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DAFTAR PUSTAKA

Alyatikah, E., Siswo, S., Safitri, R., Wahyuningsih Manurung, T., Muhamad Iqbal, R., 2022. Chemical characteristic of fly ash and bottom ash as potential source for synthesis of aluminosilicate-based materials. RJNAS] Rafflesia Journal of Natural and Applied Sciences 2, 160–166.

ASTM International, 1992. Metode Pengujian Baku Untuk Penentuan Berat Jenis (Specific Gravity) Tanah.

Awang, A.R., Marto, A., Mahir, A., 2011. Geotechnical Properties of Tanjung Bin Coal Ash Mixtures for Backfill Materials in Embankment Construction.

Badan Standardisasi Nasional, 2022. Spesifikasi Timbunan Pilihan dan Lapis Fondasi FABA, SNI 9092:2022. ed.

Badan Standardisasi Nasional, 2012. Metode Uji CBR Laboratorium. Indonesia.

Badan Standardisasi Nasional, 2008a. Cara Uji Kepadatan Ringan Untuk Tanah. Indonesia.

Badan Standardisasi Nasional, 2008b. Cara Uji Kepadatan Berat Untuk Tanah. Indonesia.

Badan Standardisasi Nasional, 2008c. Cara Uji Berat Jenis Tanah. Indonesia.

Badan Standardisasi Nasional, 2008d. Cara Uji Analisis Ukuran Butir Tanah. Indonesia.

Bhatt, A., Priyadarshini, S., Acharath Mohanakrishnan, A., Abri, A., Sattler, M., Techapaphawit, S., 2019. Physical, chemical, and geotechnical properties of coal fly ash: A global review. Case Studies in Construction Materials 11. https://doi.org/10.1016/j.cscm.2019.e00263

Cai, P., Mao, X., Wu, Q., 2025. Study on compaction characteristics of soft and hard red-bed rock fillers and energy dissipation model of particle crushing. Results in Engineering 28. https://doi.org/10.1016/j.rineng.2025.107181

Cheng, Y., Mu, W., 2026. Hydration Characteristics, Microstructure, and Mortar Properties of Incineration Bottom Ash-cement Composites. Waste Biomass Valorization. https://doi.org/10.1007/s12649-026-03518-x

Chiang, P.-C., Pan, S.-Y., 2017. Fly Ash, Bottom Ash, and Dust, dalam: Chiang, P.-C., Pan, S.-Y. (Ed.), Carbon Dioxide Mineralization and Utilization. Springer Singapore, Singapore, hlm. 253–264. https://doi.org/10.1007/978-981-10-3268-4_12

Debbarma, B., Pal, S.K., 2019. California bearing ratio and permeability behaviour of fly ash reinforced with geotextiles, Lecture Notes in Civil Engineering. https://doi.org/10.1007/978-981-13-0559-7_30

Direktorat Jenderal Bina Marga, 2025. Spesifikasi Umum 2025 untuk Pekerjaan Konstruksi Jalan dan Jembatan.

Direktorat Jenderal Bina Marga, 2024. Manual Desain Perkerasan Jalan 2024.

Direktorat Jenderal Bina Marga, 2022. Spesifikasi Khusus Timbunan Pilihan Dan Lapis Fondasi Menggunakan Abu Batu Bara/Fly Ash Dan Bottom Ash (FABA). Indonesia.

UNIVERSITAS
GADJAH MADA
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Dove, P.M., Han, N., Wallace, A.F., Yoreo, J.J. De, 2008. Kinetics of amorphous silica dissolution and the paradox of the silica polymorphs. Dial Press.

Fernández-JIMÉNEZ, A., Palomo, A., Criado, M., 2006. Alkali activated fly ash binders. A comparative study between sodium and potassium activators; [Activación alcalina de cenizas volantes. Estudio comparativo entre activadores sódicos y potásicos]. Materiales de Construccion 56, 51–65.

Golewski, G.L., 2022. The Role of Pozzolanic Activity of Siliceous Fly Ash in the Formation of the Structure of Sustainable Cementitious Composites. Sustainable Chemistry 3, 520–534. https://doi.org/10.3390/suschem3040032

Gruchot, A., Zydroń, T., 2020. Shear strength of industrialwastes and their mixtures and stability of embankments made of these materials. Applied Sciences (Switzerland) 10. https://doi.org/10.3390/app10010250

Hamdani, R., Muhardi, Satibi, S., 2017. KARAKTERISTIK MEKANIS DARI CAMPURAN ABU TERBANG DAN ABU DASAR DALAM GEOTEKNIK. Jom F TEKNIK 4.

