

Lecture Notes in Civil Engineering

Leksmono Suryo Putranto
Louis Ge
Hyunjin Ju *Editors*

Proceedings of the 4th International Conference of Construction, Infrastructure, and Materials

ICCIM 2025, 24 July 2025, Jakarta,
Indonesia

 Springer

Lecture Notes in Civil Engineering

Volume 801

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,
Australia

Anuj Sharma, Iowa State University, Ames, USA

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

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

Zhen-Dong Cui , China University of Mining and Technology, Xuzhou, China

Xinzheng Lu , Department of Civil Engineering, Tsinghua University, Beijing,
China

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, Australia, and New Zealand);
- Wayne Hu at wayne.hu@springer.com (China).

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

Leksmono Suryo Putranto · Louis Ge · Hyunjin Ju
Editors

Proceedings of the 4th International Conference of Construction, Infrastructure, and Materials

ICCIM 2025, 24 July 2025, Jakarta, Indonesia



Editors

Leksmono Suryo Putranto
Civil Engineering Undergraduate Program
Universitas Tarumanagara
Jakarta Barat, Indonesia

Louis Ge
Department of Civil Engineering
National Taiwan University
Taipei, Taiwan

Hyunjin Ju
Department of Architecture
and Architectural Engineering
Hankyong National University
Anseong, Korea (Republic of)

ISSN 2366-2557

ISSN 2366-2565 (electronic)

Lecture Notes in Civil Engineering

ISBN 978-981-95-6086-8

ISBN 978-981-95-6087-5 (eBook)

<https://doi.org/10.1007/978-981-95-6087-5>

© The Editor(s) (if applicable) and The Author(s), under exclusive license to Springer Nature Singapore Pte Ltd. 2026

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

If disposing of this product, please recycle the paper.

Organization

Steering Committee

Dr. Ir. Daniel Christianto, S.T., M.T., Universitas Tarumanagara, Indonesia
Prof. Tavio, S.T., M.T., Ph.D., Institut Teknologi Sepuluh Nopember, Indonesia
Dr. Ir. Basuki Anondho, M.T., Universitas Tarumanagara, Indonesia
Dr. Ir. Henny Wiyanto, M.T., Universitas Tarumanagara, Indonesia
Prof. Ir. Chaidir A. Makarim, MSCE, Ph.D., Universitas Tarumanagara, Indonesia
Prof. Ir. Roesdiman Soegiarso, M.Sc., Ph.D., Universitas Tarumanagara, Indonesia

Scientific Committees

Prof. Donguk Choi, Hankyong National University, South Korea
Prof. Dr. Buntara Sthenly Gan, Nihon University, Japan
Prof. Ir. A. Caroline Sutandi, S.T., M.T., Ph.D., IPU, Universitas Katolik Parahyangan, Indonesia
Prof. Ir. Buan Anshari, ST., M.Sc. (Eng.), Ph.D., Univeristas Mataram, Indonesia
Prof. Ir. Didi S. Agustawijaya, M.Eng., Ph.D., Univeristas Mataram, Indonesia
Prof. Ir. Leksmono Suryo Putranto, M.T., Ph.D., Universitas Tarumanagara, Indonesia
Prof. Ir. Yoyong Arfiadi, M.Eng., Ph.D., Universitas Atma Jaya Yogyakarta, Indonesia
Prof. Ir. Yusron Saadi, S.T., M.Sc., Ph.D., Univeristas Mataram, Indonesia
Prof. Jauhar Fajrin, S.T., M.Sc. (Eng.), Ph.D., Univeristas Mataram, Indonesia
Prof. Tavio, S.T., M.T., Ph.D., Institut Teknologi Sepuluh Nopember, Indonesia
Dr.-Ing. Ir. Agustina Kiky Anggraini, ST., M.T., Universitas Atma Jaya Yogyakarta, Indonesia
Dr. Eng. Ir. Pinta Astuti, S.T., M.Eng., Universitas Muhammadiyah Yogyakarta, Indonesia

