

Civil and Environmental Engineering for Resilient, Smart and Sustainable Solutions



Edited by
Tahar Ayadat

MIRF

Civil and Environmental Engineering for Resilient, Smart and Sustainable Solutions

1st International Conference on Civil and Environmental
Engineering for Resilient, Smart and Sustainable Solutions,
Civil Engineering Department - College of Engineering, Prince
Mohammad Bin Fahd University
AL-Khobar - Saudi Arabia, 3-5 November 2024

Editor

Tahar Ayadat¹

¹ Civil Engineering Department - College of Engineering, Prince Mohammad Bin
Fahd University, AL-Khobar - Saudi Arabia

Peer review statement

All papers published in this volume of “Materials Research Proceedings” have been peer reviewed. The process of peer review was initiated and overseen by the above proceedings editors. All reviews were conducted by expert referees in accordance to Materials Research Forum LLC high standards.

Copyright © 2025 by authors



Content from this work may be used under the terms of the Creative Commons Attribution 3.0 license. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

Published under License by **Materials Research Forum LLC**
Millersville, PA 17551, USA

Published as part of the proceedings series

Materials Research Proceedings

Volume 48 (2025)

ISSN 2474-3941 (Print)

ISSN 2474-395X (Online)

ISBN 978-1-64490-341-4 (eBook)

This book contains information obtained from authentic and highly regarded sources. Reasonable efforts have been made to publish reliable data and information, but the author and publisher cannot assume responsibility for the validity of all materials or the consequences of their use. The authors and publishers have attempted to trace the copyright holders of all material reproduced in this publication and apologize to copyright holders if permission to publish in this form has not been obtained. If any copyright material has not been acknowledged please write and let us know so we may rectify in any future reprint.

Distributed worldwide by

Materials Research Forum LLC

105 Springdale Lane
Millersville, PA 17551
USA
<https://mrforum.com>

Manufactured in the United State of America
10 9 8 7 6 5 4 3 2 1

Table of Contents

Preface

Committees

Assessment of ready-mix concrete properties in various zones of concrete samples

Nayeemuddin MOHAMMED, Mohammad Abdul MANNAN,
Intan Nurhafizah Fazriana bt HAMZANIc, Fawzyah S ALKHAMMAS, Danish AHMED,
Andi ASIZ, Mohammad Ali KHASAWNEH, Tahar AYADAT, Tasneem SULTANA..... 1

Analyzing the differences between the impacts of wind and earthquakes on base shear and drift in diagrid structures

Nayeemuddin MOHAMMED, Andi ASIZ, Shaik ABDULLA, Danish AHMED,
Muhammad AJMAL, Tahar AYADAT, Tasneem SULTANA 11

Structural damage localization and quantification in cantilever beam structure using modal strain parameters and artificial neural network

Rachid AZZI, Farid ASMA..... 20

Evaluation of concrete slab exposed to weather conditions resulting from global warming

Emad ALSHAMMARI, Mang TIA, Ahmed ALSABBAGH, Othman ALANQURI,
Abdullah ALBOGAMI..... 30

Shear capacity prediction of squat flanged walls using machine learning approach with CatBoost and CTGAN

Khalid Saqer ALOTAIBI 40

Comprehensive analysis of structural beams: Theoretical calculations and simulation analysis using ANSYS

N.J. JAIN, S. Sangita MISHRA 50

A modified design for improving pressure relief valve stability

Abdullah Alhamdan, Omar D. Mohammed, Esam Jasim 60

Site amplification using 1D seismic site response analysis in Islamabad: An application of building code of Pakistan 2021

Muhammad Aaqib, Ali Hamaiz Khan, Muhammad Aaliyan Ashraf, Jahanzeb Gul Abbasi,
Zia Ur Rehman 69

Critical building components analysis: An empirical study

Saidur Rahman Chowdhury, Shahidur Rahman Shihab, Shafinul Islam,
Muhammad Saiful Islam 77

Experimental study of BFRP-RC beams exposed to elevated temperatures

Nour GHAZAL ASWAD, Mohammed AL DAWOOD, Farid ABED, Ahmed EL REFAI 86

An optimization approach process of a 4-story RC building structural plan through generative design

Ilda RUSI, Albi ALLIAJ 93

Structural design analysis of hybrid multi-rise buildings, with CLT and LGS light weight floor system, at Neom-The Line

Danah ALOTAIBI, Rehaf ALBOGAMI, Sara ALTHUWAIQEB, Fatima ALNASSIR,
Haneen ALFAIHANI, Danish AHMED, Tahar AYADAT, Andi ASIZ,
Nayeemuddin MOHAMMED, Hala ALMADI 103

Sustainability and cost of a multi-story edifice, with CLT and LGS light weight floor system, at Neom-The Line	
Rehaf ALBOGAMI, Danah ALOTAIBI, Sara ALTHUWAIQEB, Fatima ALNASSIR, Haneen ALFAIHANI, Danish AHMED, Saidur Chowdhury, Tahar AYADAT, Mohammad Ali KHASAWNEH.....	113
Seismic assessment of reinforced concrete building strengthened with CFRP sheets using non-linear static approach	
Muhammad AJMAL, Rashid ISMAEEL, Mona ISMAIL, Danish AHMED, Tahar AYADAT	123
Cyclic performance of partially grouted reinforced masonry shear walls with boundary elements	
Abdulelah AL-AHDAL, Belal ABDELRAHMAN, Khaled GALAL	131
A study case: Seismic evaluation of existing six-story office building with flat plate structural system	
Jonathan ANDREW, Liana HERLINA, Sugeng WIJANTO, Usman WIJAYA	135
Experimental evaluation of the masonry infilled reinforced concrete frame under reverse cyclic loading	
Abhijeet A. GALATAGE, Satish B. PATIL	143
Comparative analysis of structural performance and cost efficiency of reinforced concrete and steel for a three-story warehouse in high-risk seismic zones	
Ilian DJEBBARI, Fahmy HERMAWAN, Usman WIJAYA, Easter Sista Parameswari WIBISONO	153
Numerical investigation of the seismic bearing capacity of offshore skirted foundations installed in sand using finite element limit analysis	
Alaoua BOUAICHA, Nour El Islam BOUMEKIK, Abdelhak MABROUKI.....	161
Fire behaviour of mass timber beam-to-column hybrid connections - A state-of-the-art review	
Osama (Sam) Salem	171
Thermal optimization of two-way joist slabs: A comparative study using finite element analysis	
Galal AL-MEKHLAFI, Hussain ALSADIQ, Mohammed AL-HURI, Mohammed AL-OSTA, Omar AL-AMOUDI	181
Seismic assessment of masonry infilled frame structures	
Galal AL-MEKHLAFI, Mohammed AL-OSTA, Hamdi AL-SAKKAF	191
Seismic performance of automatically generated ductile moment resisting frames	
Salim TAFRAOUT, Nouredine BOURAHLA	200
Applications of shape memory alloys in structural engineering	
Hossam EL-SOKKARY	210
Seismic response of setback building in hilly region with effect of lift well	
Pranab Kumar DAS, Mainak MALLIK	225
Refinement of tuned mass damper parameters on machine support structure using dynamic cuckoo search algorithm	
Ahmad Muinuddin MAHMOOD, Zamri MOHAMED, Rosmazi ROSLI.....	234

Nonlinear ground performance under a high shaking scenario similar to Boumerdes earthquake	
Mohamed KHIATINE, Amal MEDJNOUN, Oubaida AICHE, Ramdane BAHAR	242
Improved machine learning modeling for predicting shear capacity of RC deep beams	
Muhammad ARIF, Muhammad LUQMAN, Usama Iftikhar KHAWAJA, Nasrumin ALLAH.....	252
An overview of the mechanical and characterization aspects of self-compacting concrete in relation to the influence of catalyst	
Nayeemuddin MOHAMMED, Zainab A AL MSHAR, Andi ASIZ, Mohammad Ali KHASAWNEH, Danish AHMED, Tahar AYADAT, Tasneem SULTANA ..	263
Advancements in green sustainable concrete technologies for sustainable development in Saudi Arabia: A review in light of vision 2030	
Nayeemuddin MOHAMMED, Dalya M ALSHALI, Andi ASIZ, Tahar AYADAT, Mohammad Ali KHASAWNEH, Danish AHMED, Tasneem SULTANA.....	271
Optimizing cover concrete durability in ready mixed concrete a critical review of curing methods and their impact on performance	
Nayeemuddin MOHAMMED, Mohammad Abdul MANNAN, Hend Walid Alotaibi, Andi ASIZ, Tahar AYADAT, Mohammad Ali KHASAWNEH.....	279
Slope stability analysis: Case Study at Chwit City, Lebanon	
Layal JRADI, Bassel SEIF EL DINE, Tahar AYADAT, Andi ASIZ, Samar DERNAYKA.....	289
The influence of particle separation distance on the prediction of the suction stress curve of the simple cubic form	
MESSAST Salah, BENCHEIKH Karim, AYADAT Tahar, MEBIROUK Nadjib, AMRANE Moussa, LAOUAR Med Salah	297
Review of stone columns, piled raft foundations, and combined stone columns and piles under raft as a ground improvement techniques for soft clay soils	
Danish AHMED, Siti Noor Linda bt TAIB, Tahar AYADAT, Alsidiq HASAN, Muhammad AJMAL	306
Physical modeling in calibration chamber of the evolution of the soil stiffness around a piezocone probe under cyclic axial loading in saturated clay	
Mohammed KHOUAOUCI, Ali BOUAFIA.....	316
Variability of some geotechnical parameters in South Eastern Nigeria	
Site ONYEJEKWE, Chidi B. N. EDU, Jeremiah C. OBI.....	325
Effectiveness of marble powder to improve compaction of low-water content soil	
Oubaida AICHE, Mohamed KHIATINE, Amal MEDJNOUN, Ramdane BAHAR.....	336
Investigation of drying shrinkage, water absorption and strength properties of metakaolin based geopolymer mortars	
Rim ALLAM, Jamal KHATIB, Mohamad EZZEDINE EL DANDACHY	342
Investigation of the density, ultrasonic pulse velocity and strength properties of metakaolin based geopolymer mortars	
Layal HAWA, Jamal KHATIB, Mohamad Ezzedine EL DANDACHY	350
Influence of UV-treated polypropylene fibres on residual compressive strength of cement paste	
Daha Shehu ALIYU, Colin T. DAVIE, Enrico MASOERO	359

