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DAFTAR PUSTAKA

6Wresearch, 2023. Indonesia Block Paving Market (2026-2032) Outlook [WWW Document]. https://www.6wresearch.com/industry-report/indonesia-block-paving-market-outlook.

Adamu, M., Ibrahim, Y.E., 2024. Environmental sustainability and cost-benefit analysis of concrete containing date palm ash and eggshell powder: A response surface methodology approach. Case Studies in Chemical and Environmental Engineering 9, 100636. https://doi.org/https://doi.org/10.1016/j.cscee.2024.100636

Alhajiri, A.M., Akhtar, M.N., 2023. Enhancing Sustainability and Economics of Concrete Production through Silica Fume: A Systematic Review. Civil Engineering Journal (Iran). https://doi.org/10.28991/CEJ-2023-09-10-017

Aliyu Yaro, N.S., Sutanto, M.H., Habib, N.Z., Napiah, M., Usman, A., Muhammad, A., Jagaba, A.H., 2023. Modeling and optimization of rheological properties and aging resistance of asphalt binder incorporating palm oil mill waste using response surface methodology. Journal of Infrastructure Intelligence and Resilience 2, 100026. https://doi.org/https://doi.org/10.1016/j.iintel.2023.100026

ASI, 2023. Upaya Industri Semen dalam Pengendalian Emisi Gas Rumah Kaca [WWW Document]. https://asi.or.id/id/upaya-industri-semen-dalam-pengendalian-emisi-gas-rumah-kaca/.

Atkinson, A., Donev, A., Tobias, R., 2007. Optimum Experimental Designs, with SAS. https://doi.org/10.1093/oso/9780199296590.001.0001

Axelsson, G., 2010. Sustainable geothermal utilization – Case histories; definitions; research issues and modelling. Geothermics 39, 283–291. https://doi.org/https://doi.org/10.1016/j.geothermics.2010.08.001

Abrams, D. A. (1918). *Design of concrete mixtures* (Bulletin No. 1). Structural Materials Research Laboratory, Lewis Institute.

ASTM International. (2023). ASTM C618-23: Standard specification for coal ash and raw or calcined natural pozzolan for use in concrete. ASTM International.

Badan Geologi, 2024. PSDMBP Luncurkan Peta Potensi Panas Bumi, Dorong Pemanfaatan Langsung untuk Ekonomi Lokal, https://geologi.esdm.go.id/media-center/psdmbp-luncurkan-peta-potensi-panas-bumi-dorong-pemanfaatan-langsung-untuk-ekonomi-lokal. Jakarta.

Barbhuiya, Gulzar H, Moiz, M.A., Hasan, S.D., Zaheer, M.M., 2020. Effects of the nanosilica addition on cement concrete: A review. Mater. Today Proc. 32, 560–566. https://doi.org/https://doi.org/10.1016/j.matpr.2020.02.143

Basri, M.S.M., Mustapha, F., Mazlan, N., Ishak, M.R., 2021. Rice-husk-ash-based geopolymer coating: Fire-retardant, optimize composition, microstructural, thermal and element characteristics analysis. Polymers (Basel). 13. https://doi.org/10.3390/polym13213747

Analisis Kelayakan Teknis, Keberlanjutan Lingkungan, dan Ekonomi Silika Geothermal Sebagai Substitusi Semen dalam Pembuatan Paving block: Pendekatan Optimasi Response Surface Methodology
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Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Borja, W., Adarmouch, M., El Hafiane, Y., Daafi, Y., Tamraoui, Y., Alami, J., 2023. Synthesis of nano-silica as a promising route of recycling phosphate waste rocks and its incorporation in mortars. Sustainable Materials and Technologies 37, e00684. https://doi.org/https://doi.org/10.1016/j.susmat.2023.e00684

Bragg, W.L., 1913. The Diffraction of Short Electromagnetic Waves by a Crystal.

Badan Standarisasi Nasional., 1989. SK SNI S-04-1989-F Spesifikasi Bahan Bangunan Bagian A, Bahan Bangunan Bukan Logam. Badan Standarisasi Nasional. Indonesia.

Badan Standarisasi Nasional., 1990. Standar Nasional Indonesia 03-1968-1990 Metode Pengujian Analisis Saringan Agregat Halus Dan Kasar. Badan Standarisasi Nasional. Indonesia.

