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Muntasir Billah  
Editors

# Proceedings of the 5th International Conference on Sustainable Civil Engineering Structures and Construction Materials

SCESCM 2020

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# Preface

In current times, the civil engineering field has developed in many ways, especially on the technologies and materials, in riding along the waves of Industry 4.0. Alongside the current developments and state-of-the-art affairs, the construction industry has also been very engaging in regard to sustainability, as construction academics and practitioners all around the world strive to embedded sustainability in all aspects of construction, in order to sustain the balance in the environment for the next generation. The concept of high efficiency and effectiveness of human resources and the use of materials with low or minimal impact to the environment should be implemented in the design, construction and maintenance phase of civil engineering structures/buildings. Thus, the series of International Conference on Sustainable Civil Engineering Structures and Construction Materials has been conceived to spread the latest information, scientific findings and achievements of civil engineers around the world in regard to the applications of sustainability in all aspects of civil engineering and infrastructure facilities. This series of conference was initiated by the Civil and Environmental Engineering Department of Gadjah Mada University, in cooperation with Hokkaido University, Japan, and Karlsruhe Institute of Technology, Germany, with the organization of the inaugural first Sustainable Civil Engineering Structures and Construction Materials (SCESCM) International Conference in 2012 in Yogyakarta, Indonesia, with the theme “Enhancing the Role of Civil Engineering for Sustainable Environment”. This scholarly platform of network building and information sharing has since been routinely organized every two years (biennial) to support the agenda of sustainability in civil engineering and construction. The biennial conference is now at its fifth series (SCESCM 2020), which was virtually held from Malaysia, in December 2020. The main organizer for the fifth series is Universiti Teknologi MARA, in collaboration with Gadjah Mada University, Indonesia, Hokkaido Universiti, Japan, and Karlsruhe Institute of Technology, Germany. The theme for the fifth SCESCM was “Transforming the World, Foster the Sustainable Development Goals (SDGs)”, aimed to explore and demonstrate the range of issues, novel findings, as well as developments in the area of civil and infrastructure, conforming to the SDGs. The inclusion of SCESCM 2020 in the Lecture Notes in Civil Engineering (LNCE) highlights the latest developments in civil engineering

with research that spans across different fields in civil engineering, from structures, materials, geotechnic, environment, water resource, construction management to smart cities and built environment. The blend of various fields in civil engineering that were grounded to the theme of sustainability within the context of SDGs makes this book a comprehensive referral point for civil engineering academics, as well as practitioners in general. All the papers included in this book have been carefully reviewed and selected with approximately 75% rate of acceptance.

This book represents the blood, sweat and tears of many, and we would like to sincerely thank the SCESCM 2020 organizing committee and scientific committee for their relentless effort, commitment and invaluable contribution. Our appreciation also goes to the dedicated reviewers, authors and participants for their active role in contributing to the wealth of knowledge and advocacy on sustainability in civil engineering.

Our sincere gratitude also goes to Mr. Ramesh Kumaran and Dr. Ramesh Nath Premnath, Publishing Editors at Springer for their immense assistance and support in materializing the book.

Finally, we hope that the readers would find the book beneficial for their current tasks, as well as the source of inspiration in expanding the plethora of knowledge in future works.

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**TECHNICAL SESSION 1**  
**8 DECEMBER 2020**  
**(09.30 AM – 11.15 AM)**  
**(Kuala Lumpur Time Zone – UTC/GMT +8)**

**WEBEX 1: STRUCTURE AND MATERIALS**

1. Time : 09.30 – 09.45 AM  
Paper ID : 2  
Title : Practical Measurement Method for Structural Large Displacement Using High Speed Camera  
Author/s : Ashar Saputra and Aries Putra Purba  
Institution : University Gadjah Mada, Indonesia  
E-mail : saputra@ugm.ac.id
2. Time : 09.45 – 10.00 AM  
Paper ID : 9  
Title : Finite Element Analysis of CRTS III Slab Track Model  
Author/s : Muchtar Sufaat, Ali Awaludin, Andreas Triwiyono, Iman Satyarno, Akhmad Aminullah, Mukhlis Sunarso and Guntara Muria Adityawarman  
Institution : University Gadjah Mada and Wijaya Karya Beton Co. Ltd, Indonesia  
E-mail : muchtarsufaat@gmail.com; ali.awaludin@ugm.ac.id
3. Time : 10.00 – 10.15 AM  
Paper ID : 10  
Title : Effect of Partial Replacement of Cement with Volcanic Ash on Mechanical Behaviour of Mortar  
Author/s : Jesika Rahman, Md Shahjalal, Afia Farzana Haque, Lutful Habib, Khadiza Binte Jalal and Mohd Mezanur Rahman  
Institution : Military Institute of Science and Technology, University of Texas  
E-mail : jesikarahman547@ce.mist.ac.bd ; mdshahjalal0036@gmail.com
4. Time : 10.15 – 10.30 AM  
Paper ID : 15  
Title : Lateral Load-displacement Behaviours of Reinforced Geopolymer-concrete Column using Finite Element Analysis  
Author/s : Kukuh Kurniawan Dwi Sungkono, Iman Satyarno, Henricus Priyosulistyo and Indra Perdana  
Institution : Tunas Pembangunan University, University Gadjah Mada  
E-mail : kukuhkds.utpska@gmail.com
5. Time : 10.30 – 10.45 AM  
Paper ID : 29  
Title : Seismic Performance of Instant Steel Frame House for Post-Earthquake Reconstruction  
Author/s : Widarto Sutrisno, Iman Satyarno, Ali Awaludin, Ashar Saputra and Angga Fajar Setiawan  
Institution : University Gadjah Mada  
E-mail : widartosutrisno@mail.ugm.ac.id
6. Time : 10.45 – 11.00 AM  
Paper ID : 34  
Title : Nonlinear Modelling Laminated Petung Bamboo Under Flexural Test Based on ASTM D 143  
Author/s : Abdul Dayat Abzarih, Inggar Septhia Irawati and Bambang Suhendro  
Institution : Universitas Dayanu Ikhsanuddin, Universitas Gadjah Mada  
E-mail : inggar\_septhia@ugm.ac.id ; widayat.abzarih@gmail.com

7. Time : 11.00 – 11.15 AM  
 Paper ID : 38  
 Title : Numerical Simulation with Finite Element Method of Influence Concrete Surface Preparation to Characteristic Synthetic Wraps  
 Author/s : Andhika Mahendra A. S. Fajar  
 Institution : University Gadjah Mada  
 E-mail : andhikamahendra@mail.ugm.ac.id

## WEBEX 2: STRUCTURE AND MATERIALS

1. Time : 09.30 – 09.45 AM  
 Paper ID : 39  
 Title : Experimental Investigation of Small-Scale Truss Bridge Model for Vibration-Based Structural Health Monitoring  
 Author/s : Sukamta Sukamta, Angga Alfiannur, Susilo Adi Widyanto and Han Ay Lie  
 Institution : Diponegoro University  
 E-mail : kamt\_id@yahoo.com ; anggaalfiannur09@gmail.com
2. Time : 09.45 – 10.00 AM  
 Paper ID : 51  
 Title : Parameter Identification of Bouc-Wen Model using Firefly Algorithm  
 Author/s : Richard Frans, Yoyong Arfiadi and Junaedi Utomo  
 Institution : Atma Jaya Makassar University, Atma Jaya Yogyakarta University  
 E-mail : richardfrans.rf@gmail.com
3. Time : 10.00 – 10.15 AM  
 Paper ID : 57  
 Title : Investigation of Confined Masonry using Non-Standard Quality of Concrete and Reinforcement  
 Author/s : Andreas Triwiyono, I Gusti Lanang Bagus Eratodi, Dian Eksana Wibowo and Suprpto Siswosukarto  
 Institution : Universitas Gadjah Mada, Universitas Pendidikan Nasional, Universitas Negeri Yogyakarta  
 E-mail : andreas.triwiyono@ugm.ac.id
4. Time : 10.15 – 10.30 AM  
 Paper ID : 58  
 Title : Prospective Damper for Existing Low-rise Building at Earthquake-prone Developing Countries  
 Author/s : Yenny Nurchasanah, Bambang Suhendro and Iman Satyarno  
 Institution : Universitas Muhammadiyah Surakarta, Universitas Gadjah Mada  
 E-mail : yenny.nurchasanah@ums.ac.id
5. Time : 10.30 – 10.45 AM  
 Paper ID : 61  
 Title : Numerical Modelling of Concrete-Filled Steel Tube Columns under Eccentric Loading  
 Author/s : Joarder Md Sarwar Mujib, Avijit Pal, Ibriju Ibrahim and Tanvir Mustafy  
 Institution : Military Institute of Science and Technology, École Polytechnique de Montréal  
 E-mail : mustafy@ualberta.ca
6. Time : 10.45 – 11.00 AM  
 Paper ID : 62  
 Title : Maturity method to predict strength development self-compacting concrete using fly ash to replace a part of Portland composite cement  
 Author/s : Gidion Turuallo, Harun Mallisa, Nicodemur Rupang and Zet Mallisa