Dr. Eng. Mia Wimala, Universitas Katolik Parahyangan, Indonesia
 Dr. Eng. Ir. Oei Fuk Jin, M.Eng., Universitas Tarumanagara, Indonesia
 Dr. Eng. Rahmat Kurniawan, S.T., M.T., Institut Teknologi Sumatera, Indonesia
 Dr. Ir. Basuki Anondho, M.T., Universitas Tarumanagara, Indonesia
 Dr. Ir. Burhan Barid, S.T., M.T., Universitas Muhammadiyah Yogyakarta, Indonesia
 Dr. Ir. Edi Hartono, S.T., M.T., Universitas Muhammadiyah Yogyakarta, Indonesia
 Dr. Ir. Endah Murtiana Sari, S.T., M.M., Universitas Sains Indonesia, Indonesia
 Dr. Ir. Henny Wiyanto, M.T., Universitas Tarumanagara, Indonesia
 Dr. Ir. Hermawan, S.T., M.T., M.M., Universitas Katolik Soegijapranata, Indonesia
 Dr. Ir. I. Dewa Made Alit Karyawan, M.T., Universitas Mataram, Indonesia
 Dr. Ir. J. Dwijoko Ansusanto, M.T., Universitas Atma Jaya Yogyakarta, Indonesia
 Dr. Ir. Naomi Pratiwi, Universitas Katolik Parahyangan, Indonesia
 Dr. Ir. Nectaria Putri Pramesti, S.T., M.T., IPM ASEN Eng., Universitas Atma Jaya Yogyakarta, Indonesia
 Dr. Ir. Restu Faizah, S.T., M.T., Universitas Muhammadiyah Yogyakarta, Indonesia
 Dr. Ir. Sumiyati Gunawan, S.T., M.T., Universitas Atma Jaya Yogyakarta, Indonesia
 Dr. Ir. Wati Asriningsih Pranoto, M.T., Universitas Tarumanagara, Indonesia
 Dr. Ir. Willis Diana, S.T., M.T., Universitas Muhammadiyah Yogyakarta, Indonesia
 Dr. Alfred Jonathan Susilo, Universitas Tarumanagara, Indonesia
 Dr. Daniel Christianto, Universitas Tarumanagara, Indonesia
 Dr. Ratna Yuniarti, ST., M.Sc. (Eng.), Universitas Mataram, Indonesia
 Dr. Widodo Kushartomo, Universitas Tarumanagara, Indonesia
 Ir. Puji Harsanto, S.T., M.T., Ph.D., Universitas Muhammadiyah Yogyakarta, Indonesia
 Ir. Dian M. Setiawan, S.T., M.Sc., Ph.D., A.M.ASCE, Universitas Muhammadiyah Yogyakarta, Indonesia
 Ir. Heri Sulistiyono, M.Eng., Ph.D., Universitas Mataram, Indonesia
 Ir. Jason Lim., M.Eng., M.Sc., Pradita University, Indonesia
 Ir. Jazaul Ikhsan, S.T., M.T., Ph.D., IPM, Universitas Muhammadiyah Yogyakarta, Indonesia
 Ir. Seng Hansen, S.T., M.Sc., M.H., Ph.D., IPM, President University, Indonesia
 Ir. Taufiq Ilham Maulana, S.T., M.Eng., Ph.D. (Eng.), Universitas Muhammadiyah Yogyakarta, Indonesia
 Ir. Andryan Suhendra, M.T., Universitas Bina Nusantara, Indonesia
 Ir. Leo S. Tediando, M.T., Universitas Tarumanagara, Indonesia
 Ir. Sunarjo Leman, M.T., Universitas Tarumanagara, Indonesia
 Andri Setiawan, Ph.D., DIC, Politècnica de València, Spain
 Andry Yuliyanto, S.T., M.T., M.Sc., Institut Teknologi Sumatera, Indonesia
 Aswin Lim, Ph.D., Universitas Katolik Parahyangan, Indonesia
 Budijanto Widjaja, Ph.D., IPU, Universitas Katolik Parahyangan, Indonesia
 Hakas Prayuda, S.T., M.Eng., Ph.D., Universitas Muhammadiyah Yogyakarta, Indonesia
 Helmy Hermawan Tjahjanto, Ph.D., Universitas Katolik Parahyangan, Indonesia
 Herry Suryadi, Ph.D., Universitas Katolik Parahyangan, Indonesia
 Hyunjin Ju, Ph.D., Hankyong National University, South Korea

Jessica Gitomarsono S.T., M.Sc., Ph.D., Universitas Katolik Soegijapranata, Indonesia

Roi Milyardi, S.T., M.T., Universitas Kristen Maranatha, Indonesia

Steven Reinaldo Rusli, Ph.D., Universitas Katolik Parahyangan, Indonesia

Local Organizing Committee

Director

Ir. Oei Fuk Jin, M.Eng., D.Eng.

Chairman

Prof. Ir. Roesdiman Soegiarso, M.Sc, Ph.D.

Vice Chairman

Vittorio Kurniawan, S.T., M.Sc.

Members

Lidwina Sri Ayu D. R. Sianturi, S.T., M.T.

Ir. Yenny Untari Liucius, S.T., M.T.

