

SURAT TUGAS

Nomor: 1083-R/UNTAR/PENELITIAN/III/2022

Rektor Universitas Tarumanagara, dengan ini menugaskan kepada saudara:

1. **WIDODO KUSHARTOMO, S.Si., M.Si., Dr.**
2. **HENNY WIYANTO, Ir., M.T.**
3. **DANIEL CHRISTIANTO, S.T., M.T.**

Untuk melaksanakan kegiatan penelitian/publikasi ilmiah dengan data sebagai berikut:

Judul : INCREASING THE CALCIUM SILICATE HYDRATE AMOUNT IN REACTIVE POWDER CONCRETE USING MARBLE POWDER
Nama Media : SPEKTRA
Penerbit : JURUSAN FISIKA UNJ
Volume/Tahun : 6/2021
URL Repository : <http://journal.unj.ac.id/unj/index.php/spektra/issue/view/1332>

Demikian Surat Tugas ini dibuat, untuk dilaksanakan dengan sebaik-baiknya dan melaporkan hasil penugasan tersebut kepada Rektor Universitas Tarumanagara

01 Maret 2022

Rektor



Prof. Dr. Ir. AGUSTINUS PURNA IRAWAN

Print Security : 293cc5564a0a56720c1dd2add6c092e4

Disclaimer: Surat ini dicetak dari Sistem Layanan Informasi Terpadu Universitas Tarumanagara dan dinyatakan sah secara hukum.



Fisika



LPPM



Volume 6 Issue 1, April 2021

SPEKTRA

Jurnal Fisika dan Aplikasinya



DOI: doi.org/10.21009/SPEKTRA

e-ISSN : 2541-3392



DOI: doi.org/10.21009/SPEKTRA.061.04

INCREASING THE CALCIUM SILICATE HYDRATE AMOUNT IN REACTIVE POWDER CONCRETE USING MARBLE POWDER

Widodo Kushartomo*, Henny Wiyanto, Daniel Christianto

Civil Engineering Undergraduate Study Program, Faculty of Engineering, Universitas Tarumanagara, Jl. Let. Jend. S. Parman No. 1 Jakarta 11440, Indonesia

*Corresponding Author Email: widodo@untar.ac.id

Received: 5 December 2020

Revised: 11 February 2021

Accepted: 16 February 2021

Online: 28 April 2021

Published: 30 April 2021

SPEKTRA: Jurnal Fisika dan Aplikasinya

p-ISSN: 2541-3384

e-ISSN: 2541-3392



ABSTRACT

This research aims to make ultra high strength Reactive Powder Concrete (RPC) with marble powder as one of the components. The use of marble powder can increase Calcium Silicate Hydrate (CSH) and the strength of RPC. The research method used to achieve the objectives is experimental and divided into two steps. The first step is the characterization of a marble and micro silica powder mixture. Stoichiometry calculations are performed to determine the composition of the mixture. The test sample is made in the form of pellets consisting of a mixture of marble powder, micro silica, and water. The water content used is at 30% - 50%. Maintenance is carried out by immersion in water with the temperature of 20°C for 27 days and in steam at temperatures 200°C, 250°C, and 300°C with 2 atm pressure for 4 hours. Material characterization is carried out using X-Ray Diffraction (XRD) and Scanning Electron Microscopy (SEM). The second step in this research is the RPC compressive strength test. The test sample is made in the form of a cube measuring 50 x 50 x 50 mm. This cube is a mixture of water, cement, micro silica, marble powder, sand, and superplasticizer. Material composition is arranged based on the characterization of the sample pellet test, and maintenance of the sample cube test is carried out as in the sample pellet test.

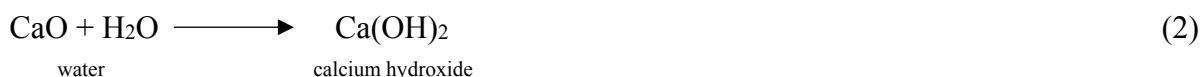
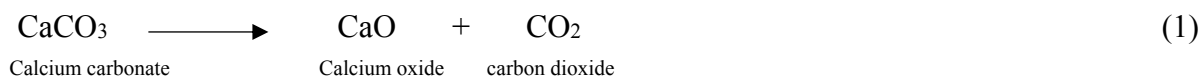
Keywords: CSH, RPC, strength, temperature, characterization

INTRODUCTION

The marble is a rock that resulted from a metamorphosis or a process made from limestone which contains carbonate. As a result of recrystallization of the structure from which the rock originates, it forms a new texture and grain regularity. Indonesian marble is estimated to be around 30-60 million years old. In Indonesia, the usage of marble is quite widespread. The use of marble can be categorized into two motifs: namely ordinario and staturio. Ordinario marble is usually used for manufacturing baths, tables, and walls, while staturio is often used for sculpture.

The processing and utilization of new marble use water, so it produces waste. This waste is accommodated in a pool (reservoir), which gradually settles then hardens. Marble waste can be used so as not to pollute the environment and economic value. Marble waste can be processed with dolomite as a mixture of building materials to reduce environmental pollution. The effects of using dolomite and waste marble powder as partial replacement of cement on the mechanical properties of concrete were investigated. Test results indicate that the optimized assay of dolomite and waste marble powder as a replacement by weight of cement had the best compressive and flexural strengths [1].

Marble has the main content of the element calcium, which binds water to form compounds in the form of calcium hydroxide, chemically written as $\text{Ca}(\text{OH})_2$. Calcium has several unique properties: chemically, calcium is alkaline. So, it quickly forms reactions with strong acids. Calcium in the calcium carbonate compound CaCO_3 releases carbon dioxide on heating to form calcium dioxide, which is usually called lime, and chemically written as follows [2].