Hardiyatmo, H.C., 2019. Mekanika Tanah 1, 7 ed. UGM Press, Yogyakarta.

Hirofumi, T., Mitchitaka, I., Toshinobu, K., 2009. An Experimental Study on Effectsof Combustion Conditionsand Coal Propertieson Fundamental Propertiesof Fly Ash by use of a Pulverized Coal Combustion Test Facility.

Hiromi, S., Hirofumi, T., Michitaka, I., Toshinobu, K., 2009. Influence of combustion conditions and coal properties on physical properties of fly ash generated from pulverized coal combustion. Energy and Fuels 23, 3406–3411. https://doi.org/10.1021/ef801028c

Hower, J.C., Henke, K.R., Dai, S., Ward, C.R., French, D., Liu, S., Graham, U.M., 2017. Generation and nature of coal fly ash and bottom ash, dalam: Coal Combustion Products (CCPs): Characteristics, Utilization and Beneficiation. Elsevier, hlm. 21–65. https://doi.org/10.1016/B978-0-08-100945-1.00002-2

Ingham, J., 2012. Delayed ettringite formation in concrete structures. Proceedings of the Institution of Civil Engineers: Forensic Engineering 165, 59–62. https://doi.org/10.1680/feng.12.00001

Jena, S., Khatri, V.N., Nainegali, L., 2025. Bearing ratio behaviour of sisal geotextile reinforced fly ash overlying clay. International Journal of Pavement Engineering 26. https://doi.org/10.1080/10298436.2025.2473618

Karim, A.M.K., Lovell, C.W., Salgado, R., 1997. BUILDING HIGHWAY EMBANKMENTS OF FLY/BOTTOM ASH MIXTURES Indiana Department of Trans portation Purdue University.

Kaushik, N.P., Ramasamy, G., 2006. Strength characteristics of compacted coal ash. Journal of the Institution of Engineers. India. Civil Engineering Division 87, 56–60.

UNIVERSITAS
GADJAH MADA
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Kim, B., Prezzi, M., Salgado, R., 2005. Geotechnical Properties of Fly and Bottom Ash Mixtures for Use in Highway Embankments. https://doi.org/10.1061/ASCE1090-02412005131:7914

Koshy, N., Jha, B., Kadali, S., Singh, D.N., 2015. Synthesis and characterization of Ca and Na Zeolites (Non-Pozzolanic Materials) obtained from Fly Ash-Ca(OH)2 interaction. Mater. Perform. Charact. 4, 87–102. https://doi.org/10.1520/MPC20140053

Laboratorium Bahan Konstruksi Provinsi Kalimantan Selatan, 2023. Sejarah California Bearing Ratio (CBR) dalam Pengujian Daya Dukung Tanah [WWW Document]. https://labkons.dinaspupr.kalselprov.go.id/post/detail/sejarah-california-bearing-ratio-cbr-dalam-pengujian-daya-dukung-tanah/57#.

Le, N.H., Abriak, N.E., Binetruy, C., Benzerzour, M., Nguyen, S.T., 2017. Mechanical behavior of municipal solid waste incinerator bottom ash: Results from triaxial tests. Waste Management 65, 37–46. https://doi.org/10.1016/j.wasman.2017.03.045

Li, R., Wei, K., Huang, Q., Xia, H., 2020. A novel method for precise measurement of unburnt carbon in boiler fly ash by ECSA® based on TG-MS. Fuel 264. https://doi.org/10.1016/j.fuel.2019.116849

Lopez, A., Gustavsson, H., Korkiala-Tanttu, L., 2021. Comparison between hydrometer and laser diffraction methods in the determination of clay content in fine-grained soils, dalam: IOP Conference Series: Earth and Environmental Science. IOP Publishing Ltd. https://doi.org/10.1088/1755-1315/710/1/012012

