LAPORAN AKHIR PENELITIAN
PENELITIAN TERAPAN UNGGULAN PERGURUAN TINGGI

PENGEMBANGAN NANOGROUT DAN NANOHARDENER UNTUK MENCIPTAKAN ENTREPRENEUR MATERIAL MAJU

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UNIVERSITAS PANCASILA
NOVEMBER 2019

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Biaya Keseluruhan	: Rp 326,455,000

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LAPORAN AKHIR PENELITIAN

1. IDENTITAS PENELITIAN(diisikan sesuai dengan proposal)

A. JUDUL PENELITIAN

PENGEMBANGAN NANOGROUT DAN NANOHARDENER UNTUK MENCIPTAKAN ENTREPRENEUR MATERIAL MAJU

B. BIDANG, TEMA, TOPIK, DAN RUMPUN BIDANG ILMU

Bidang Fokus RIRN/ Bidang Unggulan Perguruan Tinggi	Tema	Topik (jika ada)	Rumpun Bidang Ilmu
Material Maju	Teknologi Pengembangan Material Fungsional	Inovasi teknologi material bahan bangunan lokal	Teknik Sipil

C. KATEGORI, SKEMA, SBK, TARGET TKT DAN LAMA PENELITIAN

Kategori (Kompetitif Nasional/ Desentralisasi / Penugasan	Skema Penelitian	Strata (Dasar/ Terapan/ Pengembangan)	SBK (Dasar/ Terapan/ Pengembangan)	Target Akhir TKT	Lama Penelitian (Tahun)
Penelitian Desentralisasi	Penelitian Terapan Unggulan Perguruan Tinggi	SBK Riset Terapan	SBK Riset Terapan	6	2

2. IDENTITAS PENGUSUL

Nama, Peran	Perguruan Tinggi/ Institusi	Program Studi/ Bagian	Bidang Tugas	ID Sinta	H-Index
Dr. Ir. Jonbi, MM., MSi., MT	Universitas Pancasila	Teknik Sipil	Pengujian dan analisis	5996551	4
Dr. Ir. A.R. Indra Tjahjani, MT	Universitas Pancasila	Teknik Sipil	Analisis data	5996664	0
Dr. Ir. Arnoldus Markus Pattinaja, MSi	Universitas Pancasila	Teknik Sipil	Aspek lingkungan	0	0

3. MITRA KERJASAMA PENELITIAN (JIKA ADA)

Mitra	Nama Mitra
CV John Hi-Tech Contrindo	Esther Wijaya

4. LUARAN DAN TARGET CAPAIAN

Luaran Wajib

Tahun Luaran	Jenis Luaran	Status Target Capaian (accepted, published, terdaftar atau granted, atau status lainnya)	Keterangan (url dan nama jurnal, penerbit, url paten, keterangan sejenis lainnya)
2019	Paten Sederhana	Proses pendaftaran	
2019	Paten Sederhana	Proses pendaftaran	

Luaran Tambahan

Tahun Luaran	Jenis Luaran	Status Target Capaian (accepted, published, terdaftar atau granted, atau status lainnya)	Keterangan (url dan nama jurnal, penerbit, url paten, keterangan sejenis lainnya)
2019	Publikasi pada jurnal internasional bereputasi	draft	…………
2019	Publikasi pada pertemuan ilmiah internasional	Sudah dikirim	
2019	Publikasi pada jurnal nasional	draft	

5. KEMAJUAN PENELITIAN

Ringkasan penelitian berisi latar belakang penelitian, tujuan dan tahapan metode penelitian, luaran yang ditargetkan, serta uraian TKT penelitian yang diusulkan.

A. RINGKASAN

Perkembangan material bangunan khususnya material kimia konstruksi (material maju) mengalamai kemajuan yang sangat pesat. Namun sayangnya bisnis material kimia konstruksi tersebut masih dikuasai oleh pihak asing (PMA), sehingga kontribusi bagi perekonomian Indonesia sangat kecil. Untuk itu perlu dilakukan inovasi melalui penelitian yang dapat menghasilkan material sejenis yang memiliki kualitas lebih baik. Salah satu cara yang dilakukan mengembangkan material tersebut dengan menambahkan material nano silika. Penelitian ini dilakukan dalam dua tahun, pada tahun pertama dihasilkan material NanoGrout. Material yang dihasilkan harus lebih baik kualitasnya dengan material sejenis yang ada di pasaran. Untuk itu material NanoGrout yang dihasilkan diuji: kuat tekan, kuat tekan lentur, kuat tarik, kuat lekat, susut, kelecakan, pengujian SEM dan FT-IR. Penelitian pada tahun kedua dihasilkan material NanoHardener, untuk material NanoHardener dilakukan pengujian tingkat kekerasan, keausan dan SEM. Pada tahun ke dua dihasilkan juga mesin produksi (tepat guna) yang memiliki keunggulan: mudah penggunaannya, praktis dan harga relatif murah. Hasil penelitian selama dua tahun, akan dihasilkan material NanoGrout dan NanoHardener, serta teknologi tepat guna (mesin produksi) sehingga dapat menjadi pemicu terciptanya *entrepreneur* dalam bidang material maju.

Hasil penelitian berisi kemajuan pelaksanaan penelitian, data yang diperoleh, dan analisis yang telah dilakukan

B. HASIL PENELITIAN

Hasil yang sudah diperoleh : sampai bulan **November 2019** ini telah dilakukan, untuk pengujian seperti terlihat pada Tabel. 4.

Benda uji	Pengujian pada Hardener umur 1,3,7 dan 28 Hari		
	Tingkat Kekerasan	Keausan	SEM
Ho	✓	✓	✓
H1	✓	✓	✓
H3	✓	✓	✓
H5	✓	✓	✓
H7	✓	✓	✓

Status Luaran berisi status tercapainya luaran wajib yang dijanjikan dan luaran tambahan (jika ada). Uraian status luaran harus didukung dengan bukti kemajuan ketercapaian luaran dengan bukti tersebut di bagian Lampiran

C. STATUS LUARAN

- 2 buah paten sederhana dalam proses pendaftaran :
  1. NANOGROUT UNTUK MATERIAL PERBAIKAN STRUKTUR BANGUNAN DAN BEARING PAD JEMBATAN
  2. NANOHARDENER UNTUK MATERIAL PENGERAS PERMUKAAN LANTAI PABRIK DAN INDUSTRI

- Luaran Tambahan :
  1. **Effect of of Fly Ash and Bottom ash Mixed Nanosilica on mechanical properties of concrete disubmit pada International Conference on Material Engineering and Nanotechnology 2-5 December Kuala Lumpur**

  2. Publikasi paper yang akan di submit ke ASIAN JOURNAL OF CIVIL ENGINEERING (Q3) “Mechanical Properties of NanoHardener as Advanced Material for Concrete Surface Hardener”

Peran Mitra (untuk Penelitian Terapan, Penelitian Pengembangan, PTUPT, PDUPT serta KRUPT) berisi uraian realisasi kerjasama dan realisasi kontribusi mitra, baik *in-kind* dan *in-cash*.

D. PERAN MITRA

Instansi lain yang terlibat adalah cv. John Hi-Tech Contrindo, dengan kontribusi bantuan dana penelitian sebesar Rp. 15.800.000, data tentang material Grout dan Hardener, pemasaran material yang akan dihasilkan.

Kendala Pelaksanaan Penelitian berisi kesulitan atau hambatan yang dihadapi selama melakukan penelitian dan mencapai luaran yang dijanjikan

E. KENDALA PELAKSANAAN PENELITIAN

Prosentase pencairan dana yang disetujui yang terlalu sedikit/kecil dari dana yang diajukan, cukup menyulitkan peneliti

Rencana Tahapan Selanjutnya berisi tentang rencana penyelesaian penelitian dan rencana untuk mencapai luaran yang dijanjikan

F. RENCANA TAHAPAN SELANJUTNYA

Rencana Tahapan berikutnya :

- telah didaftar paten sederhana dan melanjutkan proses lanjutan.
- Publikasi paper yang akan di submit ke **ASIAN JOURNAL OF CIVIL ENGINEERING (Q3)** "**Mechanical Properties of NanoHardener as Advanced Material for Concrete Surface Hardener "**

Daftar Pustaka disusun dan ditulis berdasarkan sistem nomor sesuai dengan urutan pengutipan. Hanya pustaka yang disitasi pada laporan kemajuan yang dicantumkan dalam Daftar Pustaka.

G. DAFTAR PUSTAKA

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dst.

