4th International Conference on Rehabilitation and Maintenance in Civil Engineering (ICRMCE)

Best Western Solo Baru
July, 11-12 2018

DIES NATALIS 42 UNS 2018

"Smart Rehabilitation and Maintenance in Civil Engineering for Sustainable Construction"

UNS UNIVERSITAS SEBELAS MARET

In collaboration with:

HAKI

fib Indonesia

Partner Universities:

TU Delft Delft University of Technology

KIT Karlsruhe Institute of Technology

Brawijaya University

Muhammadiyah Yogyakarta University

UTM Malaysia University of Technology

Diponegoro University

Mataram University

Jenderal Soedirman University

Jember University

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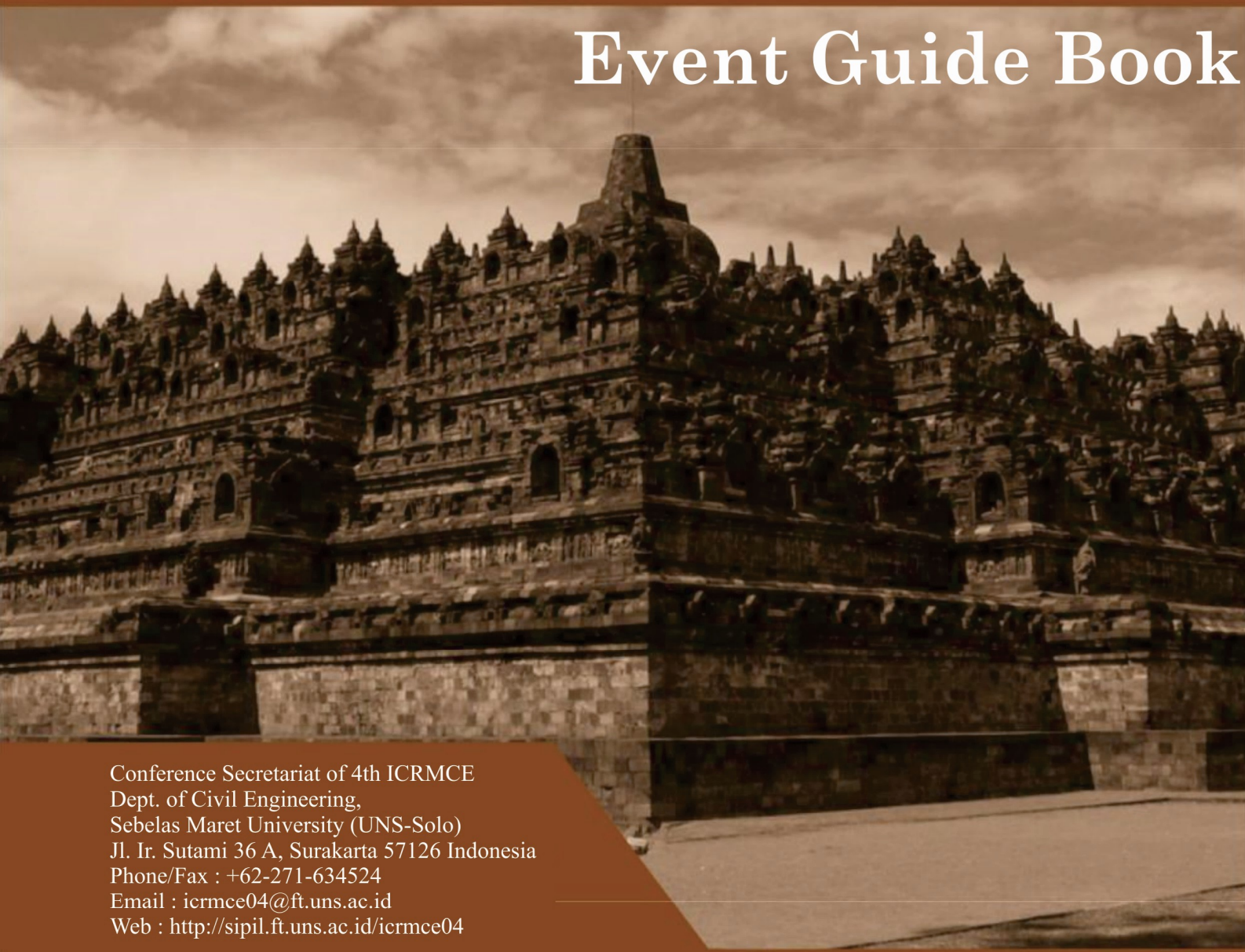
Event Guide Book



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UNS UNIVERSITAS SEBELAS MARET

In collaboration with: HAKI, fib Indonesia

Partner Universities: TU Delft Delft University of Technology, KIT Karlsruhe Institute of Technology, Hiroshima University, Muhammadiyah Sugyakarta University, UTM Malaysia University of Technology, Diponegoro University, Mataram University, Jenderal Soedirman University, Jember University

International Conference on Rehabilitation and Maintenance in Civil Engineering

Solo, Indonesia, July, 11-12 2018

This book belongs to

PREFACE

Today and tomorrow, civil engineers, researchers, educators, students and related industries from all over the world are expected to work hand-in-hand to build a sustainable future for our next generation. We do hope that this conference will be a meaningful event for sharing ideas and expertise and strengthening our network. The 4th International Conference on Rehabilitation and Maintenance in Civil Engineering (4th ICRMCE) is the continuing series of the previous ICRMCE. The theme of the conference is *Smart Rehabilitation and Maintenance in Civil Engineering for Sustainable Construction*.

Rehabilitation and maintenance in civil engineering is not less important than planning and designing. The excessive load, natural hazard, lack of construction procedures and material degradation are causes of infrastructure defects. Rehabilitation and maintenance help to extend the building and infrastructure service life. Rehabilitation is defined as the whole efforts to regain building and infrastructures functions against defect or structure weakening. This covers many aspects such as repairing, strengthening, revitalization, renovation and restoration. While maintenance is the effort to keep the building and infrastructure service as planned.

The objective of the event is to provide a forum for researchers, academicians, government agencies, consultants, and contractors to exchange experiences in technological advancement and innovation related to rehabilitation and maintenance in civil engineering. There may some relevant topics with the theme: building and infrastructure rehabilitation and maintenance, advanced technology for rehabilitation technique, special experiences on rehabilitation, infrastructure performance, performance related to natural hazards, smart materials, damage assessment, maintenance strategy, testing and inspection, restoration on historical building, service life modeling, life cycle cost analyses, code and policy, etc.

For your information, the first, second, and third ICRMCE were held successfully in 2009, 2012, and 2015 respectively. Please kindly check http://sipil.ft.uns.ac. Those events were attended by hundreds of researchers in different areas of civil engineering. Seeing to the success of previous conferences, we thought that the forum has to be enhanced and be broaden. For this, the committee offered some domestic and international institutions to participate as partners. We are very happy that some universities and institution such as TU Delft Netherland, KIT Germany, Hiroshima University Japan, UTM Malaysia (UTM), Diponegoro University Semarang, UMY Yogyakarta, Jendral Soedirman University, Jember University, Mataram University, and HATI are ready to participate. They assign some staffs as scientific committee and/or invited speaker. We are also very pleased that in this year event, the Indonesian Fédération Internationale du Béton, ***fib*** chapter Indonesia is actively involved as co-organiser.

Thus, it can be reported here that compared to the previous ones, there are significant distinction of the 4th ICRMCE:

1. The number of the paper: while we have 48, 75, 60 papers in the first, second, and third events respecively, this 4th ICRMCE, much more papers will be presented.

2. The involvement of partners: we did not offer the events to any partners for the previous events, they were solely conducted by Sebelas University. However, in this year, 4 overseas togather with 6 domestic universities plus 1 non universities were involved and have been working as partners.
3. The breakthrough symposium is being performed during the conference. The symposium is organised by fib Indonesia inviting the world class expert presenting the state of the art finding in this area.
4. We are honored that the presidient of fib has already here as one of keynote speakers and will officially open the fib Indonesia chapter.

More than 300 abstract has been submitted and finally only 140 papers are strictly selected by peer reviewer to be presented. All of the paper will be published in Scopus indexed Matec. They are coming from 14 countries such as Singapore, Thailand, Malaysia, Japan, Taiwan, Korea, Arab Emirates, Quwait, Khazakhstan, Australia, Czech, Netherland, Nigeria and Indonesia as a host. We are going to hear and discusse the presented result of the researchs. On top of that, we are here very lucky that some outstanding keynote speakers from leading universities are presenting the state of the art finding in civil engineering. They are, Prof. Masyhur Irsyam from ITB, Dr. Apiniti from Kasetsart Univ., Thailand, Prof. Petr Hajek from Czech, Prof. Sri Raviandrajah Rasiah from University Technologi of Sydney, Prof. Hung Jiung Liao from NTUST Taiwan, Prof. Keninichiro Nakarai from Hiroshima University Japan, Prof. Muhammad bin Ismail from UTM Malaysia, and Prof. Chan Weng Tat from NUS Singapore.

The committee extent very kind thanks to all participants for the success of the conference. They are Rector of UNS, the Dean of Engineering Faculty of UNS, the keynote speakers, and invited speakers. Many special thanks to PT PP, PT WIKA, PT HK, PT Adhi Karya, PT HKI, PT Brantas Abipraya, PT Global Sakti, Paton Buana Semesta, and last but not least to Yayasan Alped (a non profit scholarship institustion of the UNS Civil Engineering alumny) for supporting the conference. I would like to express special thanks to Prof. Han Ay Lie for her incredible personal support, as she works almost day and night for the conference.

Finally, on behalf of the committe, we appologise if there are many shortcomings, starting from the beginning, during, and until the end of this event.

Have a nice conference and enjoy your stay in cultural city of Solo.