Andy Prabowo, S.T., M.T., Ph.D.

Dr. Ir. Arif Sandjaya, S.T., M.T.

Ir. Aniek Prihatiningsih, M.M., M.T.

Dr. Mega Waty

Ir. Dewi Linggasari, M.T.

Dr. Ir. Wati Asriningsih Pranoto, M.T.

Dr. Widodo Kushartomo

Ir. Arianti Sutandi, M.Eng.

Dr. Ir. Najid, M.T.

Ir. Sunarjo Leman, M.T.

Anugerah Tiffanyputri, S.T., M.Sc.

Preface

This new volume of Lecture Notes in Civil Engineering contains the *Proceedings of the 4th International Conference of Construction, Infrastructure, and Materials (ICCIM 2025)*. The theme of ICCIM 2025 is Advancing Technology in Civil Engineering Towards Sustainable and Resilient Infrastructure. It highlights the conference scope, such as: Structural Engineering and Materials; Geotechnical Engineering; Transportation Engineering and Materials; Construction Management; and Water Resources. ICCIM 2025 received papers from various countries, such as Indonesia, Malaysia, Singapore, Taiwan, Japan, and South Korea. All 56 papers published in this volume went through the double-blind peer-review and plagiarism check. Each paper was reviewed by two experts of the paper's subject. The expert reviewers assessed the papers' technical contents. They would give constructive feedback to improve the papers' quality, while they also rejected them if the papers were not up to standard.

The Fourth International Conference of Construction, Infrastructure, and Materials (ICCIM 2025) was hosted by the Civil Engineering Undergraduate Program of Universitas Tarumanagara on 24 July 2025. The conference provided an international platform for professionals of their respective fields to share information about the state of the art of Civil Engineering. By having a better understanding of the current state and by establishing firm collaboration with each other, Civil Engineering stakeholders will be more prepared to thrive in a perpetually progressing civilization.

This conference is a biannual conference that we have routinely organized since 2019. With the theme that is increasingly developing following existing global problems, it is hoped that this book can convey new ideas that are very useful for future development planning. ICCIM 2025 is motivated by the development of views on sustainable development, where development does not only focus on one aspect, but all aspects of social, cultural, economic, and environmental impacts of the development. Stakeholders such as academics, researchers, experts, and policymakers must be ready to implement sustainable development for current needs. Therefore, we held a conference to accommodate ideas, input, suggestions, and other forms of thought to support the sustainable infrastructure. This conference is expected to contribute

to various studies related to development that can later be used for the benefit of the construction community.

Therefore, we acknowledge all authors who have dedicated their time to writing the papers and presenting them to this conference. Our gratitude is also conveyed to the distinguished keynote speakers who delivered an excellent speech: Prof. Louis Ge (National Taiwan University, Taiwan); Hyunjin Ju, Ph.D. (Hankyong National University, South Korea); Dr. Gustavo A. M. de Almeida (University of Southampton, United Kingdom); and Andy Prabowo, Ph.D. (Universitas Tarumanagara, Indonesia).

We also appreciate the support from 6 university partners: Nihon University, Japan; Universitas Katolik Parahyangan, Indonesia; Universitas Atma Jaya Yogyakarta, Indonesia; Universitas Katolik Soegijapranata, Indonesia; Universitas Muhammadiyah Yogyakarta, Indonesia; Universitas Mataram, Indonesia; together with all sponsors of the ICCIM event.