Lampiran berisi bukti pendukung luaran wajib dan luaran tambahan (jika ada) sesuai dengan target capaian yang dijanjikan

H. LAMPIRAN

Terlampir

Effect of Fly Ash and Bottom Ash Mixed Nanosilica on Mechanical Properties of Concrete

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Abstract. Fly ash and Bottom ash are waste produced by Electric Steam Power Plants including waste hazardous and toxic materials (B3) which causes environmental pollution. Various attempts have been made to reduce these negative impacts, such as fly ash used as a mixture of concrete and mortar, while the use with bottom ash is still very limited. So far, the use of fly ash and bottom ash is still constrained by the achievement of mechanical properties in mortar which tends to be slow compared to normal mortar. For this reason, research is needed regarding the use of fly ash and bottom ash, which are added with reactive materials such as nanosilica. The purpose of this study was to analyze the effect of mechanical properties on mortar using Fly ash mixed with nanosilica, and bottom ash with nanosilica. The percentage of fly ash usage of 10%. 20% and 30% plus 3% nanosilica, the same percentage for bottom ash and nanosilica. Mechanical properties testing includes compressive strength and tensile strength testing at the age of concrete 3.7.28 days. While testing the flexural strength at the age of 28 days of concrete. The results showed that 10% fly ash produced 45% compressive strength, 76% tensile strength and 67% flexural strength of the reference concrete. The optimum percentage for bottom ash is 20% producing compressive strength of 43%, tensile strength of 63% and flexural strength od 72%. The contribution of this study shows that fly ash and bottom ash can be used in concrete so that it can be used as a way to overcome environmental problems.

Keywords: Fly ash, bottom ash, nanosilica, compressive strength, tensile strength, flexural

Introduction

Dalam beberapa tahun ini, masih banyak industri yang menggunakan batubara sebagai pengganti bahan bakar minyak akibat stok yang makin menipis dan mahalnya harga bahan bakar minyak tersebut.
Namun proses pembakaran batubara menghasilkan limbah padat yang dihasilkan berupa fly ash dan bottom ash. Partikel abu terbang dinamakan fly ash, sedangkan abu terdapat dari bawah tungku dinamakan bottom ash. Limbah padat tersebut termasuk dalam golongan bahan limbah berbahaya dan beracun (B3) yang menyebabkan pencemaran lingkungan dan jumlahnya dari tahun ke tahun meningkat, sehingga memerlukan penanganan yang serius.

Beberapa penelitian telah dilakukan untuk mengatasi dampak negatif terhadap lingkungan tersebut, salah satunya adalah memanfaatkan *fly ash* sebagai campuran pada beton dan mortar, sedangkan pemanfaatan untuk *bottom ash* masih sangat terbatas. Persentase fly ash sebagai pengganti Portland cement yang digunakan dalam beton adalah 15-35%, bahkan sampai 65% [1,2,3]

Kendala penggunaan limbah *fly ash* dan *bottom ash* sebagai replacement semen pada beton dan mortar yakni pencapaian sifat mekanis beton yang cenderung lambat dibandingkan dengan mortar normal.
Penggunaan fly ash dengan material seperti silica fume, metakaoline dan nanosilica, ternyata dapat meningkatkan reaksi hidrasi dan pembentukan sifat mekanis [4,5]. Hal ini memperlihatkan nanosilika dan silikafume sangat reaktif dan mengubah kalsium hidroksida (CH) menjadi C-S-H [6].

Hasil penelitian menunjukkan nanosilika bubuk efektif untuk memperbaiki sifat mekanik semen mortar dan penambahan nanosilika koloidal 5% dan Fly ash 40%, secara signifikan meningkatkan proses pengerasan dan meningkatkan kuat tekan pada pasta semen[7,8].

Penelitian ini memperlihatkan efek penggunaan *fly ash* dan *bottom ash* yang dicampur dengan nanosilika, terhadap sifat mekanis beton.

2. Materials and Methods

2.1 Material

Secara kimia fly ash merupakan mineral alumino silikat yang banyak mengandung unsur-unsur Ca, K dan Na disamping juga mengandung sejumlah kecil unsur C dan N. Secara fisika fly ash terususun dari partikel berukuran slit yang mempunyai karakteristik kapasitas pengikat air dan dari sedang sampai tinggi.

Tabel 1. Komposisi kimia pada fly ash dan bottom ash

Komposisi Kimia	Banyaknya Kandungan (%)	
	Fly ash	Bottom ash
SiO_2	53,32	35,88
AL_2O_3	18.14	19,53
FE_2O_3	5,97	5,560
CaO	4,59	4,86
MgO	1,84	3,49
SO_3	0,67	0,66
Na_2O	1,51	0,88

Komposisi kimia dari *Bottom Ash* sebagian besar terdiri dari silika (Si), aluminium (Al) dan besi (Fe) dengan sedikit magnesium (Mg), kalsium (Ca), sulfat (S), natrium (Na) dan unsur kimia lain.

Nanosilika yang digunakan merek HDKN 20 dari Bratachem, memiliki ukuran 20-40 nm seperti tampak dalam Gambar III.11.

2.2 Mix desain dan kode benda uji

Pada penelitian ini terdapat tiga jenis benda uji yaitu berupa silinder dengan ukuran 10x20 cm untuk uji kuat tekan dan kuat tarik belah serta benda uji berupa balok dengan ukuran 60x15x15 cm untuk uji kuat lentur. Persentase kadar yang digunakan pada campuran beton antara lain 10%, 20% dan 30% terhadap volume semen yang dicampur dengan nanosilika sebanyak 3% terhadap volume semen yang berturut-turut diberi kode sebagai FA1, FA2, FA3 serta digunakan bottom ash dengan persentase kadar sebanyak 10%, 20% dan 30% terhadap volume semen yang dicampur dengan nanosilika sebanyak 3% terhadap semen yang berturut turut diberi kode sabagai BA1,BA2, dan BA3 yang natinya akan dibandingkan dengan beton refrensi yang diberi kode sebaagai CR. Benda uji dibuat sebanyak 91 buah dengan tujuh variasi dimana 42 buah untuk uji kuat tekan, 42 buah untuk uji kuat tarik belah dan 7 buah untuk uji kuat tarik lentur.

Mix desain

Mix desain mengacu pada SNI 03-2834-2000 dengan kuat tekan rencana sebesar f'c 35 MPa. Berikut komposisi bahan campuran yang bisa dilihat pada tabel dibawah ini.

Tabel 3. Komposisi campuran beton dalam 1 m3

Bahan	Kode

	CR	FA1	FA2	FA3	BA1	BA2	BA3
Semen (kg)	486	437	389	340	437	389	340
Kerikil (kg)	1108	1108	1108	1108	1108	1108	1108
Pasir (kg)	623	623	623	623	623	623	623
Air (liter)	170	170	170	170	170	170	170
Fly ash (kg)	-	49	97	146	-	-	-
Bottom Ash (kg)	-	-	-	-	49	97	146
Nanosilika (kg)	-	15	15	15	15	15	15

2.3 pengujian benda uji

Sebelum dilakukan pembuatan benda uji beton terlebih dahulu dilakukan pengujian terhadap mutu material yang digunakan yaitu agregat halus. Untuk sifat-fifat semen tidak dilakukan pengujian karena digunakan semen yang telah memenuhi Standar Nasional Indonesia (SNI). Pengujian agregat halus mengacu pada *American Standar Testing and Material* (ASTM) dimana pengujian yang dilakukan meliputi uji lolos ayakan (ASTM C. 117-95), berat jenis SSD (ASTM C. 128-93), penyerapan (ASTM C. 128-93), modulus kehalusan (ASTM C.33), berat isi (ASTM C.29-97) dan kandungan organik (ASTM C.40-92).

Untuk mengetahui perkembangan sifat mekanis mortar ,maka akan dilakukan pengujian yang meliputi kuat tekan, kuat tarik dan kuat lentur yang mengacu pada metode Standar Nasional Indonesia (SNI) yang mana pengujian akan dilakukan pada umur 3, 7 dan 28 hari untuk uji kuat tekan dan kuat tarik sedangkan untuk pengujian kuat lentur dikaukan pada umur 28 hari saja.