- Institution : Tadulako University  
 E-mail : turuallo@yahoo.co.uk
7. Time : 11.00 – 11.15 AM  
 Paper ID : 68  
 Title : Development of Numerical Model for Highly-Flowable Strain Hardening Fiber Reinforced Concrete (HF-SHFRC) Columns Subjected to Lateral Displacement Reversals and High Axial Loading Level  
 Author/s : Wisena Perceka, Wen-Cheng Liao and Li-Wei Tseng  
 Institution : Universitas Katolik Parahyangan, National Taiwan University  
 E-mail : perceka.wisena@gmail.com

### WEBEX 3: STRUCTURE AND MATERIALS

1. Time : 09.30 – 09.45 AM  
 Paper ID : 73  
 Title : Mechanical Properties of Eco-Friendly Self-Consolidating Concrete Containing Ground Granulated Blast Furnace Slag and Calcined Dolomite  
 Author/s : Herry Suryadi Djayaprabha, Ta-Peng Chang, Jeng-Ywan Shih and Hoang-Anh Nguyen  
 Institution : Universitas Katolik Parahyangan, National Taiwan University, Ming Chi University of Technology, Cantho University  
 E-mail : herry.suryadi@unpar.ac.id
2. Time : 09.45 – 10.00 AM  
 Paper ID : 74  
 Title : Development of Replaceable Links in Eccentrically Braced Frame Steel Structures  
 Author/s : Naomi Pratiwi, Helmy Hermawan Tjahjanto and Muslinang Moestopo  
 Institution : Universitas Katolik Parahyangan  
 E-mail : naomi.pratiwi@unpar.ac.id
3. Time : 10.00 – 10.15 AM  
 Paper ID : 77  
 Title : The Evaluation of Six Indonesian Hardwood Species According to SNI 7973:2013  
 Author/s : Wiryanto Dewobroto, Christian Gerald Daniel, Ricky Weinata Kurniawan and Au Chuenliana Audi  
 Institution : Universitas Pelita Harapan  
 E-mail : christian.geralddaniel@gmail.com
4. Time : 10.15 – 10.30 AM  
 Paper ID : 81  
 Title : Image Analysis of the Color Change on the Concrete Surface under the Change of Temperature and Humidity  
 Author/s : Naoki Tosaka, Pengru Deng and Takashi Matsumoto  
 Institution : Hokkaido University  
 E-mail : tosaka@eis.hokudai.ac.jp
5. Time : 10.30 – 10.45 AM  
 Paper ID : 88  
 Title : Dynamic Formation of Spontaneous Corrugation on Sand Surface Due to Repeated Loading of Moving Vehicles  
 Author/s : Shunji Kanie, Hao Zheng, Kai Hashimoto and Risa Endo  
 Institution : Hokkaido University  
 E-mail : kanie@eng.hokudai.ac.jp
6. Time : 10.45 – 11.00 AM

- Paper ID : 98  
 Title : Assessment and Back Analysis of a Swaying-Jetty in Dumai Indonesia  
 Authors : Merdeka Tazakka, Adecar Nugroho and Budiwan Tirta  
 Institution : PT Witteveen Bos Indonesia  
 E-mail : sanditazakka@hotmail.com
7. Time : 11.00 – 11.15 AM  
 Paper ID : 117  
 Title : Seismic Assessment of Reinforced Concrete Frame with Unreinforced Masonry infill Walls in Malaysia  
 Author/s : Nurbaiah Mohammad Noh, Nur Izzah Aznin, Muhamad Hafizi Mohamed Zin , Muhammad Azamuddin Mohd Gharib, Muhammad Ammar Zahari, and Muhammad Faiz Rushdi  
 Institution : Universiti Teknologi MARA (UiTM)  
 E-mail : baie\_7983@yahoo.com

#### WEBEX 4: SUSTAINABILITY AND BUILT ENVIRONMENT

1. Time : 09.30 – 09.45 AM  
 Paper ID : 53  
 Title : Seismic Performance Evaluation of Horseshoe Tunnel on Weathered-Sedimentary Rock Formation  
 Author/s : Jabar Raikhan Khusna Nur Aji, Angga Fajar Setiawan Setiawan and Teuku Faisal Fathani Fathani, W. Wilopo, I. M. Rey  
 Institution : Universitas Gadjah Mada  
 E-mail : jabar.raikhan@mail.ugm.ac.id
2. Time : 09.45 – 10.00 AM  
 Paper ID : 106  
 Title : Sustainable Construction and its Challenges  
 Author/s : Adhilla Ainun Musir, Siti Rashidah Mohd Nasir, Siti Hafizan Hassan, Nur Farah Asyikin Abdul Rahim and Nurul Farah Afiah  
 Institution : Universiti Teknologi MARA (UiTM)  
 E-mail : adhilla.ainun@ppinang.uitm.edu.my
3. Time : 10.00 – 10.15 AM  
 Paper ID : 115  
 Title : Removal of Nutrients, Organic Matter and Total Suspended Solids from River Water by Adsorption on Chicken Eggshell  
 Author/s : Wen-Pei Low, Fung-Lung Chang and Shwu Ying Loo  
 Institution : INTI International University  
 E-mail : wenpei.low@newinti.edu.my
4. Time : 10.15 – 10.30 AM  
 Paper ID : 132  
 Title : Effect of Roofing Material on the Quality of Harvested Rainwater  
 Author/s : Nordila Ahmad, Mohamad Faiz Nur Izzat Zakaria, Zuliziana Suif, Maidiana Othman and Siti Khadijah Che Osmi  
 Institution : Universiti Pertahanan Nasional Malaysia (UPNM)  
 E-mail : nordila@upnm.edu.my
5. Time : 10.30 – 10.45 AM  
 Paper ID : 145  
 Title : Impact of Proposed Bus Rapid Transit (BRT) Peshawar on Modal Shares of Private Modes  
 Author/s : Dr. Sameer Ud-Din, Dr. Muhammad Jawed Iqbal, Jawad Mehmood and Nasir Ali  
 Institution : National University of Sciences and Technology  
 E-mail : sameer\_uddin@hotmail.com: sameeruddin@nit.nust.edu.pk

6. Time : 10.45 – 11.00 AM  
 Paper ID : 161  
 Title : Design of Groundwater Filter Media Using Activated Carbon For Emergency Purpose  
 Author/s : Zuliziana Suif, Siti Khadijah Che Osmi, Maidiana Othman, Nordila Ahmad and Adam Muhammad Ezzat Aripin  
 Institution : Universiti Pertahanan Nasional Malaysia (UPNM)  
 E-mail : zuliziana@upnm.edu.my, sitikhadijah@upnm.edu.my
  
7. Time : 11.00 – 11.15 AM  
 Paper ID : 170  
 Title : Prediction of HMA Mixture Performance from Rheological and Rutting Evaluation of Nanopolymer Asphalt Binder  
 Author/s : Ekarizan Shaffie, Ahmad Kamil Arshad, Juraidah Ahmad, Wardati Hashim, Ramadhansyah Putra Jaya, Khairil Azman Masri and Mohd Amin Shafii, Haryati Yacoob  
 Institution : Universiti Teknologi MARA (UiTM)  
 E-mail : eka@uitm.edu.my

#### **WEBEX 5: CONSTRUCTION MANAGEMENT**

1. Time : 09.30 – 09.45 AM  
 Paper ID : 49  
 Title : Construction Supply Chains for Strategic Materials of Building Contractors in Greater Bandung  
 Author/s : I Made Bhisma Pranandya, F S C S Maisarah, and Muhamad Abduh  
 Institution : Institut Teknologi Bandung  
 E-mail : imb.pranandya@gmail.com
  
2. Time : 09.45 – 10.00 AM  
 Paper ID : 75  
 Title : Social Sustainability In Education: An Insight Into The Civil Engineering Curricular  
 Author/s : Nurul Elma Kordi, Sheila Belayutham, Che Khairil Izam Che Ibrahim and Nur Shuhada Nor Shahrudin  
 Institution : Universiti Teknologi MARA  
 E-mail : elma8207@uitm.edu.my
  
3. Time : 10.00 – 10.15  
 Paper ID : 96  
 Title : Legacy of the Games: The Urban Transformation of the Host City - The Pre-Game, Game and Post-Game Phase  
 Author/s : Shivangi Varma and Himanshu Sanghani  
 Institution : Sushant School of Art and Architecture  
 E-mail : shivangivarma.sv@gmail.com
  
4. Time : 10.15 – 10.30 AM  
 Paper ID : 124  
 Title : Cost Structure Identification for Third-Party Logistics Services in Construction Projects  
 Author/s : Fauziah Shanti Cahyani Siti Maisarah and Muhamad Abduh  
 Institution : Institut Teknologi Bandung  
 E-mail : fauziah.scs.maisarah@gmail.com
  
5. Time : 10.30 – 10.45 AM  
 Paper ID : 135  
 Title : Constraint and Fault Tree Analysis in Safety Construction System Integration

