

Stefanus Adi Kristiawan
Buntara S. Gan
Mohamed Shahin
Akanshu Sharma *Editors*

Proceedings of the 5th International Conference on Rehabilitation and Maintenance in Civil Engineering

ICRMCE 2021, July 8–9, Surakarta,
Indonesia

Lecture Notes in Civil Engineering

Volume 225

Series Editors

Marco di Prisco, Politecnico di Milano, Milano, Italy

Sheng-Hong Chen, School of Water Resources and Hydropower Engineering,
Wuhan University, Wuhan, China

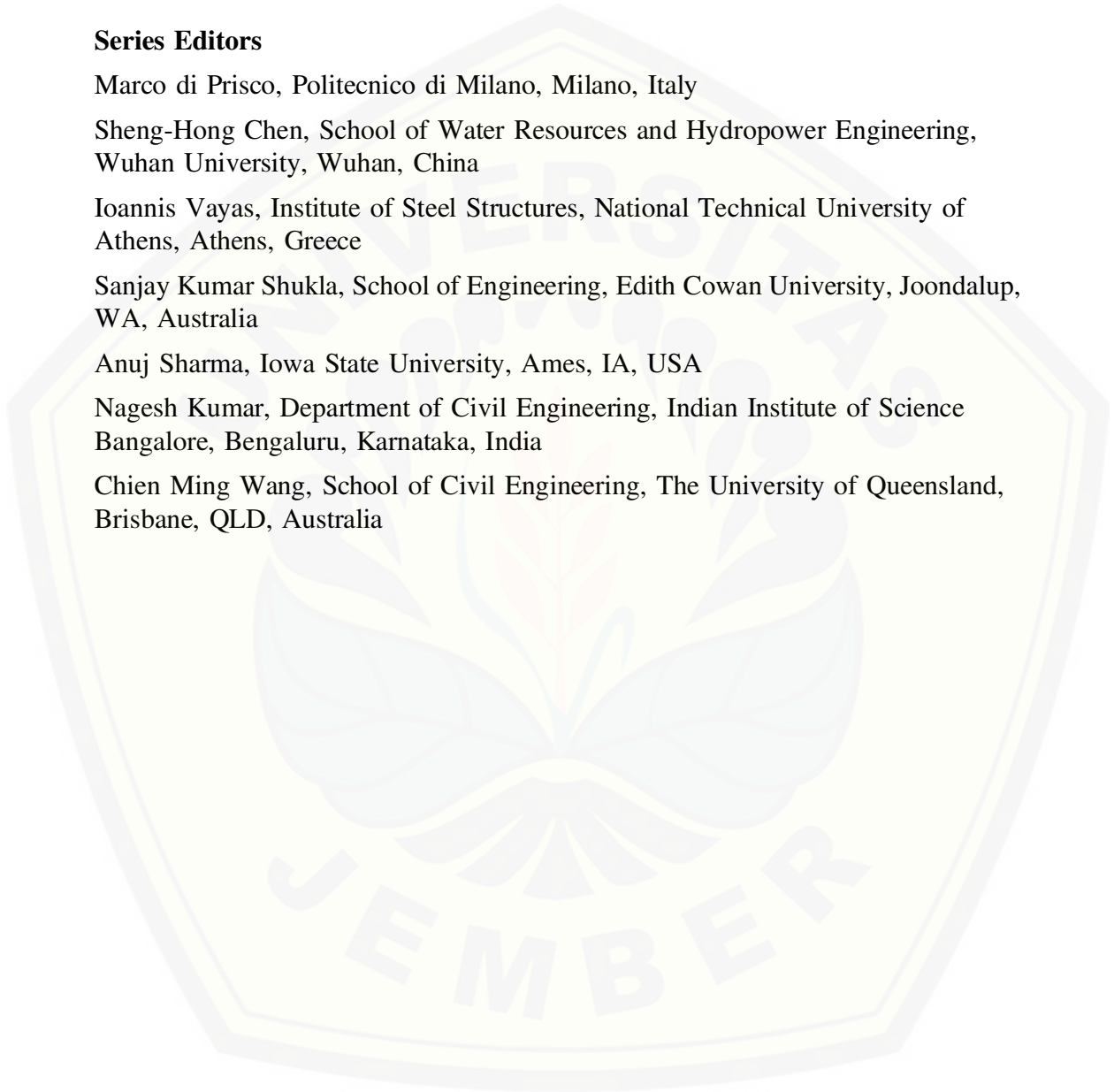
Ioannis Vayas, Institute of Steel Structures, National Technical University of
Athens, Athens, Greece

Sanjay Kumar Shukla, School of Engineering, Edith Cowan University, Joondalup,
WA, Australia

Anuj Sharma, Iowa State University, Ames, IA, USA

Nagesh Kumar, Department of Civil Engineering, Indian Institute of Science
Bangalore, Bengaluru, Karnataka, India

Chien Ming Wang, School of Civil Engineering, The University of Queensland,
Brisbane, QLD, Australia



Lecture Notes in Civil Engineering (LNCE) publishes the latest developments in Civil Engineering - quickly, informally and in top quality. Though original research reported in proceedings and post-proceedings represents the core of LNCE, edited volumes of exceptionally high quality and interest may also be considered for publication. Volumes published in LNCE embrace all aspects and subfields of, as well as new challenges in, Civil Engineering. Topics in the series include:

- Construction and Structural Mechanics
- Building Materials
- Concrete, Steel and Timber Structures
- Geotechnical Engineering
- Earthquake Engineering
- Coastal Engineering
- Ocean and Offshore Engineering; Ships and Floating Structures
- Hydraulics, Hydrology and Water Resources Engineering
- Environmental Engineering and Sustainability
- Structural Health and Monitoring
- Surveying and Geographical Information Systems
- Indoor Environments
- Transportation and Traffic
- Risk Analysis
- Safety and Security

To submit a proposal or request further information, please contact the appropriate Springer Editor:

- Pierpaolo Riva at pierpaolo.riva@springer.com (Europe and Americas);
- Swati Meherishi at swati.meherishi@springer.com (Asia - except China, and Australia, New Zealand);
- Wayne Hu at wayne.hu@springer.com (China).

All books in the series now indexed by Scopus and EI Compendex database!

More information about this series at <https://link.springer.com/bookseries/15087>

Stefanus Adi Kristiawan ·
Buntara S. Gan · Mohamed Shahin ·
Akanshu Sharma
Editors

Proceedings of the 5th International Conference on Rehabilitation and Maintenance in Civil Engineering

ICRMCE 2021, July 8–9,
Surakarta, Indonesia

Editors

Stefanus Adi Kristiawan
Department of Civil Engineering
Universitas Sebelas Maret
Surakarta, Indonesia

Buntara S. Gan
College of Engineering
Nihon University
Tokyo, Japan

Mohamed Shahin
Department of Civil Engineering
Curtin University
Perth, WA, Australia

Akanshu Sharma
Institute of Construction Materials
University of Stuttgart
Stuttgart, Germany

ISSN 2366-2557 ISSN 2366-2565 (electronic)
Lecture Notes in Civil Engineering
ISBN 978-981-16-9347-2 ISBN 978-981-16-9348-9 (eBook)
<https://doi.org/10.1007/978-981-16-9348-9>

© The Editor(s) (if applicable) and The Author(s), under exclusive license
to Springer Nature Singapore Pte Ltd. 2023

This work is subject to copyright. All rights are solely and exclusively licensed by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors, and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721,
Singapore

Foreword

The International Conference on Rehabilitation and Maintenance in Civil Engineering (ICRMCE) is a triennial conference that aims to provide a forum for researchers, academicians (professors, lecturers, and students), government agencies, consultants, and contractors to exchange experiences, technological advancement, and innovations in the world of civil engineering, specifically in the fields of rehabilitation and maintenance. The previous four ICRMCE conferences took place successfully in 2009, 2012, 2015, and 2018. Hundreds of researchers worldwide attended these events to present their scientific papers in various areas of civil engineering such as material engineering, structural engineering, geotechnical engineering, transportation engineering, and construction management.

