



PROCEEDING BOOK

International Conference on Environmentally Friendly Civil Engineering Construction and Materials *"Creating and Adapting Sustainable Technologies"*

13-14 November 2014 Manado - Indonesia

Supported by
International Office Affair and
Faculty of Engineering
Sam Ratulangi University

Editor

Dr. Isri Ronald Mangangka
and
Dr. Liany Amelia Hendrata

Proceeding of The International Conference on Environmentally Friendly Civil Engineering
Construction and Materials, 13-14 November 2014, Manado – Indonesia

p. 416

1. Structure, geopolymer and other construction materials, 2. Water resources and
environmental management, 3. Transportation and urban infrastructure, 4. Geotechnical
engineering

ISBN: 978-602-71876-0-3

© 2014 Civil Engineering Department Sam Ratulangi University. All rights reserved.

Address: Jl. Kampus Barat – Bahu
Manado 95115
Indonesia

Neither this book nor any part may be reproduced or transmitted in any form or by any means,
electronic or mechanical, including photocopying, microfilming, and recording, or by any
information storage or retrieval system, without prior permission in writing from the publisher

LIST OF COMMITTEE

STEERING COMMITTEE:

Prof. Ellen Joan Kumaat (Chairman)
Prof. Dody Sumajouw (Co-Chairman)
Prof. J. T. Sembel
Prof. Jefrey I. Kindangen

SCIENTIFIC COMMITTEE:

Prof. Dody Sumajouw (Chairman)
Prof. Henrico Manalip
Prof. Joseph Davidovits
Prof. Vijaya Rangan
Prof. Ashantha Goonetilleke
Prof. Jun Shimada
Prof. Djwantoro Hardjito
Prof. Tommy Ilyas
Prof. Ofyar Z. Tamin
Dr. Isri Ronald Manganka
Dr. Stennie Wallah

ORGANIZING COMMITTEE:

Dr. Isri Ronald Mangangka (Chairman)
Dr. Stennie Wallah (Co-Chairman)
Dr. Fella Warouw (Secretary)
Dr. Cindy Jane Supit (Treasurer)
Dr. Lianny Hendrata
Dr. Sukarno
Dr. Wiske Rotinsulu
Dr. A. K. T. Dundu
Dr. Hendra Riogilang
Dr. Reiny Tumbol
Dr. O. B. A. Sompie
Dr. Jeffry Sumarauw
dr. Wulan Kaunang
Amanda Sembel, MT.
Pankie Pangemanan, M.Si.

Merry Langi, ST.
Vebe Rambing, M.Si.
Jenny Emor, MH
Denny Kembuan, SE
Daniel Pangemanan, MH.
Beinhard Winsy Tampangela, ST
Fary Manopo
Yoost Kowimbin
Karla Pontoh

TABLE OF CONTENTS

TITLE PAGE.....	i
PREFACE.....	iii
LIST OF COMMITTEE.....	v
TABLE OF CONTENTS.....	vii

Keynote Speeches

Geopolymer Concrete Application By B. Vijaya Rangan	1
Scientific Approach to Understand the Trans-boundary Management of Groundwater Resources in Kumamoto Area, Japan By Jun Shimada	9
Climate Change Impact on Urban Stormwater Runoff: Why We Need To Be Concerned By Ashantha Goonetilleke	19
Lime Based Materials in Construction: Experimental investigations for the development and validation of atomic models By R. J. Ball, G. L. Pesce, S. C. Parker and R. J. Grant.....	29
Landslides: Anticipation and Prevention in Indonesia By Tommy Ilyas	37

Topic A

Structure, Geopolymer and Other Construction Materials

Decorative Pervious Concrete: A Solution for Aesthetically Sustainable Green Environment By Tavio and Benny Kusuma	41
Parametric Study on the Compressive Strength of Palm Oil Fuel Ash (POFA) Geopolymer Mortar By Monita Olivia, Winda Astuti H Putri, Lita Darmayanti, Iskandar R Sitompul, Alfian Kamaldi and Zulfikar Djauhari	49
Effect of Nano Silica on Durability Properties of Concretes Containing Recycled Coarse Aggregates By Faiz Uddin Ahmed Shaikh and Heasam Odoh.....	57
Effect of Reactive Powder for Compressive Strength Concrete By Tavio and Candra Gunawan.....	65
Experimental Behaviour of RC Columns Externally Confined by Reinforcing Steel Bars Subjected to Axial compression By Utari Khatulistiani and Tavio	71
Recycling of Industrial By-products in the Construction Field in Oman – An Overview By Khalifa S. Al-Jabri	81