- Author/s : Fitri Nugraheni, Adwitya Bhaskara and Alvian Purbiantoro  
Institution : Universitas Islam Indonesia, Universitas Teknologi Yogyakarta  
E-mail : fitri.nugraheni@uii.ac.id
6. Time : 10.45 – 11.00 AM  
Paper ID : 154  
Title : Identifying Competency of Housing Construction Personnel in Indonesia  
Author/s : Albani Musyafa', Dhanoe Seto Nugroho and Nelly Buldan Afifa Hidayati  
Institution : Universitas Islam Indonesia  
E-mail : 955110102@uii.ac.id ; 17511193@students.uui.ac.id
7. Time : 11.00 – 11.15 AM  
Paper ID : 155  
Title : Experiment to Determine Labour Needs in Brick Work with Space Mould Tools  
Author/s : Albani Musyafa', Irsyad Hanif Ansori and Muchammad Rizky Anugerah  
Institution : Universitas Islam Indonesia  
E-mail : 955110102@uii.ac.id ; 17511078@students.uui.ac.id

**TECHNICAL SESSION 2**  
**8 DECEMBER 2020**  
**(15.00 PM – 16.45 PM)**  
**(Kuala Lumpur Time Zone – UTC/GMT +8)**

**WEBEX 1: STRUCTURE AND MATERIALS**

1. Time : 15.00 – 15.15 PM  
Paper ID : 118  
Title : High Temperature Performance of Concrete Incorporating Recycled Glass Powders  
Author/s : Joarder Md Sarwar Mujib, Nayeem Ahmed Shuvo, Abu Bakar Siddique Ishmam and Tanvir Mustafy  
Institution : Military Institute of Science and Technology, University of Alberta  
E-mail : mustafy@ualberta.ca ; nayeemahmedshuvo@gmail.com
2. Time : 15.15 – 15.30 PM  
Paper ID : 119  
Title : The effect of Palm Oil Fuel Ash (POFA) and Steel Fiber Addition to the Mechanical Properties of Ultra High-Performance Concrete (UHPC)  
Author/s : Hafizuddin Zakare, Anizahyati Alisibramulisi, Muhd Norhasri Muhd Sidek, Aidan Newman, Nadiah Saari, Suraya Hani Adnan and Norshariza Mohamad Bhkari  
Institution : Universiti Teknologi MARA (UiTM) & Universiti Tun Hussein Onn Malaysia  
E-mail : aniz.9949@gmail.com ; aidan.newman@gmail.com
3. Time : 15.30 – 15.45 PM  
Paper ID : 120  
Title : Investigation on Fire Resistance of Concrete Incorporating Recycled Ceramic Fine Aggregate  
Author/s : Joarder Md Sarwar Mujib, Md. Maruf Hasan, Md. Rasel Molla, Tahsin Md. Zahid and Tanvir Mustafy  
Institution : Military Institute of Science and Technology, University of Alberta  
E-mail : mustafy@ualberta.ca ; marufhasan85611@gmail.com
4. Time : 15.45 – 16.00 PM  
Paper ID : 123  
Title : Image Analysis on the Deformation Behaviors of RC Beams with Simulated Deteriorations under Moving Wheel Load Fatigue  
Author/s : Takamasa Nagai, Ko Kakuma, Hiroaki Nishi, Pengru Deng and Takashi Matsumoto  
Institution : Hokkaido University, Hokkaido Regional Development Bureau, Civil Engineering Research Institute for Cold Region  
E-mail : nagai-t@eis.hokudai.ac.jp
5. Time : 16.00 – 16.15 PM  
Paper ID : 129  
Title : Investigation of Catalysed Biomass Thermoelectric Concrete with Palm Oil Fuel Ash  
Author/s : Hoong Pin Lee, Wan-Foong Chak, , Kar-Loke Teow, Wen-Zhang Lee, Nurharniza Binti Abdul Rahman, Abdullah Zawawi Awang  
Institution : INTI International University & College  
E-mail : hoongpin.lee@newinti.edu.my
6. Time : 16.15 – 16.30 PM  
Paper ID : 131  
Title : Examination on the Processes of Structural Performance Evaluation of SRC Deep Beams by FEA with NDT Results  
Author/s : Motonori Yasui, Pengru Deng and Takashi Matsumoto  
Institution : Hokkaido University  
E-mail : motonori@eis.hokudai.ac.jp

7. Time : 16.30 – 16.45 PM  
 Paper ID : 136  
 Title : Development of Time Histories Based on Shallow Crustal Earthquake Sources Considering the New Version of the Indonesian Earthquake Map  
 Author/s : Wisnu Erlangga, Mochamad Teguh and Imam Trianggoro Saputro  
 Institution : Universitas Islam Indonesia  
 E-mail : wisnuuangga@gmail.com

## WEBEX 2: STRUCTURE AND MATERIALS

1. Time : 15.00 – 15.15 PM  
 Paper ID : 151  
 Title : Bamboo Reinforced Concrete Beam  
 Author/s : Nurharniza Abdul Rahman, Choo Li Rong and Lee Hoong Pin  
 Institution : INTI International University & College  
 E-mail : nurharniza.rahman@newinti.edu.my
2. Time : 15.15 – 15.30 PM  
 Paper ID : 160  
 Title : Shear Strength Parallel to Grain for Selected Malaysian Tropical Timber According to BS EN408  
 Author/s : Norshariza Mohamad Bhkari, Lum Wei Chen, Zakiah Ahmad, Anizahyati Alisibramulisi and Muhammad Shaiful Nordin  
 Institution : Institute for Infrastructure Engineering and Sustainable Management (IIESM), Universiti Teknologi MARA (UiTM)  
 E-mail : norsharizamb@gmail.com
3. Time : 15.30 – 15.45 PM  
 Paper ID : 163  
 Title : Effect of Pineapple Leaf Fibre as Additional Material in Concrete Mixture  
 Author/s : Siti Khadijah Che Osmi, Noor Aina Misnon, Suriyadi Sojipto, Hapsa Husen and Faridah Hanim Khairuddin  
 Institution : Universiti Pertahanan Nasional Malaysia (UPNM)  
 E-mail : sitikhadijah@upnm.edu.my
4. Time : 15.45 – 16.00 PM  
 Paper ID : 172  
 Title : Flexural Behaviour of SCC Beams with Different Shear Span to Effective Depth Ratio  
 Author/s : Oh Chai Lian, Md Zain Mohd Raizamzamani, Norrul Azmi Yahya, Lee Siong Wee and Balqis Mohd Yunos  
 Institution : Universiti Teknologi MARA (UiTM)  
 E-mail : chailian@uitm.edu.my
5. Time : 16.00 – 16.15 PM  
 Paper ID : 176  
 Title : Flexural Strength and Ductility of Green Engineered Cementitious Composites Containing High Volumes of Fly Ash  
 Author/s : Siong Wee Lee, Mohd Raizamzamani Md Zain, Chai Lian Oh, Norrul Azmi Yahya and Ching Hua Goh  
 Institution : Universiti Teknologi MARA (UiTM)  
 E-mail : leesiongwee@uitm.edu.my
6. Time : 16.15 – 16.30 PM  
 Paper ID : 177  
 Title : An Experimental Study on The Influence of Ground Granulated Blast-furnace Slag (GGBS) on Bending Strength of Green Engineered Cementitious Composites

- Author/s : Mohd Raizamzamani Md Zain, Oh Chai Lian, Lee Siong Wee and Norrul Azmi Yahya  
 Institution : Universiti Teknologi MARA (UiTM)  
 E-mail : raizam@uitm.edu.my
7. Time : 16.30 – 16.45 PM  
 Paper ID : 188  
 Title : Dynamic Analysis Verification of Double-span Steel Beam under an Instantaneous Loss of Support Using Finite Element Method  
 Author/s : Nur Ezzaryn Asnawi Subki, Hazrina Mansor, Yazmin Sahol Hamid and Gerard A. R. Parke  
 Institution : Universiti Teknologi MARA (UiTM)  
 E-mail : nurezzaryn@gmail.com

### WEBEX 3: STRUCTURE AND MATERIALS

1. Time : 15.00 – 15.15 PM  
 Paper ID : 206  
 Title : Ettringite: Influence of Steam Curing and Excessive Sulphate Content  
 Author/s : Balqis Md Yunus, Muhammad Saiful Hidayat Mohd Kadari and Mohd Raizamzamani Md Zain  
 Institution : Universiti Teknologi MARA (UiTM)  
 E-mail : bmdyunus@gmail.com
2. Time : 15.15 – 15.30 PM  
 Paper ID : 207  
 Title : Geoforensic Investigation of Cavity and Settlement for Abutment Bridge Using Electrical Resistivity Imaging  
 Author/s : Abdul Samad Abdul Rahman and Ismacahyadi Bagus Mohamad Jais  
 Institution : Universiti Teknologi MARA (UiTM)  
 E-mail : kempass@hotmail.com
3. Time : 15.30 – 15.45 PM  
 Paper ID : 210  
 Title : Strength Prediction of Normal Concrete Beam with Corner Notch  
 Author/s : Mohd Hilton Ahmad and Noor Yasmin Zainor  
 Institution : Universiti Tun Hussein Onn Malaysia  
 E-mail : hilton@uthm.edu.my
4. Time : 15.45 – 16.00 PM  
 Paper ID : 216  
 Title : Structural Condition Assessment of A Log Bridge under Heavy Traffic Load (Case Study : 100 Tons Gas Engine Delivery in Central Borneo Project)  
 Author/s : Angga Trisna Yudhistira, Angga Setiawan, Irfani Nurul Huda, Ali Awaludin and Budi Suanda  
 Institution : PT.PP (Persero) Tbk, University Gadjah Mada  
 E-mail : anggatrisna1212@gmail.com
5. Time : 16.00 – 16.15 PM  
 Paper ID : 217  
 Title : The Application of Inserted Steel Pipe as an Alternative Confinement Design in Reinforced Concrete Column Plastic Hinge Regions  
 Author/s : Johanes Januar Sudjati, Iman Satyarno, Andreas Triwiyono, Bambang Supriyadi and Angga Fajar Setiawan  
 Institution : Universitas Atma Jaya Yogyakarta, Universitas Gadjah Mada  
 E-mail : januar.sudjati@uajy.ac.id
6. Time : 16.15 – 16.30 PM