This year's conference was organized by Sebelas Maret University in collaboration with Mataram University. The conference was initially scheduled offline in Mataram, Indonesia. However, due to the escalating coronavirus (COVID-19) outbreak and the need for social distancing, we decided to hold the conference online. Some reputable universities and institutions are participating in the current ICRMCE as partners. Among them are Nihon University, University of Stuttgart, National Taiwan University, TU Delft, Hiroshima University, Diponegoro University, Muhammadiyah University of Yogyakarta, Jenderal Soedirman University, University of Jember, UPN Veteran East Java, the National Center for Research on Earthquake Engineering (NCREE) Taiwan, Himpunan Ahli Konstruksi Indonesia (HAKI), and Himpunan Ahli Teknik Tanah Indonesia (HATTI).

The ICRMCE 2021 was successfully held on July 8–9. Presenters who joined this conference came from Japan, Singapore, Malaysia, China, Vietnam, Taiwan, England, the Netherlands, Kuwait, and Indonesia. Furthermore, several outstanding keynote speakers gave a presentation of the state-of-the-art findings in the field of civil engineering. Our esteemed speakers are Prof. Shyh-Jiann Hwang (National Taiwan University), Prof. Buntara Sthenly Gan (Nihon University), Dr. Edgar Bohner (VTT Technical Research Centre of Finland), and Prof. Mohamed Shahin (Curtin University).

In the process of organizing this conference, we received invaluable motivation, advice, and support from several individuals and institutions. I intend to express my gratitude and appreciation to all of them. First, my most profound appreciation goes to all organizing committee members who worked day and night preparing this conference. Special thanks to the conference and media partners for their generous support. We also express our gratitude to Prof. S.A. Kristiawan (Sebelas Maret University), Dr. Ing. Akanshu Sharma (University of Stuttgart), Prof. Mohamed Shahin (Curtin University), and Prof. Buntara Sthenly Gan (Nihon University) for their willingness to serve as the editors of the 5th ICRMCE proceedings.

Halwan Alfisa Saifullah
The 5th ICRMCE Chairman



Preface

Civil engineering infrastructures are the backbone for the continuous development of civilization. Managing these infrastructures is essential in keeping the quality of services they provide to the community. A decline in the performance of key infrastructure will have an impact on the quality of these services, which in turn can cause social and economic problems. A variety of factors affects the performance of infrastructure. In each case, the declining performance of infrastructure requires an appropriate and adaptive response to offer effective solutions. Protection, maintenance, repair, and retrofitting are part of the various solutions that can be implemented. All of these solutions are assisted by technological developments related to repair materials, methodologies, systems, management, and operational efficiency, as well as economic and social considerations.

Infrastructure performance is also inevitably affected by exposure to hazards originating from natural and environmental conditions such as earthquakes, landslides, and floods, among others. Therefore, hazard mitigation is also an interesting topic of discussion. In addition, risk reduction and safety are among the most important issues of infrastructure management. Finally, various perspectives on sustainability in civil engineering are also covered in this conference.

This book is a collection of papers presented at the 5th International Conference on Rehabilitation and Maintenance in Civil Engineering (ICRMCE) 2021 that deals with the issues stated above. The papers are grouped into sequential themes representing the structure of this book:

- Part I: Factors affecting performance of buildings and infrastructures
- Part II: Assessment, protection, maintenance, repair, and retrofitting of buildings and infrastructures
- Part III: Maintenance management of buildings and infrastructures
- Part IV: Hazard mitigation
- Part V: Risk reduction and safety management
- Part VI: Sustainability aspects in transportation engineering
- Part VII: Sustainability aspects in construction projects

- Part VIII: Sustainability aspects in water resources management
- Part IX: Construction materials for sustainable infrastructures

Postgraduate students, researchers, and practitioners who would like to update their knowledge on the topics above will find this book very useful.

Surakarta, Indonesia

Stefanus Adi Kristiawan
Chief Editor



Contents

| | |
|--|----|
| Factors Affecting Performance of Buildings and Infrastructures | |
| A Review on Application of Machine Learning in Building Performance Prediction | 3 |
| R. W. Triadji, M. A. Berawi, and M. Sari | |
| The Effect of P-Delta and P-Delta Plus Large Displacements Modelling on Lateral and Axial Displacement | 11 |
| Jonie Tanijaya and Robby S. Kwandou | |
| Effect of Regulatory Change in Earthquake Load Analysis on Structures with Irregular Shapes | 27 |
| Hendramawat Aski Safarizki and Dini Ayu Saputri | |
| Seismic Performance of Tall and Slender Minaret Structure with Hexagonal RC Wall Section by Means Fragility Curve Development | 37 |
| Erik Wahyu Pradana, Senot Sangadji, and Angga Destya Navara Noor | |
| Role of Diagonal Bars in Reinforced Concrete Deep Beams Tested Under Static Load | 47 |
| Erwin Lim and Rahmat Ramli | |
| Analysis of Reinforced Concrete Capacity for Irregular Cross-Sections Using Numerical Methods | 57 |
| Nuroji | |
| Assessment of Retaining Wall Design in Harris Skyline Tower's Basement, Surabaya | 69 |
| Siti Nurlita Fitri and Ahmad Soimun | |
| Additional Vertical Movement of the Single Pile Foundation with Combined Loads | 83 |
| Sumiyati Gunawan, Niken Silmi Surjandari, Bambang Setiawan, and Yusep Muslih Purwana | |

| | |
|---|-----|
| The Influence of the Number and Height Steps of Terraced Model on Slope Stability Analysis | 95 |
| Niken Silmi Surjandari, Siti Nurlita Fitri, and Fenty Madani | |
| Validation of TRMM Rainfall Data on Slope Stability in Karanganyar, Indonesia | 107 |
| David Raja Simare Mare, Rr Rintis Hadiani, and Raden Harya Dananjaya | |
| Rubberized Asphalt Pilot Road Trial in Kuwait | 117 |
| H. Al-Baghli, Z. S. Awadh, and S. E. Zoorob | |
| Application of the Updated PSHA on the Stability Analysis of the Meninting Diversion-Spillway Tunnel in Lombok Island—Indonesia | 129 |
| Didi S. Agustawijaya, Ria R. Marlaningtyas, Suryawan Murtiadi, Mudji Wahyudi, Muhajirah, Hartana, and Ausa R. Agustawijaya | |
| Risk and Stability Evaluation of Klego Dam, Boyolali, Indonesia | 141 |
| Suharyanto, Kresno Wikan Sadono, Rizqi Iqbal Maulana, P. Arie Bagus, and Dyah Ari Wulandari | |
| Impact of Climate Change on Dam Safety | 157 |
| Heri Sulistiyono, Ery Setiawan, and Humairo Saidah | |
| Assessment, Protection, Maintenance, Repair, and Retrofitting of Buildings and Infrastructures | |
| Investigating Materials for Refurbishment Strategies of Heritage Buildings: A Case Study of Soesman Kantoor, Semarang | 169 |
| Ferry Hermawan, Didi Wibowo Tjokro Winoto, Ismiyati, Bambang Purwanggono, and Robby Soetanto | |
| Self-monitoring and Localization of Crack of Concrete Beam with Fibers and Carbon Black Subjected to Bending | 179 |
| Genjin Liu and Yining Ding | |
| Seismic Performance Analysis of Multi-story Buildings with Addition of Bracing Based on SNI 1726: 2019 (Case Study: Airlangga University Parking Building) | 189 |
| Krisnamurti, Willy Kriswardhana, and Achmad Wahyu Ramadiyan | |
| Various Strut—Macro Modelings for Infilled Frame Analysis | 199 |
| Isyana Ratna Hapsari, Marwahyudi, Edy Purwanto, Senot Sangadji, and Stefanus Adi Kristiawan | |
| Strengthening of Non-engineered Building Beam-Column Joint to Increase Seismic Performance with Variation of Steel Plate Width | 215 |
| Edy Purwanto, P. Amarta Adri, S. A. Kristiawan, Senot Sangadji, and S. Halwan Alfisa | |