West Jakarta, Indonesia
Taipei, Taiwan
Anseong, South Korea

Leksmono Suryo Putranto
Louis Ge
Hyunjin Ju

Sponsors



American Concrete Institute
Always advancing





Liquefaction-Induced Settlement of Pile Groups via Nonlinear Time History in MIDAS GTS NX	267
Aniek Prihatiningsih and Jonathan	
Improving the CBR Value of Silt Soil Using Waste Tire and PET Plastic as Sustainable Stabilization Materials	277
Aniek Prihatiningsih and Steven Jonathan	
Comparison Load Combinations of Foundation for Bored Pile Design in the Shear Wall Area of an 18 Story Building	285
Daud Rahmat Wiyono, Asriwiyanti Desiani, Deni Setiawan, Yosafat Aji Pranata, and Andrias Suhendra Nugraha	
Prediction of Long Term Post Construction Settlement in Soft Soil Using Vacuum Preloading	295
Mikael Dylan Gunawan and Hendy Wijaya	
Transportation Engineering and Materials	
Utilization of Agro-industrial Waste in Pavements: A Study on Sugarcane Bagasse Filler and Thermal Compaction	307
Dian M. Setiawan, Maya Mitchell, Lavina Ngesti Bintari, and Wahyu Widodo	
Utilization of Rice Straw Ash for Sustainable Asphalt Concrete: Experimental and Mechanistic Analysis	317
Dian M. Setiawan, Muhammad Daffa Arjuna, Lavina Ngesti Bintari, and Noor Mahmudah	
Effect of Seawater Immersion on the Performance of Continuously Graded Asphalt Mixtures with Replacement of Steel Slag Waste as Coarse Aggregate	327
Anita Rahmawati, Anita Widiyanti, Bagus Soebandono, Wahyu Widodo, Pranawa Wiryawan, Rama Rizana, and Siti Isnaini Kurniawati Djaha	
Analysis of Workability Index on Hot Rolled Sheet Mixture—Wearing Course (HRS-WC) with Pure Asbuton Binder	337
Muji Rifai, Michael Prilas Simanjuntak, Djoko Sarwono, and Fajar Sri Handayani	
Automatic Void Detection in Asphalt Layer Using 3D Ground Penetrating Radar	347
Raihan Valentino Jaya Saputra and Chihping Kuo	
Viscosity, Shear Resistance and Stiffness Properties of 60/70 Penetration, Solid Rubber-Modified, Polymer-Modified and Pure Buton Bitumen	357
Ary Setyawan, Wibowo, and Gibran Al Munawar Cholil Mukhsin	

Improving the CBR Value of Silt Soil Using Waste Tire and PET Plastic as Sustainable Stabilization Materials



Aniek Prihatiningsih and Steven Jonathan

Abstract This study investigates the potential use of waste tire and polyethylene terephthalate (PET) plastic as sustainable stabilization additives to improve the California Bearing Ratio (CBR) value of silt soil. Silt soil, known for their low bearing capacity and poor compaction properties, poses significant challenges for infrastructure development in rapidly growing areas such as Pantai Indah Kapuk (PIK) 2, Tangerang. In this study, the soil was mixed with 2, 4, 6, and 8% waste tire and 0.2, 1, 2, and 4% PET plastic by dry weight of soil, using materials passing through a 4.75 mm sieve. Standard Proctor and CBR tests were conducted to compare the natural soil and treated samples. Natural silt soil exhibited a CBR value of 11.9%, while the mixture of waste tire material with 4% proportion recorded a CBR value of 16%, indicating an increase of approximately of 33.6% and for the mixture of PET plastic material with 2% addition yielded a CBR value of 14.7%, which equals an increase of about 22.7% compared to the natural soil. These findings highlight the potential of using waste tire and PET plastic as alternative stabilizers, offering a technically effective, cost-saving method and environmentally sustainable solution for improving the subgrade soil performance in geotechnical engineering uses.

Keywords Soil stabilization · Silt soil · Waste tire and PET plastic · CBR

1 Introduction

The strength and stability of the subgrade soil are key factors in determining the success of transportation infrastructure development, particularly in road construction. One of the main parameters that can determine whether soil can be used as a subgrade or subbase is the California Bearing Ratio (CBR) value. To determine the CBR value, soil samples are compacted at the Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) [1]. In tropical regions such as Indonesia, this

A. Prihatiningsih (✉) · S. Jonathan
Tarumanagara University, Jakarta, Indonesia
e-mail: aniekp@ft.untar.ac.id

testing is essential for pavement design, as the CBR value directly influences the required pavement thickness and thus construction cost. The bearing capacity of the subgrade is crucial in determining the thickness of the pavement [2], which can also significantly impact construction costs [11]. The CBR value plays a crucial role in determining the thickness of the pavement, where a higher CBR value allows for a thinner pavement layer in road construction, and vice versa [3].

Silt soil is commonly found at various construction sites and generally has a low CBR value, so it does not meet the minimum requirements as subgrade material without additional improvement. Silt soil is typically classified as a fine-grained soil with the primary criterion being that more than 50% of the soil's weight passes through a No. 200 sieve (0.075 mm) and has low to moderate plasticity, making it a suitable material for directly supporting structural loads. Therefore, stabilization efforts are required to enhance the bearing capacity and technical properties of silt soil [4].

On the other hand, waste tire and PET plastic have become a growing environmental problem due to the limited waste management, especially in Indonesia. According to data from the Ministry of Environment, in 2024 the total waste of over 33 million tons, the rubber waste accounts for 2.13% (around 600 thousand tons) and plastic waste accounts for 19.73% (around 5.7 million tons). Improper management of these materials can result in pollution and health hazards. Repurposing these wastes as soil additives not only mitigates environmental risks but also presents a resourceful approach to soil enhancement.