Geotechnical enhancement of expansive soils through zeolitic tuff and cement treatments Laith IBDAH, Samer RABABAH, Mohammad Ali KHASAWNEH, Hussein ALDEEKY, Abdulla SHARO.....	368
Enhancing durability and sustainability in fly ash-slag concrete using advanced metaheuristic algorithms and explainable ML for compressive strength prediction Abba BASHIR, Doha S. ALIYU, Salim I. MALAMI, Abdulazeez ROTIMI, Shaban Ismael Albrka ALI, Sani. I ABBA	378
Enhancing the durability of fine-grained soils with stabilizers under freeze-thaw cycles Samer RABABAH, Mohammad Ali KHASAWNEH, Abdulla SHARO, Hussein ALDEEKY, Ahmad AL-SAWI.....	187
The effectiveness of bio-anchorage system in reinforcing tropical residual slope Kuraisha KAMBALI, Youventharan DURASAMY, Rokiah OTHMAN, Mohd Arif SULAIMAN, Ramadhansyah PUTRA JAYA, Siti Noor Linda TAIB	397
Machine learning approach for predicting the compressive and flexural strengths of fiber-reinforced concrete mixtures Roz-Ud-Din NASSAR, Khaled ABDALGADER	407
An insightful review on the utilizing crumb rubber as partial substitute to aggregates in concrete Musa ADAMU, Veerendrakumar C. KHED, Yasser E. IBRAHIM.....	417
Mechanical characterization of lightweight expanded clay particles Ben Jamaa Haithem, Elghezal Latifa, Jamei Mehrez.....	428
Development of a SPT&DCPT correlation for coarse-grained soils: A case study Tahir YILDIZ, Yusuf BATUGE, Burak TURAL, Jad ALKHALIFA.....	438
Parametric study of footing on sandy slope soil Danish AHMED, Muhammad AJMAL, Tahar AYADAT, Andi ASIZ	448
Influence of Omani Sarooj on plasticity and california bearing ratio of expansive soil Abideen GANIYU, Al-Muhanna AL-KHAROUSI, Ahmed AL-SAIDI, Hilal AL-ALAWI.....	456
Performance of sustainable mortars containing marble waste as alternative for natural sand Ola adel QASIM, Nahla HILAL, Mohammad I. ALBIAJAWI, Nadhim Hamah SOR	464
Study of the global factor of safety for mechanically stabilized earth wall (MSE) using numerical modelling Mahmoud S. HAMMAD, Mahmoud A. HASSAN, Ayman L. FAYED.....	475
Mechanical properties and microstructures of steel-reinforced rebar exposed to heat Yousef ALSHAMMARI, Fatemah ALOWMI	486
Correlation of soft clay and shear strength in West Jakarta Zaki, M., Ngom, M.B., Misshuari, I.W., Sejati, W., Zayadi, R.	494
Machine learning approaches for predicting ultimate tensile strength in 9% Cr steels Seza DINIBUTUN, Yousef ALSHAMMARI, Jafarali PAROL, Leandro BOLZONI.....	501
The relationship between the plasticity index, the friction angle and the cohesion of the soils in Jakarta during El Niño and La Niña cycles Ngom Maïssa. B., Zaki Al Attas M., Imas Windah, Nugroho Muhammad Sapto.....	510

Enhancing metro accessibility in Riyadh: Reviewing neighborhood planning to integrate walkable, pedestrian-friendly urban environment design	
Aïssa REZZOUG, Muhammed IMRAN, Omar ALMUTAIRI	519
Concrete incorporating plastic waste: Challenges and possible solutions	
Almotaseembillah AHMED, Abubakr E. S. MUSA, Hammad R. KHALID, Subhan AHMAD	530
Failure analysis of corroded underground pipeline	
Fatemah AL-ABKAL, Adel HUSAIN	539
Effect of waste-based geopolymers on mechanical and geotechnical properties of expansive soil	
Rasil KODAH, Samer RABABAH, Mohammad Ali KHASAWNEH, Hussein ALDEEKY, Dima MALKAWI	549
Enhancing the performance of masonry structures using fiber-reinforced polymer technologies under in-plane Loading: A comprehensive review	
Houria HERNOUNE, Ouided HERIHIRI.....	559
Polyurethane grout as repair material for concrete structures: Performance evaluation	
Sadi Ibrahim HARUNA, Yasser E. IBRAHIM, Abdurra'uf M. GORA, M.N. IBRAHIM.....	569
Soil stabilization by using brick waste powder	
Avinash A RAKH, Anandrao A JADHAV, Achyut A DESHMUKH	577
The influence of fly ash characteristics as a supplementary cementitious material (SCM) on concrete's mechanical properties	
Y. SUNARNO	587
Durability properties of self-compacting concrete developed using rice husk ash and sawdust ash as substitutes for cement and used engine oil as a chemical admixture	
Abdurra'uf M. GORA, Taibat Onize Yakubu, Sadi Ibrahim HARUNA, Yasser E. IBRAHIM	597
Effect of ground motion frequency content on nuclear power plants including soil-structure interaction	
Mohamed ELSHARAWY	607
Early-age properties of silicomanganese fume and metakaolin-based cement mortar designed using RSM	
Muhammad NASIR, Ahmed Adil ALAMMARI, Abdulrahman Khalid ALKULAIBI, Mohammed Abdulghani BUSALEH, Mohammed IBRAHIM, A. B. M. Saiful ISLAM, Khalid Saqer ALOTAIBI, Fahad ANWAR	617
Melted plastics as the exclusive binder for masonry units: A sustainable solution for the construction industry	
Paul O. AWOYERA, Peter NWOKOLO.....	626
Air pollution from vehicles in Makkah, Saudi Arabia: Challenges and sustainable solutions	
Saidur Rahman CHOWDHURY, Fawzyah ALKHAMMAS, Zainab ALMSHAR, Hala ALMADI	634
A review on sources of water contamination in the Eastern Province, Kingdom of Saudi Arabia	
Salma Ali ALYAHYA, Feroz SHAIK.....	643

Renewable energy for green environment in the Eastern Province in KSA: Opportunities and sustainability	
Samar DERNAYKA, Saidur R. CHOWDHURY, Mohammad Ali KHASAWNEH, Layal JRADI, Tahar AYADAT	653
Anaerobic co-digestion of chicken manure and perennial ryegrass: Methane yield and kinetic study	
Tariq ALKHRISAT	663
Flood Simulation using rainfall-runoff-inundation (RRI) model, over Tripoli City, Lebanon	
Fouadi ALZAATITI, Jalal HALWANI, Najib NICOLAS GERGES, Mohamed SOLIMAN ...	670
Bed roughness effects on residence time distribution (RTD) parameters of vortex-type stormwater retention ponds	
S. Mahdi YAMINI, Hamid SHAMLOO, Fatemeh ARJOMANDI	678
Sustainable solid municipal waste management in Saudi Arabia: Challenges and opportunities	
M. Amin Mir, Kim Andrews, Syed M. Hasnain	688
Response surface methodology (RSM) for predicting and optimizing the pressure drop in submerged multi-jet electrolyte flow system	
Yara Sami H ALGHANNAM, Lujain Abdullah A ALTEWAIRQI, Feroz SHAIK, Faizan AHMED, Nayeemuddin MOHAMMED, Ratna Sunil BURADAGUNTA	697
Effect of root water uptake on road movement across seasonal changes	
Yuliana YULIANA, Arwan APRIYONO, Anthony Kwan LEUNG, Suraparb KEAWSAWASVONG, Viroon KAMCHOOM	707
Low-cost, in-situ groundwater monitoring methodology for data-scarce regions	
Abba IBRAHIM, Aimrun WAYAYOK, Helmi Zulhaidi Mohd SHAFRI, Noorellimia Mat TORIDI, Wada Idris MUHAMMAD	717
Effect of chloride concentration on carbon steel corrosion of boilers supplied with feed water in refineries	
Abeer ALFARHAN, Abdulmuhsen AKBAR	729
In-vessel aerobic composting with leachate recirculation and biochar for enhanced compost quality	
Amit Dharnaik, Satish Patil	736
Development model of small orifice flow using simple linear and multilinear regression	
Dina P.A HIDAYAT, Sih ANDAJANI, Muhammad A.G IMANULLAH	746
Preliminary study of water quality in the Jragung river	
L. Toffin, S. Thieble, E. Kurniyaningrum, H. Boileau, A. Rinanti, M.A. Kurniawan, A. Primahessa, N. Hazel, E. Mulia, Samuel	755
Use of electrocoagulation for treatment of wastewater	
Bhagyashri PATIL, Satish PATIL, Kishore RAVANDE	764
Water use efficiency strategy for the Universitas Trisakti FTSP building	
Shara Putri Dayantika, Bambang Endro Yuwono	774
Simultaneous brine and CO₂ utilization in construction material production: A life cycle assessment	
Aiste ZUKAITYTE, Roneta CHALIULINA, Jose-Luis GALVEZ-MARTOS,	

Ammar ELHOWERIS, Yousef ALHORR.....	784
Impact of COVID-19 lockdowns and seasonal variations on PM2.5 in Dhaka City	
Fazlul Hoque TUSHAR, Rokshana PERVIN, Md Nazrul ISLAM, Mahmudul Hoque TUHIN, Ummay Hani UMMI, Md. Amzad HOSSAIN, Tahia RABBEE.....	793
Effect of spent coffee grounds addition on biogas and methane yield from anaerobic digestion of tannery solid waste	
Solomon Kebede ASEFA, Venkata Ramayya ANCHA, Nigus Gabbiye HABTU, Mohammad AL-ADDOUS, Tarekegn Limore BINCHEBO	805
Reservoir storage simulation of Sepaku Semoi Dam Penajam Paser Utara Regency	
R.W. SAYYID KAMIL, WAHYU SEJATI	815
Development of floating concrete for use as solar photovoltaic systems using expanded polystyrene and plastic fiber over the water bodies in Bangladesh	
Arnob SARKER, Kazi Abu MANJUR, Md Shakib HOSEN, Azharul HAQ, Abdullah Al BASED, Abul Kashem Mohammad YAHIA.....	823
Rainfall-discharge modeling in Juana Watershed	
K.D. Komara, E. Kurniyaningrum, A. Rinanti, D. Pontan, R. Abdilla, H. Sattar.....	833
Role of energy services companies in promoting energy and environmental sustainability in the GCC Region	
Syed ILYAS, Muhammad ASIF	843
Municipal solid waste generation, composition and public awareness in Riyadh, Saudi Arabia	
Raouf HASSAN	852
A green-magnetic approach to textile wastewater decolorization using nickel ferrite-enhanced activated carbon from pistachio shells	
Raouf HASSAN, Reda. S. SALAMA, Bushra ISMAIL, Ahmad K. BADAWI.....	859
Chemically modified rice husk as a green filtration media for chemical oxygen demand removal from pulp and paper effluents	
Ahmad K. BADAWI, Randa M. OSMAN, Raouf HASSAN	869
Efficacy of built environment on perceived competence, autonomy, regulation, and physical activity engagement: A quantitative sustainability perspective	
Md. Dilsad Ahmed	874
Application of artificial neural networks (ANN) to evaluate centrifugal pump characteristics	
Nayeemuddin MOHAMMED, Danish AHMED, Tahar Ayadat, Faizan AHMED, Deepanraj Balakrishnan, Hiren MEWADA, Muhammad AJMAL, Tasneem SULTANA	883
Leveraging AI for Environmental Solutions addressing Climate Change, Pollution Monitoring and Sustainable Resource Management	
Noreen Sher AKBAR, Ghanwa BATOOL, Shahan SIDDIQUI, Muhammad Bilal HABIB	892
The nexus between environmental degradation and social inequality: Intersecting crises	
Laura M. STRACHAN, Gaydaa AL ZOHBI.....	903
An inquiry into Amman bus rapid transit elements	
Rana Ibrahim ABID	910