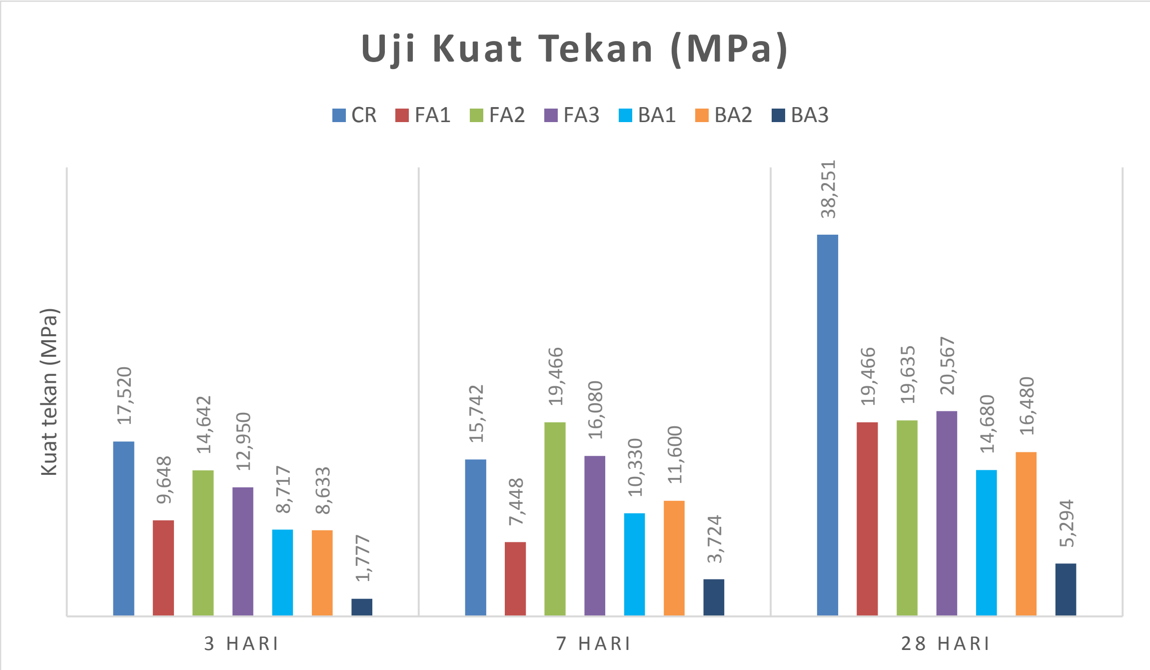
3. Result and Discussion

Hasil uji kuat tekan

Untuk mengetahui perkembangan kekuatan mortar dilakukan uji kuat tekan kubus berukuran 5x5x5 cm pada umur 3,7 dan 28 hari.

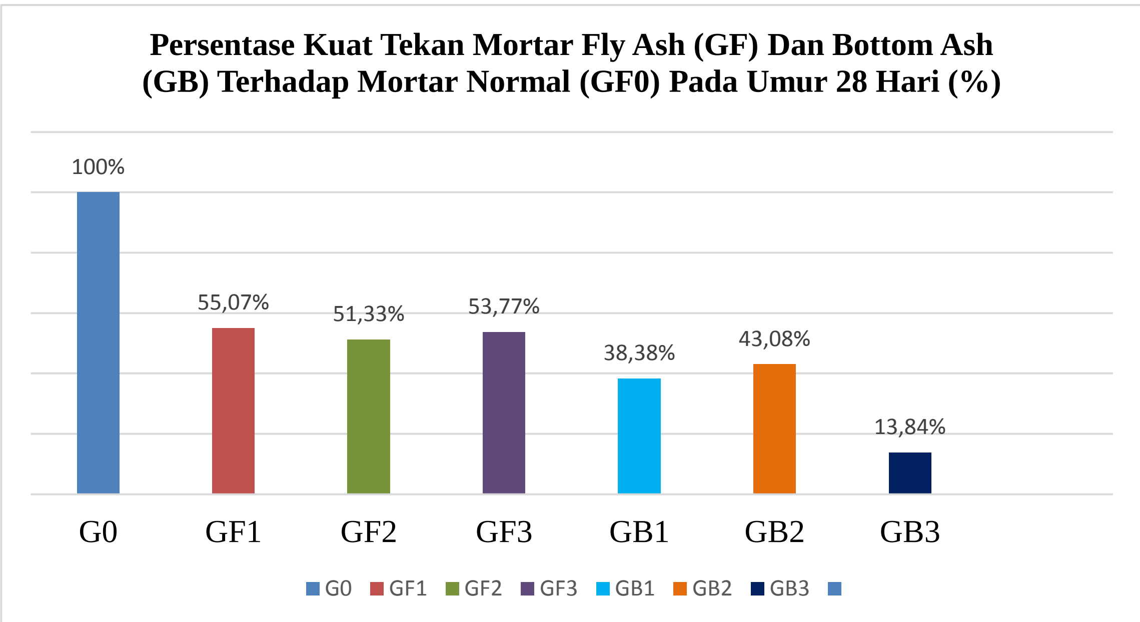
Tabel 2. Hasil uji kuat tekan mortar

Benda uji	Kuat tekan rata-rata (MPa)		
	3 Hari	7 Hari	28 Hari
CR	17,520	15,742	38,251
FA1	9,648	7,448	21,066
FA2	14,642	19,466	19,635
FA3	12,950	16,080	20,567
BA1	8,717	10,33	14,68
BA2	8,633	11,60	16,48
BA3	1,777	3,724	5,294



Gambar 1. Grafik kuat tekan

Grafik diatas menunjukan perbandingan kuat tekan mortar dengan campuran fly ash yang ditambah nanosilika (FA) dan campuran mortar dengan bottom ash yang ditambah nanosilika (BA) terhadap mortar normal (CR) pada umur 7, 3 dan 28 hari.
Dapat dilihat kuat tekan mortar dengan campuran fly ash maupun bottom ash masih belum menunjukan kenaikan kuat tekan yang signifikan bila dibandingkan dengan mortar normal pada umur 28 hari (38,251 MPa). kuat tekan optimum pada mortar dengan campuran fly ash dicapai pada presentase 10% (GF1) yaitu sebesar (21,066 MPa) sedangkan kuat tekan optimum pada mortar dengan campuran bottom ash dicapai pada presentase 20% (GB2) yaitu sebesar (16,480Mpa). Hal ini sejalan dengan penelitian yang telah dilakukan oleh (Zeidan, et al., 2017) dan (Mohd Haziman, et al., 2016) yang mengataklan bahwa penggunaan fly ash dan bottom ash sebagai pengganti semen pada campuran beton dapat menurunkan kuat tekannya.



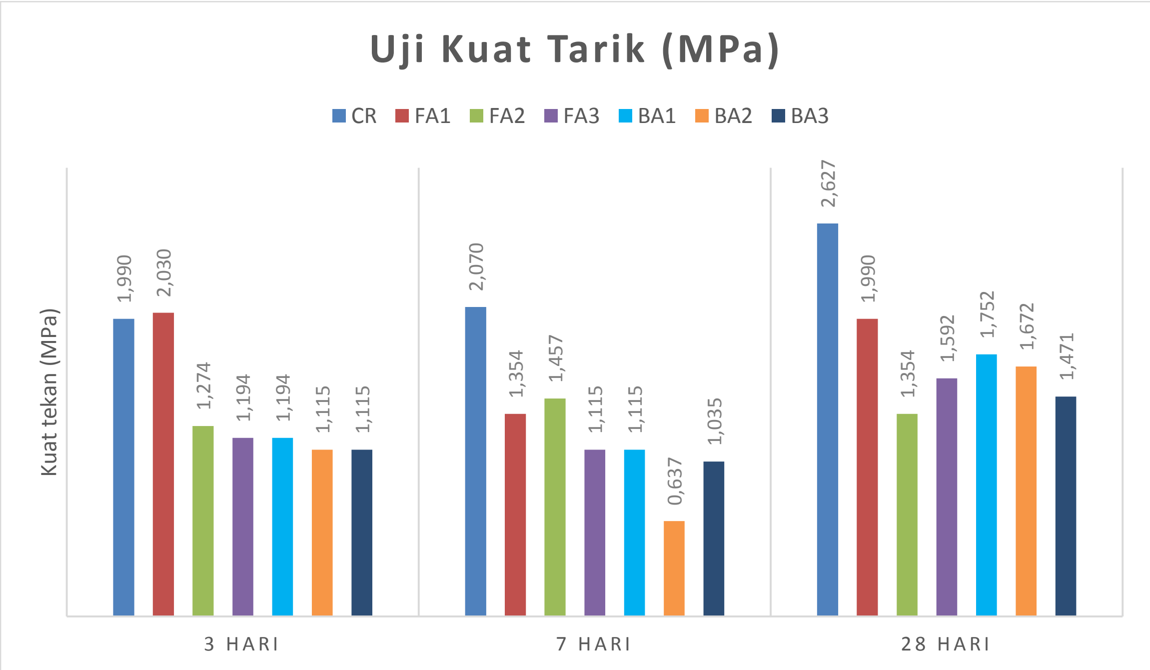
Gambar 2. Grafik Persentase Kuat Tekan

Hasil uji kuat tarik

Benda uji yang digunakan untuk pengujian kuat tarik yaitu silinder 10 x 20 cm. Dapat dilihat pengujian kuat tarik menghasilkan pola keretakan seperti pada Gambar 4.3 Pola keretakan yang didapatkan tersebut sudah sempurna karena keretakan yang merata membelah benda uji, dan dianggap nilai kuat tarik yang didapatkan sudah maksimal