Badan Standarisasi Nasional., 1996. Standar Nasional Indonesia 03-0691-1996 Bata Beton (*Paving block*). Badan Standarisasi Nasional. Indonesia.

Badan Standarisasi Nasional., 1998. Standar Nasional Indonesia 03-4804-1998 Metode Pengujian Bobot Isi Dan Rongga Udara Dalam Agregat. Badan Standarisasi Nasional. Indonesia.

Badan Standarisasi Nasional, SNI 15-2049-2004, Semen Portland

Badan Standarisasi Nasional., 2008. SNI 1970-2008 Cara Uji Berat Jenis dan Penyerapan Air Agregat Halus. Badan Standarisasi Nasional. Jakarta.

Badan Standardisasi Nasional., (2012). SNI ASTM C136:2012: Metode uji untuk analisis saringan agregat halus dan agregat kasar (ASTM C 136-06, IDT). Badan Standardisasi Nasional.

Badan Standardisasi Nasional., (2014). SNI 0302:2014: Semen portland pozolan. Badan Standardisasi Nasional.

Chaitanya, B.K., Madhavi, Y., Durga, C.S.S., Meharie, M.G., Venkatesh, C., Prasad, A.S., Alaneme, G.U., Kumar, N.S.V., 2025. Performance evaluation of concrete containing fly ash, silica fume and m-sand under high temperatures: mechanical and microstructural approach. Journal of Infrastructure Preservation and Resilience 6. https://doi.org/10.1186/s43065-025-00150-2

Chari, K., Rao, V., 2022. Durability and Microstructure Characteristics of Concrete with Supplementary Cementitious Materials. Civil Engineering Journal 8, 683–694. https://doi.org/10.28991/CEJ-2022-08-04-05

Cullity, B. D., & Stock, S. R. (2001). Elements of X-ray Diffraction, Third Edition. https://api.semanticscholar.org/CorpusID:136061819

Collins, F., 2010. Inclusion of carbonation during the life cycle of built and recycled concrete: Influence on their carbon footprint. International Journal of Life Cycle Assessment 15, 549–556. https://doi.org/10.1007/s11367-010-0191-4

Derringer, G., Suich, R., 1980. Simultaneous Optimization of Several Response Variables. Journal of Quality Technology 12, 214–219. https://doi.org/10.1080/00224065.1980.11980968

UNIVERSITAS GADJAH MADA
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Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Dixit, M.K., Fernández-Solís, J.L., Lavy, S., Culp, C.H., 2010. Identification of parameters for embodied energy measurement: A literature review. Energy Build. 42, 1238–1247. https://doi.org/https://doi.org/10.1016/j.enbuild.2010.02.016

El-Eskandarany, M.S., 2019. Recent developments in the fabrication, characterization and implementation of MgH2-based solid-hydrogen materials in the Kuwait Institute for Scientific Research. RSC Adv. https://doi.org/10.1039/c9ra00287a

Escalante, J.I., Mendoza, G., Mancha, H., López, J., Vargas, G., 1999. Pozzolanic properties of a geothermal silica waste material, Cement and Concrete Research.

Escalante-García, J.I., Gorokhovsky, A. V, Mendoza, G., Fuentes, A.F., 2003. Effect of geothermal waste on strength and microstructure of alkali-activated slag cement mortars. Cem. Concr. Res. 33, 1567–1574. https://doi.org/https://doi.org/10.1016/S0008-8846(03)00133-9

Ezziane, K., Bougara, A., Kadri, A., Khelafi, H., Kadri, E., 2007. Compressive strength of mortar containing natural pozzolan under various curing temperature. Cem. Concr. Compos. 29, 587–593. https://doi.org/https://doi.org/10.1016/j.cemconcomp.2007.03.002

Fan, H., Yu, H., Ma, Haiyan, Chen, X., Li, L., Du, Q., zhang, M., Ma, Haoxia, Wu, C., 2025. Refinement and application of life cycle assessment (LCA) for concrete: Development of a carbon emission metric normalized by salt-freezing durability and its use in designing high-durability, low-carbon, high-performance concrete. Sustainable Materials and Technologies 45, e01622. https://doi.org/https://doi.org/10.1016/j.susmat.2025.e01622