Reactive Powder Concrete (RPC) is a concrete composed of materials with microscopic particle sizes, such as cement, micro silica, quartz sand, quartz powder, and superplasticizer. RPC is concrete with excellent mechanical properties: the highest compressive strength ever achieved in making RPC ranges from 120.0 - 150.0 MPa, and the highest flexural strength ever achieved ranges from 20.0 - 30.0 MPa [3]. RPC is characterized by the use of cement and micro-silica in large quantities and does not use coarse aggregate. Because its materials have tiny particle sizes, RPC can be arranged in a compact and has a much better homogeneity when compared to concrete in general. Micro silica in RPC is a material mainly consisting of amorphous SiO_2 . The SiO_2 content in micro silica reaches 98%, far more compared to volcanic ash, flying ash, or other pozzolanic material, which only ranges between 40% - 56% [4]. Micro silica has functioned as an activator for the occurrence of pozzolanic reactions with one of the cement hydration products, namely calcium hydroxide. It also functions to fill small voids in concrete.

Research conducted on RPC [3] still shows weaknesses, one of which is covered by quartz powder. Quartz Powder in the making of RPC has a function as a pore filler. In a tiny size, high pressure, and high temperature during RPC maintenance, quartz flour can react with C-S-H to form xonolite so that the compressive strength of RPC can increase significantly [5]. In Indonesia, quartz powder is not easy to get. In order to obtain it, imports from China, India, or Europe are needed, so sustainability in making RPC becomes a huge obstacle. This research will use marble powder instead of silica powder in the manufacturing of RPC. The first reason for using marble powder instead of silica powder in making RPC is that marble powder contains calcium as its main component. This calcium is expected to react with micro silica in the pozzolanic reaction to form calcium silicate hydrate compounds. The higher volume of calcium silicate hydrate is formed, the more the strength of RPC will increase, as explained above. Secondly, marble powder is a readily available material in Indonesia and a waste from marble production plants. Thus, marble powder waste as an RPC maker material can reduce environmental pollution [6].

RESEARCH METHOD AND MATERIALS

To achieve the objectives, the research method used in data collection is experimental research in which several tests, treatments, and characterization methods are carried out to determine the amount of calcium silicate formed based on the reaction between marble powder and micro silica, using the following research steps.

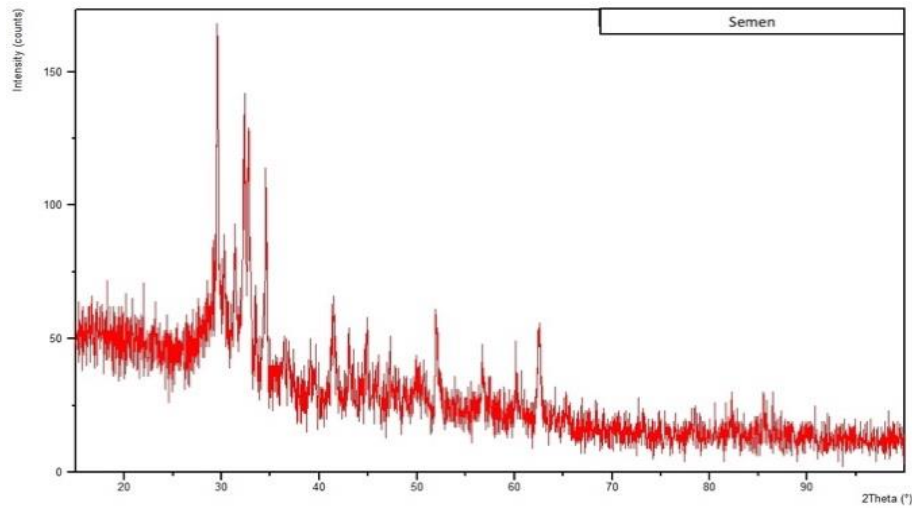
The material used in this research is cement, water, silica fume, marble powder, sand, and superplasticizer with a weight ratio of 1.00 : 0.20 : 0.25 : 0.15 : 1.10 : 0.03. Samples are made by mixing all materials into a mixer which is rotating at a speed of 1500 rpm. Samples were cast on the mold with a size of 5.0 cm x 5.0 cm x 5.0 cm and were treated by soaking in water at a temperature of 20°C for 27 days, followed by treatment at 200°C as mix-1; 250°C as mix-2; and 300°C as mix-3 in an autoclave for 4 hours and with 2 atm pressure. All samples were compared with a typical mix (without marble powder) examined using XRD, SEM, and compressive strength testing was performed.

Cement is used as a binding agent between the constituent RPC constituents. The cement used is portland cement type 1. Silica fume does not have atoms, has no common configuration, or is called amorphous. The size of the granules ranges between 0.1 - 0.2 μm . Silica fume contains 98% of SiO_2 , with fineness of 20,000 m^2 / kg and density of 2,200 kg / m^3 [4]. The sand used is quartz sand, which has SiO_2 as a major composition, 150 μm - 600 μm grain size, zone 4 on grain grading, irregular shape, and hardness of 7 mohs. Marble mainly contains calcium, which binds water to form compounds in calcium hydroxide, chemically written as $\text{Ca}(\text{OH})_2$. Each marble powder granule size ranges between 10 μm - 40 μm [6]. Superplasticizer is used to improve the workability of the mortar so that it can disperse the mortar well. The superplasticizer suitable for this research comes from polycarboxylate-based polymers.