Previous investigations into waste-based soil stabilization have examined various materials, including shredded tires, carpet fibres, and paper fibres. Among these, tire waste had the highest improvement in the tested soil properties [5]. Several studies have discussed the opportunities and challenges of utilizing waste materials for soil improvement. It has been demonstrated that the incorporation of recycled tire particles into soil mixtures can result in lower CBR values unless combined with additional stabilizing agents, which emphasizes the need for appropriate treatment and mix proportioning [6]. Other research also indicates that recycled PET strips are capable of improving both CBR and compressive strength, thereby reinforcing their potential as sustainable soil stabilizers [7]. In general, tire waste and PET plastic represent promising alternatives for ground improvement, although their effectiveness is highly dependent on dosage and soil type. This can also be demonstrated by a study using used tire waste with dimensions of 10–40 mm in length and 10–15 mm in width, with varying additions of 2, 4, 6, 8, and 10% showed a significant increase in CBR values at a 6% addition rate, with the CBR value increasing from 2.41 to 6.59% [8]. There was an experiment using tire waste that had passed through a sieve no. 4 (4.75 mm) with addition variations of 2, 4, 6, and 8%, showing the greatest increase at the 6% addition variation, with the CBR value increasing from 6.13 to 9.48% [9]. For the PET plastic waste, there was also a study that used PET plastic with dimension of 5×0.5 mm with varying additions of 0.1, 0.2, 0.3, and 0.4% showed an increase in CBR values increasing from 12.2 to 16.2% [10]. Another study that used PET plastic waste with the size less than 20 mm and bigger than 4.75 mm with addition variations of 0.5, 1, 2, 3, and 4% showed the increasing of CBR value at 2%

addition from 2.92 to 9.72% [11]. The results of previous studies indicate that either tire waste or PET plastic waste can be a promising solution to address environmental issues while improving soil performance.

Based on the background and review of previous research, the research question in this study is how the variation in the addition of tire and PET plastic waste material affects the increase in the California Bearing Ratio (CBR) value of silt soil, as well as what percentage of used tire and PET plastic material is most effective in improving the bearing capacity of silt soil.

Therefore, experimental research on the addition of tire and PET plastic waste to silt soil on CBR values is highly relevant as a solution in efforts to improve subgrade soil performance. The purpose of this research is to analyze how different proportions of tire waste and PET plastic waste influence the CBR values of silt soil, using samples taken directly from a project site in Pantai Indah Kapuk (PIK) 2, Tangerang. Unlike previous studies, which generally rely on general or laboratory-prepared soil types, this study emphasizes the importance of using actual field soil to reflect realistic construction conditions and to address a gap in site-specific soil stabilization research. In addition, this study also determines the most effective mixture ratio for soil stabilization techniques, thereby providing an environmentally friendly alternative solution in the fields of civil engineering and road construction.

2 Materials and Methods

2.1 Research Materials

This experimental study utilized silty soil collected from Pantai Indah Kapuk (PIK) 2 in Tangerang. The samples were naturally air-dried and sieved to ensure uniformity. Waste tire and PET plastic was obtained from local sources and cut into small pieces until they passed through a sieve no. 4 (4.75 mm) to standardize particle size. The proportions of tire waste used at 2, 4, 6, and 8%. For the PET plastic waste used at 0.2, 1, 2, and 4%. The proportions of both wastes were calculated based on the dry weight of the soil.

2.2 Research Methods

The research began with the laboratory testing to find out the type of the soil based on Unified Soil Classification System (USCS). The test consists of index properties, grain size analysis, Atterberg limit, and standard proctor compaction test. After the soil laboratory tests were conducted, the next step is to prepare the dry soil material and shredded tire and PET plastic waste. Control samples without the addition of additives were tested for compaction using the Standard Proctor method, based on

ASTM D698 [12] to determine the Maximum Dry Density (MDD) and Optimum Moisture Content (OMC). After the OMC is obtained, California Bearing Ratio (CBR) testing, based on ASTM D1883 [13], will be conducted using the unsoaked method three times to enhance data reliability, both for the control sample and the sample mixed with additives. After all samples have been tested, data analysis will be conducted to evaluate the effect of variations in tire and PET plastic addition on CBR value improvement and to determine the optimal proportion of additives that provide the best improvement in silt soil.