Finite Element Modeling and Experimental Tests of Parkia Speciosa Timber Connections By Yosafat Aji Pranata and Deny Anarista Sitorus	91
Performance Characteristics of Fiber-reinforced Concrete with Polyethylene Terephthalate (PET) Fiber, Part 1. Abrasion Resistance and Chloride Penetration By Ricky N Ratu and Nemkumar Banthia	101
Compressive strength of Fly Ash Based Geopolymer Concrete By Riger Manuahe, Reky S. Windah and Dody M. J. Sumajouw	111
Strength and Deformability of Confined Rectangular Reinforced Concrete Columns with Supplemental Pen-Binder By Anang Kristianto and Iswandi Imran	121
Effect of Nano-Silica Particle Addition on Compression Behaviour of Non- Stoichiometrically Cured Epoxy Resin By Markus Karamoy Umboh, Tadaharu Adachi, Masahiro Higuchi and Zoltan Major	129
Statistical Analysis of Confined Columns with Varying Reinforcement Configuration and Ratios By Benny Kusuma, Tavio and Priyo Suprobo	141
AE-SiGMA Analysis in Split-Tensile Test of Fiber-Reinforced Concrete (FRC) at Meso- Scale By Mielke R.I.A.J Mondoringin1, Masayasu Ohtsu2	155
Fly Ash and GGBS Based Geopolymer Concrete By G.Mallikarjuna Rao, Venu.M and T.D.Gunneswara Rao	165
Influence of Sulfate Attack to Reactive Powder Concrete By Widodo Kushartomo, F.X. Supartono and Octavivia	177
Preliminary Study of The Development of Volcanic Ash-Based Geopolymer Concrete By Steenie E. Wallah and Ronny E. Pandaleke	185
The Effect of Superplasticizer Variation toward the Slump of Fly Ash Based Geopolymer Concrete By Anggie Adityo Aer, Ronny E. Pandeke and Dody M.J. Sumajouw	191
Durability and Performance of Polymer Modified Ferrocement in General Application By Fahrizal Zulkarnain and Mohd. Zailan Sulieman	205
Application of European Yield Model on Joint Laterally Strength Analysis of Bamboo Component Two with Void Filled Mortar By Gusti Made Oka, Andreas Triwiyono, Suprpto Siswosukarto and Ali Awaludin	213
Sustainable Concrete with The Use of GGBS: The Maturity Method for Predicting Strength Development of Concrete By Gidion Turu'allo and Marios N. Soutsos	223
Improving the Mechanical Properties of Aluminum 6063 Structural Items by Varying the Chemical Composition By Indika De Silva, Asela Perera, Navinda Kodikara and Asanka De Silva	233

Study of Tensile Strength of Geopolymer Concrete with Amurang Fly Ash as a Source Material By Andre K. Putra I, Filia E.S. Paat, S.O. Dapas, R.S. Windah and S.E. Wallah	239
A study of Green Construction Assessment of Two Buildings in Yogyakarta By Peter F Kaming	247
Lightweight High-strength Concrete with Expanded Polystyrene Beads as Building Materials in Earthquake Zones By Tengku Fitriani L. Subhan, Tommy A.M. Tilaar and Ravi Sri Ravindrarajah	257
Development of Thermal Comfort Model in Minahasa Stilt House Industrial Production with Optimization the Effect of Outer Room Design By Debbie Augustien Jeannet Harimu	265