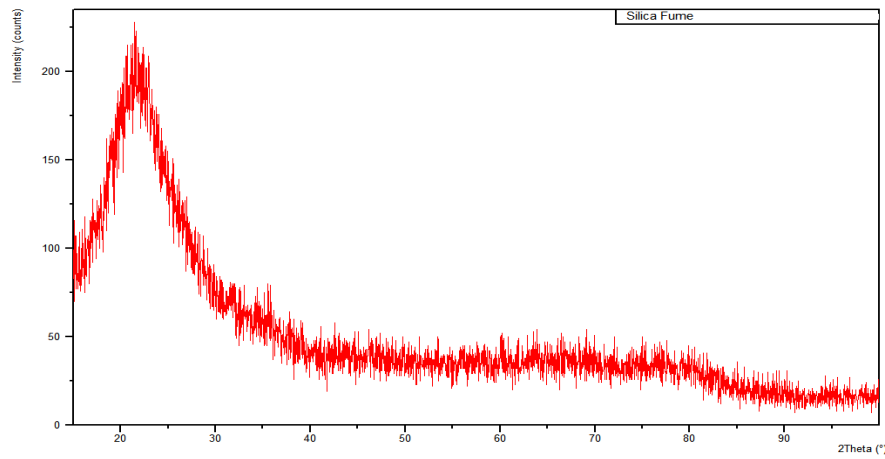
RESULTS AND DISCUSSION

XRD Characterization

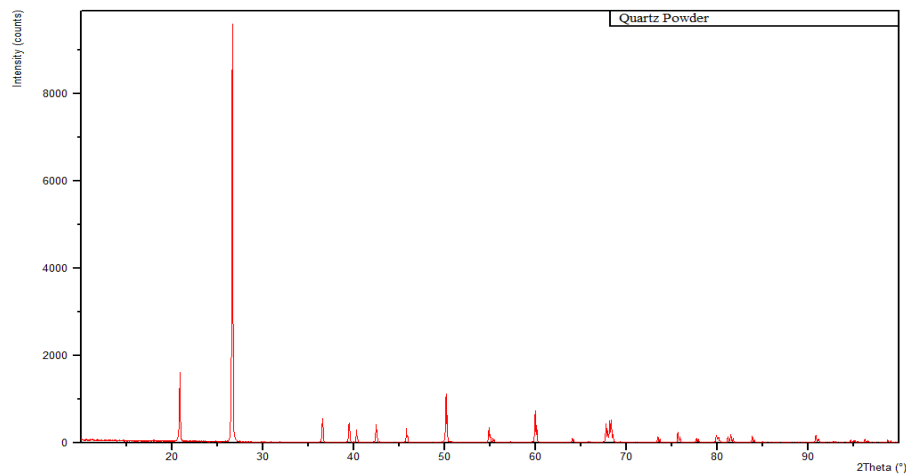
In the XRD spectrum of raw materials for cement, silica fume, and marble powder, as shown in FIGURE 1, the spectrum peaks at certain angles depict the mineral components contained therein. FIGURE 1a shows the mineral component of tricalcium silicate (C_3S) found in the diffraction angle $2\theta = 32.15^\circ, 32, 50^\circ, 34, 37^\circ$ and 41.11° . The minerals in calcium silicate (C_2S) are present at the diffraction angle $2\theta = 32.66^\circ, 33.11^\circ$ and 41.63° . Tricalcium silicate is at the diffraction angle $2\theta = 17.50^\circ, 39.40^\circ$ and 44.57° , while the mineral component of calcium aluminoferrite (C_4AF) is at the diffraction angle $2\theta = 34.38^\circ, 50,56^\circ$ and 50.74° [7]. The four minerals are the main components of cement detected in the XRD spectrum. The XRD spectrum of Silica fume is shown in FIGURE 1b. This spectrum represents amorphous material, meaning that the silica fume of the atoms is not regularly arranged [4]. This amorphous material is very reactive to calcium hydroxide $Ca(OH)_2$ at room temperature, so it is widely used in the concrete industry. The XRD spectrum of quartz is presented in FIGURE 1c, which shows the crystalline spectrum of SiO_2 calcium silica with diffraction angles $2\theta = 20.82^\circ, 26.62^\circ$ and 36.52° [8]. By finding only three diffraction angles 2θ , the type of material can already be described.



1a.



1b.

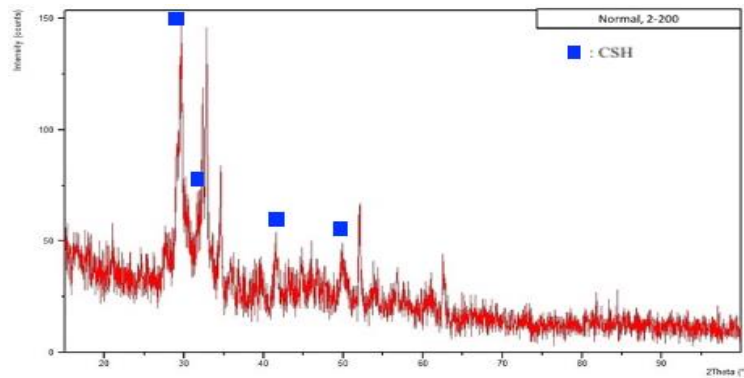


1c.