3 Results

Based on the results of soil laboratory testing, it is found that the soil type is included in the MH classification, as presented in Table 1, namely inorganic silt with high plasticity, indicated by Liquid Limit values 60.6% and Plasticity Index 20.35%. The Specific Gravity value of 2.63 indicates that the soil is clay or silt. Based on the results of the grain size distribution test, the soil sample is mainly composed of fine-grained particles. Silt makes up the largest portion at around 60%, with sand contributing about 25%, followed by 10% clay and a small amount of gravel at approximately less than 5%. Compaction characteristics showed the Optimum Moisture Content (OMC; 29%) and Maximum Dry Density (MDD; 1.358 g/cm³), indicating the soil has low bearing capacity and potential for significant volume changes due to changes in moisture content.

According to the data in Fig. 1, which is the result of laboratory compaction test, it was found that the soil achieved its peak dry density of about 1.358 g/cm³ when the moisture content was close to 29%, indicating the optimal condition for compaction. The shape of the curve showed a typical response of fine-grained soils, where density increased with added moisture up to a certain point before decreasing due to excess water. All data points followed a consistent trend and remained below

Table 1 Summary of soil sample testing

No.	Testing	Parameters	Test results
1	Index properties	Specific gravity value	2.63
2	Grain size analysis	%Gravel	4.31%; 4.26%; 4.27%
		%Sand	24.09%; 22.21%; 23.95%
		%Silt	60.85%; 62.98%; 63.56%
		%Clay	10.75%; 10.56%; 8.22%
3	Atterberg limit test	Liquid limit value	60.6%
		Plasticity index value	20.35%
4	Standard proctor compaction	Optimum moisture content	29%
		Maximum dry density	1.358 g/cm ³

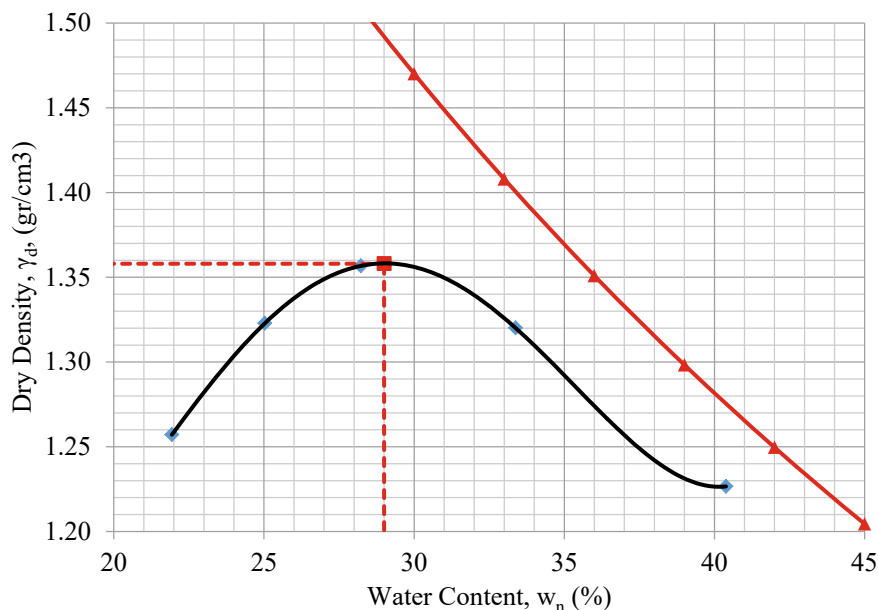


Fig. 1 Standard proctor compaction curve

the theoretical zero air voids line, reflecting realistic compaction behavior under field-like conditions.

After obtaining supporting data, CBR testing can be carried out with the condition of the tested soil must be in accordance with compaction data such as soil must be at Optimum Moisture Content (OMC) and Maximum Dry Density (MDD). CBR testing will be carried out using three samples to maintain the accuracy of the data starting from the original soil sample, a mixture of 2, 4, 6, and 8% waste tire, and a mixture of 0.2, 1, 2, and 4% PET plastic waste. For the CBR value and the percentage increase from the original soil can be seen in Table 2.

After conduction CBR testing, data such as CBR Top and CBR Bottom values are obtained by taking readings during testing. The CBR value can be calculated by finding the average value of the CBR Top and CBR Bottom values. In the natural sample, the CBR value is 11.9%. Thereafter, the sample with the addition of tire waste and PET plastic will be tested to demonstrate a notable influence on its CBR values. The addition of 2% tire waste resulted in a CBR value of 14.8%. Increasing the tire content to 4% further enhanced the CBR value to 16%, representing the peak performance among the tested variations. Interestingly, further additions of 6 and 8% led to decreases in performance, suggesting that excess tire particles may interfere with optimal particle packing or bonding.