Ferreira, S.L.C., Bruns, R.E., Ferreira, H.S., Matos, G.D., David, J.M., Brandão, G.C., da Silva, E.G.P., Portugal, L.A., dos Reis, P.S., Souza, A.S., dos Santos, W.N.L., 2007. Box-Behnken design: An alternative for the optimization of analytical methods. Anal. Chim. Acta 597, 179–186. https://doi.org/https://doi.org/10.1016/j.aca.2007.07.011

Georgescu, D., Vacareanu, R., Aldea, A., Apostu, A., Arion, C., Girboveanu, A., 2022. Assessment of the Sustainability of Concrete by Ensuring Performance during Structure Service Life. Sustainability (Switzerland) 14. https://doi.org/10.3390/su14020617

Giergiczny, Z., 2019. Fly ash and slag. Cem. Concr. Res. 124, 105826. https://doi.org/https://doi.org/10.1016/j.cemconres.2019.105826

Goldstein, J., Newbury, D., Michael, J., Ritchie, N., Scott, J., Joy, D., 2018. Scanning Electron Microscopy and X-Ray Microanalysis, Scanning Electron Microscopy and X-ray Microanalysis. https://doi.org/10.1007/978-1-4939-6676-9

Gómez-Zamorano, L.Y., Escalante-García, J.I., 2010. Effect of curing temperature on the nonevaporable water in portland cement blended with geothermal silica waste. Cem. Concr. Compos. 32, 603–610. https://doi.org/https://doi.org/10.1016/j.cemconcomp.2010.07.004

Goos, P., Jones, B., 2011. Optimal Design of Experiments: A Case-Study Approach, Optimal Design of Experiments: A Case Study Approach. https://doi.org/10.1002/9781119974017

Gorji, N.E., Pieniążek, A., Iancu, A., Norek, M., Couteau, C., Deturche, R., Tavkhelidze, A., Bibilashvili, A., Jangidze, L., 2025. SEM, EDX, AFM, and XPS analysis of surface

Analisis Kelayakan Teknis, Keberlanjutan Lingkungan, dan Ekonomi Silika Geothermal Sebagai Substitusi Semen dalam Pembuatan Paving block: Pendekatan Optimasi Response Surface Methodology
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Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

microstructure and chemical composition of nanograting patterns on silicon substrates. Opt. Quantum Electron. 57. https://doi.org/10.1007/s11082-025-08106-2

Government of Indonesia, 2025. SECOND NATIONALLY DETERMINED CONTRIBUTION REPUBLIC OF INDONESIA SUMMARY. Jakarta.

Habert, G., Miller, S.A., John, V.M., Provis, J.L., Favier, A., Horvath, A., Scrivener, K.L., 2020. Environmental impacts and decarbonization strategies in the cement and concrete industries. Nat. Rev. Earth Environ. 1, 559–573. https://doi.org/10.1038/s43017-020-0093-3

Haddouch, B., El Fadili, H., Elaatmani, M., Khadiri, M.-E., Taha, Y., Ait-Khouia, Y., 2026. Valorization of phosphate sludge through silica recovery: A sustainable approach to transform overlooked mining waste into wealth. Mater. Res. Bull. 202, 114167. https://doi.org/https://doi.org/10.1016/j.materresbull.2026.114167

Hammond, Geoffrey., Jones, Craig., Lowrie, Fiona., Tse, Peter., 2011. Embodied carbon : the Inventory of Carbon and Energy (ICE). BSRIA.

Haruehansapong, S., Pulngern, T., Chucheepsakul, S., 2014. Effect of the particle size of nanosilica on the compressive strength and the optimum replacement content of cement mortar containing nano-SiO2. Constr. Build. Mater. 50, 471–477. https://doi.org/10.1016/j.conbuildmat.2013.10.002

Hawileh, R., Abdalla, J., Nawaz, W., Zadeh, A., Mirghani, A., Nassara, A., Khartabil, A., Shantia, M., 2024. Effects of Replacing Cement with GGBS and Fly Ash on the Flexural and Shear Performance of Reinforced Concrete Beams. Practice Periodical on Structural Design and Construction 29. https://doi.org/10.1061/PPSCFX.SCENG-1339

Hottle, T., Hawkins, T.R., Chiquelin, C., Lange, B., Young, B., Sun, P., Elgowainy, A., Wang, M., 2022. Environmental life-cycle assessment of concrete produced in the United States. J. Clean. Prod. 363, 131834. https://doi.org/https://doi.org/10.1016/j.jclepro.2022.131834

IMARC Group, 2025. Indonesia Cement Market Size, Share & Analysis 2033 [WWW Document]. https://www.imarcgroup.com/indonesia-cement-market.