Topic B

Water Resources and Environmental Management

The Implication of Critical Shear Stress of Erosion on the Depth of Sediment in Brantas River – East Java By Wati Asriningsih Pranoto and Abrar Riza	287
Analysis of Treatment Performance of Constructed Stormwater Wetlands with Utilising a Simplified Conceptual Model By Isri Ronald Mangangka, Ashantha Goonetilleke, Prasanna Egodawatta, Sukarno and Cindy Jeane Supit	297
Effect of Regularly Square Ribs Roughness on Turbulent Flow Structure in Cases Two and Three-dimensional Roughness in an Open Channel By Sukarno, Lianny Hendratta, Isri Ronald Mangangka, Cindy Jeane Supit and Terunori Ohmoto	309
Rheological Characteristics of Hyperconcentrated Sediment-laden Flow By Liany A. Hendratta, Tiny Mananoma, Jeffry Sumarauw and Terunori Ohmoto	317
Identification of Water Resources at Botanical Garden in Pasir Impun, West Java, Using Georesistivity Method, Wenner Configuration By Diyan Parwatiningtyas, Achmad Sjamsuri and Dasmo	323
Water Resources Management by Modelling of Dam Operation By Cindy Jeane Supit, Isri Ronald Mangangka, Sukarno and Audy Supit	333
A Study on Performance of The Traditonal Protection to Reduce The Inundation Area in Saga Plain By Ariestides K. T. Dundu, Koichiro Ohgushi and Hiroyuki Araki	341

Topic C

Transportation and Urban Infrastructure

Evaluation of Coastal Vulnerability Assessment and Coastal Management for Karangantu Coastal Area in Banten - Indonesia By Olga Pattipawaej and Hanny Dani	351
---	-----

Arrangement of Environmentally Sound Ship Recycling Yard in Indonesia By Sunaryo and Dovan Pahalatua	361
Study on Airline Hub Eastern Part of Indonesia Facing the ASEAN Open Sky Policy: (A Case Study of Full Service Carrier Airlines in Sultan Hasanuddin International Airport) By Sakti Adji Adisasmata, Nur Ali, Mubassirang Pasra and Dantje Runtulalo	369
Enhancing Infrastructure in the Indonesia - Malaysia Border Areas Development (Case Studies in Entikong, Sanggau District, West Kalimantan) By Tommy Ilyas, Dwi Dinariana, Fitri Suryani and Henni	379
Toward Great Streets Using Urban Design Approach: The Case Study of Manado By Febriane Paulina Makalew	385

Topic D

Geotechnical Engineering

Load Settlement behavior of Bored Pile Based on The Result of Load Test and FEM By Asriwiyanti Desiani and Angel Refanie	395
Recommendation of Viscosity Values for Mudflow By Budijanto Widjaja, David Wibisono Setiabudi and Ivan Arista	401
Soil air Gas Survey at Makaroyen Village in Kotamobagu Geothermal Field, North Sulawesi, Indonesia By Hendra Riogilang, Oscar Hans Kasecke, Saartje Monintja and Cindy Jeane Supit	407
Bending Moment of Flexible Batter Piles in Sand under Horizontal Loads By Fabian J. Manoppo	413



INFLUENCE OF SULFATE ATTACK TO REACTIVE POWDER CONCRETE

Widodo Kushartomo¹, F.X. Supartono², and Octavivia³

^{1,2,3} Tarumanagara University, Dept. of Civil Engineering, Indonesia
e-mail: widodo@untar.ac.id, office@partonofondas.com, octavivia@hotmail.com

ABSTRACT

Sulfates are often present in groundwaters, particularly when high proportions of clay are present in the soil, and sea water has sulfates as a major constituent. Sulfate attack on concrete is actually a rather complex process which may involve a number of secondary processes. This is accompanied by a very large increase in solid volume, which cause a volume expansion within the paste and which generates accompanying internal stress and ultimately leads to cracking.

The use of special concrete such as reactive powder concrete can improve sulfate resistance. Ordinary portland cemen (OPC) or portland compocite cement (PCC) can be used instead of a type II cement, type II of cement that have the best performace from sulfate attack on reactive powder concrete.

KEYWORDS: concrete, sulfate, cement, resistance, cracking.