| | |
|--|-----|
| A Proposed Method of FRP Anchorage for FRP Confined Over-Reinforced Concrete Beam | 225 |
| Nuroji, Ay Lie Han, Sri Tudjono, Lena Tri Lestari, and Tiara Murtisari | |
| Experimental Investigation on the Shear Behavior of Patched RC Beams Without Web Reinforcements: Efficacy of Patching Position with Respect to the Shear Span | 233 |
| Adji P. Abrian, Stefanus A. Kristiawan, Halwan A. Saifullah, P. Muhammad Rafi, R. Muhammad Hafizh, Andreas M. Simanjuntak, and D. Abel Bismo | |
| Secondary AE Analysis of Pre-corroded Concrete Beam | 243 |
| Ahmad Zaki and Zainah Ibrahim | |
| Cable Force Prediction Technique Using Subspace and Effective Vibration Length Method | 257 |
| Muhammad Ibnu Syamsi, Hao-Lin Wang, and Chung-Yue Wang | |
| Implementation of Microbially Induce Calcite Precipitation (MICP) by Bacillus Subtilis and Adding Sand in Repairing Shear Strength Parameters of Peat | 267 |
| Firman Syarif and Dian M. Setiawan | |
| Sensitivity Analysis on the Effect of Reinforcement Materials Addition for Soil Stabilization | 277 |
| Ida Agustin Nomleni, Raden Harya Dananjaya, and Yusep Muslih Purwana | |
| Numerical Simulation of Slope Stability for Soil Embankment Reinforced with Inclined Bamboo Piles | 287 |
| Ngudiyono and Tri Sulistyowati | |
| Analysis of Community Satisfaction Level on the Road Rehabilitation and Reconstruction Project (Learn from Palu Disasters Area) | 297 |
| Andri Irfan Rifai, Eko Prasetyo, and Rhismono | |
| Seepage and Piping Control of Earth Fill Dam | 311 |
| Muhammad Zainal Arifin, Yusep Muslih Purwana, and Raden Harya Dananjaya | |
| Maintenance Management of Buildings and Infrastructures | |
| State-of-the-Art of Artificial Intelligence Methods in Structural Health Monitoring | 325 |
| I. G. E. A. Putra | |

| | |
|---|-----|
| Development of Preventive Maintenance Guidelines for Simple-Classification Government Buildings Based on Work Breakdown Structure Within the DKI Jakarta Provincial Government | 339 |
| Dyah Ayu Pangastuti and Yusuf Latief | |
| Development of Preventive Maintenance Guidelines for Electrical Components on Government Building Based on Work Breakdown Structure | 355 |
| Azhar Yudha Pradipta, Yusuf Latief, and Rossy Armyn Machfudiyanto | |
| Evaluation of the Implementation of Fire Safety Management Based on Work Breakdown Structure Affecting the Insurance Premium Costs of High-Rise Lecture Buildings | 369 |
| E. P. Mahardika, F. Muslim, Y. Latief, and P. S. Nugroho | |
| A Critical Review of Bridge Management System in Indonesia | 381 |
| Surya Dewi Puspitasari, Sabrina Harahap, and Pinta Astuti | |
| Crack and Corrosion Inspections for Coastal and Marine Concrete Infrastructure: A Review | 391 |
| Sabrina Harahap, Surya Dewi Puspitasari, and Ahmad Aki Muhaimin | |
| e-Peralatan System as an Equipment Management for Disaster Mitigation on Indonesia National Roads | 401 |
| Adityo Budi Utomo, P. Gitaning, and S. Tosan Kunto | |
| The Implementation of Functional Road Assessment on Pramuka Road Section in Klaten District | 411 |
| Amirotul Musthofiah H. Mahmudah, Syahrul Anggara Wuryatmaja, and Ary Setyawan | |
| The Evaluation of Irrigation Maintenance in Pacal Irrigation Area at Bojonegoro Regency, East Java | 425 |
| Mahdika Putra Nanda, Rintis Hadiani, and Antonius Suryono | |
| Hazard Mitigation | |
| Landslide Analysis Subject to Geological Uncertainty Using Monte Carlo Simulation (A Study Case in Taiwan) | 437 |
| Joni Fitra, Wen-Chao Huang, and Yusep Muslih Purwana | |
| The Performance of Horizontal Drain as a Landslide Mitigation Strategy | 449 |
| Putu Tantri K. Sari | |
| The Analysis of Impact and Mitigation of Landslides Using Analytical Hierarchy Process (AHP) Method | 457 |
| A. Andriani, B. M. Adji, and S. Ramadhani | |

| | |
|---|-----|
| The Stability of a Slope on Soft Soil Using the Hardening Soil Model | 467 |
| Yerry Kahaditu Firmansyah and Maharani Putri Dewanty | |
| Software Performance of Risk-Targeted Maximum Considered Earthquake (MCE_R) Calculation | 479 |
| Windu Partono | |
| Seismic Microzonation of Yogyakarta Province Based on 2019 Risk-Targeted Maximum Considered Earthquake | 489 |
| Windu Partono, Ramli Nazir, Frida Kistiani, and Undayani Cita Sari | |
| Liquefaction Potential of Volcanic Deposits During Lombok Earthquake in 2018 | 499 |
| Muhajirah | |
| Fault Structure Interpretation on the Western Part of East Java Using Second Vertical Derivative | 511 |
| Wien Lestari, Amien Widodo, Dwa Desa Warnana, Firman Syaifuddin, Rusba Saputra Rivensky, and Bagoes Idcha Mawardi | |
| Lesson Learned from Weathering Clay Shale Residual Interface Shear Strength Testing Method | 523 |
| Fathiyah Hakim Sagitaningrum, Samira Albaty Kamaruddin, Ramli Nazir, Budi Susilo Soepandji, and Idrus M. Alatas | |
| Shear Strain Evaluation on Analysis of Additional Clay Liner Layer Modeling in Ngipik Landfill, Gresik | 533 |
| Siti Nurlita Fitri | |
| Tsunami Hazard in Cilacap City Due to the Megathrust of West-Central Java Segment | 543 |
| Wahyu Widiyanto and Sanidhya Nika Purnomo | |
| Assessment of the Conditioning Factor for Flash Flood Susceptibility Potential Based on Bivariate Statistical Approach in the Wonobojo Watershed in East Java, Indonesia | 553 |
| Entin Hidayah, Gusfan Halik, and Wiwik Yunarni Widiarti | |
| Flood Management Strategies in Indonesia: A Lesson Learned from Pepe River, Central Java | 575 |
| Rian Mantasa Salve Prastica and Amalia Wijayanti | |
| Comparison of Suitable Drought Indices for Over West Nusa Tenggara | 587 |
| Humairo Saidah, Heri Sulistiyono, and I Dewa Gede Jaya Negara | |
| Small Debris Flow Simulation Using MORPHO2DH | 601 |
| Puji Harsanto, Dandy Darvin Septiandy, Berli Paripurna Kamiel, and Nursetiawan | |

| | |
|--|-----|
| Simulation of Debris Flow Using “SIMLAR” in the Watershed of Gendol River, Indonesia | 609 |
| Hendy Dwi Cahyo, Jazaul Ikhsan, and Ani Hairani | |
| Wind-Generated Wave Simulation on Payangan Beach Utilizing DELFT3D | 619 |
| Enggar Setia Baresi, Retno Utami Agung Wiyono, and Wiwik Yunarni Widiarti | |
| Risk Reduction and Safety Management | |
| Incorporating Cultural Attributes into Disaster Risk Reduction-Based Development Plans in Indonesia | 631 |
| Yusron Saadi | |
| Identification Risk Potential Hazard of Railway Project Based on the Work Breakdown Structure to Improve Safety Performance | 641 |
| D. V. Aryanto, L. S. Riantini, R. A. Machfudiyanto, and Y. Latief | |
| Identification Factors of Safety Climate, Awareness, and Behaviors to Improve Safety Performance in Telecommunication Tower Construction at PT X | 651 |
| B. F. Athaya, L. S. Riantini, and R. A. Machfudiyanto | |
| Cost Structure of Construction Safety on High Residential Buildings in Indonesia | 659 |
| Ratih Fitriani, Yusuf Latief, and Rossy A. Machfudiyanto | |
| Adaptive Traffic Signal Control Using Fuzzy Logic Under Mixed Traffic Conditions | 669 |
| Budi Yulianto | |
| Application of Fuzzy Inference System Mamdani at Pelican Crossing | 681 |
| Salsabila Naura Putri | |
| Determining the Maximum Speed Limit in Residential Area | 693 |
| Gito Sugiyanto, Fadli Wirawan, Eva Wahyu Indriyati, Yanto, and Mina Yumei Santi | |
| Identification of Traffic Accident Hazardous Location and Cost of Accidents in Developing Country (Case Study of Tabanan Regency, Bali-Indonesia) | 705 |
| Putu Alit Suthanaya and Made Oka Sugiana | |
| Characteristics of Foreign Motorcyclists in Tourism Areas in Bali | 717 |
| Cokorda Putra Wirasutama, Putu Alit Suthanaya, Dewa Made Priyantha Wedagama, and Anak Agung Gde Agung Yana | |