Investigating the impact of pavement surface features on skid resistance: A review on machine learning approach	
Mohammad Ali KHASAWNEH, Nayeemuddin MOHAMMED, Ahmad Ali KHASAWNEH, Tamer ALNAZER	923
Assessment of COVID-19 pandemic impact on daily trips in Salah al Din Governorate in Iraq	
Aslam A. AL-OMARI, Bara W. AL-MISTAREHI, Roaa J. ALAWADI, Taleb M. AL ROUSAN, Shareef S. SHAREEF	931
Moisture-induced damage in asphalt concrete pavement: A review paper to uncover the stripping phenomenon	
Mohammad Ali KHASAWNEH, Ansam SAWALHA, Mohammad Ahmad ALSHEYAB, Ahmad Ali KHASAWNEH, Amani SAWALHA.....	941
A comprehensive review of intelligent transportation systems toward alleviating traffic congestion	
Ansam SAWALHA, Amani SAWALHA, Mohammad Ali KHASAWNEH.....	951
Numerical analysis of pavement structure on expansive subgrade stabilized with surcharge pressure	
Adel Djellali, Rachida Malaoui, Zied Benghazi, Debojit Sarker, Behrooz Saghaifi	961
Incorporating 3D printing and machine learning to revolutionize transportation infrastructure: Building tomorrow	
Ansam SAWALHA, Ayah A. ALKHAWALDEH, Amani SAWALHA, Mohammad A. ALKHAWALDEH, Mohammad Ali KHASAWNEH	968
Evaluation of asphalt pavement maintenance practices in Kuwait	
Fatemah Al-Owmi, Nayef Al-Othman, Haya Almutairi, Suad Al-Bahar	978
Roads failure and sustainability challenges of Zambian roads: A review of current practice	
Nathan Ntanda CHILUKWA, Mohamed Mostafa Hassan MOSTAFA, Christopher NGWIRA.....	988
Sustainable stabilization of expansive soils using burned olive waste ash (BOWA) and lime for pavement construction	
Ibrahim FAWAIER, Samer RABABAH, Mohammad Ali KHASAWNEH, Hussein ALDEEKY, Madhar TAAMNEH, Tareq ABU-AGOLAH.....	999
Impact of crushed sand and lime on clayey soil for pavement sub- grade	
Rajshekhar G. RATHOD, Kishore RAVANDE, Nayeemuddin MOHAMMED, Tahar AYADAT, Lingala Syam SUNDAR	1010
Performance evaluation of asphalt binder modified with olive mill wastewater ash (OMWA)	
Madhar M. TAAMNEH, Aiman Q. JARADAT, Musab ABUADDOUS, Samer R. RABAB'AH, Jawad TAAMNEH	1020
An experimental investigation on dense bituminous macadam (IRC- grading 2) mixes with coal ash	
Sagar Kailas SONAWANE, Arun Kumar DWIVEDI, Premanand L. NAKTODE	1030
Analyzing locations prone to causing road crash injuries and fatalities in Saudi Arabia	
Omar ALMUTAIRI	1040

Incorporating date seed powder (DSP) into asphalt binder: A feasibility study on sustainable and economical practices in Saudi Arabia	
Rana Aldawood, Dalya Alshali, Zainab Almshar, Maryam Alkhuraim, Fawzyah Alkhammas, Mohammad Ali Khasawneh	1050
Investigating the rheological properties of rubberized-bitumen blends modified with warm mix additives	
Haya ALMUTAIRI, Zainab AWADH.....	1061
Investigation on moisture susceptibility of asphalt mixtures containing ground tire rubber and de-vulcanized rubber	
Fatemah Alasfour, Hayaa Almutairi, Suad Al-Bahar.....	1068
Evaluation of interlayer bond strength for C55 emulsion prime bituminous binders with aggregates	
Samuel ABEJIDE, Reatile PITSO	1075
Investigating top-down cracking of pavement in recycled waste plastic asphalt	
Samuel ABEJIDE, Jacob ADEDEJI, Mohamed Mostafa Hassan Mostafa	1086
Trends and challenges in traffic safety: An analysis of road accidents and fatalities in Lebanon (2011-2024)	
Layal JRADI, Raef HAJ DIAB, Bassel SEIF EL DINE.....	1099
A Study of workflow with synchronization of design process on autodesk construction cloud	
Nattasit Chaisaard, Thanom Seehatrai, Grit Ngowtanasuwan, Jinthisa Suraprasert.....	1109
A DEMATEL-based method for developing and assessing key performance indicators for construction projects	
ALAA SALMAN, SAMER AL-IMAMY	1121
Cost estimation model for residential buildings: A fuzzy expert system	
Saidur Rahman Chowdhury, Muhammad Saiful Islam, Md. Mahfuzun Nobi Mahim, Adri Das	1130
Sustainability challenges and opportunities in UAE construction industry: An analytical survey	
Yousef ALQARYOUTI, Mariam AL SUWAIDI, Raed Mohmood ALKHUWAILDI, Hind KOLTHOUM, Issa YOUSSEF, Mohammed AL IMAM	1138
Street, road, and boulevard: Permeable, smart, and creative systems transforming Riyadh	
Massimiliano GOTTI PORCINARI.....	1149
Solutions for maintenance delays in Saudi oil and gas: Integrating interpretive structure modeling and relative importance index	
Adel ALSHIBANI.....	1159
Evaluating virtual reality implementation for risk register identification: A case study of architectural project works	
Ryan Faza PRASETYO, Bambang Endro YUWONO, Darmawan PONTAN, RAFLIS, Feby Kartika SARI.....	1171
Building information modelling (BIM)-based solar path and shadow analysis for energy-efficient building design	
Fazlul Hoque TUSHAR, Tahia RABBEE, Md Shakib HOSSEN, Md Feroz MIAH,	

Siam Ul BADHON, Akram ULLAH	1179
Characteristics of compressed stabilized earth blocks for construction in Sudan	
Omer AHMED, Abdelrahman A. AWAD, Mohamedelmustafa AHMED, Yousif Hummaida AHMED, Mahmoud AHMED, Abubakr E.S. MUSA, Abbas Abdulalim ABBARA	1187
A Comprehensive bibliometric review of circular economy in the building sector: Integrating sustainable practices	
Zahwa MOUSTAFA, Muhammad ASIF, Ibrahim WUNI.....	1197
Identification of critical prone areas by using USLE: Case study -Amaravati - Andhra Pradesh - Krishna River Delta	
P. Sundara Kumar, I.L.J. Baktha Singh, P. Ranga Babu, K. Naga Raju, P. Andrew Blaze.....	1207
Sustainable public space design: Integrating ecological, economic, and social frameworks in urban environments	
Chuloh JUNG, Jamal F. NAYFEH, Nadine FAYAD, Layal Seif EL DINE, Mashael S. AL-AHMADI	1215
Smart parks in the post-COVID era: Integrating technology for urban resilience and sustainability in Riyadh, Saudi Arabia	
Chuloh JUNG, Jamal F. NAYFEH, Gaydaa AL ZOHBI,Wijdan M.N. ALDOWSARY, Mashael S. AL-AHMADI	1225
Leveraging Japan’s smart city innovations for sustainable urban development in Riyadh, Saudi Arabia	
Chuloh JUNG, Jamal F. NAYFEH, Shams M. ALSHAMASI, Heba K. BADER, Mashael S. AL-AHMADI	1235
Embodied energy minimisation techniques towards sustainable construction: A case study of Nigerian construction industry	
Kabiru Rogo USMAN, Abdelrahman HARUNA, Shamsuddeen USMAN, Ibrahim SHU’AIBU, Abbas USMAN.....	1244

Keyword Index

Preface

On behalf of the conference committee, I would like to thank all the contributors and participants in the 1st International Conference on Civil and Environmental Engineering for Resilient, Smart and Sustainable Solutions (CEES2024) which had been held at Prince Mohammad Bin Fahd University (PMU) Khobar, Kingdom of Saudi Arabia on 3-5 November, 2024. I was honored to serve as Chairman of this important event. Firstly, I would like to thank the organizing committee for their unrelenting efforts to organize this congress. In the world community, we were all aware of how important research has been in contributing to the body of knowledge and the development of prospects. The conference aims to exchange scientific information and knowledge in the development of recent and future infrastructures that are resilient, smart, and sustainable. The conference provides an excellent environment for government policy makers, practicing professional engineers, researchers, university professors, students, and general public to extend their interests and expertise in addressing and solving the infrastructure issues faced by societies. The success of CEES2024 reflects a collective commitment to advancing civil and environmental engineering practices. As participants departed Al-Khobar, they carried with them not just new knowledge but also a renewed sense of purpose in shaping a sustainable future. Finally, I thank the keynote speakers, presenters and authors for their contributions.

Dr. Faisal Yousif Al Anezi
Conference Chair

Committees

Honorary Chair

Dr. Issa H. Alansari

Conference Chair

Dr. Faisal Yousif Al Anezi

Technical Program Committee

- Dr. Erasmo Carrera, Prince Mohammad Bin Fahd University, Saudi Arabia
Dr. Jamal F. Nayfeh, Prince Mohammad Bin Fahd University, Saudi Arabia
Dr. Adel M. Hanna, University of Concordia, Canada
Dr. Mita Ray, CBE - Western University, Canada
Dr. Chandra Sekhar Matli, National Institute of Technology, India
Dr. Jamal Khatib, University of Wolverhampton, UK
Dr. Iman Hajirousouliha, Sheffield University, UK
Dr. Muhammad Imran Khan, Prince Mohammad Bin Fahd University, Saudi Arabia
Dr. Mushtaq Khan, Prince Mohammad Bin Fahd University, Saudi Arabia
Dr. Hassaine Daouadji Tahar, Tiaret University, Algeria
Dr. Mohamed ElGawady, Missouri University of Science and Technology, USA
Dr. Ömer AĞA, Associate Dean, Imam Abdulrahman Bin Faisal University
Dr. Ramli Bin Nazir, Universiti Teknologi Malaysia, Malaysia
Dr. Maria Elektorowicz, University of Concordia, Canada
Dr. Nadeem Shbeeb, Fahad bin Sultan University
Dr. Aslam Al-Omari, Jordan University of Science and Technology
Dr. Abdullah Ahmad Sharo, Sharo Al Ain University
Dr. Larbi Belagraa, University of M'Sila, Algeria
Dr. Samer Rababaah, Jordan University of Science and Technology
Dr. MiswarTumpu, University of Hasanuddin, Indonesia
Dr. Riyadh Al-Raoush, Qatar University, Qatar
Dr. Riyadh Alameri, Deakin University, Australia
Dr. Khaled E. Galal, University of Concordia, Canada
Dr. Takuro Mori, Hiroshima University, Japan
Dr. Michela Basili, Universitas Mercatorum, Italy
Dr. Mahendra Kumar Shrimali, MNIT Jaipur, India
Dr. Syed Masiur Rahman, Applied Research Center for Env. & Marine Studies, KFUPM
Dr. Sainath Vaidya, KNNU university, India
Dr. Yasmina Kellouche, Djilali Bounaama University, Algeria
Dr. Farah Hafeez, University of Concordia, Canada
Dr. Randa Oqab Mohammad Mujalli, Hashemite University
Dr. Ala Abbas, The University of Akron
Dr. Siti Noor Linda bt Taib, Universiti Malaysia Sarawak, Malaysia
Dr. Malek Brahimi, New York City College of Technology, USA
Dr. Faramarz Djavanroodi, PMU University, Saudi Arabia
Dr. Lina Zhou, University of Victoria, Canada
Dr. Basma El Zein, University of Business & Technology, Jeddah
Dr. Muhammad Nurunnabi Siddiquee, Chemical Engineering Dept. KFUPM