1. INTRODUCTION

The most widespread and common form of chemical attack is the action of sulfates on concrete. Groundwaters may have local concentrations of sulfates in the vicinity of industrial wastes such as mine tailings, slag heaps, and rubble fills. Sulfates present in rainwater from air pollution, or produced by growths, may coause slow deterioration even in concrete above ground (Mindess and Young, 1981).

External sulfate attack is the more common type and typically occurs where water containing dissolved sulfate penetrates the concrete. A fairly well-defined reaction front can often be seen in polished sections; ahead of the front the concrete is normal, or near-normal. Behind the reaction front, the composition and microstructure of the concrete will have changed. these changes may vary in type or severity but commonly include extensive cracking, expansion, loss of bond between the cement paste and agregate. The effect of these changers is an overall loss of concrete strength (Winter, 2012).

Reactive Powder Concrete (RPC) are well-known for their high strength resistance. Their very low porosity gives them important durability and transport properties and makes them potentially a suitable material for the aggressive inveroment such as ground water and seawater (Matte and Moranville, 1999).

This paper describes a study which was carried out to better understand the behaviour of the RPC especialy compressive strength and flexture strength to the influence of sulfate attack.

2. REACTIVE POWDER CONCRETE

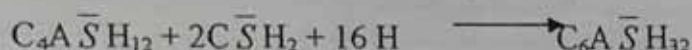
RPC composed by cement, sand, quartz powder, silica fume, steel fiber (optional) and superplasticizer. The superplasticizer, used at its optimal dosage, decreases the water to cement ratio (w/c) while improving the workability of the concrete. Convensional concrete aggregates form a set of rigid inclusions. On application of a compression force shear and tensile stresses appearing at the paste/aggregate interface generate cracks in paste. The size of these cracks is

related to extent of the zone under tensile or shear stress. For RPC, with eliminated coarse aggregate a major reduction is obtained in the size of microcracks of the following origins: external load, autogenous shrinkage and differential expansion between paste and aggregate under effect of heat treatment (Richard and Cheyrezy, 1995).

Elimination of coarse aggregates combined to optimization of granular mixture allows the obtention of an homogeneous and dense cementitious matrix that exhibits high mechanical performances (Kushartomo et al, 2013).

3. SULFATE ATTACK

Sulfate attack on concrete is actually a rather complex process which may involve a number of secondary processes. However, laboratory and field experiences have definitely established a correlation between the C3A content of a portland cement and its susceptibility to sulfate attack. The major cause is sulfoaluminate corrosion, in which ettringite is formed from monosulfoaluminate (Mindes and Young, 1981):



This is accompanied by a very large increase in solid volume, which causes a volume expansion within the paste and which generates accompanying internal stress and ultimately leads to cracking.

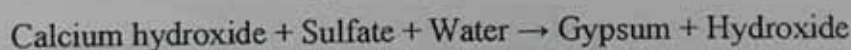
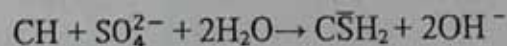
Mindes and Young (1981) describes the sulfate attack into 3 processes:

1. Penetration sulfate ion

The first process is the diffusion of sulfate ions into the pores of the concrete, which is controlled by the permeability coefficient and the diffusion coefficient of the sulfate ions.

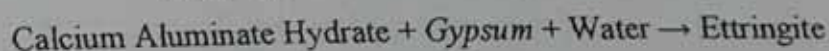
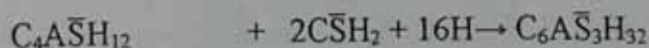
2. Gypsum corrosion

In its initial stages, gypsum corrosion may actually be beneficial, since gypsum is more soluble than calcium hydroxide and the dissolution-crystallization reaction will allow gypsum to crystallize without expansion. Equation of gypsum corrosion is as follows:



3. Sulfoaluminate corrosion

As sulfoaluminate corrosion causes internal cracking, the diffusion coefficient of the concrete will be increased, thereby accelerating further sulfate attack. Ettringite in this case is formed from monosulfoaluminate as can be seen below.