- Paper ID : 240  
 Title : Seismic Performance Comparison of Pile Supported Slab Viaduct with PHC Pile and RC Column Bored Pile in South Part of Java Island  
 Author/s : Muhamad Fauzi Darmawan, Angga Fajar Setiawan, Iman Satyarno, Ali Awaludin and Bonifacius Adiguna Yogatama  
 Institution : Universitas Gadjah Mada  
 E-mail : fauzi.d@mail.ugm.ac.id
7. Time : 16.30 – 16.45 PM  
 Paper ID : 241  
 Title : Finite Element Analysis for Developing Multi-direction Crossing Web Type Shear Panel Damper  
 Author/s : Bagas Nuralim Utama, Angga Fajar Setiawan, Iman Satyarno, Ali Awaludin and Guntara Muria Adityawarman  
 Institution : Universitas Gadjah Mada  
 E-mail : imansatyarno@ugm.ac.id ; bagas.n.u@mail.ugm.ac.id

#### WEBEX 4: SUSTAINABILITY AND BUILT ENVIRONMENT

1. Time : 15.00 – 15.15 PM  
 Paper ID : 171  
 Title : Study on Nitrogen Removal Capability of Selected Regional Sewage Treatment Plants in Klang Valley  
 Author/s : Suzana Ramli, Jurina Jaafar and Raja Baharudin Raja Mamat  
 Institution : Universiti Teknologi MARA (UiTM)  
 E-mail : suzana799@uitm.edu.my
2. Time : 15.15 – 15.30 PM  
 Paper ID : 198  
 Title : Sustainable use of Plastic Waste on Laterite Soil as Stabilizer  
 Author/s : Nurul Ibrahim, Tan Jia Jun Jia Jun, Muhammad Irfan Shahrin and Nur'Ain Mat Yusof  
 Institution : INTI International University  
 E-mail : nurulain.ibrahim@newinti.edu.my
3. Time : 15.30 – 15.45 PM  
 Paper ID : 208  
 Title : Exploration of Palm Kernel use in Construction: A Review  
 Author/s : Donald Kwabena Dadzie, A K Kaliluthin and D Raj Kumar  
 Institution : B.S.Abdur Rahman Crescent Institute of Science and Technology, Annamalai University  
 E-mail : dadzie\_civil\_2019@crescent.education,
4. Time : 15.45 – 16.00 PM  
 Paper ID : 220  
 Title : Evaluation of the Physical and Mechanical Properties of Concrete with Partial Replacement of Coarse Aggregates with Epoxy-Based E-waste (EBEW)  
 Author/s : Joseph Berlin Juanzon and Jaime Aquino  
 Institution : University of the City of Manila, Commission on Higher Education  
 E-mail : jbjuanzon@yahoo.com
5. Time : 16.00 – 16.15 PM  
 Paper ID : 228  
 Title : The Potential of Plastic Waste as Building Material  
 Author/s : Chong Lih Yen, Myzatul Aishah Kamarazaly, Soon Lam Tatt, Nurulhuda Hashim, Shirley Chin Ai Ling and Azrina Md Yaakob  
 Institution : Taylor's University  
 E-mail : MyzatulAishah.Kamarazaly@taylors.edu.my ; lihyen@outlook.com

6. Time : 16.15 – 16.30 PM  
 Paper ID : 235  
 Title : Identification Characteristic of Energy Efficient Timber House  
 Author/s : Febriane Paulina Makalew, Rilya Rumbayan and Novatus Senduk  
 Institution : Manado State Polytechnic  
 E-mail : febriane.makalew@sipil.polimdo.ac.id
  
7. Time : 16.30 – 16.45 PM  
 Paper ID : 258  
 Title : The Effect of Dominant Rainfall Duration on the Planning of Dimensions of Infiltration Well and the Reduction of Surface Runoff  
 Author/s : Sri Amini Yuni Astuti and Dinia Anggraheni  
 Institution : Universitas Islam Indonesia  
 E-mail : amini\_yuni@uii.ac.id

#### **WEBEX 5: CONSTRUCTION MANAGEMENT**

1. Time : 15.00 – 15.15 PM  
 Paper ID : 187  
 Title : Development of Entry Mode Assessment Criteria (EMAC) Model for Malaysian Construction Companies to Sustain in International Operations  
 Author/s : Norizzati Ibrahim, Che Maznah Mat Isa and Nur Izzati Abd Rani  
 Institution : Universiti Teknologi MARA (UiTM)  
 E-mail : norizzati\_ibrahim@yahoo.com.my ; izzati6752@uitm.edu.my
  
2. Time : 15.15 – 15.30 PM  
 Paper ID : 194  
 Title : Automated Web-based Condition Survey System for Heritage Monuments using Deep Learning  
 Author/s : Lukman E Mansuri and D A Patel  
 Institution : Sardar Vallabhbhai National Institute of Technology, Surat  
 E-mail : erlukman@gmail.com
  
3. Time : 15.30 – 15.45 PM  
 Paper ID : 204  
 Title : Developing Indicators of Green Operation and Maintenance of Green Supply Chain Management in Construction Industry  
 Author/s : Mochamad Agung Wibowo, Naniek Utami Handayani and Nur Farida  
 Institution : Diponegoro University  
 E-mail : agung.wibowo@ft.undip.ac.id
  
4. Time : 15.45 – 16.00 PM  
 Paper ID : 205  
 Title : Proposed Workflow of 3D Modelling conversion and enhancement in Quantity Surveying Profession  
 Author/s : Lam Tatt Soon, Hasnanywati Hassan, Nazirah Zainul Abidin, Myzatul Aishah Kamarazaly, Boon Tik Leong and Kenn Jhun Kam  
 Institution : Taylor's University, Universiti Sains Malaysia  
 E-mail : lamtatt.soon@taylors.edu.my
  
5. Time : 16.00 – 16.15 PM  
 Paper ID : 223  
 Title : Industry 4.0 in the Malaysian Construction Industry and its Adoption Challenges  
 Author/s : Mohd Afiq Azinuddin Bin Tayib, Nor Azmi Bakhary and Che Khairil Izam Bin Che Ibrahim  
 Institution : Universiti Teknologi MARA (UiTM)  
 E-mail : afiqazinuddin@gmail.com

6. Time : 16.15 – 16.30 PM  
Paper ID : 229  
Title : Customers' Interests in Sustainable Townships and Smart Home Features in Malaysia  
Author/s : Sahithi Ajjarapu, Assoc. Prof. Dr. Ir. Che Maznah Mat Isa, Divya Ganesan, Dr. Nur Kamaliah Mustaffa, Prof. Dr. Christopher Nigel Preece and Ahmad Yazed Yahaya  
Institution : Veltech Rangarajan Dr. Sagunthala R & D Institute of Science and Technology, Universiti Teknologi MARA, Abu Dhabi University, Sime Darby Property  
E-mail : chema982@uitm.edu.my
7. Time : 16.30 – 16.45 PM  
Paper ID : 236  
Title : Technology? Financial? Viability or What Challenges and Benefits of Eco and Reflective Roof in Malaysia  
Author/s : Leong Boon Tik, Tey Cheng Fern, Soon Lam Tatt, Kam Kenn Jhun and Ang Fuey Lin  
Institution : Taylor's University  
E-mail : leongboontik@gmail.com