| | |
|--|-----|
| Analysis of the Behaviour Model of Foreign Motorcyclists in Tourism Areas in Bali | 729 |
| Cokorda Putra Wirasutama, Putu Alit Suthanaya, Dewa Made Priyantha Wedagama, and Anak Agung Gde Agung Yana | |
| Knowledge and Practice of Helmet Usage Among Senior High School Students in Klaten Regency | 743 |
| Dewi Handayani, Putri Dewi Prasetianingrum, and H. M. Amirotul Musthofiah | |
| Sustainability Aspects in Transportation Engineering | |
| Investigation of CO₂ Emissions on Two Local Streets by Means of IPCC and Direct Method | 753 |
| Florentina Pungky Pramesti, Annisa Tri Utami, Iva Yenis Septiariva, and Fajar Sri Handayani | |
| Reducing the Release of Greenhouse Gases in the Rigid Pavement Material Transportation Process Unit | 763 |
| Fajar Sri Handayani, Florentina Pungky Pramesty, and Ary Setyawan | |
| Cost Effectiveness Analysis of Greenhouse Gas Emissions Reduction in the Flexible Pavement Material Transportation Process Unit | 771 |
| Fajar Sri Handayani, Florentina Pungky Pramesti, and Ary Setyawan | |
| A Probabilistic Model of Container Port Demand in Java Concerning the Port Hinterland Connectivity | 781 |
| Lydia Novitriana Nur Hidayati, Gerard de Jong, Anthony Whiteing, and Munajat Tri Nugroho | |
| Evaluation of Logistics System Performance-Based on Indonesian Government Policy | 791 |
| Muhammad Rizky Prakoso, Mohammed Ali Berawi, and Gunawan | |
| Analysis of the Influence of Region Development Factors, Individual and Activity, Internal Operator and External Operator on the Demand for the Jakarta Bandung High-Speed Rail | 799 |
| Samijan, Mohammed Ali Berawi, and Andyka Kusuma | |
| Investigating the Factors Influencing the Demand of School Bus | 811 |
| Willy Kriswardhana, Syamsul Arifin, and Ainal Akbar | |
| Sustainability Aspects in Construction Projects | |
| Key Performance Indicator for Analytical Hierarchy Process Used for Determining the Effect of Reverse Supply Chain Toward Green Building Projects | 823 |
| Hermawan, Jati Utomo Dwi Hatmoko, and Jovana Neilkelvin | |

| | |
|--|-----|
| Development of Blockchain and Machine Learning System in the Process of Construction Planning Method of the Smart Building to Save Cost and Time | 833 |
| Christiantono Tedjo, Mohammed Ali Berawi, and Mustika Sari | |
| The Development of Blockchain Based Knowledge Management System Model at EPC Projects to Improve Project Time Performance | 843 |
| D. Y. Priyambodo, M. A. Berawi, and M. Sari | |
| Risk Allocation Implementation Analysis of Public-Private Partnership for Infrastructure Project (Case Study of the Solo-Yogyakarta-NYIA Kulon Progo Highway Project) | 853 |
| Widi Hartono, Aloysia Putri Hastari Purnomo, and Sunarmasto | |
| Risk Assessment of Construction Project Scheduling | 863 |
| Zetta Rasullia Kamandang | |
| Investigating Construction Project Delay Using Fault Tree Analysis Based on Its Dominant Risk on Private Project | 873 |
| Jojok Widodo Soetjipto, Amalia Martha Sukmana, and Syamsul Arifin | |
| Implementing a Relational Database in Processing Construction Project Documents | 891 |
| Mik Wanul Khosiin and Ardian Umam | |
| Evaluation of the Public Procurement Principles Implementation in Surabaya Construction Projects | 901 |
| Patrisius Valdoni Sandi and Mohammad Arif Rohman | |
| Relationship Model Between Conceptual Cost Estimation Process of Flyover Development in the Provincial Government of DKI Jakarta with the Accuracy Level | 913 |
| Putika Yussi, Yusuf Latief, and Rossy Armyn Machfudiyanto | |
| The Sustainability Aspect of the Consulting Firm in Terms of Its Competitiveness in Indonesia | 933 |
| Nofita Harwin, Mairizal, Zelmi Sriyolja, Abd Rahman Mohd Sam, and Mohd Zaimi Abd Majid | |
| Sustainability Aspects in Water Resources Management | |
| Sustainability Analysis of Minimization of Spills from a Reservoir | 945 |
| Syamsul Hidayat, Ery Setiawan, Ida Bagus Giri Putra, M. Bagus Budianto, and Salehudin | |
| Infiltration Wells as an Alternative Eco Drainage System a Case Study in Mangkubumen Surakarta | 953 |
| Retnayu Molya, R. R. Rintis Hadiani, and Adi Yusuf Muttaqien | |

| | |
|---|------|
| Analysis of Leb Irrigation Patterns of Pipe System in Sorghum Plants in Sand Dry Lands Akar Akar Village | 965 |
| I Dewa Gede Jaya Negara, Sasmito Soekarno, Suwardji, Humairo Saidah, and Atha Adi | |
| Hourly Rainfall Simulation Using Daily Data | 975 |
| Suroso, Fatimatus Sholihah Marush, Purwanto Bektu Santoso, Irfan Sudono, Edvin Aldrian, and Nelly Florida Riama | |
| Water Quality Mapping on the Coast of Bangkalan Madura Based on the Acidity Value from Aqua MODIS Satellite Imagery | 989 |
| Hendrata Wibisana, Zetta Rasullia Kamandang, and Kartini | |
| Multi-attribute Analysis of Raw Water Treatment from Deep Wells at PDAM Tirta Mahottama, Klungkung Regency, Bali | 999 |
| Ni Kadek Dian Utami Kartini, Nurulbaiti Listyendah Zahra, Ariyanti Sarwono, Intan Rahmalia, Almira Davina Nastiti, Iva Yenis Septiariva, and I. Wayan Koko Suryawan | |
| Determination of Produced Wastewater Treatment Systems for Reclaim Water in the Oil and Gas Industry | 1009 |
| Novena Lany Pangestu, Nurulbaiti Listyendah Zahra, Ariyanti Sarwono, Intan Rahmalia, Iva Yenis Septiariva, and I. Wayan Koko Suryawan | |
| Preference of Sludge Treatment Plan in IPA II Pejompongan Water Treatment Plant | 1019 |
| Nailatul Fadhilah, Nurulbaiti Listyendah Zahra, Fatimah Dinan Qonitan, Imroatus Sholikhah, Intan Rahmalia, Iva Yenis Septiariva, and I. Wayan Koko Suryawan | |
| Design of Typical Rainwater Harvesting Storage Tanks Based on Housing Type (Case Study in Indonesia) | 1029 |
| Lina Indawati, Setyo Budi Kurniawan, Siti Rozaimah Sheikh Abdullah, and Raden Harya Dananjaya | |
| Risk Analysis of Shared Marine Space in the View of Traditional Fishermen Perceptions in the National Tourism Strategic Area of Lombok, Indonesia | 1043 |
| Ida Ayu Oka Suwati Sideman, R. M. Nyoman Budiarta, Ida Bagus Putu Adnyana, and Ngakan Ketut Acwin Dwijendra | |
| Construction Materials for Sustainable Infrastructures | |
| Residual Stress Evaluation on Cold-Formed Steel C-Section by X-Ray Diffraction | 1057 |
| T. Widya Swastika, Heru Purnomo, M. R. Muslih, R. Apriansyah, Henki W. Ashadi, and Mulia Orientilize | |