4. RESEARCH METHODE

The RPC used in this study was prepared from the following components, quartz sand with maximum size 0,6 mm was used as a fine aggregate. The specific gravity of quartz sand is 2,65 g/cm³. polycarboxylate based superplasticizer (SP) is conformity with ASTM C 494-81, type F was used in this study. The physical, chemical and mechanical properties of cement (type I, type II and PCC), properties of silica fume and quartz powder are presented in Table 1. Furthermore, to accelerate chemical reaction the highest magnesium sulfate (MgSO₄) concentration was used. Various mixture designs (mass ratio with respect to cement) silica fume, quartz as fine aggregate, quartz powder and superplasticizer are presented in Table 2.

Table 1. Physical and mechanical properties of cement, silica fume, and quartz powder

	Type I	Type II	PCC	Silica Fume	Quartz powder
Chemical composition (%)					
SiO ₂	20,15	22,6	22,5	98,0	98,6
Al ₂ O ₃	5,65	3,4	6,0	0,29	0,7
Fe ₂ O ₃	2,15	4,2	3,5	0,03	0,03
CaO	62,92	64,9	60,0	0,2	
MgO	1,14	0,90	2,25	0,09	
Na ₂ O + K ₂ O	1,15	0,05	0,45	0,23	
SO ₃	2,52	2,2	2,25	0,08	
Cl ⁻	0,001	0,01	0,015	0,01	
F.CaO (%)	0,52	1,0	1,0		
Physical properties					
Specific gravity	3,13	3,15	3,05	2,20	2,65
Initial setting (min)	130	130	130		
Final setting (min)	210	280	305		
Surface area (cm ² /g)	380	380	385		
Compressive strength (MPa)					
3 days	29,2		23,0		
7 days	43,2		30,0		
28 days	51,9		41,0		

Table 2. Composition of the mixture investigation

Materials	Type I	Type II	PCC	Type I	Type II	PCC
Cemen (kg)	757,8	759,0	753,0	730,1	731,2	725,7
Water (kg)	151,6	151,8	150,6	182,5	182,8	181,4
Silica fume (kg)	189,5	189,7	188,3	182,5	182,8	181,4
Quartz powder (kg)	189,5	189,7	188,3	182,5	182,8	181,4
Fine aggregate (kg)	1136,7	1138,5	1129,5	1095,2	1096,8	1088,6
Superplasticizer (kg)	22,7	22,8	22,6	21,9	21,9	21,8
Water/cement	0,20	0,20	0,20	0,25	0,25	0,25
Silica fume/cement	0,25	0,25	0,25	0,25	0,25	0,25
Quartz powder/cement	0,25	0,25	0,25	0,25	0,25	0,25
Fine aggregate/cement	1,50	1,50	1,50	1,50	1,50	1,50
Superplasticizer/cement	0,03	0,03	0,03	0,03	0,03	0,03

The concrete was mixed, cast, and vibrated like conventional concrete. Dry concrete powder components are mixed for 3 to 5 minutes, water is added with half on the volume superplasticizer and mixed for 3 minutes, and the second half of the volume of the superplasticizer is added and mixed for 5 minutes. The cylindrical samples were 750 mm in diameter and 150 mm long. The following curing treatment was applied to stabilize the mechanical and physical properties of specimen in steam at 90°C for 12 hours. The Sulfate attack test simulates the worst attack on the cylindrical samples used saturated solution of MgSO₄. In this severe test, the samples

are immersed in sulfate solution bath maintained 24 hours, washing with hot water, 24 hours drying oven at 105 °C, immersed again continuously for 7 times. Specimen will be tested when it's already 28 days.

5. RESULT AND ANALYSIS

These chemical reactions can lead to expansion and cracking of concrete, and/or the loss of strength and elastic properties of concrete is given in Fig. 1 dan Fig. 2, its represents comprssive strength of RPC containing different treatment. The form and extent of damage to concrete will depend on the sulfate concentration, the type of cations (eg sodium or magnesium) in the sulfate solution, the pH of the solution and the microstructure of the hardened cement matrix (Sarkar et al, 2010).