Meanwhile the sample with the addition of PET plastic waste as much as 0.2% obtained CBR value of 12.6%. Increasing the plastic content to 1% led to a moderate improvement, yielding a CBR value of 13.4%. The highest CBR value, 14.7%, was

Table 2 CBR value and percentage increase

	CBR top (%)	CBR bottom (%)	CBR value (%)	CBR value increase (%)
Original soil	12.8	11	11.9	0
2% Tire waste	16	13.6	14.8	+ 24
4% Tire waste	17.7	14.3	16	+ 33.6
6% Tire waste	16.4	14.2	15.3	+ 28.2
8% Tire waste	15.6	13.8	14.7	+ 23.2
0.2% Plastic waste	13.4	11.7	12.6	+ 5.3
1% Plastic waste	14.8	11.9	13.4	+ 11.6
2% Plastic waste	17.4	11.9	14.7	+ 22.7
4% Plastic waste	14.6	11.8	13.2	+ 10.8

observed at 2% plastic content, indicating that this percentage is the optimal dosage for enhancing soil strength. However, a rise to 4% PET plastic caused the CBR to drop to 13.2%, implying that higher concentrations may reduce compaction efficiency or hinder inter-particle contact.

The experimental investigation assessed the effect of both waste tire and PET plastic waste incorporation on the California Bearing Ratio (CBR) of silt soil. The natural (untreated) soil recorded a CBR value of 12%. The addition of waste tire material in progressive levels showed a positive impact on soil strength, with the highest CBR value of 16% achieved at 4% tire content. This represents an approximate 33.6% increase in CBR compared to the natural soil.

Similarly, PET plastic waste was added at varying proportions, with the optimal CBR value of 14.7% observed at 2% plastic content, corresponding to an increase of approximately 22.7% relative to the natural soil. Beyond these peak values, further increases in waste content led to a decline in CBR performance, indicating the existence of an optimal proportion for each type of waste.

As presented in Fig. 2, the incorporation of waste tire and PET plastic materials resulted in a noticeable increase in the bearing capacity of the silt subgrade. When used in their optimum proportions, these additives contributed to improved soil performance, offering both a technically effective stabilization method and a sustainable approach to reusing waste materials in civil engineering applications.

4 Conclusions and Recommendations

Based on the analysis in this paper, various conclusion can be drawn as follow:

1. The incorporation of waste tire and PET plastic materials into silty soil effectively increased the California Bearing Ratio (CBR) compared to the natural condition.

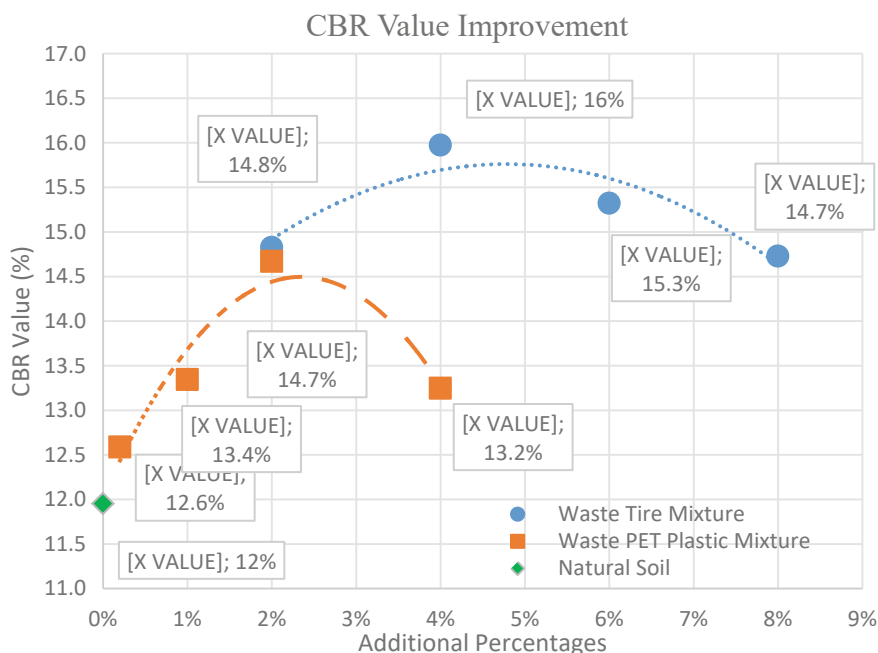


Fig. 2 Graph of CBR values and improvement

2. The optimum CBR value from tire waste was obtained at 4% content, reaching 16%, which represents a 33.6% improvement over the natural soil.
3. The optimum CBR value from PET plastic waste was achieved at 2% content, reaching 14.7%, indicating a 22.7% improvement compared to the untreated soil.
4. Increasing the content of either waste material beyond the optimal level resulted in a decline in CBR value, suggesting that excessive addition may disrupt soil structure and reduce compaction efficiency.
5. Both types of waste demonstrated potential as sustainable soil stabilizers, supporting environmental goals through the reuse of non-biodegradable materials in geotechnical applications.