Tabel 3. Hasil uji kuat tarik mortar

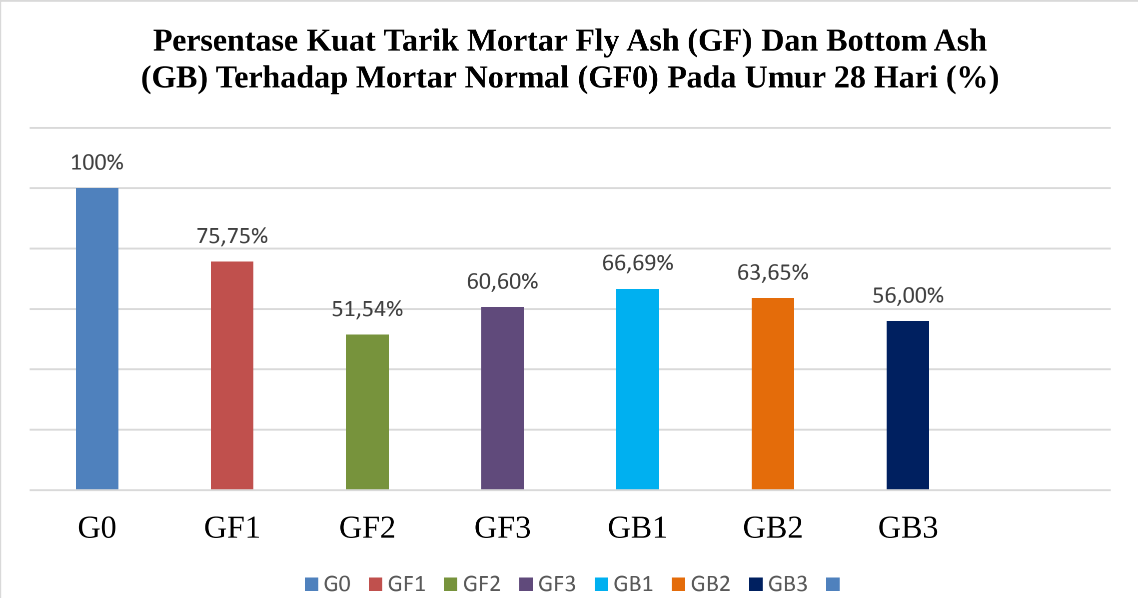
Benda Uji	Kuat Tarik Rata-rata (MPa)		
	3 Hari	**7 Hari**	**28 Hari**
CR	1,990	2,070	2,627
FA1	2,030	1,354	1,990
FA2	1,274	1,457	1,354
FA3	1,194	1,115	1,592
BA1	1,194	1,115	1,752
BA2	1,115	0,637	1,672
BA3	1,115	1,035	1,471



Gambar 3. Grafik Kuat Tarik

Berdasarkan pengujian kuat Tarik menggunakan *Fly Ash*, *Bottom Ash* dengan nanosilika sebagai pengganti semen masih belum dapat meningkatkan nilai kuat Tarik, keduanya masih memiliki nilai dibawah nilai kuat Tarik mortar normal. Kadar optimum keduanya yaitu pada presentase 10% *Fly Ash* dan 10% *Bottom Ash*. Namun pada penggunaan 10% *Fly Ash* memiliki nilai kuat Tarik lebih tinggi dibanding dengan penggunaan 10% *Bottom Ash*.

Hal ini sejalan dengan teori peneliti terdahulu yaitu Mengxiao et,al pada tahun 2015 yang menyatakan bahwa *Fly Ash* memiliki sifat sebagai pozzolan, yaitu suatu material yang mengandung silika atau alumina silika yang tidak mempunyai sifat perekat (sementasi) pada dirinya sendiri tetapi dengan butirannya yang sangat halus bisa bereaksi secara kimia dengan kapur dan air membentuk material perekat pada temperatur normal. Reaksi pozzolan *Fly Ash* berperilaku sebagai mikro agregat untuk mengisi pori beton. Pada usia lebih lanjut, *Fly Ash* mulai menimbulkan efek kimia dan meningkatkan kuat tarik beton.



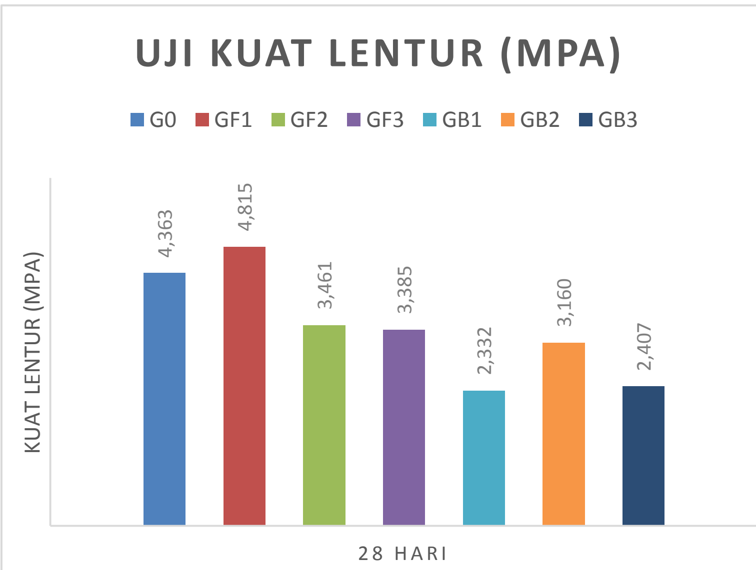
Gambar 4. Grafik Persentase Kuat Tarik

Hasil uji kuat lentur

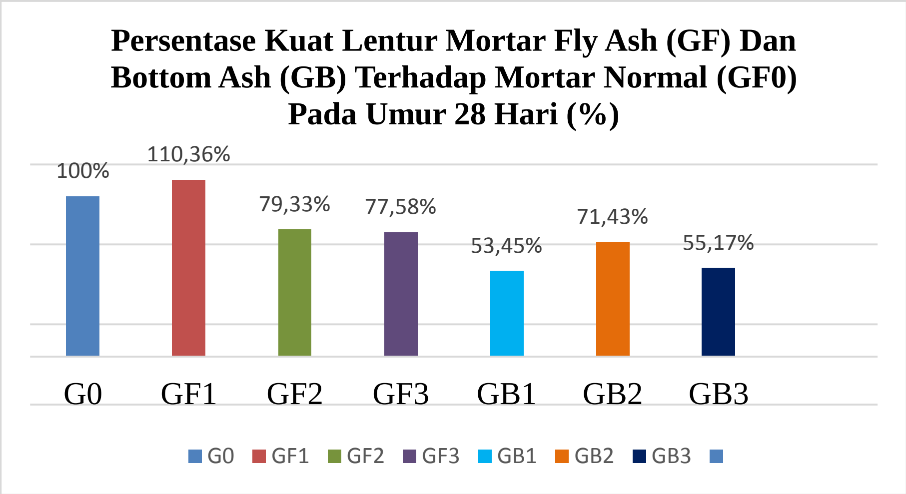
Dari hasil pengujian kuat lentur yang dilakukan pada benda uji berbentuk balok dengan ukuran 15x15x60 cm dan merujuk pada SNI 4431 tahun 2011 didapat hasil uji kuat lentur yang tertera pada Tabel 4.4 dibawah ini.

Tabel 3. Hasil uji kuat tarik mortar

Benda Uji	Kuat Lentur Rata-rata (MPa)
	28 Hari
G0	4,363
GF1	4,815
GF2	3,461
GF3	3,385
GB1	2,332
GB2	3,160
GB3	2,407



Gambar 5. Grafik Kuat Lentur



Gambar 6. Grafik Persentase Kuat Lentur

Berdasarkan pengujian kuat lentur menggunakan Fly Ash dengan nanosilika sebagai pengganti semen menunjukkan adanya peningkatan sebesar 10,36% terhadap mortar normal yaitu pada penggunan Fly Ash 10% dengan nanosilika 3%. Sedangkan pada penggunaan Bottom Ash dengan nanosilika belum menunjukkan adanya peningkatan nilai kuat lentur masih dibawah mortar normal. Namun kadar optimum yang didapat pada penggunaan Bottom Ash dengan nanosilika ini yaitu pada presentase 20% Bottom Ash yang baru mendapatkan nilai kuat lentur 79,33% dari mortar normal. Nilai kuat lentur Fly Ash dengan nanosilika lebih tinggi dibandingkan nilai kuat lentur mortar dengan penggunaan Bottom Ash dan nanosilika.

4. Conclusion

5. References

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The author thanks the financial support from Ministry of Research Technology and Higher Education of the Republic of Indonesia for this Research Grant with the Scheme of Penelitian Terapan Unggulan Perguruan Tinggi for the year 2019.

IOP Conference Series: Materials Science and Engineering

Assessment of Dome Building Damage and Repair Method

IOP Conf. Series: Materials Science and Engineering **392** (2018) 062010 doi:10.1088/1757-899X/392/6/062010

ASSESSMENT OF DOME BUILDING DAMAGE AND REPAIR METHOD

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Abstract. The paper deals with the assessment of the damage of a concrete dome type of structure and the method of repairment. Due to own weight of the dome, the concrete portion of the dome near bottom rim is in tension and the steel reinforcement was not sufficiently provided, causing cracks at bottom and leakage at top of dome. UPV tests, profometer tests and core drilling were carried out to observe the condition of existing dome. Testing results were used as bases for constructing repairment method, epoxy grout, epoxy mortar and the use of carbon fibre reinforced plastic (CFRP).