Thank you,

Yusep Muslih Purwana
4th ICRMCE Chairman

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10. Ary Setiawan
11. Syafi'i
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65. Yanto, Universitas Jenderal Soedirman, Indonesia
66. Yusep Muslih Purwana, Sebelas Maret University (UNS), Indonesia

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In cooperation with

4th ICRMCE RUNDOWN

Date/ Day	Schedules	Activities	Annotations	Locations
July, 11 2018	8.00 - 8.30	Registration Tour Registration		Registration Desk
	8.30 - 8.45	Opening: Indonesian National Anthem Reading of Event Agenda by MC	Conductor MC	Convention Room (Ruby 2)
	8.45 - 8.55	Report speech by Chairman of the Committee	Chairman	
	8.55 - 9.10	Opening and Welcoming Remark by Rector of Sebelas Maret University	Rector of Sebelas Maret University	
	9.10 - 9.15	Rewarding to Sponsorship	Rector of Sebelas Maret University	
	9.15 - 9.45	Keynote speech and plenary sessions	MC	
		Prof.Kennichiro Nakarai, Hiroshima University, "Shear Strength of Reinforced Concrete Beams: Effects of Concrete Volumetric Change and Limestone Aggregate"	Moderator : Ary Setyawan, Ph.D.	
	9.45 - 10.15	Coffee break 1	MC	Lunch and Dining Room (Ruby 1)
	10.15 - 10.45	**Prof. Hung Jiun Liao**, National Taiwan University of Science and Technology, "Ground Anchor Corrosion – the Beginning of the End"	Moderator : Ary Setyawan, Ph.D.	Convention Room (Ruby 2)
	10.45 - 11.15	**Prof. Mohammad Bin Ismail,** Universiti Teknologi Malaysia, "Rehabilitation of Corrosion of Reinforcement for Sustainable Construction"		
	11.15 - 11.45	**Prof. Ing. Petr Hajek,** Czech Technical University, "Advanced high performance concrete structures – challenge for sustainable and resilient future"		
	11.45 - 12.00	**Launching** fib **Indonesia**	fib	
	12.00 - 13.00	Pray and Lunch	MC	Lunch and Dining Room (Ruby 1)
	13.00 - 15.00	Parallel Class (shift 1)	MC, Parallel Class	Class A, B, C, D, E
		fib Mini Symposium	MC	Convention Room (Ruby 2)
	15.00 - 15.30	Coffee break 2	MC	Lunch and Dining Room (Ruby 1)
	15.30 - 17.00	Parallel Class (shift 2)	MC, Parallel Class	Class A, B, C, D, E
		fib Mini Symposium	MC	Convention Room (Ruby 2)
	17.00	End of the first day Conference	MC, Parallel Class	Class A, B, C, D, E

Date/ Day	Schedules	Activities	Annotations	Locations
July, 11 2018	19.30 - 22.00	Dinner Party	MC	Lunch and Dining Room (Ruby 1)
	19.00 – 19.30	• **Registration** • **Performance (Electone)**		
	19.30 – 19.35	Event Opening	MC	
	19.35 – 19.45	Opening Remark by Chairman of the Committee	Chairman	
	19.45 – 20.00	Opening Remark by Dean of Engineering Faculty	Dean of Engineering Faculty	
	20.00 – 20.15	Rewarding to Sponsorship	Rector of Sebelas Maret University	
	20.15 – 21.15	Performance (Electone)		
	21.15 – 21.45	• Impression Speech • Photo session • Announcement for tomorrow schedule	MC	
July, 12 2018	8.00 - 8.30	Registration		Registration Desk
	8.30 - 8.45	Opening: Reading of Event Agenda by MC	MC	Convention Room (Ruby 2)
	8.45 - 9.15	Keynote speech and plenary sessions **Prof. Chan Weng Tat,** National University of Singapore	Moderator: Dr. Eng. Syafi'i	
	9.15 - 9.45	**Dr. Sri Ravindrarajah Rasiah,** University Technology of Sydney, "Waterproofing practices in Australia for the Building Construction"		
	9.45 - 10.15	Coffee break 1	MC	Lunch and Dining Room (Ruby 1)
	10.15 - 10.45	**Prof. Masyhur Irsyam,** Bandung Institute of Technology, "Development of the National Seismic Hazard Maps 2017 for Design of Earthquake Resistance Design in Indonesia"	Moderator : Dr. Techn. Sholihin As'ad	Convention Room (Ruby 2)
	10.45 - 11.15	**Assoc. Prof. Apiniti Jotisankasa,** Kasetsart University,"Bioengineering for erosion control and slope stabilization in Thailand: research and practice"		
	11.15 - 12.00	**Yusep Muslih Purwana, Ph.D,** Sebelas Maret University, "Seeing Surakarta based on Civil Engineering Perspective"		
	12.00 - 13.00	Pray and Lunch	MC	Lunch and Dining Room (Ruby 1)
	13.00 - 15.00	Parallel Class (shift 1)	MC, Parallel Class	Class A, B, C, D, E, F, G
	15.00 - 15.30	Coffee break 2	MC	Lunch and Dining Room (Ruby 1)
	15.30 - 16.35	Parallel Class (shift 2)	MC, Parallel Class	Class A, B, C, D, E, F, G
	16.35 - 17.30	End of the second day Conference	MC, Parallel Class	Convention Room (Ruby 2)
July, 13 2018	7.30 - 8.00	Registration		Best Western Premiere
	8.00 - 12.00	Conference Tour		Yogyakarta
	12.00 - 13.00	Pray and Lunch		
	13.00 - 16.35	Conference Tour		

Note :
1 st Floor : Registration and Parallel Class
2 nd Floor : Convention Room (Ruby 2), Lunch and Dining Room (Ruby 1)

fib Mini Symposium: Past Achievements, Current Issues and Future Development of Concrete

Day	Time (WIB)			Duration (mnt)	Topic of Presentation	Invited Speaker	Moderator	Room
July, 11 2018	13.00	-	13.30	30	***From Model Code 2010 to 2020***	**Prof. Hugo Corres Peiretti** (*fib* President)	Prof. Stefanus Kristiawan	Ruby 2
	13.30	-	13.40	10	Q & A			
	13.40	-	14.10	30	***Long time efforts to improve the seismic resilience of concrete structures in Indonesia***	**Prof. Iswandi Imran** (Bandung Institute of Technology)		
	14.10	-	14.20	10	Q & A			
	14.20	-	14.50	30	***Past, present and future of prefabication***	**Dr. David Fernández-Ordóñez** (*fib* Secretary General)		
	14.50	-	15.00	10	Q & A			
	15.00	-	15.30	**Coffee Break**				
	15.30	-	16.00	30	***Biodegradation of concrete in tropical marine environment-field experimental study at north Java sea***	**Prof. Bambang Suhendro** (Gadjah Mada University)	Prof. Antonius	Ruby 2
	16.00	-	16.10	10	Q & A			
	16.10	-	16.40	30	***Progressive precast and demountable construction system from HPC for sustainable and resilient building***	**Prof. Petr Hajek** (Chair of COM7 *fib*)		
	16.40	-	16.50	10	Q & A			
	16.50	-	17.20	30	***Concrete development need in 3D printing development era***	**Hadjar Seti Adji** (Director of Human Capital Management- PT Waskita Karya)		
	17.20	-	17.30	10	Q & A			

PARALLEL CLASS A
DAY 1

Time (WIB)	Paper ID	Paper Title	Author Names	Category	Room
13.00 - 13.10		Moderator			Class A
13.10 - 13.30	343	Improvement the California Bearing Ratio of Expansive Subgrade using SiCC Column	Agus Setyo Muntohar	Invited Speaker	
13.30 - 13.40	18	Numerical modelling of dynamic stability of RCC dam	Omer Mughieda*, ADU	G	
13.40 - 13.50	19	Stability evaluation of Sermo dam, Yogyakarta, using two components acceleration time histories causes by Java subduction earthquake scenarios	Partono Windu*, Universitas Diponegoro	G	
13.50 - 14.00	22	Probabilistic Seismic Hazard Assesment for Surakarta, Central Java, Indonesia	Muhammad Adi Ibrahim*, PT Wijaya Karya (Persero) tbk; Yusep Purwana, University of Sebelas Maret	G	
14.00 - 14.10	39	Parametric Study On The Behavior Of Bagasse Ash-Calcium Carbide Residue Stabilized Soil	John Hatmoko*, Universitas Atma Jaya Yogyakarta, INDONESIA	G	
14.10 - 14.20	42	Application of Woven Tires Waste Gabion Wall as Slope Reinforcement for Preventing Landslide in Laboratory	Arwan Apriyono*, Jurusan Teknik Sipil Universitas Jenderal Soedirman	G	
14.20 - 14.30	43	Study of Geotechnical Aspect Base on GIS as Basic Design of Road	Mrs Indrayani*; Arfan Hasan; Andi Herius; Ahmad Mirza, State Polytechnic of Sriwijaya	G	
14.30 - 15.00		Question and Answer			
15.00 - 15.30		Coffee Break			Ruby 2
15.30 - 15.35		Moderator			Class A
15.35 - 15.45	46	Bearing Capacity Analysis of Helical Pile Foundation on Peat	Ferry Fatnanta, Universitas Riau; Andarsin Ongko*, University of Riau	G	
15.45 - 15.55	47	Inverse Distance Weighting Interpolated Soil Properties And Their Related Landslide Occurrences	Purwanto Santoso*; Yanto Yanto; Arwan Apriyono; Rani Suryani, Universitas Jenderal Soedirman	G	
15.55 - 16.05	55	The Effect of Cement Stabilization on the Strength of the Bawen's Siltstone	Edi Hartono*, Diponegoro University	G	
16.05 - 16.15	76	Chemical Stabilization of Expansive Soil using Wood Charcoal Powder and Salt	Paksitya Putra*; Mokhammad Farid Ma'ruf; Diah Ayu Paramiswari; Abdullah Ilham, Teknik Sipil Universitas Jember	G	
16.15 - 16.25	158	Ground Settlement Prediction of the Improved Embankment with Prefabricated Vertical Drain in Soft Soil	Siswoko Saputro*, National Taiwan University of Science and Technology	G	
16.25 - 16.35	200	Determination of the seismicity and peak ground acceleration for Lombok Island: An evaluation on tectonic setting	Didi Agustawijaya*, University of Mataram	G	
16.35 - 17.05		Question and Answer			

*G=Geotechnical *M=Management *Mt=Materials *S=Structure *H=Hydrology *T=Transportation

PARALLEL CLASS A
DAY 2

Time (WIB)	Paper ID	Paper Title	Author Names	Category	Room
13.00 - 13.10		Moderator			Class A
13.10 - 13.30	4	Proposed Concrete Compaction Method Using An Electrical Internal Vibrator: A Review Of Compaction Standard For Concrete In Laboratory According To Sni 2493:2011	agus maryoto*, Jenderal Soedirman University	Invited Speaker	
13.30 - 13.40	6	Rice Husk As An Alternative Energy For Cement Production And Its Effect On The Chemical Properties Of Cement	agus maryoto*, Jenderal Soedirman University	Mt	
13.40 - 13.50	16	Repair of Rigid Pavement Using Micro concrete Mtials	Jonbi Jonbi*, Pancasila University	Mt	
13.50 - 14.00	17	Effect of added the Polycarboxylate Ether on Slump Retention and Compressive Strength of the High Performance Concrete	Jonbi Jonbi*, Pancasila University	Mt	
14.00 - 14.10	49	Mechanical Properties of Concrete Composed of Sintered Fly Ash Lightweight Aggregate	puput risdanareni*, universitas negeri malang; M. Mirza Abdillah Pratama, Universitas Negeri Malang	Mt	
14.10 - 14.20	52	The Effect of Additional Aluminium to the Strength of Geopolymer Paste	Aulia Rahman, ITS; Januarti Ekaputri*, ITS	Mt	
14.20 - 14.30	64	The influence of molarity variations to the mechanical behaviour of geopolymer concrete	Purwanto Khusnan*, Diponegoro University; Ay Lie Han, Universitas Diponegoro; Nuroji Nuroji, Diponegoro University; Januarti Ekaputri, ITS	Mt	
14.30 - 15.00		Question and Answer			
15.00 - 15.30		Coffee Break			Ruby 2
15.30 - 15.35		Moderator			Class A
15.35 - 15.45	73	Slant shear strength of polyvinil acetat (pva) modified fiber reinforced mortar	Stefanus Kristiawan*, Universitas Sebelas Maret	Mt	
15.45 - 15.55	82	Modulus of elasticity of the graded concrete	M. Mirza Abdillah Pratama*; Bunga Arumsari Mutiara Wulandari, Universitas Negeri Malang; Zhabrinna Zhabrinna, University of Birmingham	Mt	
15.55 - 16.05	89	Microscopic Investigation on Concrete Cured Internally by Using Porous Ceramic Roof-tile Waste Aggregate	Azusa Shigeta*, Hiroshima University; Yuko Ogawa, Hiroshima University; Kenji Kawai, Hiroshima University	Mt	
16.05 - 16.15	276	Evaluation of Bond Strength Between Normal Concrete and High Performance Fiber Reinforced Concrete(HPFRC)	SK MUIZ SK ABD RAZAK*, Universiti Malaysia Perlis	Mt	
16.15 - 16.25	288	Effects of Microbial Agents to The Properties of Fly Ash-Based Paste	Kiki Dwi Wulandari*, Department of Civil Engineering, Institut Teknologi Sepuluh Nopember; Januarti Ekaputri, ITS	Mt	
16.25 - 16.55		Question and Answer			