| | |
|--|------|
| Mechanical Properties of Fine-Grained Concrete Using Fine-Red Sand and Fly Ash for Road Construction: A Case Study in Vietnam | 1067 |
| Nguyen Thanh Sang, Thai Minh Quan, May Huu Nguyen, and Lanh Si Ho | |
| A Systematic Review of Concrete Material for Noise Reduction of Transportation Sectors | 1077 |
| Ecky Ferry Ferdyan, Dewi Handayani, Sholihin As'ad, and Ubaidillah | |
| Mapping Literature of Reclaimed Asphalt Pavement Using Bibliometric Analysis by VOSviewer | 1085 |
| Mochammad Qomaruddin, Han Ay Lie, Widayat, Bagus Hario Setiadji, and Mochamad Agung Wibowo | |
| Literature Study: Alternative Materials for Hot Rolled Sheet-Wearing Course (HRS-WC) Pavement | 1095 |
| Elsa Eka Putri, Purnawan, Bayu Martanto Adji, and Bobby Herman | |
| Marshall Characteristics of Asphalt Mixture with Water Hyacinth Ash as Filler | 1109 |
| Dony Rohmad Dony, Bagus Hario Setiadji, and Bambang Riyanto | |
| The Setting Time of Portland Composite Cement Mixed with Calcium Stearate | 1119 |
| A. Maryoto, P. Hardini, and R. Setijadi | |
| Evaluation of Silt Content in Natural Sand Used as Building Materials: A Statistical Analysis Approach | 1133 |
| Jauhar Fajrin, Mulyadi, Hariyadi, and Agung Prabowo | |
| Compressive and Flexural Strength Behavior of Banana Tree Fiber Hybrid Concrete | 1143 |
| Fadillawaty Saleh, Fanny Monika, Hakas Prayuda, Bella Lutfiani Al Zakina, Martyana Dwi Cahyati, Adira Aldi, and Feri Adri Wibowo | |
| Investigation of Polypropylene Fiber Reinforced Concrete After Elevated Temperature Using Color Quantification and Alkalinity Method | 1153 |
| Ni Nyoman Kencanawati, Suryawan Murtiadi, and Zul Aida Nur | |
| The Effect of 12.5% Metakaolin and Variations of Silica Fume on Split Tensile Strength and Modulus of Rupture of High Strength Self-Compacting Concrete (HSSCC) | 1165 |
| Endah Safitri, Wibowo, Halwan Alfisa Saifullah, and Farhan Gilang Septian | |

**The Strength and Modulus of Elasticity of High Strength
Self-compacting Concrete (HSSCC) with 12.5% Metakaolin and
Variations of Silica Fume 1173**

Endah Safitri, Wibowo, Halwan Alfisa Saifullah,
and Fernanda Sarwatawadhika Perdana



Wind-Generated Wave Simulation on Payangan Beach Utilizing DELFT3D



Enggar Setia Baresi, Retno Utami Agung Wiyono,
and Wiwik Yunarni Widiarti

Abstract The Southern Coastal area of Jember has been damaged almost yearly by coastal flooding and high waves, especially Payangan Beach. A study on high waves is urgently needed for disaster risk preparedness. This study is conducted to model the high waves and simulate the effect on the beach. Delft3D-Wave model is used to provide a spatiotemporal characteristic of the event. The focus of the study is to analyze the high waves on Payangan Beach generated by wind forces. The domain model is a curvilinear grid with a grid size ranging from 130 m until 900 m. National bathymetric data and CDS Copernicus wind data were utilized as data sources. The simulation outcomes have shown that waves are generated far from the coastline across the ocean inside the fetch area. The simulations show the significant wave height increase during the high waves event according to specific meteorological characteristics from 1.6–2.0 m on normal days and exceeding 3.2 m when the high waves hit.

Keywords High waves · Delft3D · Wind-generated waves

1 Introduction

Shoreline is the point of intersection between land and sea. In this area, ocean energy reacted to the land vice versa. The system that works in this reaction mostly caused by the natural movement of the ocean which transferring energy into the system. Coastal zones are directly affected by the ocean forces especially beach and near-shore zone. Therefore, this particular area is the most dynamic in all coastal areas [1].

E. S. Baresi · R. U. A. Wiyono (✉) · W. Y. Widiarti
Civil Engineering Department, Universitas Jember, Jember, Indonesia
e-mail: retnoutami@unej.ac.id

W. Y. Widiarti
e-mail: wiwik.teknik@unej.ac.id

The most common form of ocean energy is wave. The linear waves theory or small-scale wave amplitude theory is derived from Laplace equation for irrotational flow. The equation gives solution of periodic velocity for irrotational flow which later can be utilized to derive equations from various waves characteristic for example water level, velocity, particle acceleration, waves propagation speed, and others [2].

According to the previous study conducted in Southern Seas of Jember, this particular area has high amount of energy transfer about 190 MWh/m/year with significant wave height up to 4 m [3]. In Payangan Beach, a beach located in Southern Seas of Jember, high waves occurred annually e.g. 2018 [4]. There is no known study that simulate spatial variation of high waves in this area. Thus, this study is crucial for the various purpose related to high waves effect on the Payangan Beach coastal area.

This study aims to simulate high waves and analyze the significant wave height in Payangan Beach in the last five years. Every year, this particular location hit by high waves in late July when the atmosphere pressure shift in the Indian Ocean. But only in 2020, the high waves occurred in May, two months prior to the usual period of the event. This study focused to analyze the high waves on the study site on a small-scale simulation by using national bathymetric data.

2 Methodology

2.1 Study Area

Payangan Beach exposed directly to waves coming from Indian Ocean that can measure up roughly from 2 to 5 m in a bad weather condition. Average significant wave height in Payangan Beach during normal days is ranging from 1.6 to 2.0 m. This beach has natural defense against large waves and even massive tidal wave in a form of sand dunes and highest slope compared to other two beaches nearby (Fig. 1).

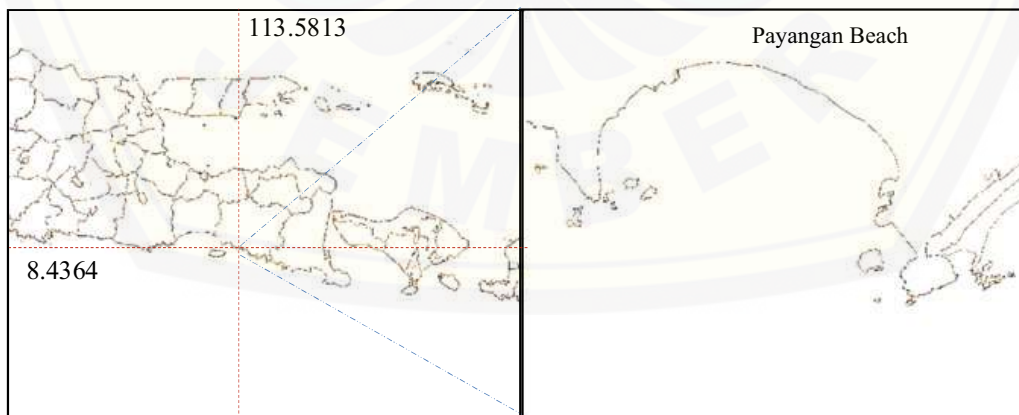


Fig. 1 Study location in east Java (left); the zoom-in map of study domain and study site at Payangan Beach (right)