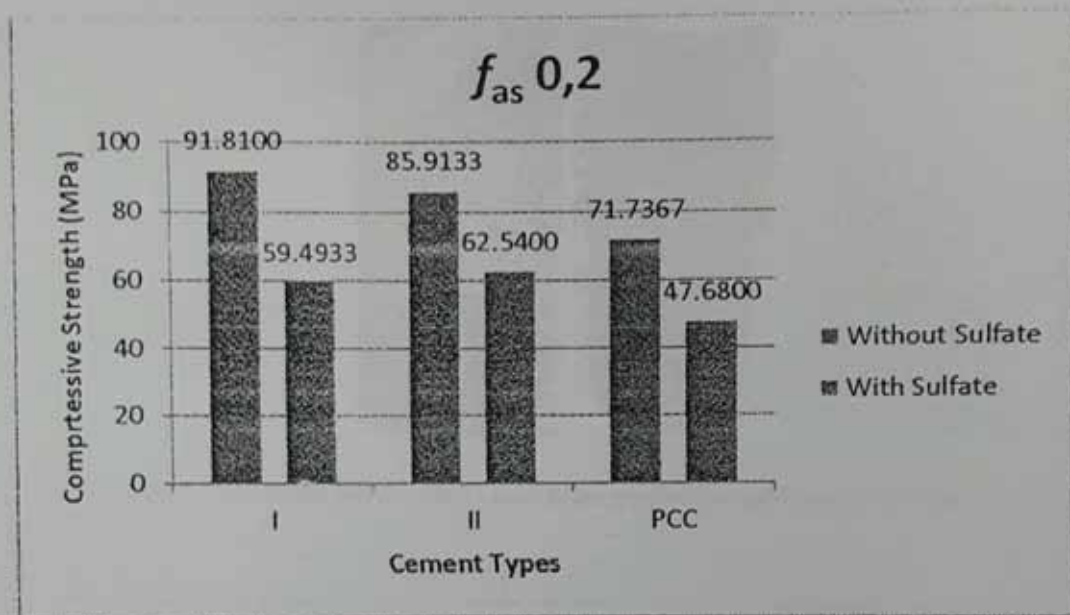


Figure 1. Compressive Strength with $f_{as} 0,2$ diagram

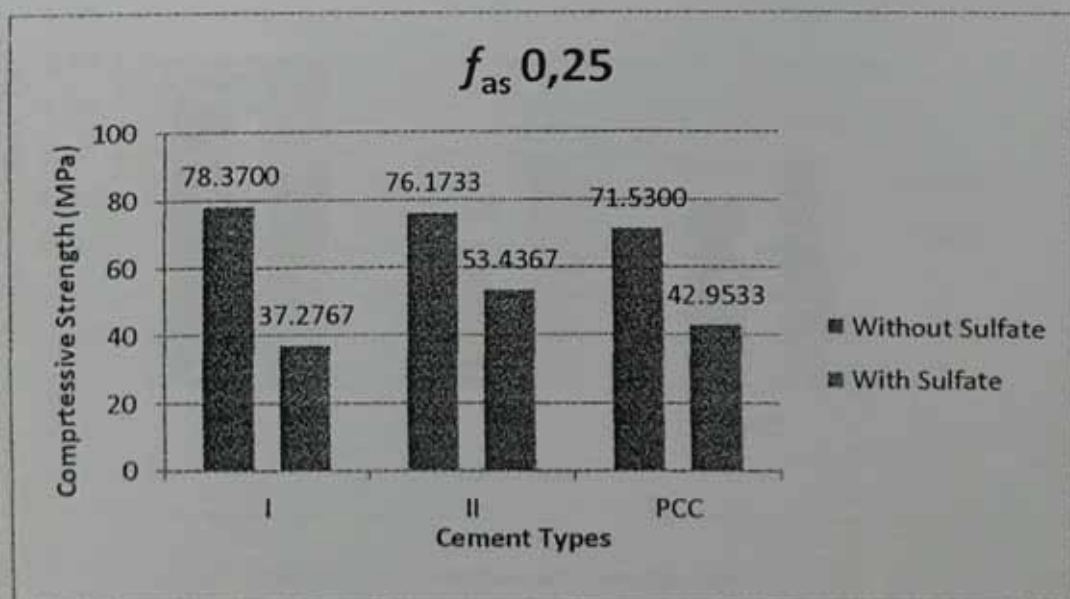


Figure 2. Compressive Strength with $f_{as} 0,25$ diagram

Figure 3 represent mass reduction indicated of sulfate attack. It can be seen face differences of RPC samples. There are no holes are formed for normal sample and any holes for sample immersed in sulfate solution, it caused reduces mass of RPC sample as given on Fig.4. Holes due to the formation of ettringite compounds that are expanding. Some cements are more susceptible to magnesium sulfate than sodium sulfate, the key mechanism is the replacement of calcium in calcium silicate hydrates that form much of the cement matrix. This leads to a loss of the binding properties. Formation of brucite ($\text{Mg}(\text{OH})_2$) and magnesium silicate hydrates is an indication of such attack.



Figure 3. Specimen before (left) and after (right) immersion in sulfate