PARALLEL CLASS B
DAY 1

Time (WIB)	Paper ID	Paper Title	Author Names	Category	Room
13.00 - 13.10		Moderator			Class B
13.10 - 13.20	201	The Effect of Egg Shell Powder on The Compression Strength of Fine-Grained Soil	Niken Surjandari*, Sebelas Maret University Surakarta	G	
13.20 - 13.30	206	Contribution of suction on the stability of reinforced soil retaining wall	Nurly Gofar*, Nanyang Technological University; Hanafiah Hanafiah, Sriwijaya University	G	
13.30 - 13.40	233	Method of Removing Secondary Compression on Clay Using Preloading	EGA DHIANTY*, Institut Teknologi Sepuluh Nopember; INDRASURYA B. MOCHTAR, Institut Teknologi Sepuluh Nopember	G	
13.40 - 13.50	235	Effect of Moisture Content of Cohesive Subgrade Soils	Dian Agustina*, Universitas Riau Kepulauan; Adnan Bin Zainorabidin, Universiti Tun Hussein Onn Malaysia	G	
13.50 - 14.00	266	Predicting Heave on The Expansive Soil	Willis Diana*, Universitas Muhammadiyah Yogyakarta	G	
14.00 - 14.10	267	Water Table Evaluation Post the Construction of Canal Blocks on Peatland in West Kalimantan, Indonesia	Henny Herawati*, Tanjungpura University; Dwi Farastika, Tanjungpura University	G	
14.10 - 14.20	275	The Effect of Lime Addition in Physical and Mechanical Soil Properties Due to Drying Process on Bengawan Solo River Embankment in Plangwot Area, Lamongan	Alpha Putri*, Institut Teknologi Sepuluh Nopember	G	
14.20 - 14.30	277	Application of Microtremor HVSR Method for Preliminary Assesment of Seismic Site Effect in Ngipik Landfill, Gresik	Siti Nurlita Fitri*, Institut Teknologi Sepuluh Nopember Surabaya	G	
14.30 - 15.00		Question and Answer			
15.00 - 15.30		Coffe Break			Ruby 2
15.35 - 15.45		Moderator			Class B
15.45 - 15.55	278	A Study on Association between Tilt Angle, Solar Insolation Exposure and Output of Solar PV Panel Using BIM 3D Modelling	SK MUIZ SK ABD RAZAK*, Universiti Malaysia Perlis	M	
15.55 - 16.05	279	The Implementation of Sustainable Concept in Waste Management through Project Life Cycle Process in Gold Coast	Zhabrinna Zhabrinna*, University of Birmingham; M. Mirza Abdillah Pratama, Universitas Negeri Malang	M	
16.05 - 16.15	297	Are Indonesia contractors ready to implement Last Planner System? - An early investigation	Jati Hatmoko*, Universitas Diponegoro	M	
16.15 - 16.25	313	Corporate entrepreneurship level: a case study of contractors in Indonesia	Harijanto Setiawan*, Universitas Atma Jaya Yogyakarta	M	
16.25 - 16.35	341	Reducing Carbon Emission in Construction Base On Project Life Cycle (PLC)	Mochamad Wibowo*, Diponegoro University Semarang	M	
16.35 - 17.05		Question and Answer			

PARALLEL CLASS B
DAY 2

Time (WIB)	Paper ID	Paper Title	Author Names	Category	Room
13.00 - 13.10		Moderator			Class B
13.10 - 13.20	92	Effect of co-existing ions on lead leaching behavior from hardened cement paste	Takumi Nishiwaki*, Hiroshima university	Mt	
13.20 - 13.30	100	Effect of Recycled Coarse Aggregate (RCA) with Surface Treatment on Concrete Mechanical Properties	Anggun Atmajayanti*; Chrisyanto Saragih G, Universitas Atma Jaya Yogyakarta; Yanuar Haryanto, Jenderal Soedirman University	Mt	
13.30 - 13.40	104	Development of Self-compacting Fibre Reinforced Structural Mortar for Concrete Repair	Ernie Sahari*; Dr. A.B.M Amrul Kaish; Nyiam Len Fong, Infrastructure University Kuala Lumpur (IUKL)	Mt	
13.40 - 13.50	108	Microstructure and mechanical properties of FA/GGBS-based geopolymer	Apriany Saludung*, Hiroshima University	Mt	
13.50 - 14.00	133	Strength development of cement-treated sand using different cement types cured at different temperatures	Lanh Ho*; Kenichiro Nakarai; Kenta Eguchi, Hiroshima University; Takashi Sasaki, Denka Co., Ltd; Minoru Morioka, Denka Co., Ltd	Mt	
14.00 - 14.10	180	The Influence Of OPC And PPC On Compressive Strength Of Alwa Concrete	Fedya Aryani*, Institut Teknologi Sepuluh Nopember Surabaya	Mt	
14.10 - 14.20	194	The usage of Andesit sand grinded and foaming-agent on porosity of foam concrete	Erwin Rommel*, Muhammadiyah University of Malang	Mt	
14.20 - 14.30	198	A Comparative Analysis of the Quality of Concrete Blocks Produced from Coconut Fibre, Oil Palm Empty Fruit Bunch, and Rice Husk as a Filler Mtials	MOHAMMAD LUTFI*, STT MIGAS	Mt	
14.30 - 15.00		Question and Answer			
15.00 - 15.30		Coffee Break			Ruby 2
15.30 - 15.35		Moderator			Class B
15.35 - 15.45	199	A Preliminary Study of the Low Density Particle Boards Quality using Rice Husk and Oil Palm Empty Fruit Bunch with Plastic Waste Adhesive	MOHAMMAD LUTFI*, STT MIGAS ; Muh Yamin, State Agricultural Polytechnic of Samarinda	Mt	
15.45 - 15.55	252	Characterization and Compressive Strength of Geopolymer Paste Based on Fly Ash	Ari Widayanti*; Ria Asih Aryani Soemitro, Institut Teknologi Sepuluh Nopember Surabaya; Hitapriya Suprayitno; Januarti Ekaputri, ITS	Mt	
15.55 - 16.05	256	The Effect Of Addition Of Banana Tree Bark For Compressive Strenght And Crack Tensile Strenght Of Rice Husk Ash Concrete	Muhammad Rizqi*, University of Jember	Mt	
16.05 - 16.15	289	Experimental Study of Accelerating High Early Strength Concrete under Elevated Temperature, Steaming, and Chemical Admixture of Normal and High Strength Concrete	Suryawan Murtiadi*, Mataram University	Mt	
16.15 - 16.45		Question and Answer			

PARALLEL CLASS C
DAY 1

Time (WIB)	Paper ID	Paper Title	Author Names	Category	Room
13.00 - 13.10		Moderator			Class C
13.10 - 13.20	12	Towards Competitive Traditional Market in Metropolitan City: a proposal of public building policy in Semarang	Ferry Hermawan*, Diponegoro University; Ismiyati Ismiyati, Diponegoro University; Himawan Indarto, Diponegoro University	M	
13.20 - 13.30	63	The Maintenance Priority for Construction Reliability and Sustainability in Ampel Mosque Surabaya	Agung Sedayu*, Maulana Malik Ibrahim State Islamic University of Malang	M	
13.30 - 13.40	95	Intelligent BIM Record Model for Effective Asset Management of Constructed Facility	Md Aslam Hossain*, Nazarbayev University; AHMAD TARMIZI HARON, FKASA	M	
13.40 - 13.50	124	Development of Quality Management System in Maintenance and Monitoring Process of Repair Work Risk-Based in Government Building	Yusuf Latief, Universitas Indonesia; Rossy Machfudiyanto*, Universitas Indonesia; Khairina Pamudji, Universitas Indonesia; Riany Aldesty, Universitas Indonesia	M	
13.50 - 14.00	126	BIM Adoption Towards the Sustainability Of Construction Industry in Indonesia	Zhabrinna Zhabrinna*, University of Birmingham; M. Mirza Abdillah Pratama, Universitas Negeri Malang; Muhammad Yusuf, University of Leeds; Richard Davies,	M	
14.00 - 14.10	143	Improvement of Business Processes in Developing Standard Operation Procedures on Government Building Maintenance Work in Indonesia	Rossy Machfudiyanto*, Universitas Indonesia	M	
14.10 - 14.20	208	Service Life Planning for Electronics, Mechanical and Electrical Components of an Hotel Building	Peter Kaming*, Universitas Atma Jaya Yogyakarta; Michael Boenardi, UAJY; Desi Maryani, UAJY	M	
14.20 - 14.30	227	Current State Mapping of Supply Chain in Engineering Procurement Construction (EPC) Project: A Case Study	Moh Sholeh*, Diponegoro University	M	
14.30 - 15.00		Question and Answer			
15.00 - 15.30		Coffee Break			Ruby 2
15.30 - 15.35		Moderator			Class C
15.35 - 15.45	263	Readiness Of Local Government In Ppp Project Development - Case Of Lrt Bandung	Revana Putri*, Institute Technology Bandung; Reini Wirahadikusumah, Institut Teknologi Bandung	M	
15.45 - 15.55	272	Optimization Of Waste Management Infrastructure Planning Using Linear Programming Model (Case Study Of Waste Management In Sragen Regency)	Albert Pramono Soesanto*, Program Studi Magister Teknik Sipil Sekolah Pascasarjana Universitas Muhammadiyah Surakarta; Mochammad Solikin, Program Studi Magister	M	
15.55 - 16.05	182	User Cost Estimation On The Construction Of Flexible And Rigid Road Pavement	Fajar Handayani*, Universitas Sebelas Maret Surakarta; Florentina Pramesti, Universitas Sebelas Maret Surakarta; Mochamad Wibowo, Diponegoro University Semarang;	M	
16.05 - 16.15	304	The Management Strategy for Government Building Disposal Process in Jakarta	Ayomi Rarasati*, Universitas Indonesia; Mulyadi Mulyadi, Universitas Indonesia	M	
16.15 - 16.45		Question and Answer			