These findings provide a foundation for improving the implementation of waste-based stabilization in geotechnical applications. Although the study demonstrated notable improvements in CBR values, it was conducted under controlled laboratory conditions, which may not fully reflect long-term behavior or field-scale performance. Future investigations should consider durability aspects under varying environmental influences, including moisture variation, temperature changes, and cyclic loading. Careful attention must also be given to the proportioning of tire and PET plastic waste, as excessive amounts may adversely affect strength characteristics [14]. In addition, evaluating hybrid use of these materials may reveal synergistic effects that contribute to improved performance and broader applicability.

References

1. Choudhary DK, Joshi YP (2014) A detailed study of CBR method for flexible pavement design. *Int J Eng Res Appl* 4(6):239–253. ISSN: 2248-9622
2. Katte VY, Mfoyet SM, Manefouet BI, Wouatong ASL, Bezeng LA (2019) Correlation of California Bearing Ratio (CBR) value with soil properties of road subgrade soil. *Geotech Geol Eng*. <https://doi.org/10.1007/s10706-018-0604-x>
3. Setyarini NLPs, Kushartomo W, Varian M (2017) Pengaruh Nilai CBR Tanah Dasar dan Mutu Beton terhadap Tebal Pelat Perkerasan Kaku Metode Bina Marga. *Jurnal Muara Sains, Teknologi, Kedokteran dan Ilmu Kesehatan* 1(1):244–250. <https://doi.org/10.24912/jmstkik.v1i1.436>
4. Haider AB, Irvanian A, Selman MH, Ekinci A (2023) Using waste PET shreds for soil stabilization: efficiency and durability assessment. *Int J Geosynth Ground Eng* 9:48. <https://doi.org/10.1007/s40891-023-00473-8>
5. Susilo AJ (2016) Enhancing the strength properties of fly ash by adding waste products. Ph.D. Dissertation, University of Kentucky. <https://doi.org/10.13023/ETD.2016.388>
6. Ahmad Azam AS, Sani S, Ming CC (2024) California Bearing Ratio (CBR) of engineered sand backfill admixed with recycled tyre wastes. *Prog Eng Appl Technol (PEAT)* 5(1):678–688. <https://doi.org/10.30880/peat.2024.05.01.073>
7. Khalid B, Alshawmar F (2023) Exploring the feasibility of using recycled PET strips with palm leaf ash for sustainable soil stabilization. *Sustainability* 15:13542. <https://doi.org/10.3390/su151813542>
8. Farooq S, Kumar A (2022) Geotechnical reuse of shredded scrap tires to reinforce the Karewa soils of Kashmir. *Int J Innov Res Comput Sci Technol* 10(3):243–250. <https://doi.org/10.55524/ijirest.2022.10.3.41>
9. Wangmo P, Selden D, Wangmo R et al (2020) Improvement of road subgrade using waste tyres. *Zorig Melong: Tech J* 4(1):1–6
10. Niyomukiza JB, Bitekateko A, Nsemerirwe J et al (2021) Investigating the effect of PET plastic bottle strips on the strength and compressibility properties of clayey soil. *IOP Conf Ser Earth Environ Sci* 894:012021. <https://doi.org/10.1088/1755-1315/894/1/012021>
11. Paramkusam BR, Prasad A, Arya CS (2013) A study on CBR behavior of waste plastic (PET) on stabilized red mud and fly ash. *Int J Struct Civ Eng Res* 2(3):232–237
12. ASTM D698-12(2021) (2021) Standard test methods for laboratory compaction characteristics of soil using standard effort (12,400 ft-lbf/ft³ (600 kN-m/m³)). ASTM International, West Conshohocken, PA. <https://doi.org/10.1520/D0698-12R21>
13. ASTM D1883-21 (2021) Standard test method for California Bearing Ratio (CBR) of laboratory-compacted soils. ASTM International, West Conshohocken, PA. <https://doi.org/10.1520/D1883-21>
14. Bezih K, Djenane M, Laouche M, Hebbache K (2025) Experimental study of shear strength and CBR improvement of silty clay soil reinforced with waste tires. *Sci Rep* 15(16494):1–16. <https://doi.org/10.1038/s41598-025-00808-7>