Dr. GirmaBitsuamlak, Western University, Canada
 Dr. Nayef Alslaihi, Eastern Province Traffic Safety Council
 Dr. Essam Jassim, PMU University, Saudi Arabia
 Dr. Muhammad Asad, PMU University, Saudi Arabia
 Dr. Mabrouk Touahmia, University of Hail, Saudi Arabia
 Dr. Muhammad Kalimur Rahman, KFUPM University, Saudi Arabia
 Dr. Alaa Salman Alobaidi, Imam Abdulrahman Bin Faisal University, Saudi Arabia
 Dr. Mohamed Baheddi, Batna University, Algeria
 Dr. M.M. Rahman, Professor, King Faisal University
 Dr. Mohamed Abdullah Almamun, Sultan Qaboos University, Oman
 Dr. Aly Mousaad Aly, Louisiana State University, USA
 Dr. Ghazi Alkhateeb, University of Sharjah
 Dr. Mohammad Irshidat, Center for Advanced Materials (CAM) Qatar University
 Dr. Jamal Nusairat, E.L. Robinson Engineering
 Dr. Januarti Jaya Ekaputri, Sepuluh November Institute of Technology, Indonesia
 Dr. Mustafa Aytekin, University of Bahrain, Bahrain
 Dr. Mohammed Mustapha Bessaim, Mascara University, Algeria
 Dr. Mohamed Khemissa, M'Sila University, Algeria
 Dr. Mohammad Reza Nikoo, Sultan Qaboos University, Oman
 Dr. Feroz Shaik, Prince Mohammad Bin Fahd University, Saudi Arabia
 Dr. Wasim Barham, Jordan University of Science and Technology
 Dr. Adel Benchabane, Biskra University, Algeria
 Dr. Mohamed Ajmal, University of Bahrain, Bahrain
 Dr. Baraa Wasfi Mistarihi, Jordan University of Science and Technology
 Dr. Omar Amoudi, Oxford Brookes University, England
 Dr. Ikrema Hassan, UNB, Canada
 Dr. Shaik Abdullah, Khaja Banda Nawaz University, India
 Dr. AlirezaBagheriSabbagh, University of Aberdeen, UK
 Dr. Mousa Bani Baker, Al-Zaytoonah University of Jordan
 Dr. Alsidqi Hasan, Universiti Malaysia Sarawak, Malaysia
 Dr. Mahdi Abdeddaim, Biskra University, Algeria
 Dr. Khalid Ahmad Mohammad Ghuzlan, Ajman University
 Dr. Hasim Altan, Prince Mohammad Bin Fahd University, Saudi Arabia
 Dr. Md. Shah Alam, University of Bahrain, Bahrain
 Dr. Salah Messast, Skikda University, Algeria
 Dr. Ahmad Al-Omari, Yarmouk University
 Dr. Massimiliano Gotti Porcinari, Prince Mohammad Bin Fahd University, Saudi Arabia
 Dr. MadharTaamneh, Yarmouk University
 Dr. Ali Bouafia, University of Blida, Algeria
 Dr. Hassan El-Chabib, Western University, Canada
 Dr. Shaikh Abdur Razzak, Professor, KFUPM
 Dr. Shiv Dayal Bharti, MNIT Jaipur, India
 Dr. Rajesh Rupakhety, University of Iceland, Iceland
 Dr. Amr Ba Rahim, C.I.R.A.M.M., Canada
 Dr. Mozahar Hossain, Professor, KFUPM, Saudi Arabia
 Dr. Meng Gong, University of New Brunswick, Canada
 Dr. Zainah Binti Ibrahim, University of Malaya, Malaysia

Dr. Sunil B. Ratna, Prince Mohammad Bin Fahd University, Saudi Arabia
 Dr. Mohammad Abdu Mannan, Unimas University, Malaysia
 Dr. Mohammed Seddik Meddah, Sultan Qaboos University, Oman
 Dr. Mohammed Azhar, Prince Mohammad Bin Fahd University, Saudi Arabia
 Dr. Usama Ali Ebead, Qatar University, Qatar
 Dr. Shantamallappa Kadaganchi, INDUS University, India
 Dr. Vishwanath Karad, MIT World Peace University, India
 Dr. P. Sundara Kumar, Bapatla Engineering College, India
 Dr. Sunil Kumar Tengali, Reva University, India
 Dr. Mohamed Bencheikh, M'Sila University, Algeria
 Dr. Farid Asma, University of Tizi-Ouzou, Algeria
 Dr. Khalid Saqer Alotaibi, Dammam University, Saudi Arabia
 Dr. Ugurcan Ozdemir, Jacob Engineering Group, Boston
 Dr. Hassan A. Abbas, Prince Mugrin University, Saudi Arabia
 Dr. Abdelkader Tahakourt, University of Bejaia, Algeria
 Dr. Nadeem Pasha, Khaja Bandanawaz University, India
 Dr. Talal Etri, Sultan Qaboos University, Oman
 Dr. Rabah Soltani, USTOran, Algeria
 Dr. Bani Feriel BRAHMI, University Constantine3, Algeria
 Dr. Praveen Kannam, REVA University, India
 Dr. Kishore Ravande, MIT-ADT University Pune, India
 Dr. Bouchaib Zazoum, Southern Arkansas University, USA
 Dr. Uneb Gazder, University of Bahrain, Bahrain
 Dr. Bilal Abu Alfoul, Hashemite University, Jordan
 Dr. Sharifan Hamidreza, The University of Texas at El Paso, USA
 Dr. Ben Ammar Ben Khadda, Biskra University, Algeria
 Dr. Satish Baliram Patil, MIT Art, Design and Technology University, India
 Dr. Zeinab Yavari, Qaboos University, Oman
 Dr. Shadi Mohmmad Ahmad Hanandeh, Al-Balqa applied university, Jordan
 Dr. Furqan Ahmad, KAUST, Saudi Arabia
 Dr. Mahmoud Enieb Osman Enieb, Assiut University, Egypt
 Dr. Muhammad Imran, Sir Syed University of Engineering & Technology (SSUET), Pakistan
 Dr. Irfan Khan, CECOS University, Peshawar, Pakistan
 Dr. Hocine Hammoum, University of Tizi-Ouzou, Algeria
 Dr. Farhad Reza, Minnesota State University, Mankato, USA
 Dr. Mohammad Ahmad Alsheyab, Iowa State University, USA
 Dr. Ansam Sawalha, American University of Madaba, Jordan
 Dr. Anas Abualia, Louisiana State University, USA
 Dr. Manjunath D C, KBNU University, India
 Dr. Omar Albatayneh, German Jordan University, Jordan
 Dr. Ahmad Ali Khasawneh, The Ohio State University, USA
 Dr. Muhammad Farooq, Prince Mohammad Bin Fahd University, Saudi Arabia
 Dr. Abdul Shakoor, University of Engineering and Technology, Peshawar, Pakistan
 Dr. Mohammad A. Hassanain, KFUPM, Saudi Arabia
 Dr. T. Yasmeen, KFUPM, Saudi Arabia
 Dr. Muhammad Nasir, Imam Abdulrahman Bin Faisal University, KSA
 Dr. Nawras Shatnawi, Al-Balqa applied university, Jordan

Dr. Muhammad Ijaz Khan, Prince Mohammad Bin Fahd University, Saudi Arabia
 Dr. Rajshekhar Gopal Rathod, MIT Art, Design and Technology University, India
 Dr. Dania Al-Oqaily, University of Notre Dame, USA
 Dr. Riaz Muhammad, University of Bahrain, Bahrain
 Dr. Nael Alsaleh, American International University, Kuwait
 Dr. Noreen Sher Akbar, Prince Mohammad Bin Fahd University, Saudi Arabia
 Dr. Arshad Khan, Hamad Bin Khalifa University, Qatar
 Dr. Nor Zurairahetty Bin Mohd Yunus, Universiti Teknologi Malaysia, Malaysia
 Dr. Firas Al Mahmoud, Lorraine University, France
 Dr. Sumant Kulkarni, REVA University, India
 Dr. Seelam Srikanth Reddy, REVA University, India
 Dr. Niaz Bahadur, University of Bahrain, Bahrain
 Dr. S M Zakir Hossain, University of Bahrain, Bahrain
 Dr. Sudarshan Sampatrao Bobad, University of PCCOER Ravet Maharashtra, India
 Dr. Ibtissem Allali, M'Sila University, Algeria
 Dr. Deepanraj Balakrishnan, Prince Mohammad Bin Fahd University, Saudi Arabia
 Dr. Nassima Bakir, M'Sila University, Algeria
 Dr. Faisal Asfand, University of Huddersfield, UK
 Dr. Mazouri Belhadri, University of Science and Technology of Oran, Algeria
 Dr. Hiren K. Mewada, Prince Mohammad Bin Fahd University, Saudi Arabia
 Dr. Gazi Iftekhar Mahmood, Prince Mohammad Bin Fahd University, Saudi Arabia
 Dr. Mohammad Arif Kamal, Aligarh Muslim University, India
 Dr. Muhammad Aaqib, National University of Technology (NUTECH), Pakistan
 Dr. Seifeddine Tabchouche, University of Setif, Algeria
 Dr. Mohamed Khouaouci, USTHB, Algeria
 Dr. Abubakr Elfatih S. Musa, KFUPM, Saudi Arabia
 Dr. Mohd Amin Mir, Prince Mohammad Bin Fahd University, Saudi Arabia
 Dr. Imran Hanif, CECOS University, Peshawar, Pakistan
 Dr. Hazrat Bilal, Hamad Bin Khalifa University, Qatar
 Dr. Sardar Muhammad Bilal, Prince Mohammad Bin Fahd University, Saudi Arabia
 Dr. Apostolos Pesyridis, Prince Mohammad Bin Fahd University, Saudi Arabia
 Dr. Kabiru Usman Rogo, Nuhu Bamalli Polytechnic Zaria, Nigeria
 Dr. Khairunisa Muthusamy, Universiti Malaysia Pahang Al-Sultan Abdullah, Malaysia
 Dr. M. I. Vara Prasad, National Institute of Technology, India
 Dr. Gaydaa Al Zohbi, Prince Mohammad Bin Fahd University, Saudi Arabia
 Dr. Bashir A. K. Saleh, Libyan Academy, Libya
 Ms. Nahla Nimr Makki, Ministry of Oil, Petroleum and Research Development Center, Iraq
 Ms. Shimol Philip, National Institute of Technology Puducherry, India
 Mr. Muhammad Sani Bello, Southeast University at Nanjing, China
 Mr. Lawrence Z. Tuleun, University of Ilorin, Nigeria

Organizing Committee

Dr. Andi Asiz
 Dr. Tahar Ayadat
 Dr. Mohammad Ali Khasawneh
 Dr. Saidur Chowdhury
 Dr. Layal Jradi

Dr. Muhammad Azhar Khan
Mr. Rusty Dela Cruz De Leon
Mr. Stephen John Limbos
Mr. Wael Yousif Mohamed Suliman
Dr. Faramarz Djavanroodi
Dr. Esam Jassim
Dr. Muhammad Asad
Dr. Muhammad Imran Khan
Dr. Mushtaq Khan
Eng. Danish Ahmed
Eng. Mohn Nayeemuddin
Eng. Samar Dernayka
Mr. Antonio Rialo Ifurong

Rainfall-discharge modeling in Juana Watershed

K.D. Komara^{1,a}, E. Kurniyaningrum^{1,b*}, A. Rinanti^{1,c}, D. Pontan^{1,d},
R. Abdilla^{1,e}, H. Sattar^{2,f}

¹Program Studi Magister Teknik Sipil, Universitas Trisakti, Indonesia

²Tokyo Institute of Technology, Tokyo, Japan

^akomarakresna@gmail.com, ^bkurniyaningrum@trisakti.ac.id, ^castririnanti@trisakti.ac.id,
^ddarmawan@trisakti.ac.id, ^eraihan051002000040@std.trisakti.ac.id, ^fhira_sattar@hotmail.com

Keywords: Curve Number, Land Use, Rainfall, Juana Watershed, Flood

Abstract. Juana Watershed has various problems, one of which is flooding during the rainy season and drought during the dry season. One of the causes of flooding is changes in land use, which results in an increase in the amount of Juana River runoff. Efforts that can be made to overcome this are by modeling rainfall discharge to approach hydrological values in the field. The purpose of this study was to examine the magnitude of the simulated discharge that occurred in the Juana Watershed. The data used were rainfall, land use maps, soil type maps, and topographic maps. The results of this modeling are a trend of changes in the curve number value (land capacity to absorb water), namely an increase in the CN value in 5 sub-watersheds, a decrease in the CN value in 2 sub-watersheds, and an equivalent CN value (stagnant) in 1 sub-watershed. The largest increase in CN value was in Juana Sub-watershed 2 of 0.93, while the largest decrease was in Gembong Sub-watershed of 0.35.