PARALLEL CLASS C

DAY 2

Time (WIB)	Paper ID	Paper Title	Author Names	Category	Room
13.00 - 13.10		Moderator			Class C
13.10 - 13.20	218	Experimental Analysis of T- Beam Reinforced Concrete with hole	Nicxson Pakpahan*, Universitas Sumatera Utara	S	
13.20 - 13.30	224	APPLICATION OF HIGH STRENGTH REINFORCING BARS IN EARTHQUAKE-RESISTANT STRUCTURE ELEMENTS	Kurniawan Kamaruddin*, Institut Teknologi Bandung; Iswandi Imran, ITB; Maulana Derry Imansyah, Institut Teknologi Bandung;	S	
13.30 - 13.40	226	Seismic performance of four-storey building with masonry infilled reinforced concrete frame	isyana hapsari*, universitas sebelas maret; Senot Sangadji, Universitas Sebelas Maret; Stefanus Kristiawan, Universitas Sebelas	S	
13.40 - 13.50	232	Numerical analysis of castellated beam with oval opening	Yanuar Setiawan*, Universitas Islam Indonesia; Ay Lie Han, Universitas Diponegoro; Buntara S. Gan, Department of	S	
13.50 - 14.00	273	PREDICTING BENDING CREEP OF LAMINATED VENEER LUMBER (LVL) SENGON (PARASERIANTHES FALCATARIA) BEAMS FROM INITIAL CREEP TEST DATA	Achmad Basuki*, Universitas Sebelas Maret	S	
14.00 - 14.10	274	One-Way Translational Magnetic Mass Damper Model for Structural Response Control against Dynamic Loadings	SK MUIZ SK ABD RAZAK*, Universiti Malaysia Perlis	S	
14.10 - 14.20	298	A Comparison of Retrofitting Methods on Nursing Faculty Building of Andalas University with Concrete Jacketing and Shear Wall Systems	Fauzan Fauzan*, Andalas University	S	
14.20 - 14.30	300	Survey, Investigation and Repairing on Concrete Wall of Waste Treatment Building	Partogi Simatupang*, Universitas Nusa Cendana	S	
14.30 - 15.00		Question and Answer			

PARALLEL CLASS D
DAY 1

Time (WIB)	Paper ID	Paper Title	Author Names	Category	Room
13.00 - 13.10		Moderator			Class D
13.10 - 13.30	118	Temporal Variations of Bedload Transport Rate and the Grain Size Distribution of Non-Uniform Size Sediment During A Constant Flow Rates	Yusron Saadi*, Universitas Mataram	Invited Speaker	
13.30 - 13.40	10	The Interrelationship between ISTN lake, Babakan lake and the surrounding wells of shallow groundwater using stable isotopes δ 2H and δ 18O for the LakeBank Filtration potential	W Marsiano; S Syafalni*; Wawan Kuswaya; M Falaqi Djamhuri, Institut Sains dan Teknologi Nasional; BungKus Pratikno, National Nuklir Energy Agency	H	
13.40 - 13.50	40	Multisite daily precipitation simulation in Singapore	Suroso Suroso*, Department of Civil Engineering, Jenderal Soedirman University	H	
13.50 - 14.00	65	The Concept of Lomaya And Pilohayanga Dam Rehabilitation Based On Technical And Economic Aspects	Ninik Khorida*, Universitas Sebelas Maret	H	
14.00 - 14.10	115	Priority Development Of Smalldam In Wonogiri Regency	fisnu pramono*, PT. Inakko Internasional Konsulindo; YUNITTA CHANDRA SARI, BBWS Bengawan Solo; Suripin Suripin, Diponegoro University	H	
14.10 - 14.20	116	Surakarta City Flood Control	fisnu pramono*, PT. Inakko Internasional Konsulindo; YUNITTA CHANDRA SARI, BBWS Bengawan Solo; Suripin Suripin, Diponegoro University	H	
14.20 - 14.30	134	Evaluation of watershed carrying capacity for watershed management (a case study on Bodri Watershed, Central Java, Indonesia)	Sriyana Sriyana*, Diponegoro University	H	
14.30 - 15.00		Question and Answer			

PARALLEL CLASS D
DAY 2

Time (WIB)	Paper ID	Paper Title	Author Names	Category	Room
13.00 - 13.10		Moderator			
13.10 - 13.20	150	Evaluation of sediment management for two large reservoirs in Lombok Island	Ery Setiawan; syamsul hidayat*; M Bagus Budianto; IB Giri Putra; Salehudin Salehudin, University of Mataram	H	
13.20 - 13.30	175	Tsunami Simulation using Particle Method	Raden Harya Dananjaya*, Universitas Sebelas Maret	H	
13.30 - 13.40	178	Field Performance of Shalow Recharge Well	Edy Susilo*, Diponegoro University	H	
13.40 - 13.50	148	Technical Audit and Performance Assessment of Irrigation Tlatak in District Magetan	Yuli Iswahyudi*, UNS	H	
13.50 - 14.00	255	Analysis of the Distribution of Domestic Wastewater in the Brantas River Area of Malang City	Bekti Prihatiningsih*, Universitas Merdeka Malang	H	
14.00 - 14.10	257	The Analysis of Ancol Polder System as Flood Prevention Infrastructure in Jakarta	Rian Mantasa Salve Prastica*, Universitas Indonesia	H	
14.10 - 14.20	261	The Impact Of Drainage Towards Roads In Maintenance Cost	Erna Ismiyani*, UNS student; Dewi Handayani, Universitas Sebelas Maret; RR. Rintis Hadiani, Universitas Sebelas Maret	H	
14.20 - 14.30	338	Assesment of temporary protection infrastructure performance related to tidal flood in Mulyorejo, Pekalongan, Indonesia	Slamet Imam Wahyudi*, Universitas Islam Sultan Agung, Semarang	H	
14.30 - 15.00		Question and Answer			

PARALLEL CLASS E

DAY 1

Time (WIB)	Paper ID	Paper Title	Author Names	Category	Room
13.00 - 13.10		Moderator			Class E
13.10 - 13.30	318	Design and optimization of a rubber-bitumen blend in preparation for a rubberized-asphalt road trial in the State of Kuwait	Salah Zoorob*, KISR	Invited Speaker	
13.30 - 13.40	1	Data Mining Applied for National Road Maintenance Decision Support System	Andri Irfan*, Universitas Internasional Batam; Susanty Handayani, Jabodetabek Transportation Authority	T	
13.40 - 13.50	339	Data Mining Applied for Earthwork Movement Optimization of Toll Road Construction Project	Andri Irfan*, Universitas Internasional Batam	T	
13.50 - 14.00	5	Analysis Of Air Pollution As An Impact Of The Change Of Mass Transportation Design	Ismiyati Ismiyati*, Diponegoro University; Ismiyati Ismiyati, Diponegoro University	T	
14.00 - 14.10	7	Performance Analysis of Underpass Gilingan Development	Setiono ST, MSc, Universitas Sebelas Maret; Budi Yulianto*, Sebelas Maret University	T	
14.10 - 14.20	8	Analysis of Signalized Intersections Performance Using IHCM Method and PTV VISTRO Software	Budi Yulianto*, Sebelas Maret University; Setiono ST, MSc, Universitas Sebelas Maret	T	
14.20 - 14.30	13	Control Of Urban Parking Based On Zoning Rates In The Context Of Sustainable Transportation	Ismiyati Ismiyati*, Diponegoro University	T	
14.30 - 15.00		Question and Answer			
15.00 - 15.30		Coffee Break			Ruby 2
15.30 - 15.35		Moderator			Class E
15.35 - 15.45	41	Evaluation of Hub and Spoke Airport Networks in Sumatra Island, Indonesia to increase Efficiency of Air Transportation	Gito Sugiyanto*, Universitas Jenderal Soedirman	T	
15.45 - 15.55	44	Analysis of Travel Pattern and the Need to Develop Sustainable Transportation Infrastructure in Sarbagita Metropolitan Area, Bali-Indonesia	Putu Suthanaya*, Udayana University	T	
15.55 - 16.05	81	Assessment Of Magetan Regency's Road Performance Based On Pavement And Off Pavement Components	Joko Haryanta*, UNS	T	
16.05 - 16.15	105	Correlation Analysis between Speed Bumps Dimensions and Vehicles Speed in Residential Area	RA Dinasty Purnomo A*, Universitas Sebelas Maret; Dewi Handayani, Universitas Sebelas Maret; syafii syafii, Universitas Sebelas Maret	T	
16.15 - 16.25	138	Application of Deflection Bowl Parameters for Assessing Different Structures of Road Pavement	Bagus Hario Setiadji*, Diponegoro University	T	
16.25 - 16.35	144	The Influences of Age and Gender of Students' Motorcycle Riders on Traffic Violations and Accidents in a Small City using a Structural Equation Model	I Suteja*, Universitas Mataram	T	
16.35 - 16.45	146	The Sustainability of Public Transport Operation Based on Financial Point of View	ARIF BUDIARTO*, CIVIL ENGINEERING DEPARTEMENT UNIVERSITY OF SEBELAS MARET SURAKARTA	T	
16.45 - 17.15		Question and Answer			

PARALLEL CLASS E

DAY 2

Time (WIB)	Paper ID	Paper Title	Author Names	Category	Room
13.00 - 13.10		Moderator			Class E
13.10 - 13.20	154	A Study of CO2 Emission Reduction Due to Transportation Activities in Brebes District through Road Repair	Fajar Mubarok*, Universitas Sebelas Maret; Dewi Handayani, Universitas Sebelas Maret; Syafi'i Syafi'i, Univeristas Sebelas Maret	T	
13.20 - 13.30	101	Assessment Of The Road Based On Pci And Iri Roadroid Measurement	Donny Putra*, Universitas Sebelas Maret	T	
13.30 - 13.40	204	The Influence of Vehicle Speed Changes at Mechanistic Performance of Asphalt Mixture	Senja Rum Harnaeni*, Doctoral Program in Civil Engineering, Faculty of Engineering, UNS, Surakarta	T	
13.40 - 13.50	238	Evaluation of Urban Freight Transport Operations in Surakarta City	Budi Yulianto*, Sebelas Maret University	T	
13.50 - 14.00	251	Analysis of Influencing Factors on Using Rental Bikes at Shopping Tourism Sites in Surakarta	Erlin Setyowati*, Universitas Sebelas Maret; Dewi Handayani, Universitas Sebelas Maret	T	
14.00 - 14.10	285	System Model For Physical Conditions of Road Components In Magetan District	Ferro Gilang Kencana*, Universitas Sebelas Maret	T	
14.10 - 14.20	295	Performance Evaluation of a Trunk-A Road in North Central Nigeria	Mustapha Mohammed Alhaji*, Federal University of Technology, Minna; Musa Alhassan, Federal University of Technology, Minna	T	
14.20 - 14.30	311	Application of Android-based Parking Violations Reporting System to Support Green Campus Program	Setiono ST, MSc, Universitas Sebelas Maret; Budi Yulianto*, Sebelas Maret University	T	
14.30 - 14.40	322	The Analysis of Land Use Weights on Road Trace Selection	Mrs Indrayani*, State Polytechnic of Sriwijaya; Erika Buchari, Sriwijaya University; Dinar D.A. Putranto, Sriwijaya University; Edward Saleh, Sriwijaya University	T	
14.40 - 15.00		Question and Answer			