Table 1 Wind data distribution

| Wind speed (knot) | Wind direction (%) | | | | | | | | Days (%) |
|----------------------|--------------------|------|------|------|-------|------|-------|------|----------|
| | N | NE | E | SE | S | SW | W | NW | |
| 0–3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.14 | 0.00 | 0.00 | 0.00 | 0.14 |
| 3–6 | 1.74 | 2.90 | 1.88 | 0.39 | 21.11 | 0.24 | 3.77 | 0.43 | 32.46 |
| 6–9 | 3.38 | 4.11 | 2.71 | 0.24 | 16.91 | 0.24 | 5.89 | 0.97 | 34.44 |
| 9–12 | 2.42 | 2.46 | 1.21 | 0.14 | 13.91 | 1.01 | 6.76 | 0.97 | 28.89 |
| 12–15 | 0.14 | 0.05 | 0.10 | 0.00 | 1.59 | 0.29 | 0.24 | 0.05 | 2.46 |
| 15–18 | 0.00 | 0.00 | 0.10 | 0.00 | 0.77 | 0.29 | 0.14 | 0.00 | 1.30 |
| 18–21 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | 0.05 | 0.00 | 0.00 | 0.14 |
| 21–24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.05 | 0.00 | 0.00 | 0.10 |
| 30–33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.00 | 0.00 | 0.00 | 0.05 |
| Days | 7.68 | 9.52 | 5.99 | 0.77 | 54.64 | 2.17 | 16.81 | 2.42 | 100.00 |

2.2 Wind Data Analysis

Wind data of this study was obtained from Class III Meteorological Station located in Banyuwangi which was the closest wind station to the study site. The data that was obtained from Class III Meteorological Station is the final wind data derived from u_{10} and v_{10} wind data. In the equation below [5, 6], the θ means meteorology wind direction angle in radians.

$$u = -|V| \sin \theta \quad (1)$$

$$v = -|V| \cos \theta \quad (2)$$

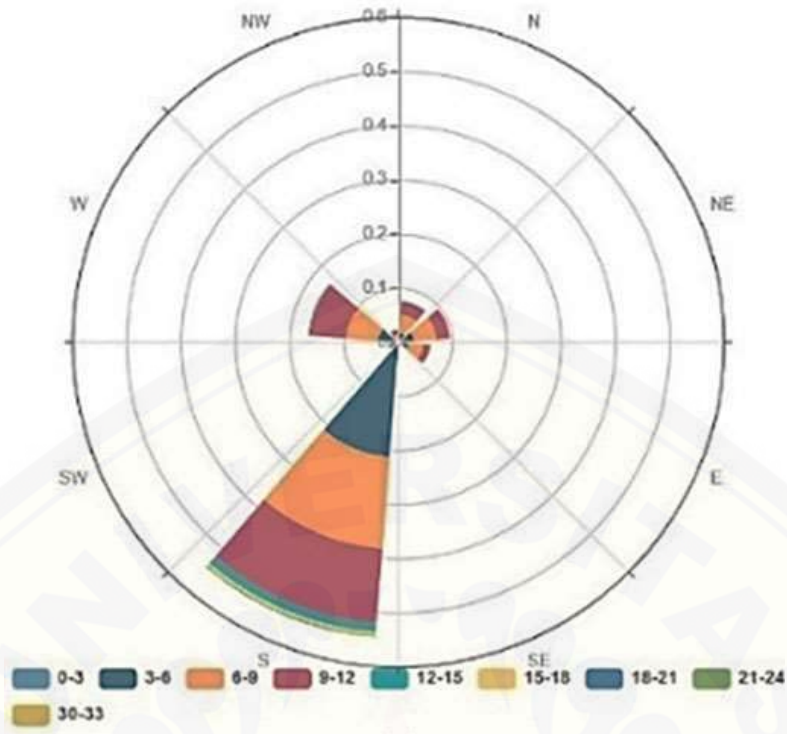
$$|V| = \sqrt{(u^2 + v^2)} \quad (3)$$

In addition, spatial variation of wind data namely ERA5-Interim wind data was obtained from Climate Data Store Copernicus that was measured by Aeolus satellite. The data that was gathered classified within 3 speed interval, $0 < U < 3$, $3 < U < 6$, $6 < U < 9$, up to $30 < U < 33$.

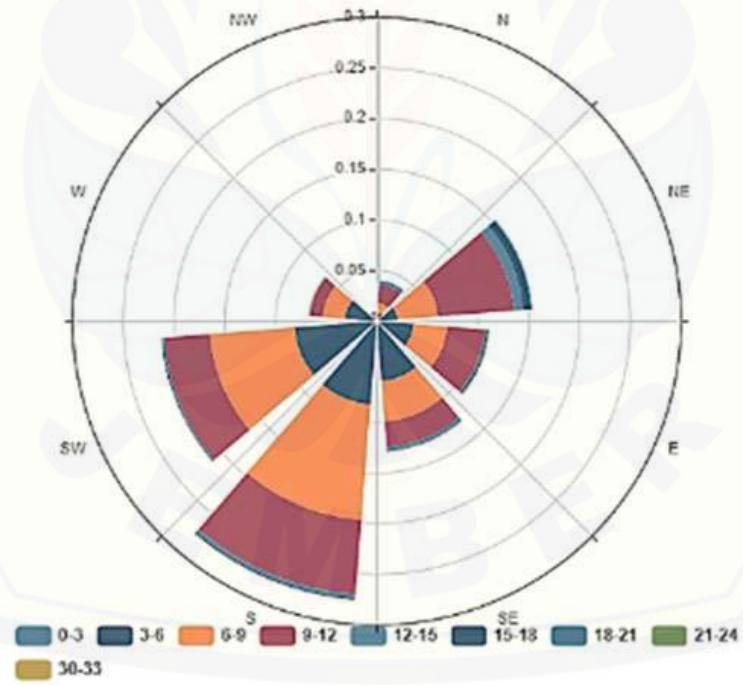
Table 1 shows wind data distribution and Fig. 2 shows wind rose of the study location. Based on the data, the main direction of wind is South (225°) which is 54.64% from total wind data.

2.3 Wave Simulation Using Delft3D

Delft3D-WAVE is able to compute various geospatial even meteorological parameters, wave dispersion calculation, wave generation by wind force, non-linear interaction between the waves, and wave dissipation [7]. In this study, Delft3D-WAVE is utilized based on the Simulating Waves Nearshore (SWAN) spectral model.



(a)



(b)

Fig. 2 Wind rose based on a peak wind direction; b mean wind direction

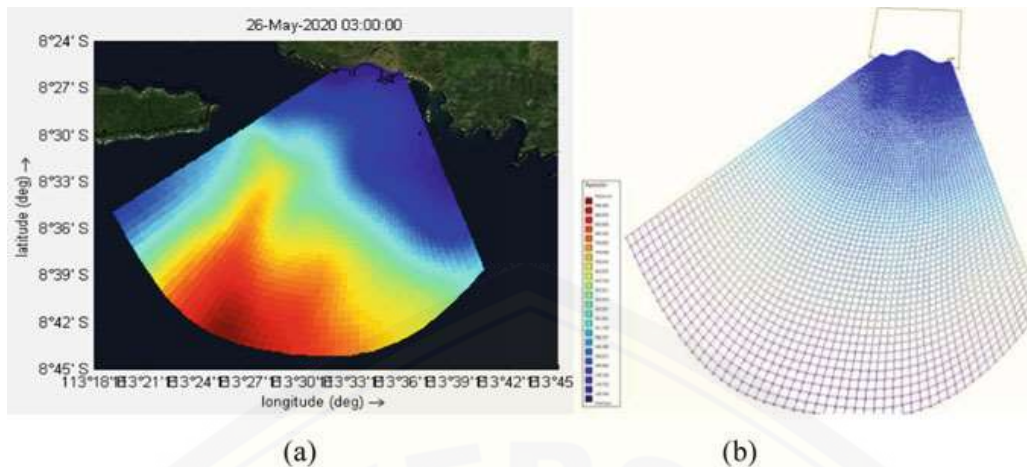


Fig. 3 a Depth generated from bathymetric data projected on ESRI visual; b simulation grid

In this study, bathymetric data that was used is the bathymetric data obtained from Indonesian Geospatial Information Agency with 6-arcsecond resolution. Wind input used in this simulation is taken from Class III Meteorological Station which have temporal resolution of 24 h (daily). In addition, wind data from ERA5-Interim provided by CDS Copernicus which have temporal resolution of 1 h (hourly) is used to generate meteo file as input file in Delft3D simulation. The bathymetric data is mapped in Fig. 3a. The grid used within the study domain ranges from 138.346 m to 946.482 m shown in Fig. 3b.