Introduction

The development of community activities along with the population growth rate has triggered regional growth with various developments in several sectors. This condition results in the formation of land use characteristics in river basins. Changes in land use in river basins (DAS) have a dominant influence on surface runoff and river flood discharge; this affects climate change conditions [1]. Surface runoff conditions significantly in river basins based on peak time and flood volume [2]; this is influenced by the type and area of land cover [3]. One component in seeing the characteristics of river basins is based on land cover change conditions. Floods are the most frequent disasters in Indonesia, with 1531 incidents [4]. Floods trigger infrastructure damage, threaten the lives of living things, and cause economic crises. Floods occur in almost all regions of Indonesia, one of which is in Central Java Province. Juana Watershed is one of the flood retention areas, based on the masterplan planned in 1891, including the construction of a lower embankment on the Serang Lama River (Wulan River), causing floodwaters to overflow into the Juana area and making the Juana area a sedimentation area. Flood disasters that occur in the Juana River basin occur every year, especially during the rainy season, and peak in December to March. There was a 70-cm-high puddle that inundated six sub-districts in 2023 and 2022.

Rainfall is one of the most important climate components that can affect the determination of water availability in a region and also affect human life activities [5]. Climate change can cause a variety of hydrological cycle processes [6], including increased rainfall variations [7] and changes in evaporation rates [9]. Increasing global temperatures will increase the rate of evapotranspiration and accelerate the water cycle [9], which has an impact on the uneven distribution of water vapor in the atmosphere, causing high rainfall in one region and extreme drought in another region [10]. Changes in rainfall patterns in Indonesia with regional development conditions will cause a delay in the start of the rainy season and a tendency for the rainy season to end earlier [1]. This means



that the rainy season occurs in a shorter time but the intensity of rainfall is higher [11]. Rainfall is one of the important climate elements for human activities. Rainfall has characteristics that vary according to space and time, so the availability of adequate data is important to understand the characteristics of rainfall in a region [12]. The hydrological cycle is closely related to elevation [13]. Apart from elevation factors, other additional factors that influence rainfall also need to be considered, including land cover [13].

The phenomenon of rain transformation into surface runoff and flood discharge is a complex natural process, so it is necessary to simplify the actual reality in the form of modeling. Hydrological modeling, namely the Hydrologic Modeling System/HEC - HMS (2000) developed by the US Army Corps Engineers, is a rainfall flow model software that looks at momentary events (events) and continuous events. Flood hydrographs in water catchment areas are influenced by several factors, including rainfall and watershed characteristics. The process of rainwater loss due to evaporation, infiltration, interception, and surface runoff is based on the parameters CN (curve number), % impervious, and initial abstraction so that it affects river and reservoir discharge [14]. In this study, the Juana Watershed, consisting of 8 sub-watersheds, was selected as the training location. Rainfall factors and land use changes that occur in the Juana Watershed affect runoff and flood discharge. It is necessary to study the condition of the curve number against discharge fluctuations in the Juana River.

Material and Method

Material

Geographically, the Juana Watershed is elongated, located between $06^{\circ}36'46''$ LS and $06^{\circ}59'27''$ LU and between $110^{\circ}46'44''$ BT and $111^{\circ}14'47''$ BT and has an area of 1.282,14 km², divided into 8 (eight) sub-DAS, namely JU, JU-1, JU-2, Juana 1, Juana 2, Juana 3, Logung dan Gembong. Juana Watershed is located in 2 districts, namely Kudus Regency and Pati Regency, Central Java Province. Pati Regency dominates the Juana Watershed with 91.71%, while Kudus Regency has 8.29% of the area in the Juana Watershed.

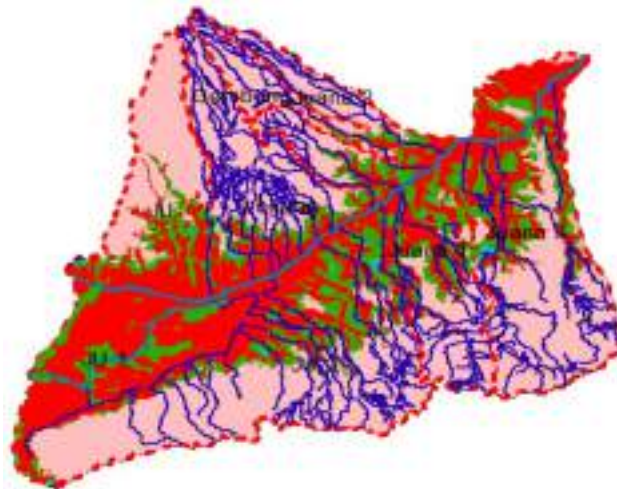


Figure 1. Juana Watershed

The data used in this study are as follows: Topographic map, Juana watershed map, land use map, rainfall data and climatology data. This study compares landuse in 2013 with 2018. Juana watershed have 10 station for rainfall recording, namely Prawoto RW32, 164 SR Kudus , 186 Jan 4 Tanjungrejo, 182 Gembong, 126 SR 17 Wilalung, 194 Kayen, 191 Cabean/ Kedung, 184 Pati and 159 Jan 6Cendono Dawe. Range rainfall data start from 2009 until 2018.

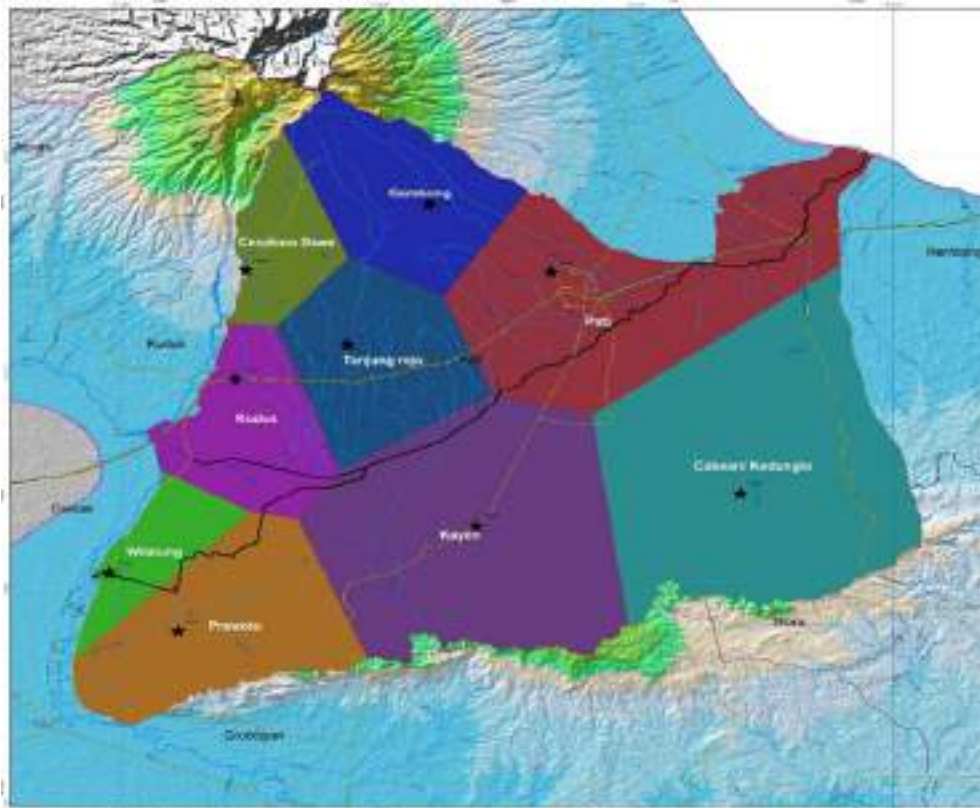


Figure 2. Rainfall station at Juana Watershed

Method

The steps of the research carried out were as follows:

- Hydrological analysis by collecting rainfall data for 10 years (2009-2018) from 10 rainfall stations in the Juana watershed, as shown in Figure 2.
- Digitizing watershed parameters by ArcGIS 10.5 software for basin modelling.
- Digitizing land cover and hydrological soil grouping. Some sources that are often used as references in soil grouping in an analysis are soil data from FAO (Food and Agriculture Organization of United Nations and International Institute for Applied Systems Analysis (IIASA).
- Analysis of the flood discharge using the Soil Conservation Service Curve Number (SCS-CN) method with the software tools of the Hydrologic Engineering Center-Hydrologic Modeling System (HEC-HMS).
- Analysis of the design rainfall by return period using normal, gumbel, log normal, and log pearson tipe III method. The result of design rainfall to be used must comply with the requirements of the skewness coefficient (C_s), variation coefficient (C_v), and kurtosis coefficient (C_k). After performing the frequency analysis calculations, the next step involves conducting goodness-of-fit tests using the Chi-square and Smirnov-Kolmogorov tests. These goodness-of-fit tests determine whether the selected distribution type is appropriate for the given data[15].

Result

Hydrology Analysis

The calculation of rainfall distribution in Juana Watershed uses four methods for each station, namely the Normal, Log-Normal, Log-Pearson Type III, and Gumbel distribution methods. The results were obtained using the chi-square and Smirnov Kolmogorov tests. A summary of the design rainfall analysis is in Table 1. The distribution to be used must comply with the

requirements of the skewness coefficient (C_s), variation coefficient (C_v), and kurtosis coefficient (C_k) according to Table 2. From the digitization results, the Juana Watershed area is 1,282.14 km² which is divided into 8 Sub-DAS as shown in Figure 2.