PARALLEL CLASS F
DAY 1

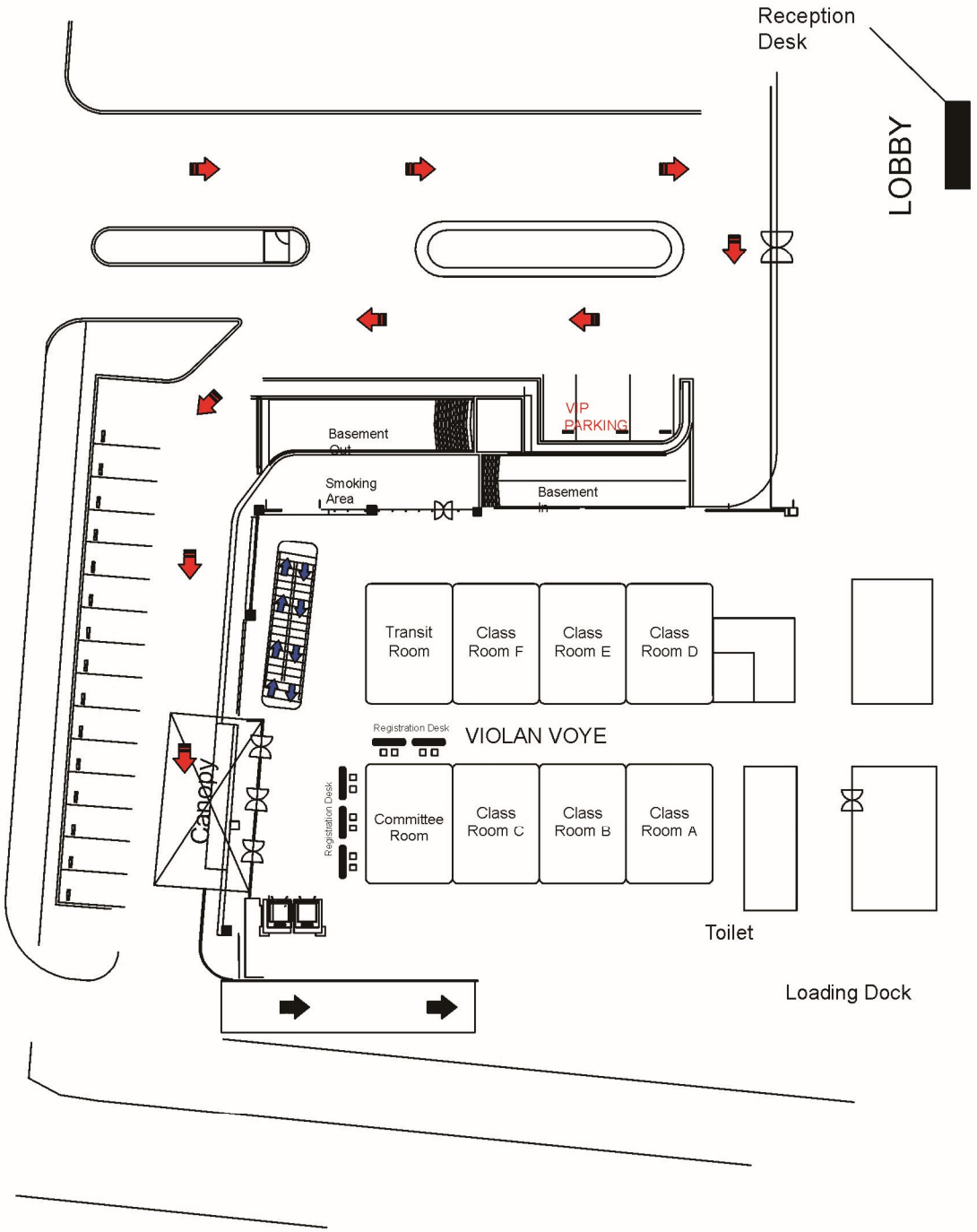
Time (WIB)	Paper ID	Paper Title	Author Names	Category	Room
13.00 - 13.10		Moderator			Class F
13.10 - 13.20	140	Study of Inertia Weight Parameter for Boundary Element Inverse Analysis to Detect RC Corrosion	Syarizal Fonna*, Syiah Kuala University	S	
13.20 - 13.30	58	Analysis of Steel Reinforced Functionally Graded Concrete Beam Cross Sections	Shota Kiryu, Nihon University; Ay Lie Han, Universitas Diponegoro; Ilham Nurhuda, Diponegoro University; Buntara S. Gan*, Nihon University	S	
13.30 - 13.40	210	Aerodynamic Performance of Long Span Steel Truss Bridges in Indonesia	Made Suangga*, Bina Nusantara University; Herry Irpanni, Directorate General of Highway, Ministry of Public Work and Housing	S	
13.40 - 13.50	183	Diagonal Reinforcement as Strengthening to Increase the Stiffness and Strength of Concrete Frame	Yenny Nurchasanah*, Universitas Muhammadiyah Surakarta	S	
13.50 - 14.00	306	Comprehensive condition assessment program on the fire damaged structure – a project case in Singapore	Gunawan Budi Wijaya*, Universitas Kristen Petra	S	
14.00 - 14.10	37	Numerical Analysis on Stress and Displacement of Tapered Cantilever Castellated Steel Beam with Circular Openings	Taufiq Ilham Maulana*; Hakas Prayuda; Bagus Soebandono; Martyana Dwi Cahyati; Eva Hanifatu Zahra, Universitas Muhammadiyah Yogyakarta	S	
14.10 - 14.20	96	Application of NDT Apparatus for Possible Use as Structural Health Monitoring of Concrete Building in the Field	Akmaluddin Akmaluddin*, Universitas Mataram	S	
14.20 - 14.30	320	Crashworthiness assessment of double-hull tanker structures under ship grounding actions	Aditya rio prabowo; Jung Min Sohn; Dong Myung Bae, Pukyong National University; Bangun Harsritanto*, Universitas Diponegoro	T	
14.30 - 14.40	114	The study of ultrasonic pulse velocity on plain and reinforced damaged concrete	Ni Nyoman Kencanawati*, Mataram University	S	
14.40 - 15.00	20	Question and Answer			

PARALLEL CLASS F
DAY 2

Time (WIB)	Paper ID	Paper Title	Author Names	Category	Room
13.00 - 13.10		Moderator			Class F
13.10 - 13.20	121	Analytical Study on Creep Shear Failures of RC Slender Beams without Web Reinforcements	Halwan Saifullah; Kenichiro Nakarai*, Hiroshima University; Nobuhiro Chijiwa, Tokyo Institute of Technology; Koichi Maekawa, Yokohama National University	S	
13.20 - 13.30	142	Influence of Shape Modification and Stirrups On the Axial Capacity of Concrete Columns	Ida Bagus Rai Widiarsa*, Universitas Udayana; Ida Bagus Dharma Giri, Universitas Udayana	S	
13.30 - 13.40	145	Shear Properties Evaluation of Natural Fibre Reinforced Epoxy Composites Using V-Notch Shear Test	Jauhar Fajrin*, Universitas Mataram; Nasmi Sari, Universitas Mataram	S	
13.40 - 13.50	153	Dynamic Bayesian Updating Approach for Predicting Bridge Condition Based on Indonesia-Bridge Management System (I-BMS)	Jojok Widodo Soetjipto*, Universitas Jember; Tri Joko Wahyu Adi; Nadjadji Anwar, Institut Teknologi Sepuluh Nopember Surabaya	S	
13.50 - 14.00	161	Performance of Composite Local Glass Fibre Sheets and Epoxy on Flexural Strengthening of Reinforced Concrete Beams	I Ketut Sudarsana*, Universitas Udayana	S	
14.00 - 14.10	169	Comparative Study on Behaviour of Reinforced Concrete Beam-Column Joints with Reference to Monolith and non-monolith Connection	Ninik Catur Endah Yuliati*, Universitas Merdeka Malang; Sri Murni Dewi; Wisnumurti Wisnumurti; Ari Wibowo, Universitas Brawijaya	S	
14.10 - 14.20	192	Improving Resilience of Moment Frames Using Steel Pipe Dampers	Junaedi Utomo*, Universitas Atma Jaya Yogyakarta	S	
14.20 - 14.30	185	Analytical Prediction on Tension Force of Stirrups in Concrete Beams Longitudinally Reinforced with CFRP Bars	Rendy Thamrin*, Universitas Andalas	S	
14.30 - 15.00		Question and Answer			
15.00 - 15.30		Coffee Break			Ruby 2
15.30 - 15.35		Moderator			Class F
15.35 - 15.45	188	A Comparative Study of Base Isolation Systems featured with Lead Rubber Bearing and Pendulum in Light Rail Transit Structure	Santi Nuraini*; Asdam Tambusay; Priyo Suprobo, Institut Teknologi Sepuluh Nopember	S	
15.45 - 15.55	312	The effect of HVFAC as substitution of fine aggregates to the shear strength of reinforced concrete beams	Ade Lisantono*, Universitas Atma Jaya Yogyakarta	S	
15.55 - 16.05	323	Performance of Glue Laminated Timber Beams Composed of Sengon Wood (Albizia falcatara) and Coconut Wood (Cocos nucifera) with Nylon-Threads Reinforcement	Kusnindar Kusnindar*, Brawijaya University	S	
16.05 - 16.15	79	Stress-strain response of high-volume fly ash self-compacting concrete (HVFA-SCC) under uniaxial loading and its effect on the reinforced HVFA-SCC nominal strength	Stefanus Kristiawan*, Universitas Sebelas Maret	S	
16.15 - 16.25	340	Analysis of Floating House Platform Stability Using Polyvinyl Chloride (PVC) Pipe Material	Henny Adi*, UNISSULA	S	
16.25 - 16.55	30	Question and Answer			