1. Introduction

The dome type of structural system was widely applied since the early 80s, when concrete material was made by using conventional methods and ready-mix was yet not present. After some years, damages occured on several structures, in crack and leakage occurences. These occured due to nonuniformity and high permeability of the concrete and insufficient reinforcement. Similar problems occured in a dome structural system at Halim Perdanakusumah, Jakarta which constructed at that time. The dome is of spherical type, with 44 meters in diameter and 25.7 meters in height. The dome is functioned as coverage of national radar system. The dome is made of concrete, 0.08 meter thick at dome tip and varied to 0.5 meter at the bottom. Several damages occured; i.e., leakage at upper portion of the dome, and cracks at lower portion of the dome. Prompt action to remedy the damages was required to save important national radar system. The paper deals with several test carried out to find the factors that caused the damages, and based on tests finding, to establish the method of repair. The tests included non-destructive test (NDT), and destructive test. Non-destructive test consists of Ultrasonic Pulse Velocity (UPV) and Profometer test. Destructive test consists of core drill test and chipping. Based on test finding, method of structural repairment was established. The results of non-destructive and destructive tests may be compared [1]. The estimate of concrete compresion strength obtained by means of combined method is better than that obtained by single method [2]. The waves velocity decreases by 1-3% with degree of substitution and the overall waves velocity increases with material age [3]. While In SCC, the core drilling direction relative to the casting direction had no significant on compressive strength value [4].

2. Field Survey and Testing.

Some field surveys and laboratory testings were carried out, classified in non-destructive test (NDT) and destructive test. The NDT test consists of ultrasonic pulse velocity (UPV) test and profometer test.

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The destructive test consists of core drill and concrete chipping. The field investigation to verify the accuracy of previously obtained information with condition survey to assess the physical condition.

2.1 Ultrasonic Pulse Velocity Test

Ultrasonic pulse velocity (UPV) test is intended for observing the uniformity of existing concrete and existency of cracks. Indirect method was applied (Fig.1) The UPV test were carried out at five location to observe dome concrete crack region.

Figure 1: UPV test

2.2 Core Drill Test

Core drilling (Fig.2.) is intended for obtaining specimen out of existing concrete was before test in laboratory to find compression strength of concrete. The size of specimen cylinder is 200 mm height and 100 mm diameter. Coring is performed along the dome around 8 points with a height variation of 50 mm and 100 mm from the dome base.

Figure 2: Core Drilling

2.3 Profometer Test

Profometer test is intended for inspecting the existing dimensions and spacing of the reinforcing bars. The testing was carried out at eight locations ranging from a height of 500 mm from the bottom to the top of the dome. See Fig. 3 as explanation. The results are Meridian reinforcing 2 D13 with 10 cm distance and 10 mm diameter longitudinal reinforcement with 30 cm distance.

Figure 3: Profometer Testing

2.4 Destructive Test

Destructive test carried out was chipping of concrete so as to be able to inspect the size and spacing of reinforcing bars (Fig.4). The results were then compared to the ones obtained out of profometer test, which turned out to be the same result with the test results of the profometer.

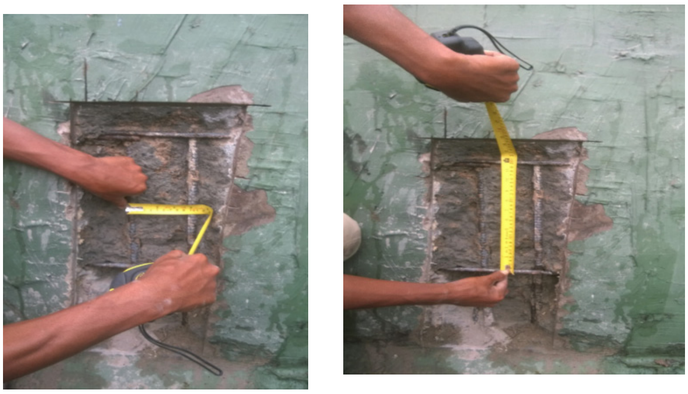

Figure 4: Destructive Test

3. Result and Discussions

3.1 Non Destructive and Destructive Test

The UPV test results show that the crack depth in the dome building is 65-100 mm. The crack depth of 65-100 mm occurred larger than the concrete cover is 50 mm. This indicates the cracks a structural crack. So it needs repair by injection with epoxy material. Based on 4 samples of coring tested press obtained concrete strength f'c 20 MPa

The Destructive test results show that the meridian reinforcement is 13 mm in diameter while the longitudinal reinforcement diameter is 10 mm

3.2 Stuctural Analysis

Two kinds of analysis were carried out on dome structure. The first was the problem concerning leakage. The second related to the cracks problem.

3.2.1 Leakage Problem

The cracks occured at the top portion of the dome. It is understood that at the time the dome was built, the concrete ready-mix or mix design were not present. Therefore, the concrete pouring was carried out by conventional method. As consequence, the concrete honeycomb exists at some location and permeability of the concrete was relatively high.

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3.2.2 Cracks Problem

The crack occurence can be described by conducting an analysis with respect to dome dead load as follows [5]. The dimension of the Dome: height of 25.7 m, circumference of 134.8 m, thickness varies from 80.0 mm at dome tip to 500.0 mm on the bottom of the dome. Therefore, a conclusion is drawn, the dome is half sphere shaped with the radius of 25.0 m.

The next dome was analysed with a computer program of SAP (Structural Analysis Program). The dome is represented by a discrete model by using finite element. By taking forces into account including self-weight and plus live load of 10.0 kN/m^2. Ultimate moment distribution is given in Table 1.

Table 1: Moment Capacity and Reinforcement

Level	Investigation data	Slab thickness	Average spacing 2D13 Vertical	D10 Horizontal	f'c=20MPa fy=400 & 240 Capacity M22(kN.m)
Level 6 m	Level 2.2m t=300	300	172.5	230	123.641
Level 8 m	Level 7.2m t=180	180	152.5	310	71.51
Level 10 m	assumed	160	162.5	260	59.89
Level 12 m	assumed	140	202.5	225	41.229
Level 14 m	assumed	120	27	222.5	25.778
Level 16 m	assumed	100	16	282.5	16.484
Level 18 m	assumed	80	17	207.5	11.072
Level 22 m	Level 24,23,22 t=80	80	220	240	8.95
Meridian membrane force = -220 kN/m and Longitudinal memberan force = 220 kN/m					

From above analysis it is shown that the hoop reinforcement of the dome is inadequate at bottom portion until the height of 3.8 meters. This inadequacy should be strengthened.

Based on the results of non-destructive test, destructive and structural analysis, then the next must be considered all repair materials have limitations, and the material specifier and user should select the materials [6]. The selection of Retrofitting materials uses CFRP because it has a low weight, high stiffness, corrosion resistance, lower maintenance cost and faster installation time [7]. Then based on the results of previous research that CRFP can increase shear resistant and confinement in members subjected to high and deformation reversals [8,9,10]. CFRP laminate have been recognized as effective method for their repair and retrofitting [11,12].

4. Method of Repairment

There are two kinds of problem experienced by the dome; i.e., leakage problem and crack problem. The repairment methods of the two problems are described in the following.

4.1Repairment of Leakage

The leakage causes problem since the dome function is to cover delicate radar system equipments. The leakage had to be overcome as soon as possible. The repairment was indeed simple; i.e., to fill the porous region of existing concrete with epoxy grout and further screeding with epoxy mortar.

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4.2Repairment of Cracks

To overcome cracks that occur the first step of Injection with epoxy material using a special tool pressurized. the epoxy point distance is 250 mm. injection performed from bottom to top

Since inadequate reinforcing bars are embedded in the concrete, then it was not possible to insert additional reinforcing bars in the concrete. Another way to strengthening the hoop reinforcing bars was adopted. The method of repairment was to use carbon fibre reinforced plastic (CFRP). The need for CFRP material was computed as follows. The demand of CFRP usage on the lower area with height of 0.629 x 22m = 13.838 m is done as shown below. The total tension force is 1522.18 kN. the CFRP was needed is 304 mm^2 and reinforcement width required is 2.53 m.

Based on the safety factor, therefore, 3,8m was attached. The installment of the repairment is shown in Figure 5.

Figure 5: Instalment of CFRP to Strengthening Dome

5. Conclusions

The dome experienced damages as leakage and cracks due to rather poor construction method and inadequate hoop reinforcement at bottom of the dome. Since the dome was intended for housing delicate national radar system equipments, prompt action to overcome problems was necessary.

The handling of the problem was executed in several steps. First, several field surveys and sampling were carried out. The testing was carried out in non-destructive and destructive kinds of testing. The testing results that the leakage was due to high permeability of the existing concrete. The cracks were due to inadequacy of hoop reinforcing bars at bottom region of the dome.

The repairment was carried out in two steps. First, the leakage problem was overcome by epoxy grout and epoxy mortar at problematic region of the dome. Secondly, the cracks at bottom portion of the dome was overcome by Injection with epoxy, then covering internal and external surfaces of bottom portion of the dome by carbon fibre reinforced plastic (CFRP). The region covered was from support until 3.8 meter height.

