing from you, Many thanks!

Ms. Sharon Fan
Managing Editor, MDPI
No. 21 Cuijingbeili, Tongzhou District, Beijing, China
Skype: live:sharon.fan_2
Infrastructures (www.mdpi.com/journal/infrastructures)
Remote Sensing (www.mdpi.com/journal/remotesensing)

/Infrastructures/ is indexed by ESCI (Web of Science), Scopus

Remote Sensing’s Impact Factor (2019): 4.509, 5-Year Impact Factor (2019): 5.001
Top Open Access Journal in Remote Sensing

--
News:

Welcome to meet us at #415 @AAG2020 (https://www2.aag.org/aagannualmeeting/) in U.S. this April.

From: y.arifin@ulm.ac.id
Sent: 23 March 2021 0:04
To: Ms. Madalina Buzatu
Subject: RE: [Infrastructures] Manuscript ID: infrastructures-1127055 - Reminder - Graphical Abstract Needed

Dear Ms. Madalina Buzatu,

Thank you for the guidance. Please find the GA for our article attached.

Best regards, Arifin

Sent from Mail for Windows 10

From: Ms. Madalina Buzatu
Sent: 22 March 2021 14:34
To: y.arifin@ulm.ac.id
Cc: Infrastructures
Subject: [Infrastructures] Manuscript ID: infrastructures-1127055 - Reminder - Graphical Abstract Needed

Dear Dr. Arifin,

Thank you very much for your reply. Yes, all papers need an self-explanatory graphical abstract that should fulfill the following requirements:

1. The GA should be a high-quality illustration or diagram in any one of the following formats: PNG, JPEG, EPS, SVG, PSD or AI.

2. Written text in the GA should be legible. Make sure the reader can easily read the smallest font size of a character, number or symbol.

3. The minimum required size for the GA is 560 × 1100 pixels (height × width). When submitting larger images, please make sure to keep to the same ratio.

4. Avoid large blank space in the GA. There should be a proper distance between the actual content of the picture and the margins.

5. The GA should not be totally same as a Figure in the manuscript.

6. The GA should not be a simple combination of the Abstract part and a Picture (even just a Figure from the main text). We need to avoid long blocks of text in the GA.

Do not hesitate to contact us if you have any questions.

We look forward to hearing from you soon.

Kind regards,

Ms. Madalina Buzatu
Assistant Editor
Email: buzatu@mdpi.com
MDPI OPEN ACCESS PUBLISHING ROMANIA SRL
Str Avram Iancu 454, Floresti, Cluj, Romania
www.mdpi.com

On 3/22/2021 7:22 AM, y.arifin@ulm.ac.id wrote:
> Dear Ms. Madalina Buzatu,
>
> Sorry for the delay in responding to your email. I received notification
> via email that the article had been published.
>
> I'm not sure what the GA is all about; do I have to reproduce it
> according to the instructions below?
>
>
>
> Best regards, Arifin
>
>
>
> Sent from Mail <https://go.microsoft.com/fwlink/?LinkId=550986> for
> Windows 10
>
>
>
> *From: *Ms. Madalina Buzatu <mailto:buzatu@mdpi.com>

> *Sent: *20 March 2021 1:14
> *To: *Yulian Arifin <mailto:y.arifin@ulm.ac.id>
> *Cc: *Eka Agustina <mailto:h2a512011@mhs.ulm.ac.id>; Fransius Andhi
> <mailto:h2a512012@mhs.ulm.ac.id>; Setianto Samingan Agus
> <mailto:samingan.agus@mottmac.com>; Infrastructures Editorial Office
> <mailto:infrastructures@mdpi.com>
> *Subject: *[Infrastructures] Manuscript ID: infrastructures-1127055 -
> Reminder - Graphical Abstract Needed
>
>
>
> Dear Dr. Arifin,
>
>
>
> Thank you for your proofread version of your manuscript. We will further
>
> process the paper and keep you informed about its status. Meanwhile, we
>
> would like to kindly ask you to provide us with a self-explanatory
>
> graphical abstract of your paper as soon as possible.
>
>
>
> The graphical abstract will be used along with the abstract in the
>
> journal's table of contents and search results. It should fulfill the
>
> following requirements:
>
>
>
> 1. The GA should be a high-quality illustration or diagram in any one of
>
> the following formats: PNG, JPEG, EPS, SVG, PSD or AI.
>
>
>
> 2. Written text in the GA should be legible. Make sure the reader can
>
> easily read the smallest font size of a character, number or symbol.
>
>
>
> 3. The minimum required size for the GA is 560 × 1100 pixels (height ×
>
> width). When submitting larger images, please make sure to keep to the
>
> same ratio.
>

>
>
> 4. Avoid large blank space in the GA. There should be a proper distance
>
> between the actual content of the picture and the margins.
>
>
>
> 5. The GA should not be totally same as a Figure in the manuscript.
>
>
>
> 6. The GA should not be a simple combination of the Abstract part and a
>
> Picture (even just a Figure from the main text). We need to avoid long
>
> blocks of text in the GA.
>
>
>
> We are looking forward for your reply.
>
>
>
> Have a nice weekend!
>
>
>
> Kind regards,
>
>
>
> Ms. Madalina Buzatu
>
> Assistant Editor
>
> Email: buzatu@mdpi.com
>
> MDPI OPEN ACCESS PUBLISHING ROMANIA SRL
>
> Str Avram Iancu 454, Floresti, Cluj, Romania
>
> www.mdpi.com
>
> /Geomatics/ is Recruiting Editors
>
> https://www.mdpi.com/journal/geomatics/announcements/2226
>
>
>
> Remote Sensing 2020 Best Cover Awards Open for Vote (Vote deadline: 20

>
> February 2021)
>
>
>
> Voting link: https://www.surveymonkey.com/r/MRYTHLQ
>
>
>
> Twitter Link: https://twitter.com/RemoteSens_MDPI/status/1351063826628816898
>
>
>
> Disclaimer: MDPI recognizes the importance of data privacy and
>
> protection. We treat personal data in line with the General Data
>
> Protection Regulation (GDPR) and with what the community expects of us.
>
> The information contained in this message is confidential and intended
>
> solely for the use of the individual or entity to whom they are
>
> addressed. If you have received this message in error, please notify me
>
> and delete this message from your system. You may not copy this message
>
> in its entirety or in part, or disclose its contents to anyone.
>
>
>
> On 3/19/2021 12:03 PM, Infrastructures Editorial Office wrote:
>
>
>

From: MDPI – Office of the Publisher
Sent: 24 March 2021 21:01
To: y.arifin@ulm.ac.id
Subject: Reprints for Recently Published Article with MDPI -- infrastructures-1127055

Dear Dr. Arifin,

Congratulations on your recently published article infrastructures-1127055 in our journal Infrastructures.
If you were interested in ordering reprints of your article, we can provide 10, 20 or more full-color copies,
printed on 135 g/m2 glossy paper (2x stitched), with the individual designed covers on front- and back.
Orders are processed rapidly and we ship globally at a fair price.

You can place your order directly at http://www.mdpi.com/2412-3811/6/3/48/reprints/.

For any questions please do not hesitate to contact me.

Kind regards,

Tim Gasser
Administrative Assistant

MDPI
St. Alban-Anlage 66
CH-4052 Basel, Switzerland
Tel. +41 61 683 77 34
Fax +41 61 302 89 18
E-mail: publisher@mdpi.com
http://www.mdpi.com/