**TECHNICAL SESSION 3**  
**9 DECEMBER 2020**  
**(09.30 AM – 11.15 AM)**  
**(Kuala Lumpur Time Zone – UTC/GMT +8)**

**WEBEX 1: STRUCTURE AND MATERIALS**

1. Time : 09.30 – 09.45 AM  
Paper ID : 55  
Title : Mechanical Properties of Fly Ash Bottom Ash (FABA) Geopolymer Hybrid Concrete using Portland Cement  
Author/s : Monita Olivia, Rizky Noviandri, Gunawan Wibisono and Iskandar Romey Sitompul  
Institution : Universitas Riau  
E-mail : monitaolivia@gmail.com
2. Time : 09.45 – 10.00 AM  
Paper ID : 182  
Title : The Correlation Between Split Tensile and Flexural Strength with Compressive Strength of Crumb Rubber-Rice Husk Ash Concrete  
Author/s : Habib Abdurrahman, Gunawan Wibisono, Mia Qoryati, Iskandar Romey Iskandar and Monita Olivia  
Institution : Universitas Riau  
E-mail : g.wibisono@eng.unri.ac.id ; habib.abdurrahman@student.unri.ac.id
3. Time : 10.00 – 10.15 AM  
Paper ID : 243  
Title : Numerical Model of Finned Circular Shear Panel Damper for Multi-direction Seismic Excitation  
Author/s : Andika Monanta Emilidardi, Angga Fajar Setiawan, Iman Satyarno and M. Sunarso  
Institution : Universitas Gadjah Mada  
E-mail : angga.fajar.s@ugm.ac.id ; andika.emilidardi@mail.ugm.ac.id
4. Time : 10.15 – 10.30 AM  
Paper ID : 246  
Title : Investigation of Fast Connection (Slot Clamp Type) Mechanics for Instant Steel House with Finite Element Analysis: Back to Build Post-Disaster  
Author/s : Angga Fajar, Ashar Saputra, Iman Satyarno and L.Himawan  
Institution : Universitas Gadjah Mada  
E-mail : angga.fajar.s@ugm.ac.id
5. Time : 10.30 – 10.45 AM  
Paper ID : 251  
Title : Method Assessment of Bridge Conditions Using Vibration Mode Patterns  
Author/s : Sukamta Sukamta, Bagus Acung Billahi, Susilo Adi Widyanto and Han Ay Lie  
Institution : Diponegoro University  
E-mail : bagusacung50@gmail.com
6. Time : 10.45 – 11.00 AM  
Paper ID : 253  
Title : Quantification of Bacteria Self-Healing Efficiency on Concrete Cracks  
Author/s : Hamidah Mohd. Saman, Noorhana Hussain, Mohd. Khairil Iqmal Ghazali and Kartini Kamaruddin  
Institution : Universiti Teknologi MARA (UiTM)  
E-mail : hamid929@uitm.edu.my
7. Time : 11.00 – 11.15 AM

- Paper ID : 254  
 Title : Feasible Design Tensile Capacity of Post-Installed Anchors Based on The New Eurocode 2: Part 4 (2018)  
 Author/s : Lieu Thai Ng, Eva S.W. Wong and Daniel T.W. Looi  
 Institution : Swinburne University of Technology, Konsortium Malaysia  
 E-mail : lthng@swinburne.edu.my
- 8 Time : 11.15 – 11.30 AM  
 Paper ID : 67  
 Title : Study on Partial Replacement of Cement with Limonite in Mechanical Strength of Mortar  
 Author/s : Md. Shahjalal, Jesika Rahman, Afia Farzana, Lutful Habib, Khadiza Binte Jalal and Mohd Mezanur Rahman  
 Institution : Military Institute of Science and Technology, University of Texas,  
 E-mail : mdshahjalal0036@gmail.com
- 9 Time : 11.30 – 11.45 AM  
 Paper ID : 22  
 Title : Optimal Sensor Placement for Accelerometer in Single-Pylon Cable-Stayed Bridge  
 Author/s : Akhmad Aminullah, Bambang Suhendro and Raka Bagus Panuntun  
 Institution : University Gadjah Mada  
 E-mail : akhmadaminullah@ugm.ac.id, bsuhendro@ugm.ac.id, [raka.bagus.p@mail.ugm.ac.id](mailto:raka.bagus.p@mail.ugm.ac.id)

## WEBEX 2: STRUCTURE AND MATERIALS

1. Time : 09.30 – 09.45 AM  
 Paper ID : 261  
 Title : The Maximum Allowable Peak Ground Acceleration of a Six Storey Building Based on Micro tremor and Numerical Analyzes  
 Author/s : Agustinus Sri Pandu and Henricus Priyosulistyo  
 Institution : Universitas Gadjah Mada  
 E-mail : priyo\_ugm@ugm.ac.id
2. Time : 09.45 – 10.00 AM  
 Paper ID : 263  
 Title : The Bond Strength and Damping Properties of Mortar Joint using Rubber Tire Crumbs  
 Author/s : Restu Faizah, Henricus Priyosulistyo and Akhmad Aminullah  
 Institution : Universitas Muhammadiyah Yogyakarta, Universitas Gadjah Mada  
 E-mail : restu.faizah@umy.ac.id
3. Time : 10.00 – 10.15 AM  
 Paper ID : 265  
 Title : Using Calcium Oxide and Accelerator to Control the Initial Setting Time of Mortar in 3D Concrete Printing  
 Author/s : Antoni Antoni, David Christian Widjaya, Alexander Ricardo Koentjoro Wibowo, Jimmy Chandra, Pamuda Pudjisuryadi and Djwantoro Hardjito  
 Institution : Petra Christian University  
 E-mail : antoni@petra.ac.id
4. Time : 10.15 – 10.30 AM  
 Paper ID : 266  
 Title : Numerical Simulation of Spalling and Moisture Evaporation in Concrete Tunnel Linings Exposed to Fire  
 Author/s : Zobaer Saleheen and Renga Rao Krishnamoorthy  
 Institution : Universiti Teknologi MARA (UiTM)

- E-mail : shauravce100@gmail.com, rao@uitm.edu.my
5. Time : 10.30 – 10.45 AM  
 Paper ID : 267  
 Title : Optimization on Geometry Design of Double-Layer Space Trusses  
 Author/s : Yazmin Hamid and Nurul Najihah Abd Rahim  
 Institution : Universiti Teknologi MARA (UiTM)  
 E-mail : minbelle@yahoo.com
6. Time : 10.45 – 11.00 AM  
 Paper ID : 269  
 Title : Numerical Investigation of Structural Behavior of Timber-Glass Composite Wall Panel  
 Author/s : Maged Abdullah and Mohd Khairul Kamarudin  
 Institution : Universiti Teknologi MARA (UiTM)  
 E-mail : mkhairul3965@uitm.edu.my ; maged7135@gmail.com
7. Time : 11.00 – 11.15 AM  
 Paper ID : 270  
 Title : Effect of Palm Oil Bottom Ash (POBA) On Concrete Mechanical Properties of Fresh and Hardened Ultra-High-Performance Concrete (UHPC)  
 Author/s : Izzani Farhana Baharudin, Nurul Huda Suliman, Sakhiyah Abdul Kudus and Nuradila Izzaty Halim  
 Institution : Universiti Teknologi MARA (UiTM)  
 E-mail : nurul\_huda@uitm.edu.my ; ezzanyy96@gmail.com
8. Time : 11.15 – 11.30 AM  
 Paper ID : 193  
 Title : Effect of Replacement Area Ratio on Bearing Capacity Improvement of Peat Soil Columns Stabilised using MUF-P Polymer Resin  
 Author/s : Mohd Nazrin Mohd Daud, Nik Norsyahariati Nik Daud and Jestin Jelani  
 Institution : Universiti Putra Malaysia & National Defence University Malaysia  
 E-mail : hassan\_seth@yahoo.com

### WEBEX 3: STRUCTURE AND MATERIALS

1. Time : 09.30 – 09.45 AM  
 Paper ID : 272  
 Title : Impacts of Steel LNG Tanks Aspect Ratio on Seismic Vulnerability Subjected to Near-Field Earthquakes  
 Author/s : Noor Sharari, A. Hokmabadi and R. Xu  
 Institution : University of Technology Sydney  
 E-mail : noor.sharari@student.uts.edu.au
2. Time : 09.45 – 10.00 AM  
 Paper ID : 273  
 Title : Load-Displacement Behavior of Soil-Pile Interaction under Lateral Action  
 Author/s : Thevaneyan Krishta David and Renga Rao Krishnamoorthy  
 Institution : Universiti Teknologi MARA (UiTM)  
 E-mail : thevaneyan@uitm.edu.my
3. Time : 10.00 – 10.15 AM  
 Paper ID : 274  
 Title : Shear Failure of Pile in Clay due to Soil- Structure Interaction  
 Author/s : Thevaneyan Krishta, Syahrie Safri Peter and Renga Rao Krishnamoorthy  
 Institution : Universiti Teknologi MARA (UiTM)