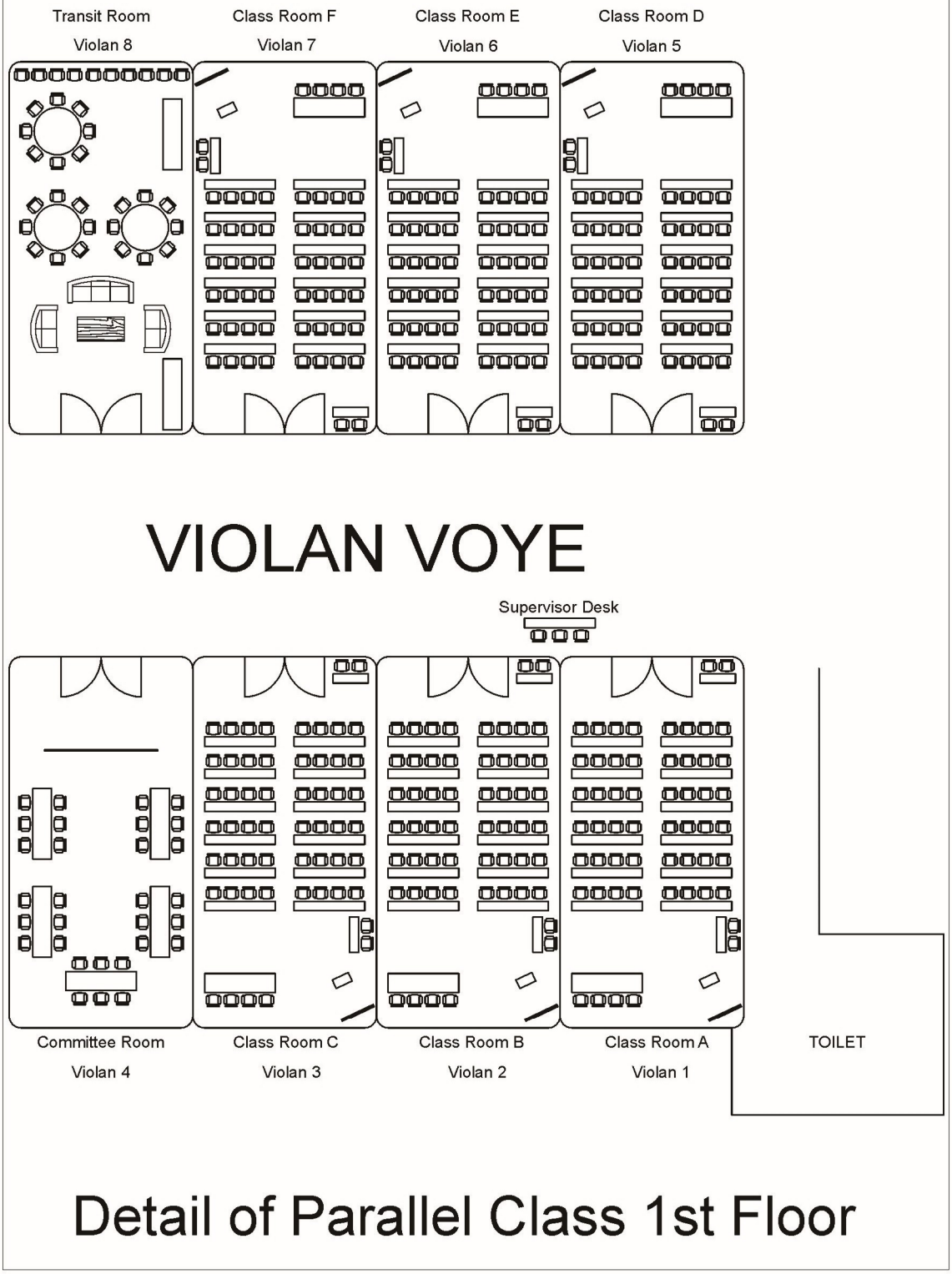
PARALLEL CLASS G
DAY 2

Time (WIB)	Paper ID	Paper Title	Author Names	Category	Room
13.00 - 13.10		Moderator			Ruby 1
13.10 - 13.30	56	Shear-bond behaviour of Fibre Reinforced Polymer (FRP) rods and sheets	Ay Lie Han*, Universitas Diponegoro; Buntara S. Gan, Nihon University; Agung Budipriyanto, Institut Teknologi Sepuluh Nopember	Invited Speaker	
13.30 - 13.40	3	Structural Performance Evaluation of Vertical Housing Model due to Increased Seismic Loads in Semarang Indonesia	Arnie Widyaningrum*; Yanuar Haryanto; Nor Intang Setyo Hermanto, Universitas Jenderal Soedirman	S	
13.40 - 13.50	9	Building evaluation using two component acceleration time histories causes by shallow crustal fault earthquakes with maximum magnitude 7 Mw	Partono Windu*, Universitas Diponegoro	S	
13.50 - 14.00	34	Numerical Study on Beam-Column Connection of Cantilever Precast Concrete Beam with Asymmetric Shape under Static Load	Hakas Prayuda*; Robbi'al Rollyas Syandy; Bagus Soebandono; Taufiq Ilham Maulana; Martyana Dwi Cahyati, Universitas Muhammadiyah Yogyakarta	S	
14.00 - 14.10	88	Peak Ground Acceleration at Surface for Mataram City with a Return Period of 2500 Years using Probabilistic Method	Rian Mahendra Taruna*, Mataram University; Vrieslend Haris Banyunegoro, Stasiun Geofisika Mata Ie. BMKG; Gatut Daniarsyad, Earthquake and Tsunami Center of BMKG	G	
14.10 - 14.20	67	Flexural Performance of HPFRC Plates using PPC and Variation of Steel Fiber Composition	Krisnamurti Krisnamurti*, University of Jember; Agoes Soehardjono; Achfas Zacoeb, University of Brawijaya; Ari Wibowo, Universitas Brawijaya	S	
14.20 - 14.30	74	Effect of monotonic lateral load on the performance of reinforced graded concrete column	M. Mirza Abdillah Pratama*; Gista Prasiwi, Universitas Negeri Malang; Zhabrinna Zhabrinna, University of Birmingham; puput risdanareni, universitas negeri malang	S	
14.30 - 15.00		Question and Answer			

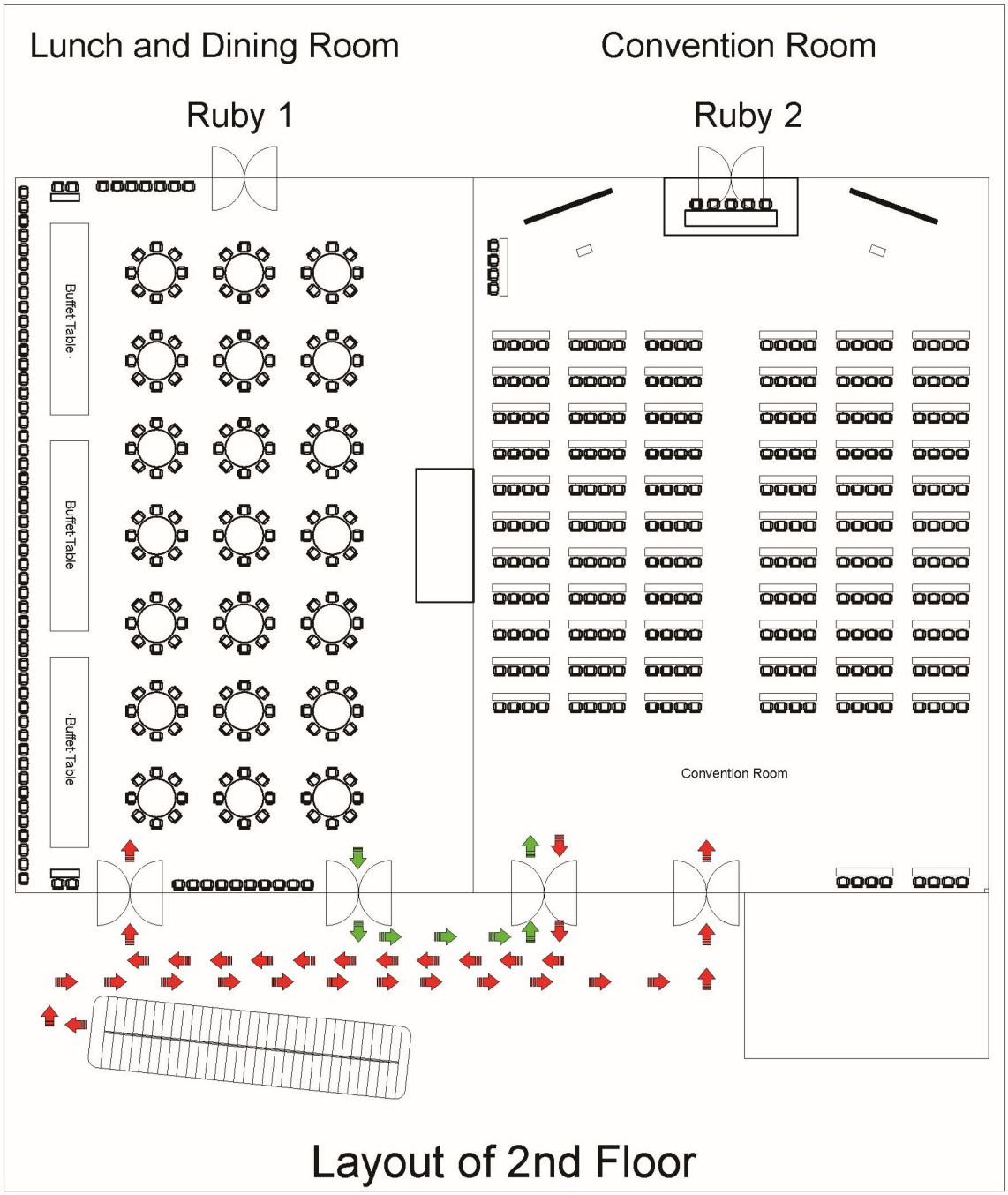


Note : MPV Cars @Basement Parking Area

Layout of Parallel Class 1st Floor



Detail of Parallel Class 1st Floor



Layout of 2nd Floor

Telkom University
College Building

BNI BSD Building
Construction Project

Tamansari Iswara

Casablanca Non-highway
Flyover Project

PT WIJAYA KARYA (Persero) Tbk.

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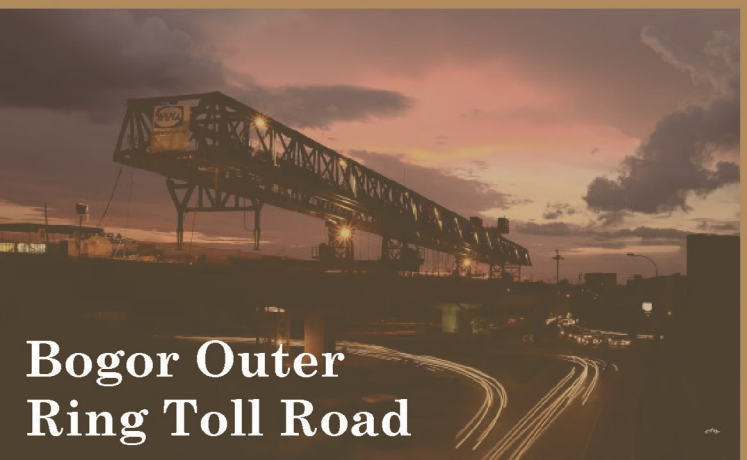
http://www.wika.co.id/project/