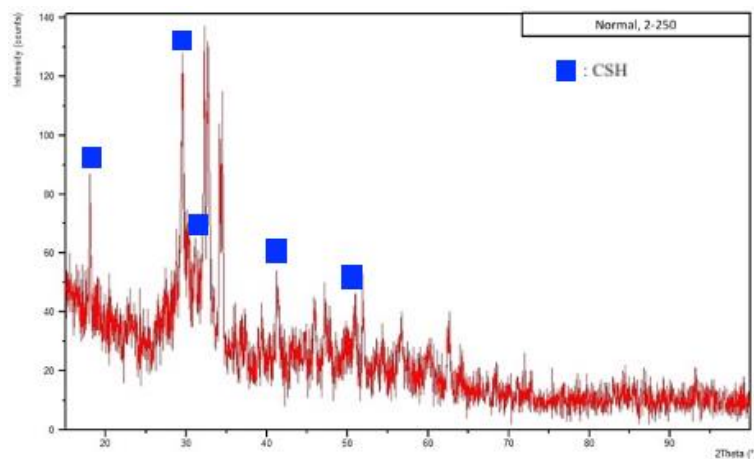
FIGURE 1. XRD Patterns of: a. Cement, b. Silica Fume, c. Silica sand.

This research is conducted on concrete with typical composition, which means that the concrete is only composed of cement, water, silica fume, and superplasticizer. The XRD

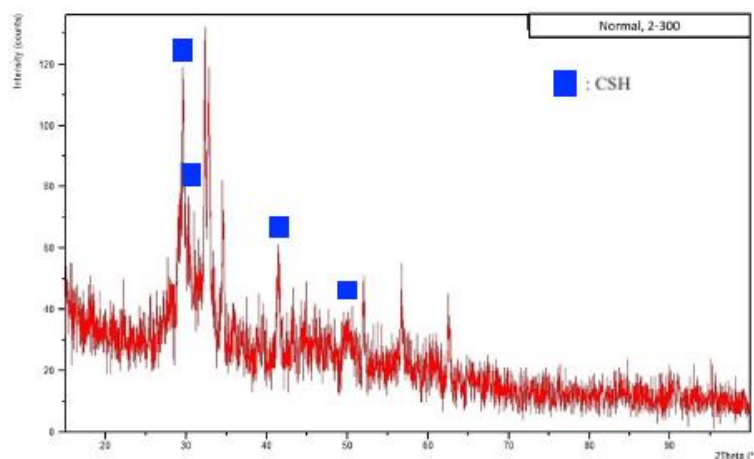
spectrum of concrete with a standard composition is shown in FIGURE 2. This spectrum clearly shows the presence of calcium silicate hydrate or known as (CSH) [9], at a diffraction angle of 2θ 16.9°, 29.2°, 32.0°, 42.7°, 49.8°.



2a.



2b.

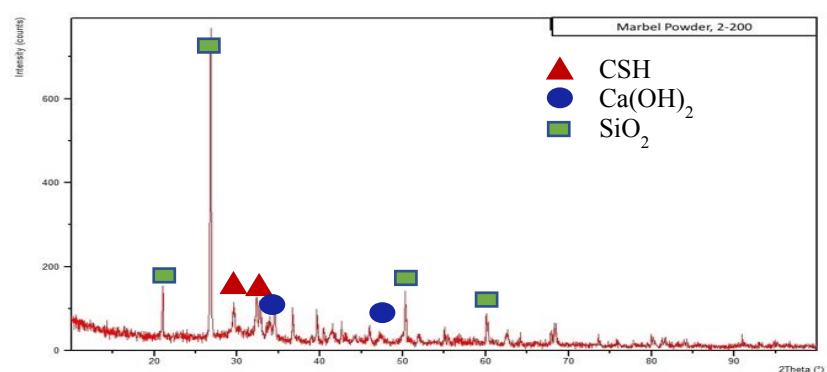


2c.

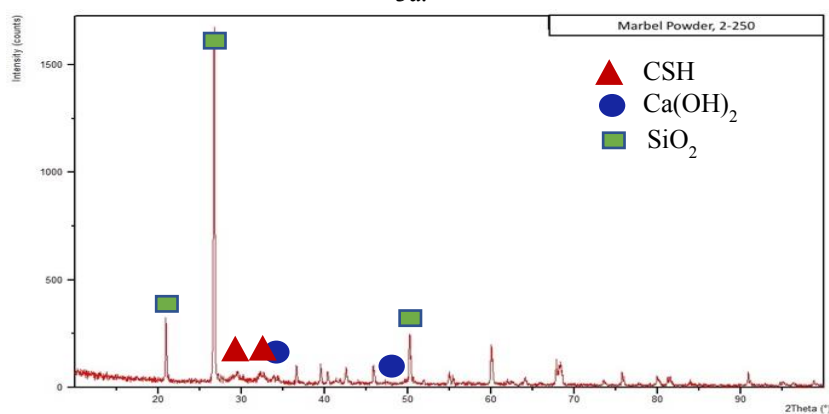
FIGURE 2. XRD Patterns of the standard mix at temperatures: a. 200°C, b. 250°C, c. 300°C.