- E-mail : thevaneyan@uitm.edu.my
4. Time : 10.15 – 10.30 AM  
 Paper ID : 275  
 Title : RC beams Strengthened with Near Surface Mounted Carbon Fiber Reinforced Polymer (CFRP) Plate at Short Term Saltwater Exposure  
 Author/s : Amiruddin Mishad, Mohd Hisbany Mohd Hashim, Azmi Ibrahim, Mohammad Hazizi Jamal and Dicken Anak Baboh  
 Institution : Universiti Teknologi MARA (UiTM)  
 E-mail : amiruddinmishad@uitm.edu.my
5. Time : 10.30 – 10.45 AM  
 Paper ID : 276  
 Title : Assessment on Bonding Strength of Cross Laminated Timber made from Light Red Meranti Manufactured by Vacuum Press Method  
 Author/s : Muhammad Shaiful Nordin, Norshariza Mohamad Bhkari, Lum Wei Chen Nazatul Syuhada Zainal and Zakiah Ahmad  
 Institution : Malaysian Timber Industry Board (MTIB), Universiti Teknologi MARA (UiTM)  
 E-mail : shanacshan@gmail.com
6. Time : 10.45 – 11.00 AM  
 Paper ID : 278  
 Title : Effect of Kenaf Core to the Physical Properties of Cement-Sand Brick for Non-Load Bearing Walls  
 Author/s : Mohd Fadzil Arshad, Nurul Aini Salehuddin, Zakiah Ahmad, Mohd Zaim Mohd Nor and Abdul Hadi Hassan  
 Institution : Universiti Teknologi MARA (UiTM)  
 E-mail : mohdfadzil.arshad@uitm.edu.my, aein86@yahoo.com
7. Time : 11.00 – 11.15 AM  
 Paper ID : 279  
 Title : Bond Strength of Different Mechanically Rebar-Spliced Embedded in Concrete under Pull Out Test  
 Author/s : Nursafarina Ahmad, Nur Fitriah Mohd Rohzi, N.S.N Ain Fatimah Nik Mahmood and M. Hadri Hamidun  
 Institution : Universiti Teknologi MARA (UiTM)  
 E-mail : nursafarina1131@uitm.edu.my
8. Time : 11.15 – 11.30 AM  
 Paper ID : 224  
 Title : Influence of solvable connections on the life cycle assessment of a facade system  
 Author/s : Leonie Scheuring, Melanie Werner, Franziska Rehde and Bernhard Weller  
 Institution : Technische Universität Dresden, Germany  
 E-mail : leonie.scheuring@tu-dresden.de

#### **WEBEX 4: SUSTAINABILITY AND BUILT ENVIRONMENT**

1. Time : 09.30 – 09.45 AM  
 Paper ID : 259  
 Title : Evaluation of Hot Mix Asphalt Mixtures Design Modified with Hydrate Lime  
 Author/s : Noorfaizah Hamzah, Nur'Ain Mat Yusof, Adnan Derahman and Mustaqim Mohamad  
 Institution : Universiti Teknologi MARA  
 E-mail : noorfaizah1209@uitm.edu.my ; dradnan@uitm.edu.my
2. Time : 09.45 – 10.00 AM

- |  |             |   |   |
|--|-------------|---|---|
|  | Paper ID    | : | 277   |
|  | Title       | : | Evaluating the Impact of Junction Type on Emissions Level |
|  | Author/s    | : | Masria Mustafa and Nur Amirah Mohammad Noor               |
|  | Institution | : | Universiti Teknologi MARA                                 |
|  | E-mail      | : | masria@uitm.edu.my  |
3. Time : 10.00 – 10.15 AM
- |  |             |   |  |
|--|-------------|---|--|
|  | Paper ID    | : | 268  |
|  | Title       | : | Effectiveness of Waste Glass as Filler in Hot Mix Asphalt                    |
|  | Author/s    | : | Noorfaizah Hamzah, Nur'Ain Mat Yusof, Adnan Derahman and Ahmad Hafizi Rosely |
|  | Institution | : | Universiti Teknologi MARA  |
|  | E-mail      | : | noorfaizah1209@uitm.edu.my ; nurainyusof@uitm.edu.my                         |

#### **WEBEX 5: CONSTRUCTION MANAGEMENT**

1. Time : 09.30 – 09.45 AM
- |  |             |   |  |
|--|-------------|---|--|
|  | Paper ID    | : | 238  |
|  | Title       | : | Reviewing Quality Control Management of Road Construction Projects     |
|  | Author/s    | : | Debby Willar, Anak Agung Diah Parami Dewi and Febriane Paulina Makalew |
|  | Institution | : | Manado State Polytechnic, Udayana University                           |
|  | E-mail      | : | debbywillar@gmail.com  |
2. Time : 09.45 – 10.00 AM
- |  |             |   |   |
|--|-------------|---|---|
|  | Paper ID    | : | 260   |
|  | Title       | : | Review of Previous Research Methods in Assessing the Benefits of Building Information Modeling (BIM) Investment in the AEC Industry |
|  | Author/s    | : | Jeri Adin Ardani, Christiono Utomo, Yani Rahmawati, and Cahyono Bintang Nurcahyo  |
|  | Institution | : | Sepuluh Nopember Institute of Technology (ITS), Universiti Teknologi Petronas   |
|  | E-mail      | : | jeriadinardani@gmail.com  |

# *Certificate of Appreciation*

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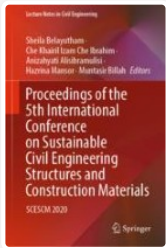


Prof. Dr. Zakiah Ahmad

Dean, Faculty of Civil Engineering, Universiti Teknologi MARA (UiTM), Malaysia




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# Using Calcium Oxide and Accelerator to Control the Initial Setting Time of Mortar in 3D Concrete Printing

[Antoni Antoni](#) , [David Christian Widjaya](#), [Alexander Ricardo Koentjoro Wibowo](#), [Jimmy Chandra](#), [Pamuda Pudjisuryadi](#) & [Djwantoro Hardjito](#)

Conference paper | [First Online: 07 April 2022](#)

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## Abstract

In recent years, 3D printing has attracted a lot of attention in the construction industry. Compared with general concrete construction, 3D concrete printing has higher flexibility in creating concrete's shape and design. 3D concrete printing requires the precise control of fresh concrete properties such as flowability, extrudability, and resistance to segregation during printing process. The initial setting time of the concrete also needs to be

controlled as it needs to adhere to the next layer and then harden rapidly in order to support the upper layer. This study proposes a method to control the initial setting time of the concrete for the 3D printing process by using a mixture of calcium oxide powder and accelerators. The study showed that using 5–10% calcium oxide and 2–4% accelerator by mass of cement, the initial setting of the concrete can be varied. It is also shown that adding only accelerator prolongs the setting time of the mixture due to the plasticizer contained therein. By using calcium oxide power, the initial setting time of the concrete can be hastened and the combination of calcium oxide powder and accelerator can reduce the initial setting time while maintaining good workability of the mixture. The addition of accelerator also increases the early compressive strength of the concrete mixture.

Keywords

- 3D concrete print**
- Calcium oxide**
- Accelerator**
- Initial setting time**
- Compressive strength**

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# Using Calcium Oxide and Accelerator to Control the Initial Setting Time of Mortar in 3D Concrete Printing

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**Abstract.** In recent years, 3D printing has attracted a lot of attention in the construction industry. Compared with general concrete construction, 3D concrete printing has higher flexibility in creating concrete's shape and design. 3D concrete printing requires the precise control of fresh concrete properties such as flowability, extrudability, and resistance to segregation during printing process. The initial setting time of the concrete also needs to be controlled as it needs to adhere to the next layer and then harden rapidly in order to support the upper layer. This study proposes a method to control the initial setting time of the concrete for the 3D printing process by using a mixture of calcium oxide powder and accelerators. The study showed that using 5–10% calcium oxide and 2–4% accelerator by mass of cement, the initial setting of the concrete can be varied. It is also shown that adding only accelerator prolongs the setting time of the mixture due to the plasticizer contained therein. By using calcium oxide powder, the initial setting time of the concrete can be hastened and the combination of calcium oxide powder and accelerator can reduce the initial setting time while maintaining good workability of the mixture. The addition of accelerator also increases the early compressive strength of the concrete mixture.

**Keywords:** 3D concrete print, calcium oxide, accelerator, initial setting time, compressive strength.

## 1 Introduction

Three-dimensional (3D) printing, also known as “additive manufacturing,” is an advanced manufacturing process that can automatically generate complex geometric shapes from a computer-assisted model [1,2]. Currently, limited forms of building structures are available due to restricted shapes of formwork but with 3D concrete printing method various complex shapes can be constructed [3]. The 3D concrete printing construction method still faces many challenges that need to be address simultaneously [4], from the construction process[5–8], printing machines and its precision and tolerance [9,10], design and structural modelling [11,12], and the hardened properties of the fabricated member [13–15]. The material used in 3D printing

has several factors that need to be considered, including extrudability, shape retention, thixotropy, and buildability [16–18].

In 3D concrete printing, extrudability can be defined as the ability of a material to be pumped out through the extruder or nozzle without any interference/blockage in the pipe [19]. Like extrudability, shape retention is also an important factor for 3D concrete printing. After extrusion, the material must retain its shape according to the dimensions of the extruder. Thixotropy can be defined as the time interval during which the material loses its extrudability; for 3D printing concrete, this is always earlier than the setting time [20].

In 3D printing, buildability is a challenging problem. To overcome this, the material that has been extruded must produce sufficient viscosity and yield stress before the second layer begins to fall on it [21,22]. The main challenge is to determine the best mix of materials to be able to flow out from the printing nozzle smoothly as well as to make a mortar that does not experience slump or sagging and self-compaction after extrusion [23,24]. Although these two requirements contradict each other, they can be achieved by successively separate processes. First, the material must be extrudable and maintain its shape when applied to a printing bed. Second, the layer that has been applied must not sag with the application of the layer above it. Finally, the material must have good bonding between layers in order to achieve better rigidity and strength. Therefore, materials that have high yield stress and low viscosity are the best materials for this method [25,26].