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Effect of added the polycarboxylate ether on slump retention and compressive strength of the high-performance concrete

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Abstract. It is well known that workability of high performance concrete (HPC) is dependent on slump value of concrete mixture. Moreover, slump retention is the most sensitive compared to a well-known slump value because it represents the durability of concrete mixture for its applications in the field of civil engineering. This research used the polycarboxylate ether (PCE) to increase slump value of concrete mixture and then verified the effect of PCE on the slump retention and compressive strength of different high-performance concretes. 0%, 0.5%, 1%, 2% of PCE were added into concrete mixture to yield a minimum compressive strength of f'c 50 MPa. The slump retention tests were performed at 0, 15, 30, 45, 60 and 75 minutes while the compressive strength tests were carried out at 3, 7, 14 and 28 days for every concrete sample. The result findings showed that the optimal concrete performance can be achieved by adding 2% of PCE to reach at a slump retention value of 45 minutes and a compressive strength of 53.84 MPa. Effect of PCE on the slump retention and compressive strength has been verified to contribute an insight into the application of a proper designed workability of HPC.

1 Introduction

The needs of high performance concrete (HPC) for construction in Indonesia will increase from the year to year due to the government policies have been aligned to focus on infrastructure development as foundation for dynamic economic growth. However, many constraints faced by concrete producers in the manufacturing of HPC should have to look at a dedicated solution. One is how HPC can retain its existing slump retention capability to ensure that the application of HPC in civil engineering industry can achieve the best performance with high workability. Many recent studies highlight established applications

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of nanoparticles such as silver nanoparticles, titania polyvinylalcohol–alginate beads, and polycarboxylate ether (PCE) as superplasticizer to rapidly emerging applications in the civil and environmental engineering and discuss future research directions [1-3]. Therefore, it has been reported that the addition of superplasticizer can improve the workability of HPC by using a very low w/c ratio [4].

Many manufacturers can produce the HPCs of being characterised with a long period of slump retention for maintaining the existing concrete workability. The use of superplasticizer has been proven to be effective in fabricating a long retardation concrete setting and long slump retention. However, uncontrolled use of the PCE as superplasticizer to improve the workability can cause a low compressive strength of the HPC [5].

Further the quantity of superplasticizer added to a concrete mixture is a concern for many producers of HPC in civil engineering industry due to the role of superplasticizers during the hydration of cement is very complex and is still not fully understood [6]. It is suggested that the importance is how to adjust the quantity of PCE added to get a proper mixture of HPC to produce a long slump retention and high compressive strength value [7]. Therefore, the objectives of this study are (1) to obtain a proper quantity of PCE added into concrete's mixture for obtaining optimal composition of HPC and (2) to assess the performance of HPC as it can be verified from the values of long slump retention and high compressive strength. The benefit of this research can help producers in manufacturing HPC with an optimal composition of PCE.

2 Materials and methods

2.1 Materials

This paper evaluates the effects of PCE level in concrete mixture and experimental method on the observed HPC performance of measured using different compositions of PCE with a concrete mix design of added 0% of PCE as the reference. This study used the materials of (1) type-1 Ordinary Portland Cement (OPC), (2) coarse aggregate of quarry Purwakarta, (3) fine aggregate from Galunggung quarry and (4) superplasticizer of PCE (Normet type Tamcem 21 RA).

2.2 Concrete mix design

The local materials were used for concrete mix design and they have been reported previously by Jonbi et al., [8,9]. Table 1 shows the concrete mix design of four different PCE composition.

Table 1. Concrete mix design with f'c 50 MPa

Material	Unit	BK0	BK1	BK2	BK3
OPC	kg/m^3	484,12	484,12	484,12	484,12
Fine aggregate	kg/m^3	793,12	793,12	793,12	793,12
Coarse aggregate	kg/m^3	971,04	971,04	971,04	971,04
Water	kg/m^3	193,65	193,65	193,65	193,65
PCE	l/m^3	0	2,42	4,84	9,68

The addition of PCE was classified by a nomenclature that BK0 is the concrete's mix that designed for the addition of 0% PCE, BK1 for the addition of 0.5% PCE, BK2 for the addition of 1% PCE and BK3 for the addition of 2% PCE, as shown in Table 2.

Table 2. Nomenclature and number of compressive strength test

Code	PCE	Age of concrete (d)				Number of Sample
		3	7	14	28	
BK0	0%	3	3	3	3	12
BK1	0.5%	3	3	3	3	12
BK2	1%	3	3	3	3	12
BK3	2%	3	3	3	3	12

2.3 Measurements of slump retention and compressive strength

Figure 1 shows the test of slump retention for the verification of decreasing slump flow according to the standard ASTM C 143-90. The measurements of slump retention were carried out at 0, 15, 30, 45, 60 and 75 minutes.

Fig. 1. Testing of slump retention

This study used a cylindrical tube of having dimensions of 150 mm external diameter and 300 mm high to follow the standard ASTM 39. Figure 2 shows the measurement equipment testing of compressive strength. Compressive strength of the HPC samples was performed at 3, 7, 14 and 28 d of the concrete's age.

Fig. 2. Testing of compressive strength

Correlation between the slump retention and the compressive strength for the HPC sample was verified using the results of testing the slump retention at 0, 15, and 30 minute and testing the compressive strength at 7 and 28 day.

3 Results and discussion

3.1 Slump retention

The results of slump retention for mixture of concrete with the variables of adding PCE by 0%, 0.5%, 1% and 2% and mixing time by 15, 30, 45, 60 and 75 minutes can be analysed to get better understanding of the workability of HPC. Figure 3 shows that the workability of HPC is still able to be used in construction industry since the slump retention behavior of concrete with a composition of 2% PCE can be maintained until 45 mn with a slump value of 10 cm. Meaning that the proper amount of added PCE would be effective in improving the slump retention due to the addition of PCE can induce greater physico-chemical surface interactions through electrostatic interactions [10-12].

Empirical evidence shows that the addition of PCE in a mixture of concrete may improve the workability of HPC. The HPC performance of improved by the addition of PCE by 15% and 20% can reach at 45 mn of slump retention capability. This study verified that the synthesis of designed HPC by adding 2% of PCE superplasticizer can have an optimal slump retention capability of 45 mn, and then after 45 mn the compressive strength slowly continues to decrease [7, 13].

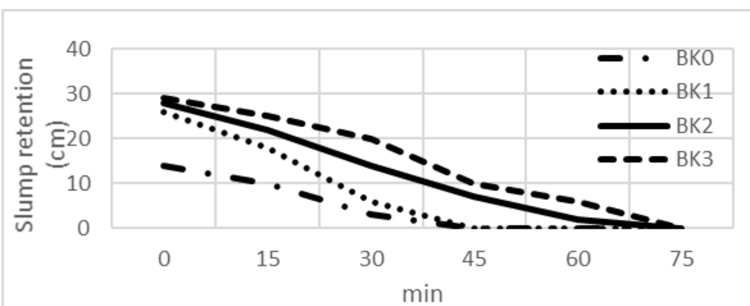

Fig. 3. Results of testing the slump retention

3.2 Compressive strength

Figure 4 shows that the increasing of PCE added into a concrete slurry can increase the compressive strength of HPC to get verified at concrete's age of 3 d. The figure shows the increase in compressive strength from 25.62 to 30.26 to 31.93 to 34.22 MPa because of the addition of PCE into the mix of concrete increases from 0% to 0.5% to 1% and to 2%, respectively. The increase of compressive strength can also be verified at the ages of 7, 14 and 28 d. The compressive strength has never reached at its planned compressive strength of f'c 45 even at age of 28 d due to the addition of PCE by 0%. It can reach at its planned compressive strength of f'c 45 at age of 28 d by the addition of PCE by 0.5%. By adding 1% of PCE into concrete slurry, the compressive strength reaches at 47.87 MPa, which is 2.42 MPa higher than its planned compressive strength of f'c 45, at age of 14 d and 49.81 MPa, which is 4.36 MPa higher than its planned compressive strength of f'c 45, at age of 28 d. Finally, by adding 2% of PCE into a mixture of concrete, the compressive strength can reach at 50.81 MPa, which is 2.94 MPa higher than the compressive strength of HPC of added 1% of PCE, at age of 14 d and 53.84 MPa, which is 4.03 MPa higher than the compressive strength of HPC of added 1% of PCE, at age of 28 d.

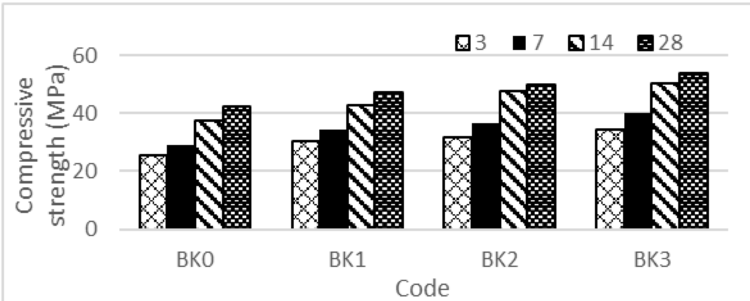

Fig. 4. Results of testing the compressive strength.