Bogor Outer
Ring Toll Road

Jembatan
Merah Putih

http://www.pt-pp.com/our-business/project

CONSTRUCTION & INVESTMENT

PT. PP (Persero) Tbk

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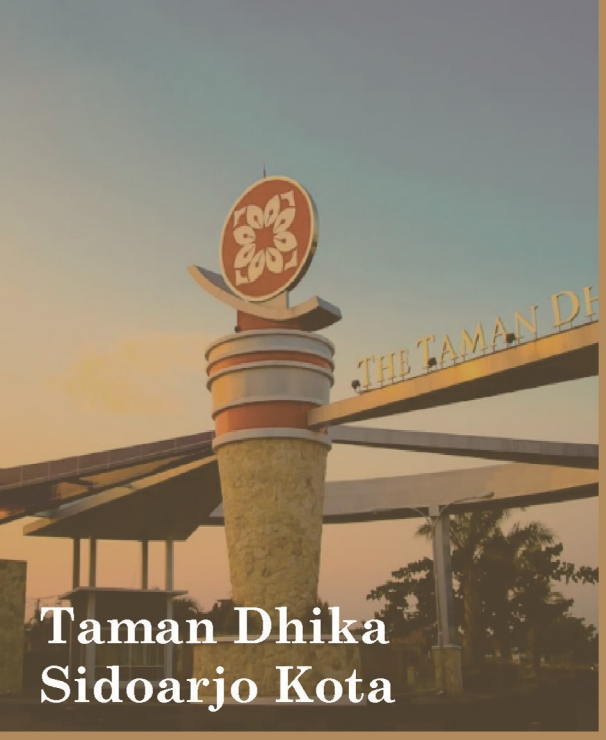

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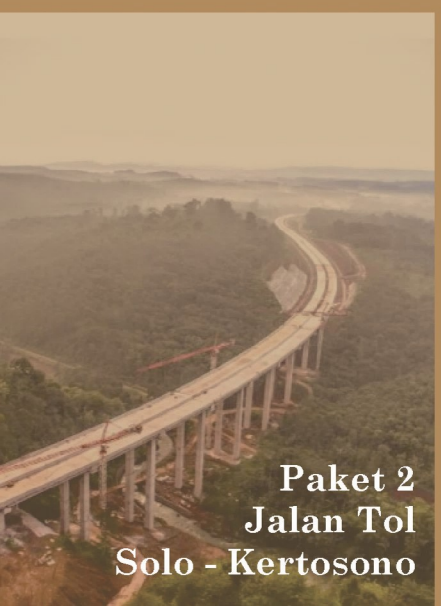

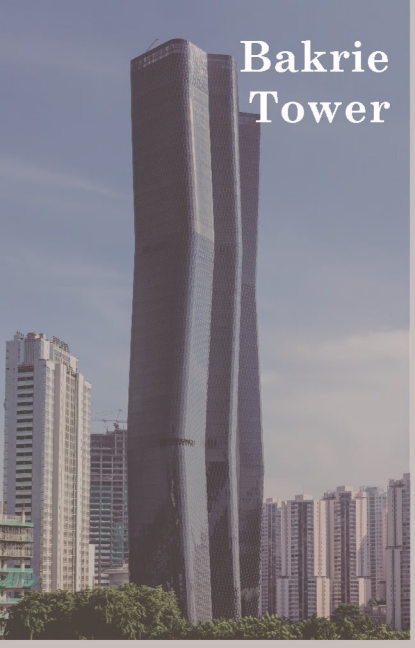

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HAKI

Data mining applied for earthworks optimisation of a toll road construction project

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Abstract. The length of the toll roads operating in Indonesia is still less than in other countries. Significant acceleration is needed to keep up with the country's traffic needs. Acceleration of development should be supported by the development capacities of road operators, one such capacity being earthworks. Data on earthworks can be utilised as a knowledge base and processed via a data mining approach, the results of which form the basis for interpretation and productivity predictions. The aim of this study is to develop a decision support system for the earthworks of a toll road construction project using the approach of data mining historical cases. The data mining approach used an artificial neural network and support vector machine analysis methods. The result is multi-objective optimisation with a genetic algorithm using real-world data from previous Indonesian toll road construction. This work aims to present a practical alternative for the optimisation of earthworks.

1 Introduction

The length of the toll roads operating in Indonesia is low compared to that of other countries. This is despite various parties' belief that the availability of infrastructure has an important role in the growth of the national economy [1]. The growth of transportation infrastructure is key to improving growth and development. From a number of infrastructure provisions, the transport infrastructure sector has a multidimensional impact on the economic growth of other sectors [2]. To realise overall growth, the government must ensure the availability of reliable and adequate transportation infrastructure, supporting its substantial and decisive role in the productivity of the country.

To reach the development level of other countries and achieve the toll road development target, various strategies can be utilised, one of which is simultaneous development in various locations. To make this possible, the toll road development organiser and all stakeholders must continue to develop themselves to maintain, expand and improve the performance of development activities. Simultaneous development in numerous locations can cause problems, one of which relates to resource constraints. For example, the resources required for earthworks require serious attention, because failure in this stage will have an impact on the overall development process [3].

The resources required for earthworks consist of methods of execution, mechanical and human resources, and costly equipment. Developments in technology and road construction methods have encouraged an increased use of machinery in every construction project. Indeed, mechanical tools are vital resources in construction projects [4]. However, the cost

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of earthwork equipment is high. Therefore, the role of construction management in the field of earthworks can have a strong influence on the overall efficiency and profitability of construction work.

The level of efficiency and effectiveness of a piece of earthwork equipment is based on the productivity of the tool. Productivity is used as a guide in determining the duration of each job and the amount of earthwork equipment required. An earthwork equipment management system is operated continuously for roadworks, comprising design, planning, development, operation, maintenance, and control. All stages of the construction management system cycle have equally important roles. The stages of an earthwork equipment management system have a significant influence on maintaining the performance of construction management if followed continuously over a long time. Construction engineering activities have a vital role in improving project performance in terms of meeting budgets; schedules; and safety, quality, and sustainability standards [5]. Earthwork equipment management systems can be developed using various data approaches and other historical records.

Historical data on the productivity and effectiveness of the earthwork equipment used in previous construction projects can be used to plan future work through accurate interpretation and prediction. Very large datasets are only information without meaning if not interpreted accurately and translated into accurate predictions. Thus, a model that can provide a good approach to the interpretation process is needed. Data mining (DM) is one of the most widely used approaches for data interpretation in various disciplines. Through the artificial intelligence (AI) approach, DM has enormous potential to assist in interpretation and prediction [6]. In construction management and earthworks, AI can serve as a better approach to analysis [7].

Various attributes of the construction management system for earthworks should receive balanced attention. Earthworks, a basic operation for any type of construction, depend heavily on equipment. The productivity and safety of earthwork equipment are determined by the effective management of the equipment [8]. All issues and objectives should be addressed and resolved thoroughly by the system on an ongoing basis. Where multiple objectives must be achieved simultaneously, a multi-objective optimisation (MOO) approach is required. In general, there is no single optimisation solution that can simultaneously generate minimum or maximum values for all objectives [9]. Finally, a good construction management system is a system capable of providing a tool for users and decision makers that allows them to easily understand and use the system.

Based on some of the above concepts, further development of earthwork optimisation is needed to take full advantage of DM for optimisation and priority determination as a strategy to increase the productivity of earthwork equipment. This approach is expected to be an alternative that complements some of the other existing model concepts. The optimisation result must be able to provide solutions for the improvement of earthwork optimisation models in a toll road construction project.

2 Literature review

Earthworks include all work related to digging, breaking, loosening, loading, hauling, transporting, dumping, filling, spreading, levelling, or compacting soil or rock using earthwork equipment [10]. These jobs are widely required in civil works such as construction of highways, dams, embankments, irrigation canals, canals, and airports. Although the common term is earthworks, it is not only limited to soil but sometimes also related to rocks. Indeed, earthwork equipment can be utilised for both soil and rock [11]. What is meant by soil here is the top layer of the earth's surface, being relatively soft, not very compact and

composed of loose granules, whereas rock is harder, more compact and composed of rock-forming minerals.

2.1 Earthwork productivity

Productivity is the ratio of generated output to the input resources used, based on some measure of value. In a construction project, the input for the productivity ratio is the value of the construction process, which can be separated into labour costs, materials, costs, methods and equipment. The success or failure of a construction project depends on the effectiveness of resource management [12]. In a system, generally "something" that works to run it is needed, namely organisation. Organisational effectiveness is the key characteristic that drives the success of the subsystems. The human factor becomes the determinant for achieving a defined level of productivity. To obtain the desired level of productivity and minimise any risk that may occur while prioritising safety and health, the project leaders must understand the capabilities and limitations caused by the condition of the project location [13].

According to another approach, productivity is the capacity of equipment per unit of time (m^3/h); by this measure, earthwork equipment is an important factor in projects, especially large-scale construction projects. The purpose of the use of earthwork equipment is to facilitate the work so that the expected results can be achieved more easily in a relatively short time compared to manual techniques. The productivity of the equipment depends on its capacity, cycle time, and equipment efficiency. The work cycle in material transfer is a recurring activity. The time required in the above activity cycle is called cycle time. The cycle time itself consists of several elements [14].

2.2 Optimisation of earthwork equipment productivity

An optimisation approach to earthworks is needed to optimise limited resources to meet the growing need for earthwork activities [15]. This is in line with the research undertaken by Parente et. al., who strengthened their research by deepening the detailed optimisation of earthwork as the scope of land work management for toll road construction [7]. The use of the latest technological approaches is growing, especially in the optimisation of earthwork management systems, for example, the use of case-based database reasoning [16]. This study examines the potential benefits of the record-keeping process and the historical data on road maintenance collected in the database, especially the decision-making process, which is then interpreted and used to model optimisation for subsequent decisions. This complements previous research by integrating case-based reasoning, eigenvector methods, and web technologies to use historical data and expert opinions in the field of road maintenance to create intelligent systems with a mathematical approach and utilise the capabilities of the cloud as a database.

2.3 Data mining

The understanding and deepening of the field of science have an important influence on the success of designing a DM algorithm. In recent times, DM has begun to be used in scientific engineering and civil engineering [17]. A database is only a set of data without meaning if it is not analysed using the right algorithm approach [18]. Furthermore, Fu also said that based on reviews conducted in recent years, DM's ability to grow in a particular domain is dependent on the number of researchers who continuously develop a particular algorithm. In simple cases, scholarship can help identify the right features to model the data. The preparation of a scientific database can also help design business goals that can be achieved using in-depth database analysis.

DM tasks are established based on the ability of DM to solve various problems through interpretation and other statistical operations on the data [19]. Depending on the type of pattern found, DM tasks are usually classified into two categories, namely predictive and descriptive. The predictive approach uses inference on the data to predict unknown values of the output variables, taking into account the known values of the input variables [20]. The descriptive approach characterises and summarises the various general properties of the data to improve the understanding and provision of extensive information. The utility of a DM task depends on the ability of the user to identify the initial problem and the purpose of completion.

3 Methods

Some tools, equations, algorithms and source code used to answer research questions, develop models, construct syntheses, and display modelling results will be described in detail in this section. To achieve accurate results from research, the work should be performed appropriately and systematically.

3.1 Data

Productivity data was mostly obtained from toll road business entities and the Toll Road Regulatory Agency. This data represents a historical record of earthwork projects, earthwork equipment productivity, and other important information. The earthwork equipment productivity data obtained from toll road business entities range from 2010 to 2017. Some of the data is not complete, but the DM approach can be used to estimate lost or biased data in the database. In addition to the information obtained from toll road business entities, data was also sourced from earthwork equipment standard specifications. The case studies in this work used data from the construction of the trans-Java toll road, as shown in Table 1.

Table 1. Data distribution for modelling.