Examination using X-ray diffraction in mix-1, mix-2, and mix-3 samples is shown in FIGURE 3. In FIGURE 3, the intensity of the quartz spectrum dominates the appearance of other

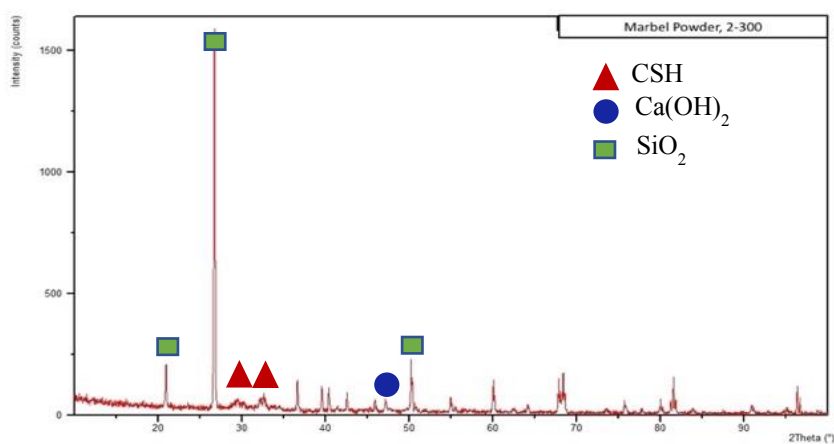
spectra, such as the CSH spectrum. However, the CSH spectrum is still evident in the position of the material. FIGURE 3a shows the CSH spectrum, which is much clearer when compared to the mix-2 spectrum of FIGURE 3b and the mix-3 spectrum of FIGURE 3c. This shows that maintenance using an autoclave at 200°C can increase CSH formation compared to maintenance at 250°C and 300°C. The appearance of the XRD spectrum in FIGURE 3 also shows the use of quartz flour in the process of making reactive powder concrete can increase the formation of CSH in concrete. CSH in concrete has a crucial function, which is to form strength. The CSH spectrum is not the same as the SiO₂ spectrum because CSH is a semi-crystal and not a pure crystal.



3a.



3b.



3c.

FIGURE 3. XRD Patterns of concrete sample: a. mix-1, b. mix-2, c. mix-3.

SEM Analysis

The formation and distribution of hydration products of hydrated cement paste with three different mix proportions are pictured below. The microstructure of the three mixes was examined and compared with the normal mix. The microstructure and strength properties of all three mixes were correlated based on the hydration products formed after 28 days. The reason behind the strength of the concrete was analyzed and explained based on the growth of hydration products in the microstructure of concrete mixes.

The SEM micrograph pictures in FIGURE 4 illustrate the microstructural variation during the hydration process and production of hydration products in Mix 1. The rate of hydration was sufficient to achieve the strength of concrete. C-S-H formation was complete. The development of chemical reaction between the portlandite from marble powder $\text{Ca}(\text{OH})_2$ and silica in the silica fume results in the concrete having inadequate strength. In the SEM micrograph, the lower presence of ettringite was clearly evidenced in the micrograph, which leads to the increase of development and distribution of C-S-H gel in the hardened concrete.



FIGURE 4. SEM Micrograph of Mix-1

The microstructure of the hydrated cement paste of Mix-2 was shown in FIGURE 5. The considerable strength obtained in this mix was due to the pozzolanic activity of silica fume. The chemical reaction of silica fume with the portlandite $\text{Ca}(\text{OH})_2$ leads to the production of additional CSH gel, which was the main reason for the strength of this mix [10,11,12]. The rate of hydration process in Mix-2 was similar to the typical concrete mix, but the existence of mineral elements was quite different from Mix-3, which manipulates the strength of concrete curing temperature. Even though the strength of the concrete mix was not up to the anticipated level, it reached a considerable strength, which means it can also be used as a replacement for the normal concrete mix in certain concreting works.

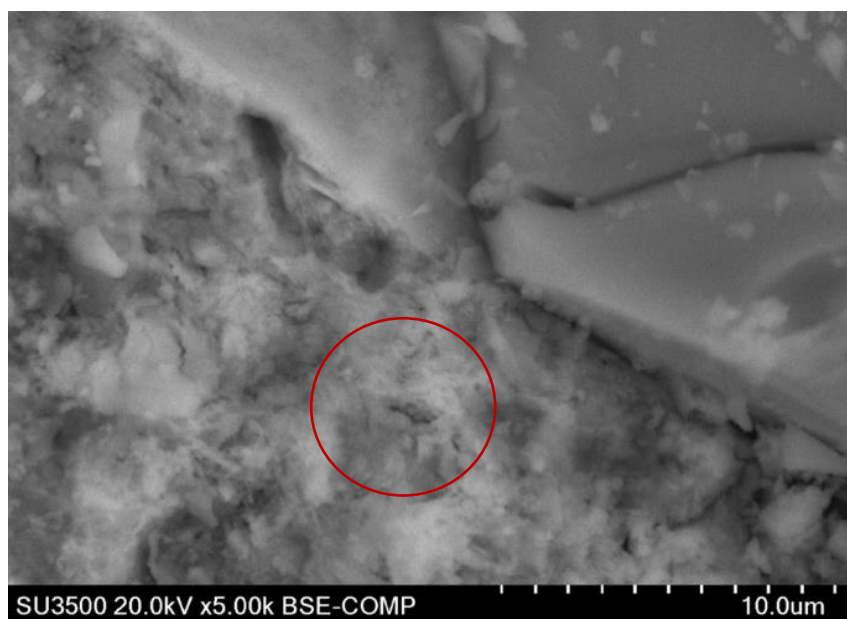


FIGURE 5. SEM Micrograph of Mix-2

In FIGURE 6, The SEM image of Mix-3 visualizes the microstructure of hydrated cement paste. From the SEM micrograph of the hardened concrete, the distribution of CSH was nearly decreased due to elevated curing temperature. In this mix, the range of CSH development was lower, which may be due to unreacted particles of marble powder present in the mix. The accumulation of other major mineral elements, such as Portlandite Ca(OH)_2 and Calcite (CaCO_3) crystals, are found in the microstructure of the mix. The main reason for the decrease in strength was the lack of hydration of particles, which is present in the hardened cement matrix. In other words, the amount of CSH formed is lower than in mix-1. The utilization of supplementary materials such as marble powder in the mix was unsuccessful because of the lack of chemical reaction between marble powder and the silica fume in curing temperature [6]. In this mix, due to the unreacted particles in the hardened cement paste, the strength of concrete mix was affected.