3 Results

3.1 Simulation Results

Generally, results of Delft3D-WAVE simulations in 2017, 2018, 2019, and 2020 show significant wave height of 2.5 m to 4.5 m nearshore and around 5 m offshore. The high waves in 2018 almost similar to those in 2017 with the difference margin around 5–10%.

Figures 4 and 5 show simulation results based on SWAN modeling in Delft3D when high waves occurred on July 25th, 2017. Figure 4a shows significant wave height of 2.5–4.5 m at the coastal area. Those high waves may be the cause of coastal flooding in the coastal area as occurred on July 25th, 2017. Figure 4b shows peak wave period more than 11 s in offshore while in coastal area, peak wave period ranges from 6 to 10 s. Figure 5 shows that waves approaching the beach at angle of 80° and shifting to 70° then around 55° to 60° when the waves arrive at the beach.

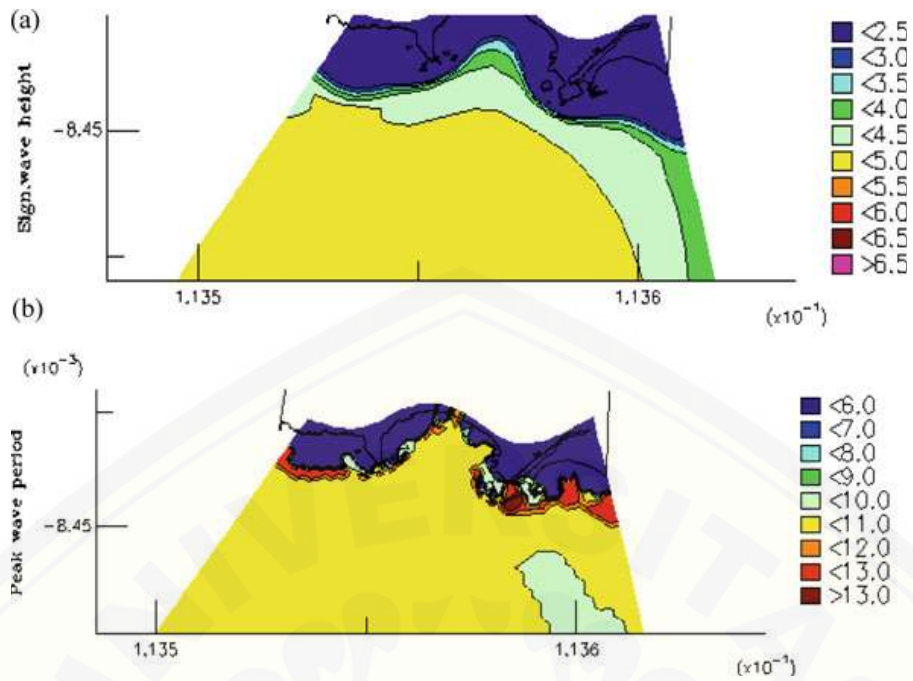


Fig. 4 Simulation result on July 25th, 2017. **a** Significant wave height; **b** peak wave period

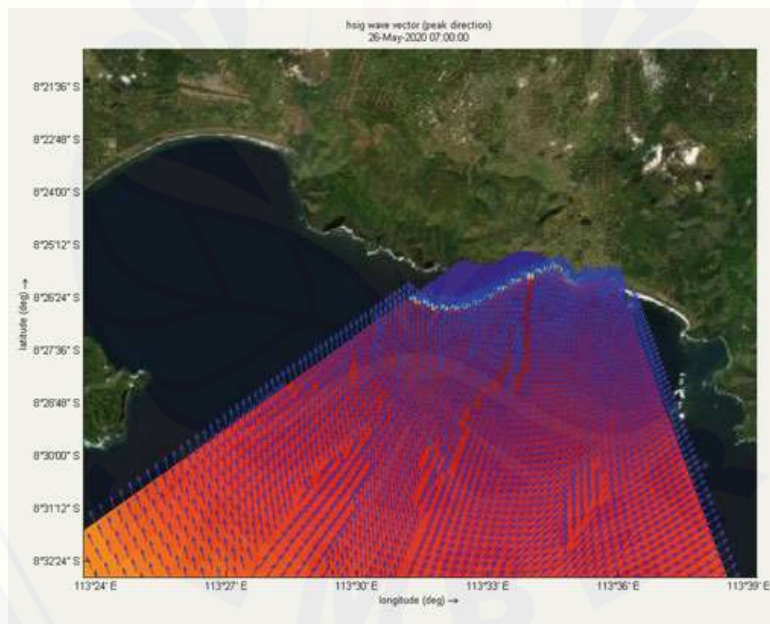
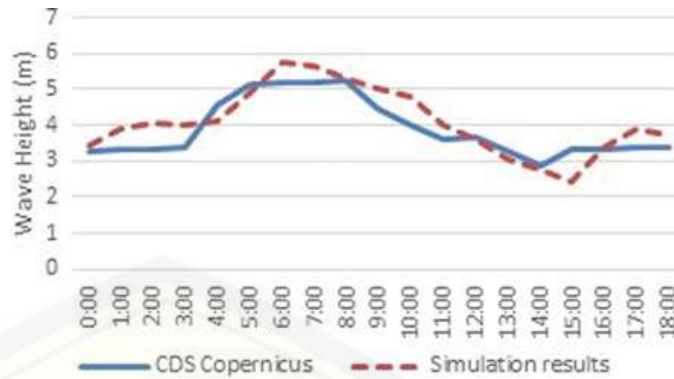


Fig. 5 Peak wave direction

Fig. 6 Comparison between simulated significant wave heights and CDS Copernicus observation data on July 2017



When high waves occurred, maximum wave height at 20 km offshore from Payangan Beach reached 3.9 m until 5.5 m. The simulation results coincide with the observed data from CDS Copernicus.

Figure 6 shows comparison between simulated wave heights on July 25th, 2017 and CDS Copernicus observation data. The results show that the highest simulated wave height was 5.8 m at 6 am, while based on CDS Copernicus observation data, the highest wave height was 5.2 m at 7 am. The simulated results show close prediction of CDS Copernicus data. The waves were generated from 8.55 m/s wind speed.

Simulation result in 2019 is different from those in 2017 and 2020 because the wave height is outstanding. The peak direction (Fig. 7a) not from 80° but vary from 62° to 77.5°. The significant wave height reached 6 m to 7 m in nearshore of Payangan Beach (Fig. 7b).

Figure 8a shows comparison between simulated wave heights on July 26th, 2019 and CDS Copernicus observation data. The results show that the highest simulated wave height was 6.9 m at 8 am, while based on CDS Copernicus observation data, the highest wave height was 5.9 m at 8 am. Although there are simulated results overestimated the observed wave height, the simulation was able to reproduce the similar time of maximum wave height at 8 am. The outstanding high waves were also confirmed by the captured video shown in Fig. 8b.