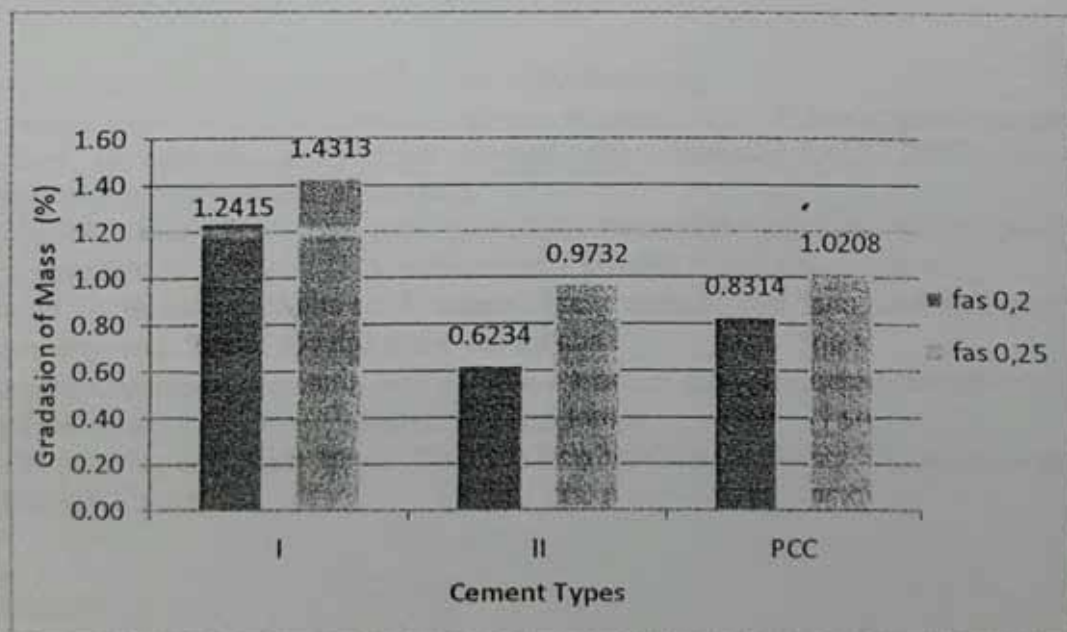


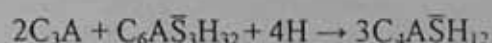
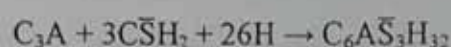
Figure 4. Gradation of mass diagram

In the composition of the cement, C_3A compound is a compound that was attacked by sulfate. Composition of C_3A in type II cement is the least as much as 6%, so the cement Type II

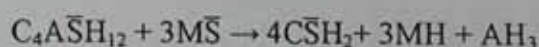
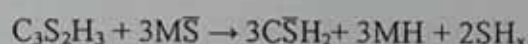
said to be good for sulfate attack. If C_3A met with gypsum, it form ettringite that cause the crack expands and causes the compressive strength of concrete decreased.

It can be seen from the results of compressive strength test, specimens with Type II cement mixture produces % reduction in compressive strength at least compared to cement Type I and PCC. So it can be said that the Type II cement is the cement that has good resistance to sulfate compared with Type I cement and cement PCC.