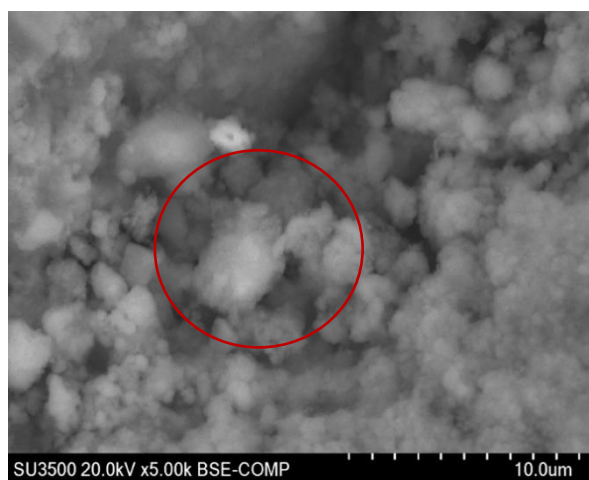


FIGURE 6. SEM Micrograph of Mix-3

Compressive Strength

Compressive strengths of four concrete mixes were determined after 28 days, and their comparison details are pictured in FIGURE 7. The concrete cubes were tested for compressive strength after 28 days of curing, and a higher value of compressive strength was obtained in Mix-1, which was slightly higher than mix-2. Even though Mix-3 did not reach the target strength, 50,0 MPa, it reached enough strength to be used as an alternative for the standard concrete mix in specific concreting works.

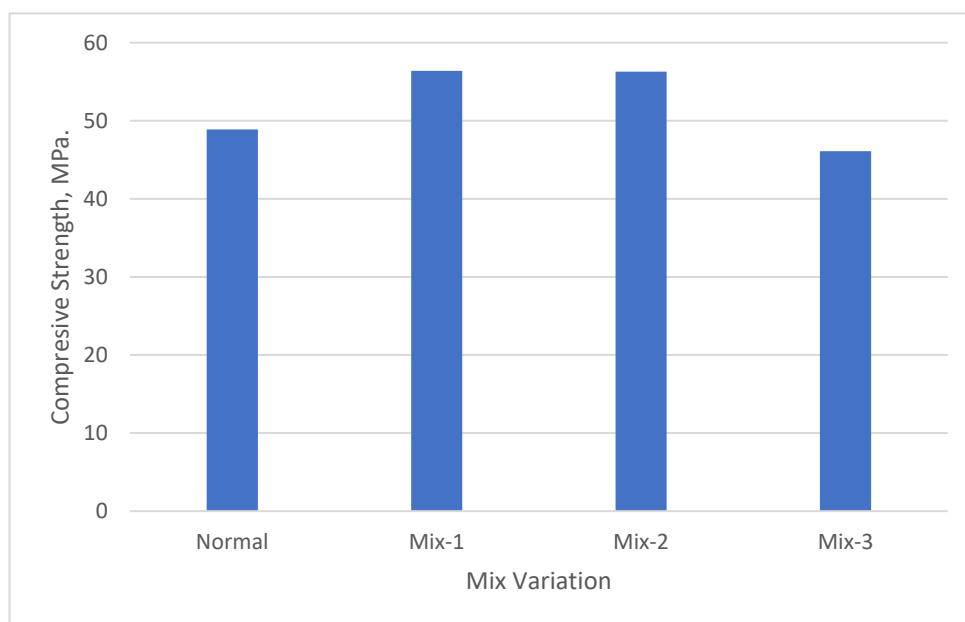


FIGURE 7. Concrete Compressive Strength

CONCLUSION

The conclusion obtained from the experimental study is that the addition of marble powder to reactive powder concrete (RPC) can increase the amount of calcium silicate hydrated (CSH). The increase in the amount of calcium silicate hydrated occurred due to the pozzolanic reaction between silica fume and marble powder. The rate of the pozzolanic reaction can be increased by applying pressure and increasing the temperature during the curing process.

Increasing the amount of hydrated calcium silicate in reactive powder concrete increases the compressive strength of the concrete. The increased amount of hydrated calcium silicate on RPC with the addition of marble trunks can be maximized if RPC is cured using an autoclave at a pressure of 2 atm and a temperature of 250°C for 4 hours.

REFERENCES

- [1] Ali Ergun, "Effects of the usage of diatomite and waste marble powder as partial replacement of cement on the mechanical properties of concrete," *Construction and Building Materials*, vol. 25, no. 2, p. 806-812, 2011.
- [2] S. Mindess and J. F. Young, "Cemen," *Concrete*, Prentice-Hall, New Jersey, USA, 2002.