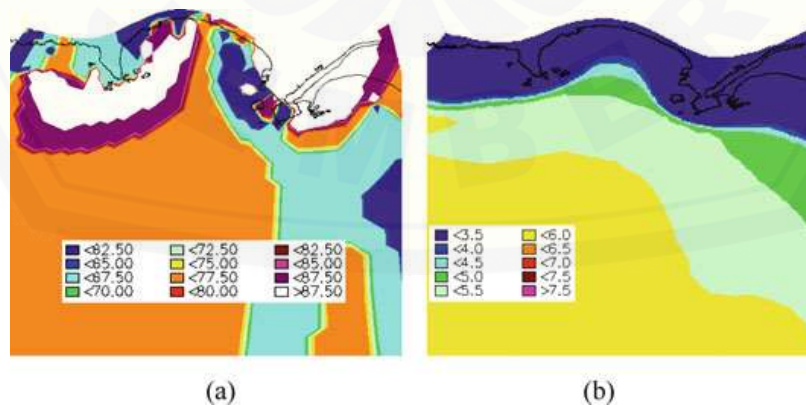


Fig. 7 Simulation result on July 26th, 2019. **a** Peak wave direction; **b** significant wave height

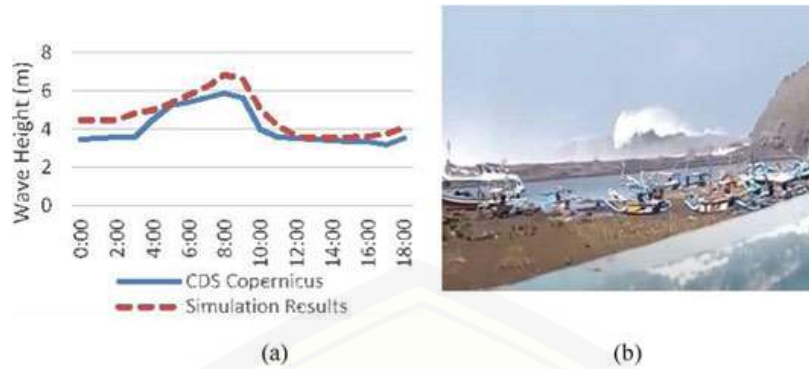


Fig. 8 a Comparison between simulated significant wave heights and CDS Copernicus observation data on July 26th, 2019; b Payangan beach high waves documentation [8]

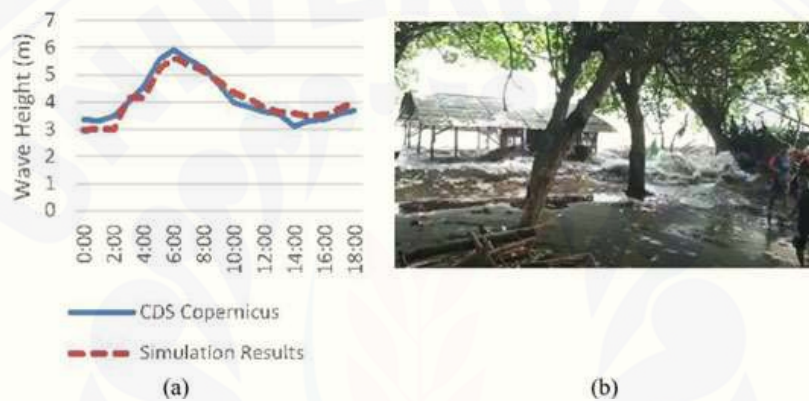


Fig. 9 a Comparison between simulated significant wave heights and CDS Copernicus observation data on May 2020; b Payangan beach high waves documentation on May 27th 2020 high waves [9]

Different from 2017 and 2019, in 2020 the high waves occurred not in July but in May. Figure 9a shows comparison between simulated wave heights on May 27th 2020 and CDS Copernicus observation data. The results show that the highest simulated wave height was 5.6 m at 6 am, while based on CDS Copernicus observation data, the highest wave height was 5.9 m at 6 am. The waves were generated from 7.42 m/s wind speed. The simulated results slightly underestimated the observed wave height. However, the simulation was able to reproduce the similar time of maximum wave height at 6 am. The high waves were also confirmed by the photo shown in Fig. 9b.

4 Structural Measures

In order to protect the beach along with the community living within the area of study in Payangan Beach, one of the best solutions is to create safety measures based

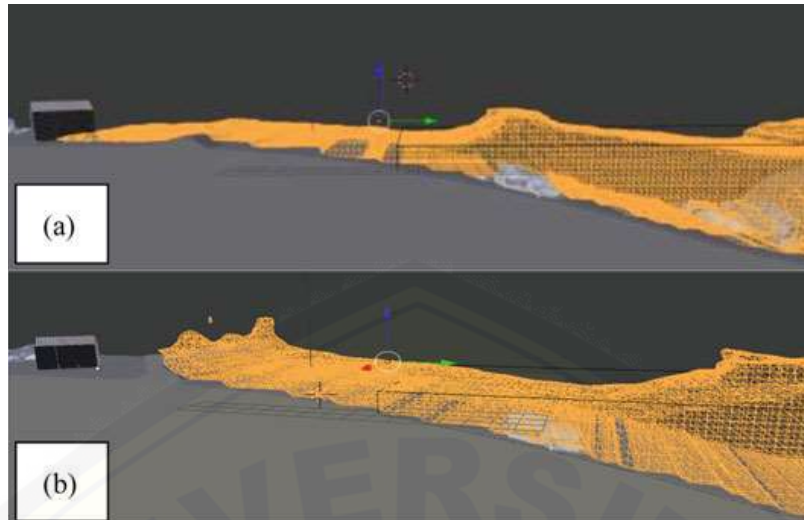


Fig. 10 High waves **a** without sea wall as protective measures; **b** with sea wall as protective measures

on the simulated wave height. Based on consideration and effectiveness according to the events, the best measures considered is to build a sea wall.

Sea wall is a coastal defense structure built parallel to the coastline to mitigate coastal flooding by blocking and or reflecting waves force to another direction so the wave will less affect the area protected by the sea wall. Sea wall vary in shape and type which based on the site condition. Payangan Beach condition require sea wall because of the direct wave effect on the beach during high waves.

Figure 10 show illustration of Payangan Beach without sea wall (Fig. 10a) and with sea wall (Fig. 10b). Without sea wall, waves will propagate to the coastal area and inundate residential area. By constructing sea wall, waves will be reflected and the residential area will be protected from severe inundation.

5 Conclusions

High waves occurred at Payangan Beach is significantly high because of the direct exposure of wind and wave from the open ocean. Wind meteorological direction is from the South with wind speed vary from 3.9 m/s to more than. When high waves occurred, the wind speed vary from 5 m/s to 16 m/s and generate waves with significant wave height of 3.4–5 m.

The high waves occurred in 2015, 2016, 2017, and 2018 show significant wave height of 2.5–4.5 m nearshore and around 5 m offshore with difference margin around 5–10%. However, in 2019 high waves occurred with significant wave height reached 6–7 m in nearshore of Payangan Beach. The significant wave height creating massive wave that visible from the distance. In 2020, high waves occurred two months prior than the other five years which always occurred in late July.

Preventive measures must be taken into consideration to protect the coastal area and residential area located in Payangan Beach. The most effective solution is to build coastal protection structure to cope with high waves and inundation that caused the coastal flooding. Sea wall has high efficiency to hold waves energy and to protect the residential area from inundation. However, with this solution, there may be sediment transport around the seawall. Further study is necessary to analyze coastal protection structure and the effect to the beach.

References

1. Coastal Engineering Research Center (1984) Shore Protection Manual, Vol 1. US Army Corps of Engineers, Washington DC
2. Triatmodjo B (1999) Teknik Pantai [Coastal Engineering]. Beta Offset, Yogyakarta
3. Warpindyasmoro HS (2018) Wave energy potency in east java coast. MATEC Web Conf 177:10–18
4. High Waves Attacked a Shop in Payangan Beach. <https://www.youtube.com/watch?v=6yZIZBshfas>. Last accessed 2020/12/11
5. Ostrenga D (2019) Derive wind speed and direction with MERRA-2 wind components. <https://disc.gsfc.nasa.gov/information/data-in-action?title=Derive%20Wind%20Speed%20and%20Direction%20With%20MERRA-2%20Wind%20Components>. Last accessed 2021/7/2
6. Yuwono N (1982) Teknik Pantai, Vol I. Biro Penerbit Keluarga Mahasiswa Teknik Sipil FT UGM, Yogyakarta
7. Deltares (2014) Delft3-Wave User Manual. Deltares, Delft
8. High waves in Payangan on July 2019. <https://www.youtube.com/watch?v=iATXCUStZUQ>. Last accessed 2021/6/1
9. High waves in Jember Payangan on May 2020. <https://www.youtube.com/watch?v=rMFgTJDimaA>. Last accessed 2021/6/1