Table 1. Recapitulation of Design Rainfall by Return Period in Sub-Watershed

JU 1				
Return period (year)	Normal	Gumbel	Log Normal	Log Pearson Tipe III
100	169.06	217.17	181.92	188.79
50	161.70	199.45	170.91	178.13
25	154.54	181.60	160.82	164.61
10	143.89	157.54	146.91	146.61
5	133.29	138.49	134.25	132.17
2	103.42	109.73	104.17	110.30
JU				
Return period (year)	Normal	Gumbel	Log Normal	Log Pearson Tipe III
100	331.20	474.61	443.53	435.38
50	309.30	421.80	389.32	391.03
25	287.94	368.59	342.87	333.28
10	256.21	296.88	283.88	263.18
5	224.61	240.12	235.21	213.32
2	135.59	154.39	138.49	147.39
JU2				
Return period (year)	Normal	Gumbel	Log Normal	Log Pearson Tipe III
100	165.92	216.26	195.63	163.62
50	158.23	197.72	180.81	157.87
25	150.74	179.05	167.44	149.84
10	139.60	153.87	149.39	139.91
5	128.50	133.95	133.34	128.83
2	97.26	103.86	96.81	106.69
LOGUNG				
Return period (year)	Normal	Gumbel	Log Normal	Log Pearson Tipe III
100	177.62	263.77	406.07	273.96
50	164.46	232.05	326.66	228.20
25	151.64	200.09	264.24	185.19
10	132.57	157.00	192.81	136.33
5	113.59	122.90	140.86	104.12
2	60.11	71.40	58.19	65.19
JUANA 1				
Return period (year)	Normal	Gumbel	Log Normal	Log Pearson Tipe III
100	148.11	191.72	184.99	139.57
50	141.45	175.66	170.04	136.38
25	134.95	159.48	156.64	132.30
10	125.30	137.67	138.65	124.89
5	115.69	120.41	122.78	116.80
2	88.62	94.32	87.19	98.80

GEMBONG				
Return period (year)	Normal	Gumbel	Log Normal	Log Pearson Tipe III
100	303.57	462.64	364.18	553.55
50	279.27	404.06	314.23	406.72
25	255.58	345.04	272.15	298.02
10	220.38	265.49	219.80	196.43
5	185.32	202.53	177.66	142.25
2	86.58	107.43	97.56	90.97

JUANA 2				
Return period (year)	Normal	Gumbel	Log Normal	Log Pearson Tipe III
100	256.55	380.88	322.57	410.10
50	237.56	335.09	280.69	325.64
25	219.05	288.97	245.12	256.66
10	191.54	226.79	200.40	184.27
5	164.14	177.59	163.98	140.50
2	86.97	103.26	93.20	92.54

JUANA 3				
Return period (year)	Normal	Gumbel	Log Normal	Log Pearson Tipe III
100	127.01	221.94	188.21	112.14
50	121.76	335.09	170.10	111.29
25	116.64	288.97	154.12	109.96
10	109.04	226.79	133.11	106.83
5	101.47	177.59	115.02	102.52
2	80.15	103.26	76.24	90.12

Table 2. Parameter Test

JU 1					JU				
Chi Square Test					Chi Square Test				
	Normal	Gumbel	Log Normal	Log Pearson Tipe III		Normal	Gumbel	Log Normal	Log Pearson Tipe III
X ² Calculated	2.000	2.000	2.000	2.000	X ² Calculated	0.400	4.400	1.200	2.000
X ² Cr	3.841	3.841	3.841	3.841	X ² Cr	3.841	3.841	3.841	3.841
Information	ok	ok	ok	ok	Information	ok	not ok	ok	ok
Smirnov Kolmogorof Test					Smirnov Kolmogorof Test				
Δ max	0.162	0.162	0.162	0.082	Δ max	0.164	0.164	0.121	0.165
Δ criticism	0.410	0.410	0.410	0.410	Δ criticism	0.410	0.410	0.410	0.410
Information	ok	ok	ok	ok	Information	ok	ok	ok	ok

JU 2					LOGUNG				
Chi Square Test					Chi Square Test				
	Normal	Gumbel	Log Normal	Log Pearson Tipe III		Normal	Gumbel	Log Normal	Log Pearson Tipe III
X^2 Calculated	2.000	0.400	2.000	2.000	X^2 Calculated	2.000	2.000	3.600	2.000
X^2 Cr	3.841	3.841	3.841	3.841	X^2 Cr	3.841	3.841	3.841	3.841
Information	ok	ok	ok	ok	Information	ok	ok	ok	ok
Smirnov Kolmogorof Test					Smirnov Kolmogorof Test				
Δ max	0.130	0.130	0.083	0.121	Δ max	0.127	0.127	0.032	0.138
Δ criticism	0.410	0.410	0.410	0.410	Δ criticism	0.410	0.410	0.410	0.410
Information	ok	ok	ok	ok	Information	ok	ok	ok	ok

JUANA 1					GEMBONG				
Chi Square Test					Chi Square Test				
	Normal	Gumbel	Log Normal	Log Pearson Tipe III		Normal	Gumbel	Log Normal	Log Pearson Tipe III
X^2 Calculated	7.600	1.200	1.200	1.200	X^2 Calculated	4.400	11.600	2.000	0.400
X^2 Cr	3.841	3.841	3.841	3.841	X^2 Cr	3.841	3.841	3.841	3.841
Information	Not ok	ok	ok	ok	Information	Not ok	Not ok	ok	ok
Smirnov Kolmogorof Test					Smirnov Kolmogorof Test				
Δ max	0.086	0.086	0.097	0.123	Δ max	0.150	0.150	0.303	0.084
Δ criticism	0.410	0.410	0.410	0.410	Δ criticism	0.410	0.410	0.410	0.410
Information	ok	ok	ok	ok	Information	ok	ok	ok	ok

JUANA 2					JUANA 3				
Chi Square Test					Chi Square Test				
	Normal	Gumbel	Log Normal	Log Pearson Tipe III		Normal	Gumbel	Log Normal	Log Pearson Tipe III
X^2 Calculated	1.200	8.400	2.000	1.200	X^2 Calculated	2.000	6.800	3.600	0.400
X^2 Cr	3.841	3.841	3.841	3.841	X^2 Cr	3.841	3.841	3.841	3.841
Information	ok	Not ok	ok	ok	Information	ok	Not ok	ok	ok
Smirnov Kolmogorof Test					Smirnov Kolmogorof Test				
Δ max	0.102	0.102	0.071	0.078	Δ max	0.102	0.111	0.098	0.166
Δ criticism	0.410	0.410	0.410	0.410	Δ criticism	0.410	0.410	0.410	0.410
Information	ok	ok	ok	ok	Information	ok	ok	ok	ok

Note: Ok = Accepted; Not ok= Rejected; Cr= critical

Analysis of Land Cover and Curve Number (CN) Value of the Juana Watershed

The curve number value describes the physical characteristics of the watershed in the form of soil, hydrological conditions and land use. The Juana watershed has 9 types of land cover, namely secondary dry forest, plantation forest, settlements, dryland agriculture, dryland agriculture mixed with shrubs, rice fields, ponds, shrubs, and water bodies. The CN value is determined using the SCS-CN method by combining land use with the Soil Hydrology Group. In addition, the soil hydrology group is divided into A, B, and C based on its texture. External texture determines the hydrology group because it is related to the effective water capacity of the soil and affects

infiltration. The results of the curve number analysis calculation for 8 sub-watersheds are shown in Figure 3. The increase in built-up land cover has the potential to influence the hydrological cycle [16]. The characteristics soil at Juana Watershed based on curve number are loam, sandy loam, and sand

Surface Runoff in the Juana Watershed

Flood hydrograph analysis in this study uses the HEC-HMS model [17], which includes basin and meteorological models, control specifications, time series data, losses, transformed baseflow, and river channels. These parameters are needed to determine the flood discharge value according to the return period in the Juana Watershed. Flood discharge analysis comparing the HEC-HMS model with SCS-CN for various return periods is shown in Table 3. The results in Table 3 are then plotted in Figure 4.

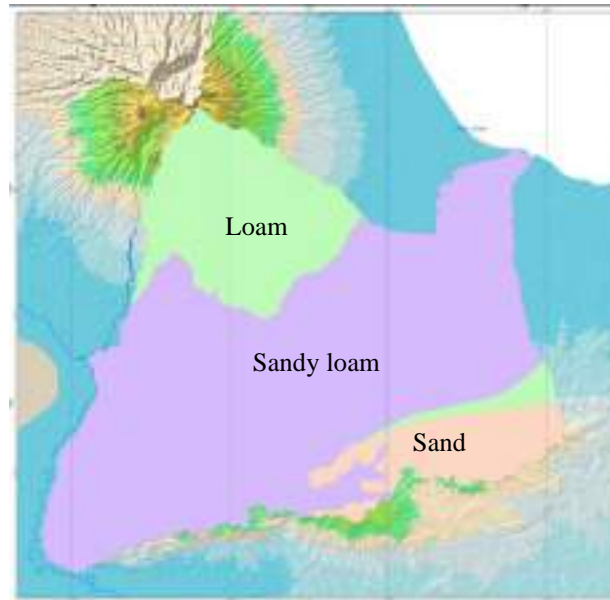


Figure 3. Soil properties in Juana Watershed

There is no Automatic Water Level Recorder measuring device on the Juana River, so a synthetic unit flood hydrograph calculation using the SCS method with a return period of 25 years was carried out on 9 Juana Sub-DAS. The calculation was carried out in 2 observation years (2013 and 2018).

Table 3. Recapitulation SCS-CN Method

No	Sub-watershed	SCS-CN	
		2013	2018
1	JU 1	85.74	85.75
2	JU	1,155.64	1,155.75
3	JU 2	74.53	85.69
4	Logung	636.14	643.64
5	Juana 1	96.37	93.47
6	Gembong	110.88	108.07
7	Juana 2	144.23	153.95
8	Juana 3	130.54	132.62

Hydrograph analysis comparison between HEC HMS model and SCS-CN using the flow ratio tool. Flow ratio calibration is carried out until the RMSE value of the peak discharge or time series (overall hydrograph) is <5%. The same method is carried out on all sub-watersheds with 2 years

of observation (2013 and 2018). The result is a comparison of the peak discharge that occurred during 24 hours in the table 4 and figure 4.

Table 4. Flood Discharge Based on SCS-CN and HEC HMS Models (m^3/s)

NO	SUB	SCS CN		HEC HMS Trial 1		HEC HMS Trial 2		HEC HMS Trial 3	
		2013	2018	2013	2018	2013	2018	2013	2018
1	JU1	85.74	85.75	285.20	285.20	142.60	142.60	85.60	85.60
2	JU	1,155.64	1,155.75	2,652.30	2,652.30	1,326.10	1,326.20	1,193.50	1,193.50
3	JU2	74.53	85.69	616.60	627.80	308.30	313.90	61.70	81.60
4	Logung	636.14	643.64	1,939.40	1,942.60	969.70	971.30	581.80	582.80
5	Juana 1	96.37	93.47	711.70	708.70	355.80	354.30	113.90	106.30
6	Gembong	110.88	108.07	426.10	424.90	213.10	212.40	106.50	106.20
7	Juana 2	144.23	153.95	509.50	514.90	254.70	257.50	152.90	154.50
8	Juana 3	130.54	132.62	1,076.20	1,077.70	538.10	538.90	161.40	161.70

The table above shows the peak discharge that occurs over 24 hours, for example in the JU 1 sub-DAS the peak discharge occurs at hour 10 based on land use in 2013 and 2018. This flood hydrograph can be seen in the image below.

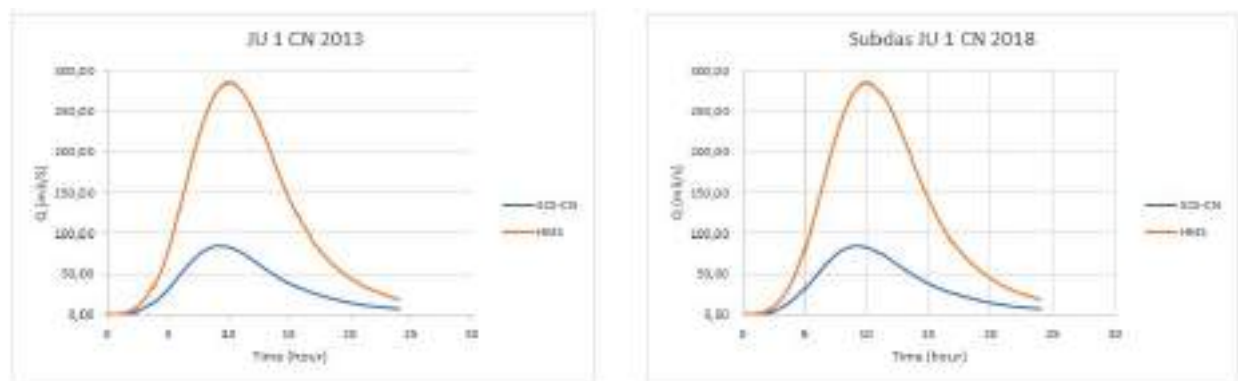


Figure 4. Hydrograph Comparison Chart Between SCS and HMS Models

It was found that out of 8 Sub-watershed, there was an increase in the curve number value in 5 Sub-watershed, a decrease in the curve number value in 2 Sub-watershed, and the same value (constant) in 1 Sub-watershed. Furthermore, hydrological modelling was carried out using the SCS CN method with HEC HMS, which was calibrated with the HSS SCS calculation (SCS-CN), and it was found that 4 Sub-watershed experienced an increase in the peak flood, 2 Sub-watershed experienced a decrease in the peak flood discharge, and 2 other Sub-watershed did not experience a decrease or increase in the peak flood discharge. The increase (4 Sub-watershed) or decrease (2 Sub-watershed) in the peak flood discharge was linear or in line with the increase or decrease in the curve number value. Meanwhile, 1 Sub-watershed that experienced an increase of 0.002, namely JU, did not experience an increase in the peak flood discharge.