- [3] W. Kushartomo *et al.*, “Mechanical Behaviour of Reactive Powder Concrete with Glass Powder Substitute,” EACEF5, *Procidia Engineering*, vol. 125, pp. 617-622, 2015.
- [4] R. Maddalena, C. Hall, and A. Hamilton, “Effect of silica particle size on the formation of calcium silicate hydrate [C-S- H] using thermal analysis,” *Therm. Acta*, vol. 672, pp. 142-149, 2019.
- [5] W. Kushartomo *et al.*, “Pengaruh Penambahan Quartz Powder pada Reactive Powder Concrete terhadap Terbentuknya Kalsium-Silikat-Hidrat,” *Jurnal Teknik Sipil-ITB*, vol. 20, no. 3, Dec 2013.
- [6] P. J. Chavhan and S. D. Bhole, “To Study the Behaviour of Marble Powder as Supplementary Cementitious Material in Concrete,” vol. 4, pp. 377-381, April 2014.
- [7] K. L. Scrivener *et al.*, “Quantitative Study Of Portland Cement Hydration By X-Ray Diffraction/Rietveld Analysis And Independent Methods,” *Cement and Conc. Research*, vol. 34, iss. 9, pp. 1541-1547, Sept 2004.
- [8] R. F. Zuo *et al.*, “Mineralogical And Chemical Characteristics Of A Powder And Purified Quartz From Yunnan Province,” *De Gruyter*, vol. 8, iss. 1, June 2017, DOI: 10.1515/geo-2016-0055.
- [9] W. A. Hunnicutt, “Characterization Of Calcium-Silicate-Hydrate And Calcium-Alumino-Silicate-Hydrate,” M. S. thesis, Dept. Civil Eng, Univ. of Illinois, Illinois, Urbana, 2013.
- [10] A. Nonat, “The structure and stoichiometry of C-S-H,” *Cement and Concrete Research*, vol. 34, iss. 9, pp. 1529-11534, Sept 2004.
- [11] S. Y. Hong and F. P. Glasser, “Phase Relations in The CaO–SiO₂–H₂O System to 200 °C at Saturated Steam Pressure,” *IJIRS, Eng. Tech*, vol. 6, iss. 6, June 2017.
- [12] A. S. Adithya Saran and P. Magudeswaran, “SEM Analysis on Sustainable High-Performance Concrete,” *IJRSET*, vol. 6, no. 6, pp. 10237-10246, June 2017.

SUBJECT INDEX

attenuation	49, 52, 53, 54, 61, 62, 63, 64, 65, 66, 68, 69
automated reading	1
backscatter	61, 63, 64, 65, 68, 69, 70
bone structure	61, 65, 69
characterization	20, 21, 23, 24, 25, 27, 28, 35, 47, 85, 86
chemical properties	20, 37
composite materials	37, 38, 44, 45
CSH	25, 30, 31, 32, 33, 34
data acquisition	9, 10, 11, 12, 13, 14, 15, 17, 18
dry surface	71
GMPE	49, 50, 51, 52, 53, 55
granular simulation	71
Hexagonal	19, 21, 22
image processing	1, 2, 3, 4, 5, 6, 7, 8
LIGT	1, 2, 3, 4, 5, 6, 7
mechanical properties	26, 34, 37, 38, 41, 44, 45, 46, 47, 65
moisturized surface	71, 73
numerical data	9, 10, 11, 12, 13, 14, 15
Osteoporosis	61, 62, 63, 64, 69, 70
Palu earthquake	49, 57
peak ground acceleration	49, 51, 54
physical properties	19, 20, 21, 23, 37, 44
porous horizontal surfaces	71
pseudo-spectral acceleration	49, 51
purun tikus fiber	37, 38, 39, 40, 41, 42, 44, 45
rocket flight test	9
RPC	25, 26, 27, 34
RX320 statical test	9
seed-mediated hydrothermal	19, 20, 23
strength	9, 11, 12, 14, 15, 16, 17, 25, 26, 27, 31, 32, 33, 34, 37, 39, 40, 41, 42, 43, 44, 45, 50, 69
sulfur doping	19
temperature	1, 2, 3, 4, 5, 6, 7, 16, 20, 21, 25, 27, 28, 30, 32, 33, 34, 39, 77
temperature measurement	1, 2, 3
ultrasound	61, 62, 63, 64, 65, 66, 69, 70
ZnO nanorod	19, 20, 21, 22, 23, 24

AUTHOR INDEX

Achsan Rifani	1
Akhmad Safi'i	37
Akrajas Ali Umar	19
Amalia Nasrurroh	49
Ari Sulisty Rini	19
Bagus H. Jihad	9
Bagus Wicaksono	9
Bambang Sunardi	49
Dadan Sumardani	71
Daniel Christianto	25
Dewi Mulyati	71
Endang Wijaya	61
Erfan Handoko	71
Farhan Yusuf	61
Fauzi Bakri	71
Gianto	1
Handjoko Permana	71
Hendri Subakti	49
Henny Wiyanto	25
Irwan Setiawan	1
Kurdianto	9
Lies Banowati	37
Mawaddatur Rahmah	37
Muhammad Fikri Hayqal Hiola	49
Ni Larasati Kartika Sari	71
Ninis Hadi Haryanti	37
Riandini	61
Setiadi	9
Suryajaya	37
Tora Oktaviana	61
Umiatin	61
Vera Firmansyah	1
Widodo Kushartomo	25
Yanuar Hamzah	19
Yolanda Rati	19

AUTHOR GUIDELINES ([DOWNLOAD HERE](#))

SPEKTRA: Jurnal Fisika dan Aplikasinya is a continuously published three times a year scientific journal which is using blind review by system. SPEKTRA accepts original article is dedicated to all physics practitioners includes: Instrumentation and Computational Physics; Material Physics; Medical Physics and Biophysics; Astrophysics; Theoretical Physics; Particle and Nuclear Physics; Environment Physics; Renewable Energy; and other fields related to the application of physics.