No	ID	Segment	Model Development			
			Learning	Validation	Optimisation	GIS (next)
1.	CP	Cipali	√			
2.	PP	Pejagan Pemalang	√			
3.	SS	Semarang-Solo		√	√	√
4.	SK	Solo Kertosono	√			
5.	KM	Kertosono-Mojekerto	√			
6.	MS	Mojokerto Surabaya	√			
7.	SB	Serpong-Balaraja	√			

3.2 Allocation of earthwork equipment

The allocation of earthwork equipment determines the duration and cost of the construction required, so the optimal use and placement of the equipment are very important. The allocation of equipment should not only take into account the minimisation of time and cost of construction but also maximise the efficiency of the equipment. In turn, using equipment efficiently maximises a project's sustainability. The earthwork equipment to be allocated consists of trucks, excavators, spreaders, and compactors. Equipment allocation simulation was performed for one equipment plant that is considered to have the same organisation.

4 Discussion

This study developed a predictive model of earthwork equipment productivity using a DM approach, without any restrictions on the input data considered. Through consideration of the classification or regression approach, alternative evaluation steps may also be undertaken. For regression, the evaluation process is based on the difference between the observed value and the estimated value (error value). In general, the lower the error value, the better the prediction model of earthwork equipment productivity, where the error (value = 0) is the ideal value to be achieved.

In this model, three measurements were taken, namely MAD, RMSE and R^2. Models with low MAD and RMSE values and R^2 values close to unit values can be interpreted as models with high prediction accuracy. RMSE is more sensitive to extreme values compared to MAD because RMSE uses the squared value of the difference between the measurement results and the predicted model results. Compared to MAD, the RMSE for a model is likely to be larger. Comparing these error values for models will provide different perspectives on which to base model selection.

In the domain of scientific engineering, in addition to requiring a high degree of accuracy, the ability to interpret the modelling results is critical. The ability of a DM approach to interpret a dataset is strongly influenced by the power of the data-driven model for that purpose. When a black box DM approach is implemented with multiple regression (MR), artificial neural network (ANN) and support vector machine (SVM) algorithms involving complex mathematical expressions, then the data-driven procedure should be able to model the data. In this case, the interpretation of the model is done to obtain the input variable measurement for the productivity prediction model.

This model is evaluated with a confidence level of 95% according to the t-student distribution. All DM models with MR, ANN and SVM training algorithms use four input variable attributes. Table 2 presents the predictive capacities of all training outcomes, comparing their performance in terms of earthwork equipment productivity prediction scores based on MAD, RMSE, and $R^{2.}$ This table shows that productivity values can be accurately predicted by each of the three DM models, especially the ANN and SVM models.

Table 2. Error metrics model DM.

Model	MAD	RMSE	R2
MR	0.72 ± 0.01	0.91 ± 0.02	0.54 ± 0.00
ANN	0.48 ± 0.02	0.62 ± 0.01	0.89 ± 0.02
SVM	0.57 ± 0.01	0.73 ± 0.01	0.77 ± 0.01

The table 2 shows the standard error and R^2 for each model developed. The DM model that uses the ANN algorithm has the smallest MAD and RMSE values as well as the highest R^2 value. The performances of the predictive models using ANN and SVM algorithms are acceptable and appropriate to be used in calculating road performance predictions because they have R^2 values greater than 0.70. In this research, the selected prediction model for the productivity of earthworks equipment was the DM model using the ANN algorithm.

The interpretation of the regression analysis used in DM (package rminer) provides a graphical interpretation tool consisting of a regression error characteristic (REC) curve, with the error tolerance illustrated on the x-axis and the percentage prediction value of road performance depicted on the y-axis. The resulting curve describes the error rate in the form of a cumulative distribution function (CDF). The error rate here is defined as the difference between the predicted f(x) and actual earthwork productivity at every point (x, y). The approach is also a squared residual $(y - f(x))^2$ or absolute deviation $|y - f(x)|$ based on error metric mapping.

The REC analysis results describe the effect of the main attributes that move dynamically. In the road performance prediction model with ANN, this attribute is the earthwork equipment plant consisting of trucks, excavators, spreaders, and compactors. Productivity increased following the allocation of prepared equipment. The overall changes in productivity values in the prediction model are illustrated in Figure 1.

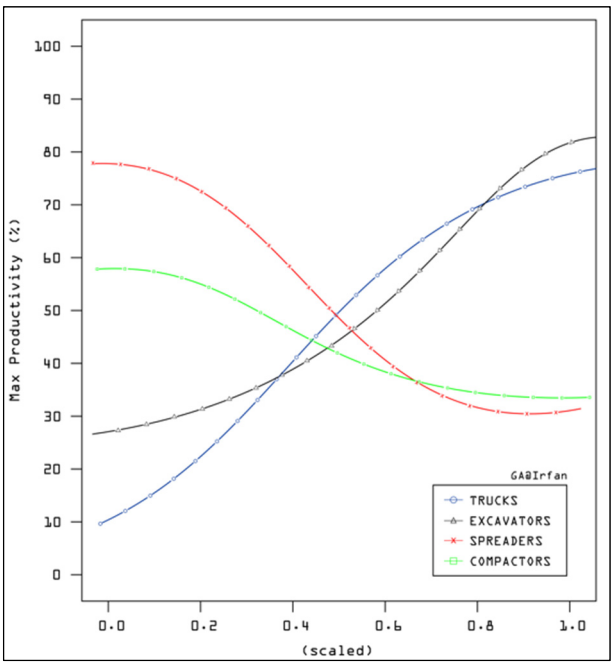

Fig. 1. REC curveS for the prediction model.

The developed DM model can assess the contribution rate of each variable as well as the attribute that becomes the input data in the model. A parameter vector is selected in the DM model to explain that it is a uniform function and not parameters as in the parametric approach. The only condition for a uniform function is to generate a matrix of non-negative definite variance. There are several methods that can be used to predict hyperparameter values. The value of θ can be estimated in this DM using a cross-validation method. The hyperparameters used are H (2, 4, …, 10) and γ (2-15, 2-13, …, 23). This value produces the most precise model with optimal run time. Further models can be developed by trying other hyperparameters. The contribution of each attribute and dimension is its relative importance in modelling.

The Pareto solution approach is used to determine the DM-based optimisation model. The solution is structured to produce optimisation of the production value and the magnitude of the mechanical displacement cost. The optimisation results used as the basis for decision making will be illustrated in the application of the model. The toll road project data summarised in Table 1 was used as a simulation section. The optimisation was performed with various allocation equipment scenarios. The optimal earthwork equipment allocation program was chosen using the Pareto solution approach. The selected Pareto model used to construct the earthwork movement optimisation model can be seen in Figure 2.

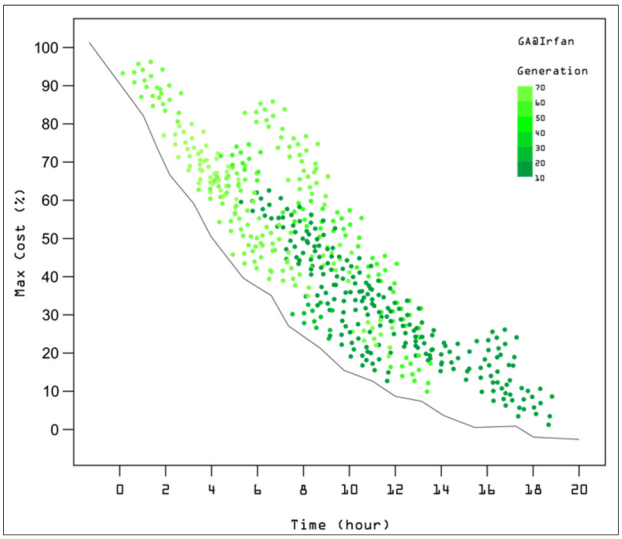

Fig. 2. Pareto front.

By using this choice model, this system is capable of achieving a high impact on both earthwork duration and project cost for a toll road project. In Figure 3, it can be seen that the level of work in each group of earthwork equipment in the form of the original distribution arrangement is not well structured, while the optimal distribution is quite well arranged. In the original distribution of equipment, the limited productivity of the excavator team (approx. 350 m^3/hr) resulted in the trucks, which have a much higher potential productivity of almost 2,000 m^3/h, being forced to wait for the material to be extracted before being able to transport it to a stockpiled and compacted area.

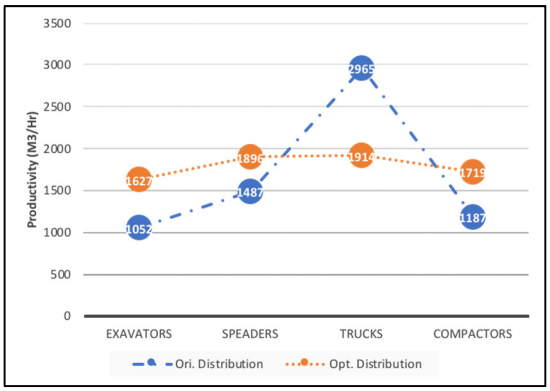

Fig. 3. Comparison between original and optimal equipment distributions.

Figure 4 is an illustration of the optimisation of the use of mechanical equipment via the Pareto approach. The optimisation is performed by utilising a genetic algorithm approach based on data mining [21]. In this figure, each point represents a viable distribution solution and optimal equipment for earthworks projects, evaluated in terms of the associated duration (in hours) and cost (maximum cost. The output system presents several solutions that correspond to optimal trade-offs between cost and duration, where the maximum sustainability is guaranteed in accordance with the methodology mentioned above. The completion of the earthwork depends on the conditions of the field, the weather and the presence of the equipment, so some flexibility in the model is needed.

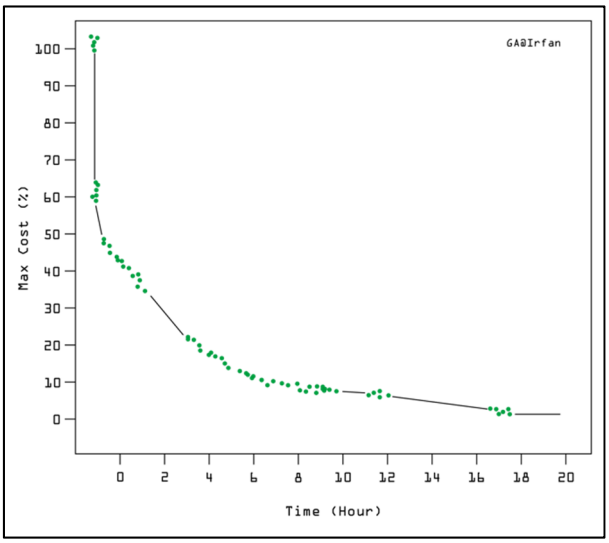

Fig. 4. The output of an optimisation run.

5 Conclusion

This paper presents a model for utilising big data on earthworks for a toll road construction project to obtain optimisation of equipment productivity. We began by arranging the allocation of equipment in each workgroup. The productivity of each arrangement of equipment is predicted by utilising DM techniques and, in particular, the ANN technique, a model with excellent predictive capacity for large data. Furthermore, we performed the optimisation using the Pareto approach with multiple generation options. With the Pareto approach, we obtained options for optimal allocation of equipment at minimal cost.

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