Imbabi, M.S., Carrigan, C., McKenna, S., 2012. Trends and developments in green cement and concrete technology. International Journal of Sustainable Built Environment 1, 194–216. https://doi.org/https://doi.org/10.1016/j.ijsbe.2013.05.001

Iñiguez-Sánchez, C., Gómez-Zamorano, L., Alonso, M., 2012. Impact of nano-geothermal silica waste and chloride content on pore solution, microstructure, and hydration products in Portland cement pastes. J. Mater. Sci. 47, 3639–3647. https://doi.org/10.1007/s10853-011-6210-4

Iler, R. K., (1979). The chemistry of silica: Solubility, polymerization, colloid and surface properties, and biochemistry. Wiley-Interscience.

ICPI. (1995). ICPI Tech Spec Number 1: Glossary of Definitions for Segmental Concrete Pavement. Washington, DC: Interlocking Concrete Pavement Institute.

UNIVERSITAS GADJAH MADA
Analisis Kelayakan Teknis, Keberlanjutan Lingkungan, dan Ekonomi Silika Geothermal Sebagai Substitusi Semen dalam Pembuatan Paving block: Pendekatan Optimasi Response Surface Methodology
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Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Jenie, S.N.A., Ghaisani, A., Ningrum, Y.P., Kristiani, A., Aulia, F., Petrus, H.T.M.B., 2018. Preparation of silica nanoparticles from geothermal sludge via sol-gel method. hlm. 020008. https://doi.org/10.1063/1.5064968

Kementerian ESDM, 2020. Potensi Pengembangan Energi Panas Bumi di Indonesia [WWW Document]. https://ebtke.esdm.go.id/lintas/id/investasi-ebtke/sektor-panas-bumi/potensi.

Kementerian Pekerjaan Umum, 2025. Rencana Strategis Kementerian Pekerjaan Umum Tahun 2025-2029. Jakarta.

Khairuddin, F.H., Misnon, N.A., Mahyan, A.R., Mohd Tawil, S.N., Jusli, E.A., Binti Katman, H.Y., Albrka Ali, S.I., 2025. Durability, microstructure, and chemical properties of interlocking concrete paver block with silica fume, dalam: IOP Conference Series: Earth and Environmental Science. Institute of Physics. https://doi.org/10.1088/1755-1315/1548/1/012010

Kiran, G.U., Nakkeeran, G., Roy, D., Alaneme, G.U., 2024. Optimization and prediction of paver block properties with ceramic waste as fine aggregate using response surface methodology. Sci. Rep. 14. https://doi.org/10.1038/s41598-024-74797-4

Kurda, R., de Brito, J., Silvestre, J.D., 2017. Combined influence of recycled concrete aggregates and high contents of fly ash on concrete properties. Constr. Build. Mater. 157, 554–572. https://doi.org/https://doi.org/10.1016/j.conbuildmat.2017.09.128

Klug, H. P., & Alexander, L. E., (1974). X-ray diffraction procedures for polycrystalline and amorphous materials (2nd ed.). John Wiley & Sons.

Lee, N., Jeong, Y., Kang, H., Moon, J., 2020. Heat-induced acceleration of pozzolanic reaction under restrained conditions and consequent structural modification. Materials 13. https://doi.org/10.3390/ma13132950

Limbachiya, V., Ganjian, E., Claisse, P., 2016. Strength, durability and leaching properties of concrete *paving block*s incorporating GGBS and SF. Constr. Build. Mater. 113, 273–279. https://doi.org/https://doi.org/10.1016/j.conbuildmat.2016.02.152

Lin, Y., Alengaram, U.J., Ibrahim, Z., 2023. Effect of treated and untreated rice husk ash, palm oil fuel ash, and sugarcane bagasse ash on the mechanical, durability, and microstructure characteristics of blended concrete – A comprehensive review. Journal of Building Engineering 78, 107500. https://doi.org/https://doi.org/10.1016/j.jobe.2023.107500