The article consists of:

- Title: specific and effective, no more than 30 words, written by capital letters in all words.
- Author's identity: Author's full names (without degree), institutional address (including name institution, address, postal code, city, and country), and author's email must write fully and clearly.
- Abstract: it is written in a paragraph which consists of 250 words maximum. Abstract is written sequentially from background of the study, objective of the study, methods, results, and conclusion.
- The keywords must be included on the same page as abstract. It consists of 3-5 words which are chosen genuinely so that reflects the concept of article.
- Introduction: serves the purpose of leading the reader from a general subject area to a particular field of research. It establishes the context of the research being conducted by summarizing current understanding and background information about the topic, stating the purpose of the work in the form of the hypothesis, question, or research problem, briefly explaining your rationale, methodological approach, highlighting the potential outcomes your study can reveal, and describing the remaining structure of the paper. By introducing and reviewing key sources of prior research in that area to **show where gaps exist or where prior research has been inadequate** in addressing the research problem.
- Figure Caption. Example writing "FIGURE 1," which is the label must be written in capital and bold Times New Roman size 9. If the image has a lot of parts, you can use the label (a), (b), and so on.
- Table Caption. Example writing "TABLE 1," is the label description table bold, and capital. Description flat table placed above the middle of the table.
- Equations should be placed in the middle with his right equation number (flush right). Here are tips on writing an equation in accordance with the template SPEKTRA:
 - Copy, paste, and edit examples of Equation (1) in templates (very are suggested).
 - Manually enter the equation, via the **MathType**
 - Edit the number of equations.
 - Before you manually enter the equation or edit the number of equations please install the MathType. Please download how to install MathType by access <http://journal.unj.ac.id/unj/index.php/spektra/equation>
- Methods: it discusses the research design, data collection, data sources such as the population and sample, and data analysis. It is written with sentences in paragraphs, not in sequences using points.
- Results: it contains the data and information that has been collected. The finding systematically must be supported by charts, tables, figures or informative illustrations.
- Discussion: it shows a further explanation about the finding. Compare the finding with another research's finding and do not repeat what has been written in finding.
- Conclusion: it should clearly state the result of correlated objective (and may also possible with future direction).
- Reference cited according to [IEEE System](#) numbered in accordance with the order of references in the research and in accordance with the sequence number in the bibliography. The number is written before "." dot. In writing the citations and references, authors are recommended to use reference management software, such as Mendeley or Zotero. The reference must include **80 % primary sources in the past 10 years.**
- References: it must be written according to [IEEE System](#), numbered in accordance with the order of references in the research and in accordance with the sequence number in the bibliography.
This is an example to write the reference:
 - [1] J. K. Author, "Title of chapter in the book," in Title of His Published Book, xth ed. City of Publisher, Country if not USA: Abbrev. of Publisher, year, ch. x, sec. x, pp. xxx-xxx.
 - [2] J. K. Author, "Title of report," Abbrev. Name of Co., City of Co., Abbrev. State, Rep. xxx, year.
 - [3] Name of Manual/Handbook, x ed., Abbrev. Name of Co., City of Co., Abbrev. State, year, pp. xx-xx.
 - [4] J. K. Author, "Title of paper," in Unabbreviated Name of Conf., City of Conf., Abbrev. State (if given), year, pp. xxx-xxx.

- Some tips to do a final check of your article before it is submitted to SPEKTRA:
 1. Write down your paper using SPEKTRA Manuscript Template.
 2. Make sure you save as Microsoft Word 1997-2003. If you have size problem, you can save as “.docx”.
 3. Create PDF files from your article.

Manuscript Template

Manuscript Template of SPEKTRA available in two version. For authors, please download at the following link.

- 1) [Manuscript Template \(English version\)](#)
- 2) [Manuscript Template \(Bahasa Indonesia version\)](#)

IEEE Style Referencing

SPEKTRA using IEEE style of writing citations and bibliography. Instructions of writing citations and bibliography please download at the following link [IEEE Style Referencing](#)

Manuscript Assessment Process

Any accepted manuscript will be reviewed by at least two reviewers, plus editorial comments. The author is required to revised the manuscript according to reviewer comments and editors. Editor team will process it for later publication. For peer review process diagrams please go to [Peer Review Process](#) page.

Submission Technical Summary

- 1) SPEKTRA (manuscript template) format ([Manuscript Template of SPEKTRA](#)).
- 2) Format of SPEKTRA references list ([Refrence Format SPEKTRA](#)).
- 3) Fill the online form of:
 - (i) [Authorship Agreement](#)
 - (ii) [Copyright Statement](#)
 - (iii) [Ethics Statement](#)
- 4) Selected paper will be published in SPEKTRA issue: April | August | December (the author should completed all review and revision process).
- 5) Submit papers and revised papers submitted through the journal submission system, tutorials and instructions can be seen on the next points below.
- 6) Registration tutorial at SPEKTRA ([How to Register in SPEKTRA](#)).
- 7) Tutorial: submit in SPEKTRA ([How to Submit in SPEKTRA](#)).
- 8) Tutorial: tutorial read the review results and upload the revised file ([Review Result and Revised File](#)).
- 9) Instructions for writing mathematical equations in New Office 365 ([How to Writing Equation Using MathType](#)).
- 10) Confirm submitted/revision paper to spektra@unj.ac.id.
- 11) Any accepted manuscript will be reviewed by at least two reviewers, plus editorial comments. To making a quickly review and publishing process, please following the focus and scope of Spektra. The article will be rejected if the scope does not match with SPEKTRA scope.

SPEKTRA is published in collaboration:



**Program Studi Fisika
Universitas Negeri Jakarta**



**LPPM
Universitas Negeri Jakarta**



**PSI:
Physical Society of Indonesia**



**GCD:
Green Circle Digital**