C_3A in the cement compounds also affect the sulfate reaction which affected by gypsum. The main initial reaction of C_3A and gypsum reacts with water to form trisulfoaluminate / ettringite. If the sulfate is all consumed before C_3A completely hydrate, then ettringite transform to another calcium sulfoaluminate hydrate containing less sulfate called monosulfoaluminate.



At higher concentrations of sulfate, gypsum corrosion can contribute greater. Magnesium Sulfate can be even more aggressive because of the possibility of additional corrosive reaction due to the presence of magnesium ions, which can decompose both C-S-H and the calcium sulfoaluminates (Mindes and Young, 1981):



6. CONCLUSION

Based on the research, we can conclude some of the following:

- Reactive Powder Concrete with a mixture of cement type II has a good resistance against sulfate, because the compressive strength only decreased by 27.2057% on the highly concentrated (saturated) sulfate attack.
- Reactive Powder Concrete is good for resistance to sulfate attack due to the weight loss of the test specimen is not up 1.5% to sulfate attack that has a high concentration.
- Based on this research, Type II cement is the cement that has good resistance to sulfate compared with Type I cement and cement PCC.
- Reactive Powder Concrete is best used on structures that are directly related to ground water and sea water, for examples foundation and harbor.
- In responding to sulfate attack, Reactive Powder Concrete with PCC cement more efficient than type II cement.

7. REFERENCE

- Bonneau O, Vernet C, Moranville M, and Aitcin P. C. (2000), Characterization of The Granular Packing and Percolation Threshold of Reactive Powder Concrete, Cement and Concrete Research, Vol. 30, pp. 1861 – 1867.

- Matte, V., Moranville, M. (1999), Durability of Reactive Powder Composites: Influence of Silica Fume on The Leaching Properties of Very Low Water/Binder Pastes, Cement and Concrete Composites 21, pp. 1-9.
- Mindess, Sidney and Young, J.F. (1981), "Concrete", Prentice-Hall, America
- Richard, P. and Cheyrezy, M. (1995), Composition of Reactive Powder Concrete, Cement and Concrete Research, Vol. 25, No.7, 1995, pp. 1501 – 1511.
- Sarkar S., Mahadevan S., Meeussen, J.C.L., Van Der Sloot, H., Kosson, D.S. (2010), Numerical Simulation of Cementitious Materials Degradations Under External Sulfate Attack, Cement and Concrete Composites 32, pp. 241-252.
- Kushartomo, W., Makarim, C.A., Sumawiganda, S., Supartono, F.X., (2013), Pengaruh Penambahan Quartz Powder pada Reactive Powder Concrete terhadap Terbentuknya Kasum-Silikat-Hidrat, Jurnal Teknik Sipil ITB Vol. 20 No. 3, pp. 187 - 193.
- Winter, Nicholas, B. (2012), Understanding Cement, WHD Micronalysis Construction, Ltd, December.

CERTIFICATE OF ATTENDANCE

AWARDED TO

DR. WIDODO KUSHAR TOMO

FOR BEING THE SPEAKER OF
INTERNATIONAL CONFERENCE ON
ENVIRONMENTALLY FRIENDLY
CIVIL ENGINEERING CONSTRUCTION AND MATERIALS
"CREATING AND ADAPTING SUSTAINABLE TECHNOLOGIES"

13-14 NOVEMBER, MANADO - INDONESIA

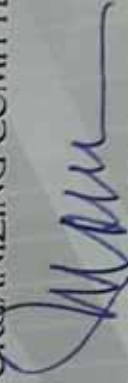
ORGANIZED BY
INTERNATIONAL AFFAIRS OFFICE AND FACULTY OF ENGINEERING
SAM RATULANGI UNIVERSITY

RECTOR OF
SAM RATULANGI UNIVERSITY



PROF. DR. IR. ELLEN J. KUMAAT, M.SC., DEA

CHAIRMAN OF
ORGANIZING COMMITTEE



IR. ISRI R. MANGANGKA, MENG., PH.D



UNIVERSITAS SAM RATULANGI