López-Perales, J.F., Alonso-Alonso, M.C., Vázquez-Rodríguez, F.J., Guzmán-Hernández, A.M., Gómez-Zamorano, L.Y., Rodríguez-Castellanos, E.A., Puente-Ornelas, R., 2024. Geothermal Nano-SiO2 Waste as a Supplementary Cementitious Material for Concrete Exposed at High Critical Temperatures. Materials 17. https://doi.org/10.3390/ma17174381

Mayasari, D., Yuhanah, T., Wicaksono, B., 2019. Pengaruh Penambahan Lumpur Geothermal Dan Serat Baja Ban Bekas Terhadap Beton. FORUM MEKANIKA 8, 19–28. https://doi.org/10.33322/forummekanika.v8i1.341

Meng, L.Y., Wang, Y.S., Sun, F., Lin, R., Wang, X.Y., 2025. An integrated strength-carbon emissions-total cost model for silica fume concrete. Case Studies in Construction Materials 22. https://doi.org/10.1016/j.cscm.2025.e04327

UNIVERSITAS
GADJAH MADA
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Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Meyer, R., Nachtsheim, C., 1995. The Coordinate-Exchange Algorithm for Constructing Exact Optimal Experimental Designs. Technometrics 37, 60–69. https://doi.org/10.1080/00401706.1995.10485889

Mikell Groover, 2010. Fundamentals of modern manufacturing materials processes and systems 4th Edition.

Monteiro, P., Mehta, P., 2006. Concrete: Microstructure, Properties and Materials, McGraw-Hill.

Mouna, Y., Suryanto, B., 2025. Recycled Aggregate Concrete: Effect of Supplementary Cementitious Materials and Potential for Supporting Sustainable Construction. Materials 18. https://doi.org/10.3390/ma18225183

Müller, H.S., Breiner, R., Moffatt, J.S., Haist, M., 2014. Design and Properties of Sustainable Concrete. Procedia Eng. 95, 290–304. https://doi.org/https://doi.org/10.1016/j.proeng.2014.12.189

Mulyono, T. 2004. Teknologi Beton. Andi Publishing. Yogyakarta.

Nawar, N., Irtiza, T., Chowdhury, I.A., Chowdhury, S.R., 2025. Optimization of micro-silica replacement levels for high strength and low-absorption sustainable concrete. Research on Engineering Structures and Materials. https://doi.org/10.17515/resm2025-1055ma0721rs

Nuaklong, P., Jongvivatsakul, P., Pothisiri, T., Sata, V., Chindaprasirt, P., 2020. Influence of rice husk ash on mechanical properties and fire resistance of recycled aggregate high-calcium fly ash geopolymer concrete. J. Clean. Prod. 252, 119797. https://doi.org/https://doi.org/10.1016/j.jclepro.2019.119797

Nurkholis Meiyati, I., Sri Agustin, R., Supri Murtiono, E., 2016. PEMANFAATAN LUMPUR GEOTHERMAL (GEOTHERMAL SLUDGE) UNTUK PENGGANTI SEBAGIAN SEMEN TERHADAP KUAT TEKAN MORTAR SEBAGAI SUPLEMEN BAHAN AJAR MATA KULIAH TEKNOLOGI BETON PROGRAM STUDI PENDIDIKAN TEKNIK BANGUNAN UNS.

Nurzal, N., Zakir, Z., 2014. Pengaruh Komposisi Fly Ash terhadap Kuat Tekan Pada Pembuatan *Paving block*. Jurnal Teknik Mesin, 4(1).

Olofsson, J., Börjesson, P., 2018. Residual biomass as resource – Life-cycle environmental impact of wastes in circular resource systems. J. Clean. Prod. 196, 997–1006. https://doi.org/https://doi.org/10.1016/j.jclepro.2018.06.115

Olvianas, M., Najmina, M., Prihardana, B.S.L., Sutapa, F.A.K.P.G., Nurhayati, A.A., Petrus, H.T.B.M., 2015. Study on the Geopolymerization of Geothermal Silica and Kaolinite. Adv. Mat. Res. 1112, 528–532.