The results (Table 3) of testing at age of 28 d with the variable of PCE added by 0%, 0.5%, 1% and 2% have the compressive strengths of 42.47, 47.05, 49.81, and 53.84 MPa, respectively. The maximum value of compressive strength was verified to reach at 53.84 MPa the workability of HPC of added 2% PCE with an increase in compressive strength of 26.77% compared to that of added 0.5% PCE. Empirical evidence verified that the addition of superplasticizer into a mixture of concrete can increase workability of the HPC due to the presence of PCE nanoparticles in concrete slurry fills the cavities of concrete and thus can result in strengthening of bonds among the concrete materials the [14-16].

Table 3. Results of increasing the compressive strength

Addition of PCE (%)	Compressive strength (MPa)	Increase of compressive strength
0	42.47	0%
0.5	47.05	10.80%
1	49.81	17.29%
2	53.84	26.77%

3.3 Relation between slump retention and compressive strength

The results (Fig. 5) of plotting a correlation between the slump retention and the compressive strength reveals that the decreasing of slump retention does not make a significant decrease in compressive strength of the HPC. The compressive strengths of testing at 0, 15 and 30 mn have not clearly affect the value of slump retention at the performance of HPC measured at the ages of 7 and 28 day.

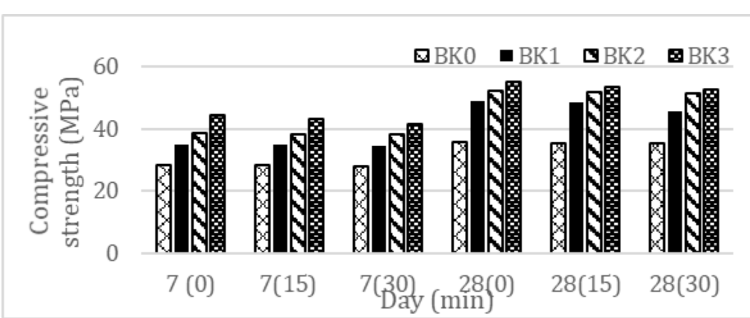

Fig. 5. Correlation between the slump retention and the compressive strength

4 Conclusions

This study used four different concrete mix designs of HPC with the variable of added 0%, 0.5%, 1% and 2% of the PCE to verify the slump retention capabilities and compressive strengths. By analysing the results of slump retention and compressive strength can conclude that:

1. The optimal slump retention of 45 mn with its value of 10 cm can be achieved by adding 2% of PCE.
2. A very high compressive strength of 53.84 MPa for HPC can be achieved by adding 2% of PCE, thre is an increase in the compressive strength of 26.77% compared to the control sample of HPC without addition of PCE.
3. Slump retention does not affect the compressive strength of HPC.

The Authors thanks the financial support from ministry of Research Techology and Higher Education of the Republic of Indonesia for Research Grant with the scheme of Penelitian Terapan Unggulan Perguruan Tinggi for the year 2018.

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Mechanical properties of nanogrout as advanced material for construction

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Abstract. The fast rate of development in the construction sector has created a necessity for the introduction of new types of materials that possess better mechanical properties such as tensile strength, compressive strength, and flexural strength. Grout materials are required for pad bearings and structural repairs. Studies have revealed that grout materials that are readily available on the market but the problem is that they generally have limited strength, as well as using materials on a micro scale. Hence, it is of great necessity to develop grout materials using materials at the nanoscale, one of such materials is the nano silica, which can improve the mechanical properties. The objective of this research is to determine the optimal content of nano-silica in grout material. The initial mix was given the code G0. After this, the nano-silica was added with 1% content (code G1), 2% content (G2), 3% (G3), and lastly 5% nano silica content (G5). Compressive strength tests were performed when the grout was aged 1, 3, 7, and 28 days. Whereas flexural strength test was also performed out at 28 days. According to the research, it was well seen that the most optimal nano silica content was at 3% (G3). The contribution of this research is to introduce nanogrout as an advanced material, to combat the challenges of the drastically increasing complex construction work in the future.

1. Introduction

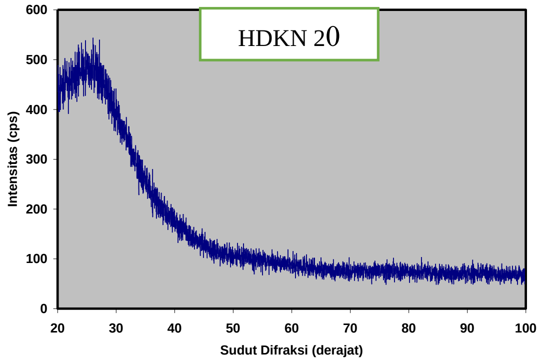
Grout materials play significant roles in structural repairs, honeycomb, spalling on columns, beams, and precast concrete. Furthermore, grout material is majorly applied in bearing pads on bridge structures and machine foundations. One significant benefit of using grout material is that it has high compressive strength, non-shrinkage, high resistance to vibration and it is non-corrosive. Research has revealed that grout material has resistance to acids. Hence it can be employed in the repair of holes in underground buildings [1, 2].

Grout material is also used as injection material to repair spoilt jobs on damaged buildings. In many scenarios, concrete injection using grout aids in filling the existing cavities [3]. Grout material can be produced by mixing 3% silica fume, 10-30% fly ash and 40% slag instead of cement [4]. In a research on the effects of nano silica, two types of nano silica were directly compared. One of the nano-silica was in powdered form while the other was in colloidal form. Concerning the mechanical properties of concrete, from the results, it was visible that nano silica in the powdered is more effective in the enhancement of the mechanical properties of cement mortar [5]. The result also showed that the addition of 5% colloidal nano silica and 40% Fly ash, significantly improved the hardening process and enhanced the compressive strength of the cement paste [6]. nanogrout is defined as a grout material added with nano silica. This research performed an analysis of the mechanical properties of nanogrout as an advanced material for construction.

2. Methodology

The grout material used is a ready-mix material produced by John Hi-Tech Contrindo, and nano silica HDKN 20, with grain sizes of 20-40 nm, produced by Bratachem.

(a)



(b)

Figure 1. (a) Nanosilica HDKN 20 (b) Hasil XRD HDKN 20

The various Specimens and testing applied in this research are shown in Table 1. G0 is grout material without nano silica as reference grout. G1 is grout material plus 1% nano silica from grout weight, G2 is added 2%, G3 (3%) and G5 (5%).

Table 1. Specimens and testing

Code	Compressive strength and Tensile strength test				Flexural Strength
	1 day	3 day	7 day	28 day	28 day
G0	✓	✓	✓	✓	✓
G1	✓	✓	✓	✓	✓
G2	✓	✓	✓	✓	✓
G3	✓	✓	✓	✓	✓
G5	✓	✓	✓	✓	✓

In the specimen, the compressive strength, tensile strength, and flexural test were performed as illustrated in Figure 2. Compressive strength testing was done by ASTM C 109/C109M and tensile strength is termed ASTM C496 / C496M [7,8]. The compressive strength testing of the specimen was performed in a cube which has 50 mm x 50 mm x 50 mm. The compressive and tensile strength tests were carried out at concrete ages 1, 3, 7 and 28 days. Flexural testing accordance with ASTM C78/C78-18, the specimen of the beam: 150 mm x 150 mm x 600 mm, tested at 28 days.

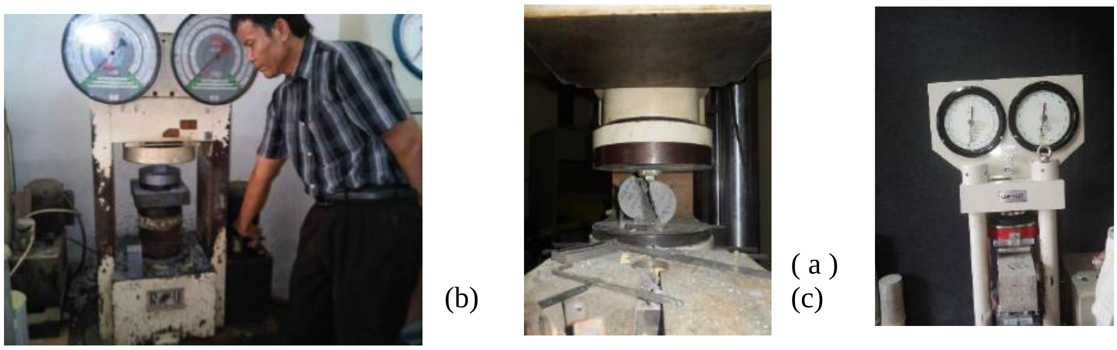


Figure 2. Compressive strength (a) Tensile Strength (b) and Flexural strength (c)

3. Results and discussion

3.1. Compressive strength

Figure 3 shows the value of concrete compressive strength at the ages of 1, 3, 7 and 28 days. At the age of 1 day, specimen G1, G2 and G3 an increase was observed in compressive strength of 14%, 0,6%, and 23%. while in the G3 there was a decrease of 29%. At the age of 3 and seven days G1, G2, and G3 there was a significant increase in compressive strength, but at G5 there a decrease was observed in compressive strength.