The exact composition of the binder and aggregate, and the particle size distribution should be designed carefully for better printability of different construction designs [27–29]. Various additives, such as superplasticizer, retarder, and accelerators, can be used to increase the strength of the printed material. An accelerator is not sufficient to produce such material if the ratio is not adjusted correctly while an inadequate retarder does not allow the material to be pumped through hoses, which can damage the pump and the distribution system [26].

One behavior of the fresh concrete properties that also influence the buildability is the windows of time for the best printing result [30,31]. After the addition of water into the mixture, certain time need to be elapsed for the chemical reaction to proceed before the fresh concrete exhibit a suitable yield stress and viscosity for the printing process. This behavior further complicated the printing process and the material need to be precisely controlled for the optimum results. The optimum period is closely related to the initial setting time of the mortar, as it is varied with the mixture composition of the fresh mortar.

This study explores the use of local sand and cement as the material for the 3D concrete printing process and calcium oxide powder and accelerator to control the initial setting time of the mortar mixture. The high content of calcium oxide in cementitious mixture is known to cause flash setting in concrete [32], and adding small amount of it can hasten the setting time of the concrete and give the concrete structural strength to sustain the following layer. To modify the yield stress and viscosity of the mortar matrix, accelerator with plasticizer effect is also added in to the mixture. By adding or reducing the amount of the admixture, the setting time hence the printing time can be controlled. Such a parametric material study can show the behavior of the additive and can be used as a guide to modify the mix design to comply with machine

and design requirements. The evaluated fresh and hardened mortar properties include workability, initial setting time, and compressive strength.

## 2 Experimental Study

### 2.1 Materials and Mix Design

The fresh and hardened behavior of 3D-printed concrete is studied by investigating the mortar mixture with various admixture. The fine aggregate was sourced from Lumajang quarry in East Java, the cement used was Ordinary Portland cement from Semen Indonesia, the calcium oxide (CaO) powder was obtained from a local producer, and the accelerator used was Sikacim from SIKA. The fine aggregate was graded before mixing to ensure uniform consistency. The Fineness Modulus of the sand used was kept at 2.19. CaO was selected to increase the strength and to speed up the initial setting time and accelerator was added to improve the workability and early age strength of the mortar. Before deciding on the mix design for this study, several preliminary tests were conducted to investigate the dosage required for each parameter, additional admixture such as superplasticizer and calcium hydroxide was also considered as the potential candidate to accelerate the initial setting time, however the effect was found to be reversed, i.e. the initial setting time of the mixture was prolonged.

The mix design for 3D concrete printing was compiled from other studies where the mass ratio of sand to cement can be varied from 0 to 2.5. Adding more sand can increase the yield stress but susceptible to bleeding occurrence, while the addition of fine powder such as fly ash, nano silica, or nano clay can improve the cohesion of the mixture [16,28,33]. Hence for the current study, the ratio of sand to cement was selected at 0.5 to reduce the need of other fine powder material in the mixture. The high amount of cement in the mixture also can provide a high strength buffer due to the imperfect condition of the printing process, the bond between layers, and uncertainty in the mortar compaction. Water to cement ratio was kept at 0.3 from the preliminary trial that give the optimum workability. The resulting mix designs investigated in this study are shown in Table 1.

**Table 1.** Mixture codes and mix design of the mortar

Mix Code	w/c	Water (gr)	Cement (gr)	Sand (gr)	CaO (gr)	Accelerator (gr)
C					-	-
CA2	0.3	60	200	100	-	4
CA4					-	8
CCo5					10	-
CCo5A2	0.3	60	200	100	10	4
CCo5A4					10	8
CCo10					20	-
CCo10A2	0.3	60	200	100	20	4
CCo10A4					20	8

## 2.2 Specimen Preparation and Testing

Materials and equipment were prepared according to the mix design. Mixing was done by dry mixing cement and sand evenly before pouring water into the mixture. The accelerator was then slowly added while stirring followed by the CaO powder. After the mixture was uniform, it was poured into the flow table cone to measure its flow diameter in the flow table test according to ASTM C230 [34]. The test was carried out at room temperature ranging from 28 to 30°C and at a relative humidity of 78–80%. The target flow diameter can be correlated with the yield stress of the mortar, and the flow diameter of 13-23 cm is suitable to be used as the printing material for the 3D concrete printing process, with the optimum value at 15-19 cm, according to Tay et al [30].

The mixture was then cast into 5 cm cube formworks for compressive strength test and filled halfway into 15 cm cube molds for the setting time test. The setting time test was done using a mortar penetrometer and the penetration stress recorded in correlation with time since the addition of water. The mortar penetrometer test was conducted in according to ASTM C403 [35].

The compressive strength specimens were cured in water at room temperature until one day before the compressive strength test. The compressive strength test is conducted at 3, 7, 14, and 28 days from casting, with three replications using universal testing machine.

## 3 Results and Discussion

### 3.1 Preliminary Study

A preliminary study is needed to determine the material variables that would be used as the boundary condition in this study. The change of initial setting time is an essential factor in 3D concrete printing and the dosage of admixtures that influence the change is still unknown.

The materials considered as the admixture were calcium oxide, calcium hydroxide, accelerator, and superplasticizer. It was observed that each admixture has a different effect on the initial setting time. The addition of superplasticizer always causes longer initial setting time because the water to cement ratio was kept constant for all mix designs. Combination of superplasticizer and calcium oxide or calcium hydroxide always resulted in longer setting time than the control (cement only) mixture. Adding calcium hydroxide only also has a slower initial setting time than the control mixture, similar to the superplasticizer, even though it is combined with an accelerator.

Meanwhile, the accelerator has a similar initial setting time with the control mixture and the addition of calcium oxide powder always produced a mixture with faster initial setting time.

After conducting a preliminary test, superplasticizer and calcium hydroxide were not used because they did not accelerate the initial setting time. When a longer initial setting time is needed, for example, with long printing cycle time, these admixtures can be considered. Accelerator, when combined with calcium oxide, produced faster initial

setting time than the mix design control. The CaO powder dosage used was 5% and 10% of the cement mass and the accelerator was used at 2% and 4% of the cement mass; thus, their combined effect on the initial setting time could be observed. The maximum limit for CaO was set at 10% due to possible flash setting and low workability at higher CaO dosage.

### 3.2 Workability Control

The flow diameter measures mortar workability in the flow table test. The accelerator dosage is limited to 4% because the initial setting time can be extended further when adding dosage beyond that, as the accelerator chosen in this research also contain some plasticizer. The result of the flow diameter of the mixture is shown in Fig. 1.

Adding CaO to the mortar mixture reduced the workability slightly while the accelerator produced a larger flow diameter. Addition of CaO at 5% and 10% reduced the flow diameter from 14.6 cm to 14 cm and 11.8 cm, respectively. The addition of 2% and 4% accelerator, by mass of cement, increased the mixture flow to a pumpable condition. This result showed that CaO and accelerator could be added together to control the initial setting time and workability of the mortar mixture.

The mixture composition of the mortar still need to be adjusted with the parameters of the printing machine, thus the optimization process of the mix design still excluded the addition of supplementary cementitious materials into the concrete mixture. Furthermore, to control the consistency of the mixture, viscosity modifying agent (VMA) can also be added into the mixture when the flow diameter is too high [36].

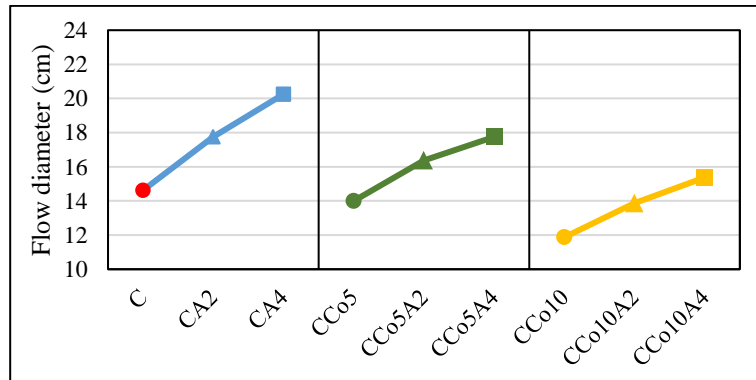


Fig. 1. Flow diameter of the fresh mortar with variations of additive.

### 3.3 Initial Setting Time

The initial setting time test was carried out using the mortar penetrometer at 15-minute intervals for all of the mixtures. The initial setting time is defined as the time needed until the penetration pressure reached 500 psi, however the changes of the penetration resistance can give the indication of the hardening process in the mortar mixture. Higher

penetration resistance showed increase of stiffness and strength to sustain the upper layer in the 3D printing process. This hardening process is essential in reducing the elastic buckling and plastic collapse at high upper layer count [37].

The change in the mortar's hardening process can be observed by its initial setting time as seen in Fig. 2. The solid red line was the control mixture without any admixture. It can be seen that the time needed to reach the initial setting time decreases with increasing CaO dosage. The reduction of setting time was shown to progress at exponential rate with the increase of CaO dosage. At 5% dosage, the setting time was reduced 21 minutes, while from 5 to 10% dosage, the initial setting time reduction was 40 minutes. A faster setting time occurred when adding CaO mostly because of the increase of temperature due to the exothermic reaction of the CaO. At higher CaO dosage the mixture could cause very rapid setting even flash setting and could reduce the workability of the mixture.