Pacheco-Torgal, F., Miraldo, S., Ding, Y., Labrincha, J.A., 2013. Targeting HPC with the help of nanoparticles: An overview. Constr. Build. Mater. 38, 365–370. https://doi.org/https://doi.org/10.1016/j.conbuildmat.2012.08.013

Pambudi, N., Itoi, R., Yamashiro, R., Yoseph, B., Tusara, L., Jalilinasrabady, S., Jaelani, K., 2015. The behavior of silica in geothermal brine from Dieng geothermal power plant, Indonesia. Geothermics 54, 109–114. https://doi.org/10.1016/j.geothermics.2014.12.003

Analisis Kelayakan Teknis, Keberlanjutan Lingkungan, dan Ekonomi Silika Geothermal Sebagai Substitusi Semen dalam Pembuatan Paving block: Pendekatan Optimasi Response Surface Methodology
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Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Penteado, C., Carvalho, E., Lintz, R., 2015. Reusing ceramic tile polishing waste in *paving block* manufacturing. J. Clean. Prod. 112. https://doi.org/10.1016/j.jclepro.2015.06.142

Permana, I., Nirwanto, Y., Ismawati, I., Nuriansyah, R., Rahmawati, G., Ardian Pratama, N., Fadhlurrahman A, S., Nur Fadila, A., 2025. Characterization and Quality Improvement of Organic Compost Using Geothermal Brine from PT Pertamina Geothermal Energy. Jurnal Biogenerasi 10, 2191–2200. https://doi.org/10.30605/biogenerasi.v10i4.7388

PT Pertamina Geothermal Energy Tbk, 2025. Laporan Tahunan 2025 Annual Report. Jakarta.

PT PLN (Persero), 2021. Rencana Usaha Penyediaan Tenaga Listrik (RUPTL) 2021 - 2030. Jakarta.

Puentes, J., Barluenga, G., Palomar, I., 2015. Effect of silica-based nano and micro additions on SCC at early age and on hardened porosity and permeability. Constr. Build. Mater. 81, 154–161. https://doi.org/10.1016/j.conbuildmat.2015.02.053

Ranjan, M., Kumar, S., Sinha, S., 2024. Nanosilica's Influence on Concrete Hydration, Microstructure, and Durability: A Review. Journal of Applied Engineering Sciences 14, 322–335. https://doi.org/10.2478/jaes-2024-0040

Raymond H. Myers, Douglas C. Montgomary, Christine M. Andersoon-Cook, 2009. RESPONSE SURFACE METHODOLOGY.

Sargam, Y., Wang, K., 2021. Influence of dispersants and dispersion on properties of nanosilica modified cement-based materials. Cem. Concr. Compos. 118, 103969. https://doi.org/https://doi.org/10.1016/j.cemconcomp.2021.103969

Sebayang, S., Diana, I.W., Purba, A., 2011. Perbandingan Mutu *Paving block* Produksi Manual Dengan Produksi Masinal. Jurnal Rekayasa Teknik Sipil Universitas Lampung 15.

Soares Pereira, L.M., Milan, T.M., Tapia-Blácido, D.R., 2021. Using Response Surface Methodology (RSM) to Optimize 2G Bioethanol Production: A 1 review 2 3.

Subramaniam, D.N., Sathiparan, N., 2023. Comparative study of fly ash and rice husk ash as cement replacement in pervious concrete: mechanical characteristics and sustainability analysis. International Journal of Pavement Engineering 24, 2075867. https://doi.org/10.1080/10298436.2022.2075867

Sukanto, Soenoko, R., Suprapto, W., Irawan, Y.S., 2019. Parameter Optimization of Ball Milling Process for Silica Sand Tailing. IOP Conf. Ser. Mater. Sci. Eng. 494, 012073. https://doi.org/10.1088/1757-899X/494/1/012073

Sulardjaka, S., Rahman, M.S., Wahyudianto, C., 2013. PENGARUH WAKTU DAN TEMPERATUR SINTER TERHADAP DENSITAS DAN POROSITAS KOMPOSIT ALUMINIUM YANG DIPERKUAT LIMBAH GEOTHERMAL. ROTASI 15, 28. https://doi.org/10.14710/rotasi.15.4.28-32

Szanyi, J., Rybach, L., Abdulhaq, H.A., 2023. Geothermal Energy and Its Potential for Critical Metal Extraction—A Review. Energies (Basel). https://doi.org/10.3390/en16207168

Sukmana, N.C., Prasetyono, D.E., Anggarini, U., 2017. Optimasi Komposisi Paving Block Limbah Pasir Silika Sand Blasting dengan Metode Taguchi 4, 15–19.