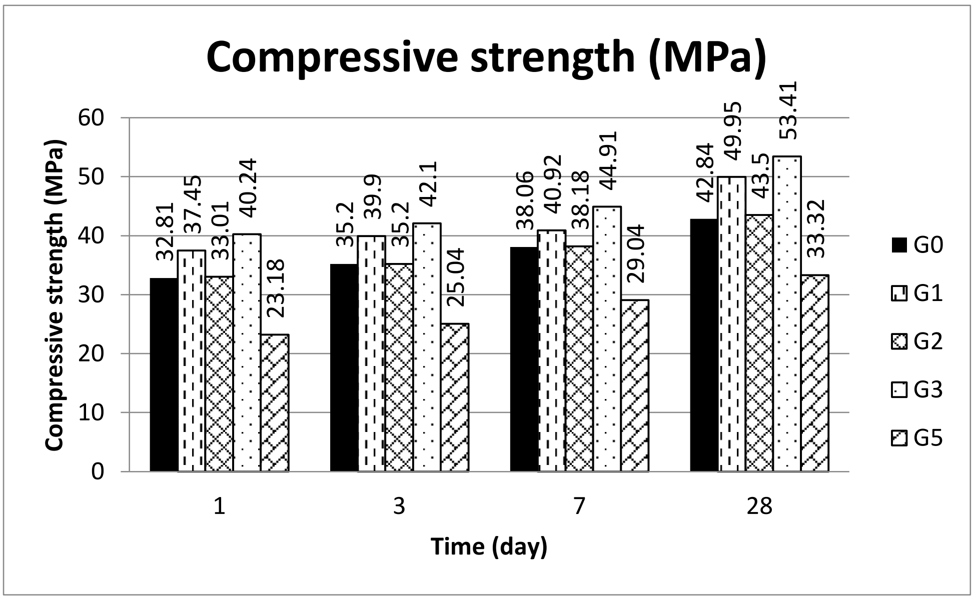


Figure 3. Result of compressive strength

At the age of 28 days, the G1 specimen has an increase in compressive strength of 16.6%, in G2 by 1.5% and G3 by 24.6%. In spite of this, in G5 there was a decline of 22%. The increment of nano silica with a percentage of 1%, 2%, and 3% can increase the compressive strength of G1 G2 and G3. This because the pozzolanic activity of nano silica was very high, this also increased the amount of C-S-H and resulted in higher densification of the matrix, thereby increasing the strength and the interfacial transition zone denser [9,10]. While in G5 there was a reduction in compressive strength because the addition of nano-silica with a percentage of 5% occurred the effect of agglomeration. As a result, nanosilica cannot be dispersed with a cement matrix so that pores and concrete are not homogeneous; this is in line with previous studies [11, 12].

3.2. Tensile Strength

The results of tensile strength tests are shown in Fig. 4. Both decreasing and decreasing trends exist in the mechanical properties by changing the quantity of nano-silica. The concrete tensile strengths of G1 and G3 in the age of 1 day demonstrates an increase in tensile strength of 5.1% and 18.8%, while in G2 and G5 there was a decrease of 2.5% and 10.2%. At three days the tensile strength of the G1 and G3 increased by 4% and 8.4%, but at G2 and G5 there was a reduction of 14.7% and 21.4%.

At 28 days the tensile strength in G3 increased the tensile strength with an increase of 20.9%, in G1, G2, and G5 a decrease of 10.3%, 19.55 and 15% was observed. From a general look of things, according to the ACI formula for tensile strength of concrete which was 0.5√fc, the G3 tensile strength is 3.65 MPa while the tensile strength test results were 21.05 MPa. The increase in the dosage of nano silica led to the rise in the values of tensile strength at the age of 28 days [13].

The results of the grout tensile strength test revealed a higher increase than if using the ACI formula, thus the ACI formula for the concrete is inappropriate for use in nanogrout.

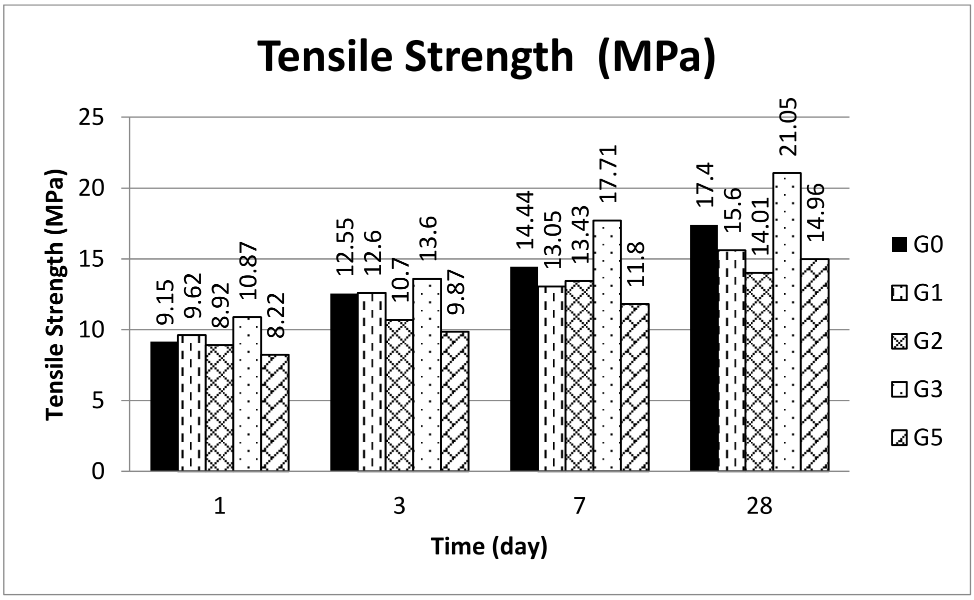


Figure 4. Result of tensile strength

3.3 Flexural Test

The results of tensile strength tests are shown in Fig. 5. The flexural strengths of G1 and G3 in the age of 28 days had an increase of 0.2% and 25.6 %. At G2 and G5 there was a decrease of 23.8% and 61.8%. By ACI-318M-05 [14], for the concrete flexural strength of 0.62√f'c and other researchers [15], flexural strength is 0.75 √f'c, the values of flexural strength are 4.53 MPa and 5.5 MPa. While the test results on the G3 is 5.39, this result in line with the existing formula thus flexural strength for concrete can be used in nanogrout.

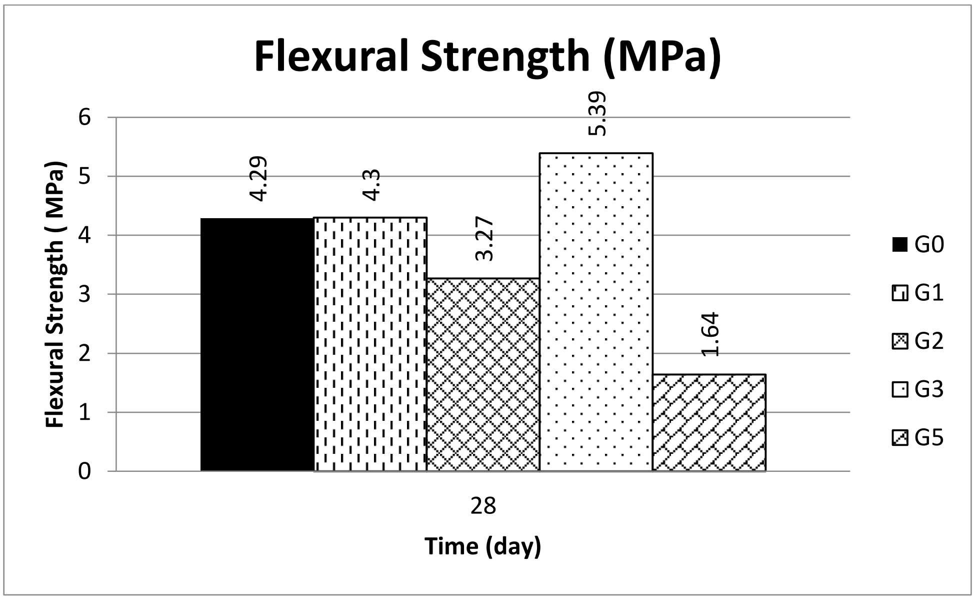


Figure 5. Result of flexural strength

4. Conclusion

Optimal nano silica addition of 3% produces the best nanogrout, which can be an advanced material for construction.

Nanogrout (G3) significantly improved the mechanical properties for compressive strength 24.6%, tensile strength 20.9% and flexural strength 25.6%.

Acknowledgement

The author expressed his gratitude to KEMENRISTEKDIKTI for the assistance of research funding through a PTUPT scheme for the 2018 budget year.

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