On the contrary to the CaO, the initial setting time increased with increasing accelerator dosage. The mortar mixture with addition of accelerator only have longer initial setting time compared to the control mixture, however the benefit of adding accelerator is found on the increase of workability and the early strength of the mortar. The combination of CaO and accelerator changed the initial setting time at a different rate and can be utilized to control the behavior of the fresh concrete in the 3D printing process.

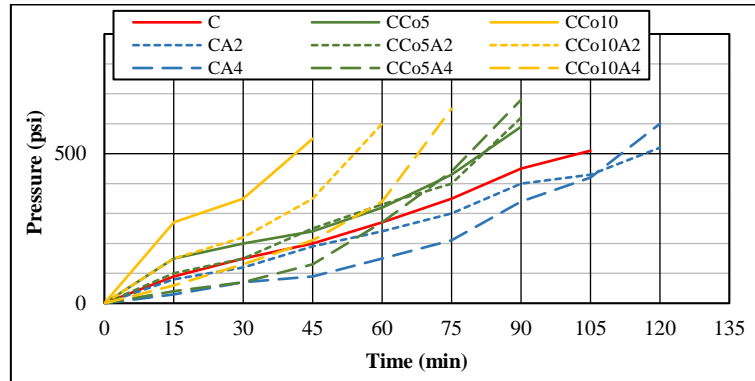


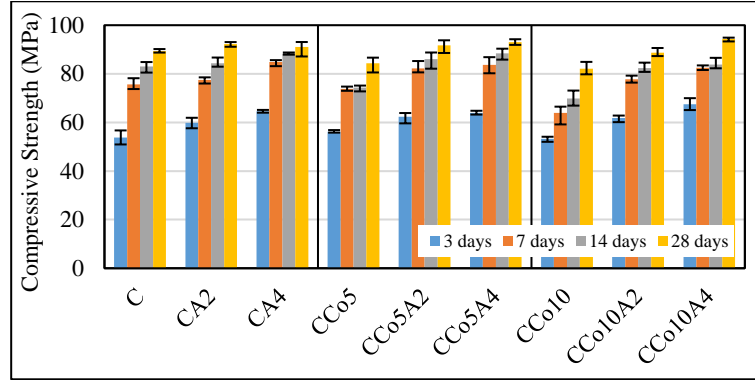
Fig. 2. Penetration pressure into the fresh mortar to measure the hardening process with time.

### 3.4 Compressive Strength

The compressive strength test was carried out to examine the effect of adding CaO and accelerator on the mortar strength. The concrete compressive strength test was carried for each variable at 3, 7, 14, and 28 days. The results of the mortar compressive strength test are shown in Fig. 3.

The compressive strength of the mortar was very high due to the low sand to cement ratio and low water to cement ratio. The high cement content also aimed to cause a faster initial setting time and increase the cohesion of the mixture. The use of accelerator was also found to increase the early strength and later strength of the mortar

mixture. Adding 5% CaO did not have any detrimental effect on the compressive strength. At 10% CaO, there was a reduction in the compressive strength of the mortar. However, with the addition of accelerator, the final strength of the mixture for each CaO series can be increased and is higher than the control mortar.



**Fig. 3.** Increase of compressive strength of the mortar specimen with age.

The effect of using an accelerator on the initial setting time tends to be less beneficial but not detrimental because it does not slow down the initial setting time. However, when considering its benefit to increase the compressive strength, it is more beneficial because the accelerator increases the initial and final compressive strength. This is shown by the CA4 mixture strength at 3 days of 64.6 MPa while the 28-day compressive strength was 91.1 MPa.

Using only CaO reduced the initial and final strength of the mortar with a higher strength loss at higher CaO dosage. The CCo10 achieved a 3-day strength of 53.3 MPa and 28-day strength of 82.0 MPa, and lower than that of the control mortar. The best combination of faster initial setting time and compressive strength was found with the CCo10A4 mixture with an initial setting time of 60–90 minutes and the highest 28-day compressive strength of 94.3 MPa.

## 4 Conclusions

The results of this research lead to the following conclusions:

- The combination of calcium oxide and accelerator as an additive can control the initial setting time of the concrete material needed in the 3D concrete printing process. Calcium oxide can cause a higher reaction rate in the concrete while the accelerator can control the concrete flowability and increase the compressive strength.
- Calcium oxide can hasten the initial setting time of the concrete; however, the dosage should be limited to 10% to avoid possible flash setting or rapid hardening at higher dosage.

- Mortar workability needs to be increased by the use of accelerator as the calcium oxide tends to reduce the workability. The target flow diameter should be greater than 13 cm in the flow table test to ensure a good extrusion process.
- By changing the CaO and accelerators dosage, the optimum printing window can be adjusted to achieve the best rheological properties of the fresh concrete. However the optimum dosage need to be determined to comply with the printing machine parameter and concrete mixture.

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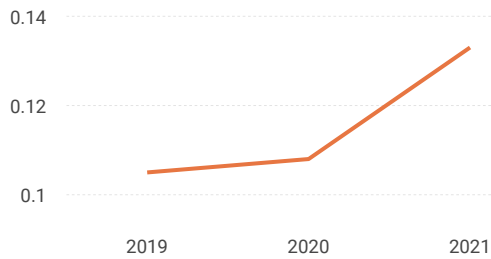
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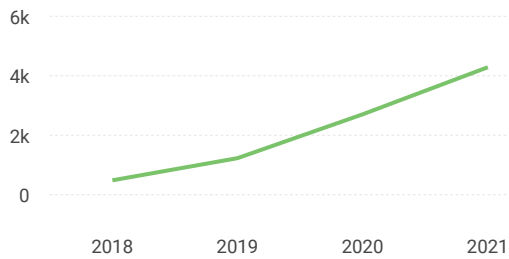
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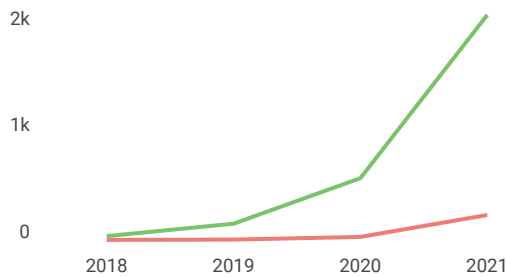
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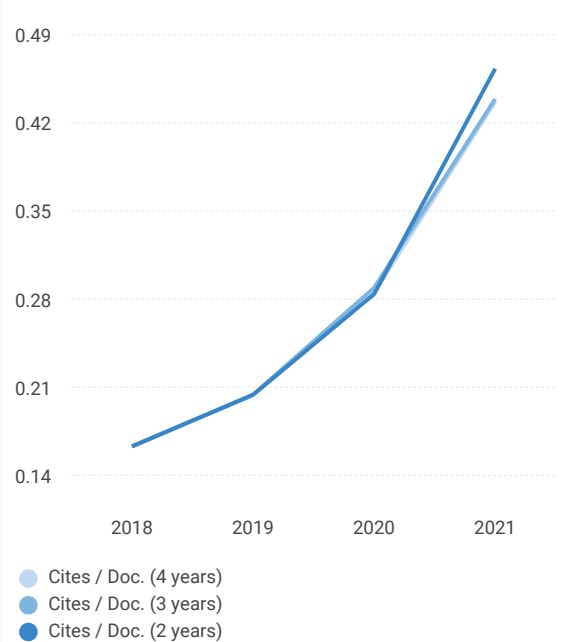
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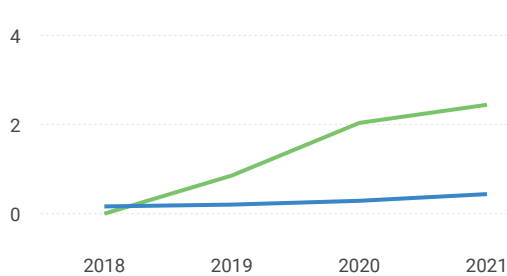
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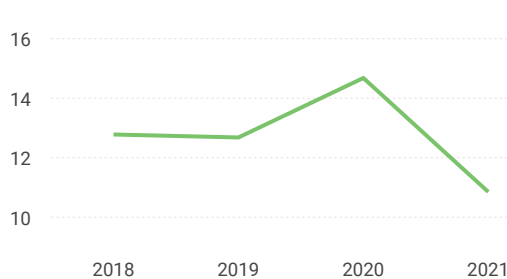
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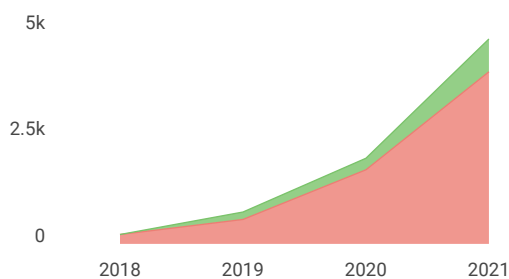
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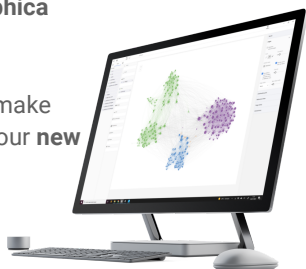
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