Analisis Kelayakan Teknis, Keberlanjutan Lingkungan, dan Ekonomi Silika Geothermal Sebagai Substitusi Semen dalam Pembuatan Paving block: Pendekatan Optimasi Response Surface Methodology
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Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Teixeira, A.H.C., Junior, P.R.R.S., Silva, T.H., Barreto, R.R., da Silva Bezerra, A.C., 2020. Low-carbon concrete based on binary biomass ash-silica fume binder to produce eco-friendly *paving block*s. Materials 13. https://doi.org/10.3390/ma13071534

Thomas, B.S., Yang, J., Bahurudeen, A., Abdalla, J.A., Hawileh, R.A., Hamada, H.M., Nazar, S., Jittin, V., Ashish, D.K., 2021. Sugarcane bagasse ash as supplementary cementitious material in concrete – a review. Materials Today Sustainability 15, 100086. https://doi.org/https://doi.org/10.1016/j.mtsust.2021.100086

Torres, A. de J., Aguiar, M.B. de, Santos, W.J. dos, Wang, K., Garcia, D.C.S., 2024. The influence of sugarcane bagasse ash on the microstructure of autoclaved cementitious material: Comparative study with amorphous and crystalline silica. Journal of Materials Research and Technology 33, 1309–1321. https://doi.org/https://doi.org/10.1016/j.jmrt.2024.09.152

Turk, O., Yehia, S., Abdelfatah, A., Elchalakani, M., 2024. Sustainable concrete production: The potential of utilizing recycled waste materials. Journal of Building Engineering 98, 111467. https://doi.org/https://doi.org/10.1016/j.jobe.2024.111467

Turner, L.K., Collins, F.G., 2013. Carbon dioxide equivalent (CO2-e) emissions: A comparison between geopolymer and OPC cement concrete. Constr. Build. Mater. 43, 125–130. https://doi.org/https://doi.org/10.1016/j.conbuildmat.2013.01.023

Tjokrodimuljo, K. 1992. Teknologi Beton, Biro Penerbit Keluarga Mahasiswa Teknik Sipil Universitas Gajah Mada, Yogyakarta.

Uddin, M.A., Bashir, M.T., Khan, A.M., Alsharari, F., Farid, F., Alrowais, R., 2024. Effect of Silica Fume on Compressive Strength and Water Absorption of the Portland Cement–Silica Fume Blended Mortar. Arab. J. Sci. Eng. 49, 4803–4811. https://doi.org/10.1007/s13369-023-08204-x

Wang, X.Y., 2019. Effect of carbon pricing on optimal mix design of sustainable high-strength concrete. Sustainability (Switzerland) 11. https://doi.org/10.3390/su11205827

Xing, W., Tam, V.W.Y., Le, K.N., Hao, J.L., Wang, J., 2023. Life cycle assessment of sustainable concrete with recycled aggregate and supplementary cementitious materials. Resour. Conserv. Recycl. 193, 106947. https://doi.org/https://doi.org/10.1016/j.resconrec.2023.106947

Xu, W., Lo, T., Wang, W., Ouyang, D., Wang, P., Xing, F., 2016. Pozzolanic Reactivity of Silica Fume and Ground Rice Husk Ash as Reactive Silica in a Cementitious System: A Comparative Study. Materials 9, 146. https://doi.org/10.3390/ma9030146

Yadav, B., Rusia, S., Pandey, J.S., Singh, H.S., Maurya, A.D., Chauhan, A., Mathur, U., Pal, K., 2025. Statistical modeling and optimization of waste glass-based paver block properties. Next Materials 9. https://doi.org/10.1016/j.nxmate.2025.101236

Zamir Hashmi, S.R., Khan, M.I., Khahro, S.H., Zaid, O., Shahid Siddique, M., Md Yusoff, N.I., 2022. Prediction of Strength Properties of Concrete Containing Waste Marble Aggregate and Stone Dust—Modeling and Optimization Using RSM. Materials 15. https://doi.org/10.3390/ma15228024