Conclusion

Based on the results of the analysis of land use and CN values from 2013 to 2018 in the Juana River Basin, which is divided into 8 sub-basins, there has been a trend of changes in land use that has resulted in changes in the curve number value (land's ability to absorb water). The trend that occurred was an increase in the CN value in 5 sub-basins, a decrease in the CN value in 2 sub-

basins, and an equivalent CN value (stagnant) in 1 sub-basin. From the results of the HEC HMS flood hydrograph model calibrated with HSS SCS statistics, the CN value was obtained to be directly proportional to the curve number value. If there is an increase in the CN value, the resulting flood discharge will increase; conversely, if there is a decrease in the CN value, the flood discharge value (time series hydrograph and flood peak) will decrease, so that the increase in the CN value results in an increase in discharge in a river basin (DAS), namely in the Juana DAS.

References

- [1] Kurniyaningrum, E., Kurniawan, M.A. Climate Change Effect on Water Balance For Water Critically in Upper Bogowonto Watershed, Indonesia. IOP Conf. Series: Earth and Environmental Science, 2022, pp. 1-10. <https://doi.org/10.1088/1755-1315/1195/1/012053>
- [2] Ranzi, R., Boicchio, M., & Bacchi, B. (2002). Effects on floods of recent afforestation and urbanisation in the Mella River (Italian Alps). *Hydrology and Earth System Sciences*, 6(2), 239-<https://doi.org/10.5194/hess-6-239-2002>
- [3] Kadri, T., Kurniyaningrum, E., Limantara, L.M. Hydrology Characteristics in Krukut River Riparian Buffer Zone. *Journal of Southwest Jiaotong University*, 2021, 56(6), pp. 277-284. <https://doi.org/10.35741/issn.0258-2724.56.6.23>
- [4] BNPB. (2023). IRBI (Indeks Risiko Bencana Indonesia). 01, 1-338.
- [5] Kementerian PPN/Bappenas. Rencana Aksi Nasional Adaptasi Perubahan Iklim Kajian Basis Ilmiah Proyeksi Iklim Atmosferik
- [6] K. E. Trenberth, "Conceptual framework for changes of extremes of the hydrological cycle with climate change," *Clim. Change*, 1999. https://doi.org/10.1007/978-94-015-9265-9_18
- [7] P. Pathak, A. Kalra, S. Ahmad, dan M. Bernardez, "Wavelet-Aided Analysis to Estimate Seasonal Variability and Dominant Periodicities in Temperature, Precipitation, and Streamflow in the Midwestern United States," *Water Resour. Manag.*, 2016, doi: 10.1007/s11269-016-1445-0. <https://doi.org/10.1007/s11269-016-1445-0>
- [8] P. R. Hosang, J. Tatu, dan J. E. X. Rogi, "ANALISIS DAMPAK PERUBAHAN IKLIM TERHADAP PRODUKSI BERAS PROVINSI SULAWESI UTARA TAHUN 2013 - 2030," *EUGENIA*, 2012. <https://doi.org/10.35791/eug.18.3.2012.4101>
- [9] H. Tian et al., "Model estimates of net primary productivity, evapotranspiration, and water use efficiency in the terrestrial ecosystems of the southern United States during 1895-2007," *For. Ecol. Manage.*, 2010, doi: 10.1016/j.foreco.2009.10.009. <https://doi.org/10.1016/j.foreco.2009.10.009>
- [10] K. Hayhoe et al., "Past and future changes in climate and hydrological indicators in the US Northeast," *Clim. Dyn.*, 2007, doi: 10.1007/s00382-006-0187-8. <https://doi.org/10.1007/s00382-006-0187-8>
- [11] Diposaptono, B. Erosi Pantai (Coastal Erosion), Prosiding Pelatihan Pengelolaan Wilayah Pesisir Terpadu, (online) <http://repository.ipb.ac.id/handle/123456789/24571>, 2009.
- [12] Misnawati, M., Boer, R., June, T., & Faqih, A. Perbandingan metodologi koreksi bias data curah hujan chirps, *Limnotek: perairan darat tropis di Indonesia*, 2018, 25(1).
- [13] Kurniyaningrum, E., Faluty, M.D., Mulya, H.D., Andayani, S., Hidayat, DPA., Sejati, W., Sattar, H. 2024. Factor For Correcting The Rainfall Of Chirps Satellite Data Against Observation Data On The Ciliwung Watershed (Case Study Of Kemayoran Meteorologi Station). *International Journal on Livable Space*, 9(2), 75-84. <https://doi.org/10.25105/livas.v9i2.19919>

- [14] Stathis, D., Sapountzis, M., & Myronidis, D. (2010). Assessment of land use change effect on design storm hydrograph using the SCS curve number method. *Fresenius Environmental Bulletin*, 19(9), 1928-1934.
- [15] V.T. Chow, *Applied Hydrology*. New York: McGraw-Hill, 1988.
- [16] Kurniyaningrum, E., Rinanti, A., Herlina, L., Putra, D.T., Sattar, H. 2024. The Relationship Between Land Surface Temperature and Water Availability: A Preliminary study. *Understanding Global Digital Era Technologies and Transformations in Social, Environment, Peace & Business Development Perspectives in Society*, 40-53.
- [17] Feldman, Arlen D. 2000. *HEC-HMS Technical Reference Manual*. USACEHEC., Davis, CA
- [18] Asdak, Chay. 2010. *Hidrologi dan Pengelolaan Daerah Aliran Sungai*. Cetakan ke 5, Gadjah Mada University Press, Yogyakarta.

Keyword Index

3D Building	123	Bearing Capacity	161, 448
3D Printing	968	Bed Roughness	678
Abou Ali River	670	BFRP	86
Accessibility	519	Bibliometric Review	1197
Activated Carbon	859	BIM Maturity	1109
Additive Manufacturing	968	BIM	200
Adhesion	1075	Binders	1075
Admixture	263	Bio-Anchorage	397
Aggregates	1075	Biochar	736
Air Quality	793	Biogas	805
Air	634	Biomass	653
Algorithms	923	Bio-methane	805
Alkaline Activation	549	Bitumen	1030, 1061
Alkaline Activator	350	Bituminous Pavement	1030
Amman	910	BOD	764
Anaerobic Digestion	805	Boiler	729
Analysis	289	Bond Strength	569
Angle of Internal Friction	448	Bottom Ash	1030
ANNOVA	697	Boundary Elements	131
ArcGIS	1207	Brick Powder	577
Arid Area	336	Brine	784
Artificial Intelligence	252, 883, 892	Building Components	77
Artificial Neural Network	20, 378	Building Information Modeling (BIM)	1179
ASCE 41-17	135	Building Performance	153
Asphalt Binder	1020, 1050	Building Sector	1197
Asphalt Concrete Pavement	941	Building	1130
Asphalt	978	Built Environment	874
Atterberg's Limit	577	Bulking Agents	736
Autodesk Construction Cloud	1109	Buoyancy	823
Automation and Optimization of RC Structural Design	200	Burned Olive Waste Ash	999
Base Shear	11	Bus Rapid Transit	910
BCP 2021	69	Calcium Silicate Hydrate	359
Beam-To-Column Connections	171	Calibration Chamber	316
		California Bearing Ratio Test	577
		Carbon Capture	784
		Carbon Dioxide	729

Carbon Emission	113	Convolutions Networks	892
Case Study	289	Correlation Analysis	501
Catalyst	263	Correlation	510
CatBoost Machine Learning	40	Corrosion	539, 729
CBR Tesi	336	Cost Efficiency	153
Cement Content	1187	Cost of Construction	577
Cement Paste	359	Cost	1130
Cement Stabilization	187, 368	Countermeasures	1040
Centrifugal Pump	883	Cover Concrete	279
CFRP Retrofitting	123	COVID-19 Pandemic	793, 931, 1099
Chicken Manure	663	Crack	77, 1086
Chicken Swarm Optimization	378	Cross-Laminated Timber (CLT)	103, 113
Chloride Concentration	729	Crumb Rubber	417, 1061
Chromium Steels	501	Crushed Sand	1010
Chwit	289	CS Algorithm	234
Circular Economy	1197	CTGAN	40
Clay	181	Curing	1, 279
Clean Water and Sanitation	643	Curve Number	833
Climate Change	30	Cyclic Axial Loading	316
Climate Forecasting	892	Cyclic Loading	131, 143
Coal Ash	1030		
COD Removal	869	Daily Trips	931
COD	764	Damage	77
Coefficient of Variation	325	Data Fusion	892
Color Removal	859	Date Seeds Powder	1050
Combined Foundation System	306	DCPT	438
Community Engagement	717	DEEPSOIL Software	242
Composting	736	Defects	77
Compressed Stabilized Earth Blocks (CSEB)	1187	Deformation Control	153
Compressive Strength	1, 342, 407, 587, 617, 1187	Delay	1159
Concrete	181, 263, 271, 279, 407, 464, 569, 823	DEM and Micro-Watershed Basins	1207
Construction and Demolition Waste	577	DEMATEL	1121
Construction Projects	1121	Dense Bituminous Mixes	1030
Construction	271	Density	448
Containment Buildings	607	Density-Based Clustering	1040
Contamination	643	Depth of Slope (H)	448
		Desalination	784
		Design Spectrum	69

Design Working Procedures	1109	Environmental Solutions	892
Diagrid	11	Equivalent Linear Approach	242
Direct Shear Test	397	ESCOs in GCC Region	843
Disenfranchised	903	E-Shopping	931
Domestic Water Demand	815	ETABS	103
Drift	11	Expanded Clay	428
Drop-Weight Impact Test	569	Expanded Polystyrene (EPS)	823
Drying Shrinkage	342	Expansive Soil	187, 368, 456, 999
Ductility	123	Expansive Subgrades	961
Dumper	60	Experts	1159
Durability	342, 597, 988	Externally Bonded FRP	559
Dynamic Performance	60		
		Failure	539
Earth Quake Load	11	FEACONS IV	30
Earthquake Frequency Content	607	Ferrite	486
Earthquake-Resistant Design	143	Fiber	823
Eastern Provinces	643	Fine Aggregate	417, 464
Ecological Sustainability	1215	Finite Element Analysis	50, 181, 191
Economic Challenges	1138	Finite Element Method	961
Economic Crisis	1099	Finite Element Modelling	475
Economic Impact	1197	Fire Endurance Testing	171
Efficiency	883	Fire Protection	171
El Niño	510	Fire	86
E-Learning	931	FLAC2D Software	242
Electrocoagulation (EC)	764	Flat Plate	135
Electrodes	764	Flexible Pavements	961
Elevated Temperatures	86	Flexural Strength	407
Embodied Energy	1244	Flexure	86
Emulsion Prime	1075	Floating Concrete	823
Energy Dissipation	143	Flood Modeling	670
Energy Efficiency Building	1179	Flood Routing	815
Energy Efficiency	843, 892, 1235	Flood	833
Energy Minimisation	1244	Floor Slabs	530
Energy	653	Flow	617
Environment	688	FLOW-3D	678
Environmental and Social Justice	903	Fly Ash	587, 1030
Environmental Degradation	903	Fly Ash-Slag Concrete	378
Environmental Impact	1197	Footings	448

Foundation	306	Hypoplastic Model	707
Free Swell	368		
Freeze-Thaw Cycles	187	ICT Integration	1235
Frequency	143	Impact	634
Fresh Concrete	263	Indian Roads Congress	1030
Friction	923	Industrial Waste Ash	549
FRP	559	Industrial Wastewater Treatment	869
Fully Grouted	131	Infilled RC Frames	191
Fundamental Period and Mode Shape	225	Infrastructure and Operational Elements	910
Fuzzy Expert System	1130	Infrastructure	1099
		Intelligent Transportation System	951
Geogrids	475	Interference	539
Geopolymer Mortar	350	Interlayer Bond	1075
Geopolymer	342, 549	Inundation	670
Geospatial Analysis	717	ISM	1159
Geotechnics	510	Iso Electric Point	1075
Geothermal	653	ITS	910
Global Warming	30		
Granular Materials	428	Japanese Smart City Development	1235
Green Buildings	774	Jragung River	755
Green Concrete	271	Juana Watershed	833
Green Filters	869		
Green Magnetic Adsorbent	859	Kinetic Analysis	663
Greenhouse Gases	843	Kingdom of Saudi Arabia	643
Ground Response Analysis	242	KPI	1121
Ground Water	643	Kuwait	978
Groundwater Depth	717		
Groundwater Level	717	La Niña	510
Groundwater Measurements	717	Laboratory	746
		Land Use	833
Hadejia-Jama'are River Basin	717	Landfill	688, 852
Heat	486	Large Number of Cycles	316
High-Temperature	359	Lateral Stiffness	191
Hinges	123	LDPE	626
HPDE	626	Leachate	736
Human Scale	1149	Lebanon	289, 1099
Hybrid Building	113	Lessons-Learned	1121

Life Cycle Assessment	784	Microstructure	486
Lift Adjusting	60	Mineralization	784
Light Gauge Steel (LGS)	103, 113	Model	746
Lime stabilization	187	Modelling	617
Lime	1010	Moderate-to-Vigorous Physical Activity (MVPA)	874
Limit Analysis	161	Modified Proctor Test	577
Linear Regression	501, 746	Mohr-Coulomb Criterion	242
Linear Shrinkage	368, 1187	Moisture Sensitivity	1068
Lockdown Impact	793	Moisture-Induced Damage	941
Locked Wheel	923	Moment-Resisting Frames (MRFs)	200
Longitudinal Joints	978	Moth Flame Optimization	378
Long-Term Deflection	530	MSE	475
Low Water Content	336	Multi Jet Electrolyte Flow	697
Low-Carbon Footprint	549	Multilevel Modeling	1040
Machine Learning Model	407	Multi-Rise Buildings	103
Machine Learning	252, 501, 746, 923, 968	Municipal Solid Waste	852
Magnesium Carbonates	784	Municipal Waste	688
Maintenance	978, 1159	NASA	892
Makkah	634	Near-Surface Mounted	559
Management	852	Neom-The Line	113
Marble Powder	336	Nesquehonite	784
Marble Waste	464	Neural Networks	883
Marshall Stability Test	1030	New Construction	210
Masonry Structures	131	Nickel Ferrites	859
Masonry Unit	626	Nigerian Construction Industry	1244
Masonry	559	Nonlinear Analysis	242
Mass Timber Buildings	171	Nonlinear Model	242
Material Design	617	Nonlinear Response Spectrum	242
MATLAB	1130	Nuclear Structures	607
Mechanical Properties	350, 464, 486, 587, 626	Numerical Analysis	448
Mechanically Stabilized Earth Wall	475	Numerical Modelling	475
Melted Plastics	626	Numerical Simulation	297, 678
Membership Function	1130	Oil and Gas	1159
Metakaolin	342, 350	Olive Mill Wastewater Ash	1020
Meteorological Factors	793	Oman	456
Methane Production	663		

One-Dimensional Nonlinear Site Response Analysis	69	Pore Water Pressure	707
Open Shallow Wells	717	Post-COVID Era	1225
Optimization	697	Potholes	1086
Organic Manure	688	Power	883
Orifice Flow	746	Pozzolan	456
Oxidation	764	Premature Failure	988
		Pressure Drop	697
Parametric Design	93	Pressure Relief Valves	60
Parametric Study	448	Pressurized System	60
Partially Grouted	131	Prime Coats	1075
Particle Crushing	428	Prisms	86
Particulate Matter (PM10, PM2.5)	634	Probability Density Function	325
Pavement Design	988, 999	Professional Challenges	1138
Pavement Surface	923	Project Performance Analyzer (PPA)	1121
Pavement	30, 941, 1068	Project Performance	1121
Pearlite	486	Project	1130
Pedestrian Comfort	519	Pseudo-Static Approach	161
Pedestrian Infrastructure	519	Public Transportation	910
Penetration	1020	Pushover Analysis	123
Perceived Autonomy	874	Push-Over Analysis	200
Perceived Competence	874	Pushover	135
Perennial Ryegrass	663		
Performance Levels	135	Rainfall	833
Performance	306, 678	Ramberg-Osgood Model	242
Performance-based Assessment	123	Random Forest	501
Performance-based Seismic Design (PBSD)	200	RC Infilled Frame	143
Piles	306	RCDBs	252
Plastic Waste Concrete	530	Ready Mix Concrete	1, 279
Plastic Waste Recycling	626	Recycled Aggregate	271
Plaxis 3D	448	Recycled Waste Plastic	1086
PM2.5 Levels	793	Recycling	530
Pollution Detection	892	Regression	494
Pollution Index	755	Reinforced Concrete (RC)	103
Pollution Load Capacity	755	Relationships Digraph	1121
Pollution	634	Relative Density	438
Polypropylene Fibres	359	Renewable Energy	843
Polyurethane Grout	569	Renewable Raw Materials	859

Renewable	653	Seismic	210
Repair	569	Self-Compacting Concrete	263, 597
Reservoir Storage Simulation	815	Sensor Networks	892
Residence Time Distribution	678	Setback Distance	448
Residual Compressive Strength	359	Setback Structure	225
Response Surface Methodology	697	Settlement	77, 707
Retaining Wall	475	Shade Trees and Urban Greening	519
Retrofit	210	Shadow Simulation	1179
Rice Husk Ash	597	Shape Memory Alloys	210
Risk Identification	1171	Shear Mechanism	252
Risk Register	1171	Shear Strength and Physics Informed Neural Networks (PINNs)	252
Riyadh Metro	519	Shear Strength	40, 510
Riyadh Urban Strategy	1235	Shear Walls	131, 123
Riyadh	852, 1149	Sidewalk and Pavement Design	519
Road Safety	1099	Sieve Analysis	577
Root Cause Analysis	539	Simulated Annealing	93
Root Tensile	397	Simulation Analysis	50
Root Water Uptake	707	Simulation	1171
RRI Model	670	Site Characterization	438
Rubber	1068	Site Factors	69
SAI	587	Site Investigation	438
Sand, Skirted Footing	161	Slope Stability	289, 397
Sandy Slope Soil	448	Smart City Design	1225
SAP2000	103	Smart Parks	1225
Sarooj	456	Smart Sustainable City	1149
Saturated Clay	316	Social Impact	1197
Saudi Vision 2030	1225	Social Inequality	903
Sawdust Ash	597	Social Sustainability	1215
SCM	587	Societal Challenges	1138
Scrap Tire	417	Soft Soil	494
Seasonal Condition	707	Softening Point	1020
Seismic Analysis	607	Soil Characterization	1187
Seismic Behaviour	143, 225	Soil Compaction	336
Seismic Design	153	Soil Erosion	1207
Seismic Evaluation	135, 191	Soil Investigation	494
Seismic Response	93	Soil Properties	510
Seismic Simulation	242	Soil Stabilization	549

Soil Stabilization	577, 961, 999	Suction	297
Soil Stiffness	316	Sun Path Analysis	1179
Soil Structure Interaction	607	Supplementary Cementitious Materials	378, 617
Soil Variability	325	Surcharge Pressure	961
Soil	297, 1010	Surface Water	643
Soil-Structure Interaction	448	Survey	852
Solar Panel	823	Sustainability	456, 519, 688, 843, 869, 988, 999, 103, 1068, 1197
Solar	653	Sustainable Buildings	113
South Eastern Nigeria	325	Sustainable Construction	626, 784, 1138, 1244
Spatial Implementation	1215	Sustainable Material	1050
Spatial Interpolation	717	Sustainable Physical Activity	874
Spent Coffee Grounds	805	Sustainable Public Space Design	1215
Sponge City	1149	Sustainable Urban Planning	1235
Spring Tension	60	Sustainable	271
SPT	438	Synchronization	1109
Squat Flanged Reinforced Concrete Wall	40		
Stabilization	1010	Tannery Solid Waste	805
State-Of-The-Art Review	210	Technological Challenges	1138
Statistical Analysis	617	Temperature	729
Steel Rebar	486	Tensile Strength	501, 1068
Stiffness	143	The Line (Neom)	103
Stone Columns	306	Thermal Expansion of Concrete	30
Stormwater Retention Pond	678	Thermal Optimization	181
Strain Modal Analysis	20	Toolbox	1130
Strategy	774	Top-Down Cracking	1086
Stray Current	539	Torsional Control	153
Strengthening	171, 559	Traditional Analysis	50
Strengths	464	Traffic Accidents	1099
Stripping	941	Traffic Congestion	951
Strong Column-Weak Beam	123	Traffic Fatalities	1099
Structural Beam	50	Traffic Management	951
Structural Concrete	279	Traffic Safety	1040
Structural Damage Identification	20	Transportation Infrastructure	951, 968, 1050
Structural Design	103	Trip Mode	931
Structural Efficiency	103	Trip Purpose	931
Subgrade	1010		
Suction Stress	297		

Tropical Residual Soil	397	XGBoost	407
Tuned Mass Damper	234		
Two-Way Joist Slab	181	Zambia	988
Ultraviolet Treatment	359	Zeolitic Tuff	187, 368
Unconfined Compressive Strength	187	Zeolitic Tuff	368
Unconfined Compressive Strength	368	Zeta Potential	1075
Uniaxial Compression Test	428		
Unsaturated Soil	297		
Urban Competitiveness	1215		
Urban Planning	519		
Urban Spaces	1149		
Urban Sustainability	1225		
Used Engine Oil	597		
USLE	1207		
Vehicle	634		
Vertically Irregularity	225		
Vibration Mitigation	234		
Vibration	60		
Virtual Reality	1171		
Viscosity	1020, 1061		
Visual Programming	93		
Vulnerable Communities	903		
Wadi	1149		
Warm Additives	1061		
Waste Management	736		
Wastewater Treatment	764, 859		
Water Absorption	1, 342		
Water Efficiency	774		
Water Quality	755		
Water Resources	643		
West Jakarta	494, 510		
Whale Optimization	378		
Wind Load	11		
Wind	653		
Workability	587		
Workflow	1109		