Ma, Z., Wang, W., Li, J., Gao, J., Lu, G., Song, H., Wu, H., Guo, Y., 2023. Long-term dissolution behavior of amorphous aluminosilicate in sodium hydroxide solution for geopolymer synthesis using circulating fluidized bed combustion fly ash. Constr. Build. Mater. 394. https://doi.org/10.1016/j.conbuildmat.2023.132143

Martínez-Ramírez, S., Fernández-Carrasco, L., 2012. Carbonation of ternary cement systems. Constr. Build. Mater. 27, 313–318. https://doi.org/10.1016/j.conbuildmat.2011.07.043

Meier, S.A., Peter, M.A., Muntean, A., Böhm, M., 2007. Dynamics of the internal reaction layer arising during carbonation of concrete. Chem. Eng. Sci. 62, 1125–1137. https://doi.org/10.1016/j.ces.2006.11.014

Mohebbi, M., Rajabipour, F., Scheetz, B.E., 2017. Evaluation of two-atmosphere thermogravimetric analysis for determining the unburned carbon content in fly ash. Adv. Civ. Eng. Mater. 6, 258–279. https://doi.org/10.1520/ACEM20160052

Mu, Y., Saffarzadeh, A., Shimaoka, T., 2017. Influence of ignition process on mineral phase transformation in municipal solid waste incineration (MSWI) fly ash: Implications for estimating loss-on-ignition (LOI). Waste Management 59, 222–228. https://doi.org/10.1016/j.wasman.2016.09.028

Pemerintah Republik Indonesia, 2021. Penyelenggaraan Perlindungan Dan Pengelolaan Lingkungan Hidup. Indonesia.

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

Pemerintah Republik Indonesia, 2014. Pengelolaan Limbah Bahan Berbahaya Dan Beracun. Indonesia.

PLN, 2025. FABA PLN Bermanfaat.

Pontes, J., Santos Silva, A., Faria, P., 2013. Evaluation of pozzolanic reactivity of artificial pozzolans, dalam: Materials Science Forum. Trans Tech Publications Ltd, hlm. 433–438. https://doi.org/10.4028/www.scientific.net/MSF.730-732.433

Reddy, C.S., Mohanty, S., Shaik, R., 2018. Physical, chemical and geotechnical characterization of fly ash, bottom ash and municipal solid waste from Telangana State in India. International Journal of Geo-Engineering 9. https://doi.org/10.1186/s40703-018-0093-z

Rojas, M.F., Sánchez de Rojas, M.I., 2003. The effect of high curing temperature on the reaction kinetics in MK/lime and MK-blended cement matrices at 60 °C. Cem. Concr. Res. 33, 643–649. https://doi.org/10.1016/S0008-8846(02)01040-2

Sekretariat Direktorat Jenderal Ketenagalistrikan, 2025. Statistik Ketenagalistrikan 2024.

Shanthakumar, S., Singh, ; D N, Asce, M., Phadke, R.C., 2010. Methodology for Determining Particle-Size Distribution Characteristics of Fly Ashes. https://doi.org/10.1061/ASCEMT.1943-5533.0000042

Špak, M., Raschman, P., 2016. Mechanical properties of mortars prepared by alkali activated fly ash coming from different production batches, dalam: Solid State Phenomena. Trans Tech Publications Ltd, hlm. 140–145. https://doi.org/10.4028/www.scientific.net/SSP.244.140

Substrata, 2025. Optimum Moisture Content & How to Check It [WWW Document]. URL https://www.substrata.us/blog/optimum-moisture-of-soil (diakses 9.3.26).

Suraneni, P., Burris, L., Shearer, C.R., Douglas Hooton, R., 2021. ASTM C618 Fly Ash Specification: Comparison with Other Specifications, Shortcomings, and Solutions.

Tajudin, A.N., Setyarini, N.L.P.S.E., Darmawati, D.S., 2018. The Influence of CBR Value and Overloading on Flexible Pavement Mechanistic Response.

Toth, P.S., Chan, H.T., Cragg, C.B., t.t. Coal ash as structural fill, with special reference to Ontario experience.

Trifunovic, P.D., Marinkovic, S.R., Tokalic, R.D., Matijasevic, S.D., 2010. The effect of the content of unburned carbon in bottom ash on its applicability for road construction. Thermochim. Acta. https://doi.org/10.1016/j.tca.2009.10.022

Turan, C., Javadi, A.A., Vinai, R., Beig Zali, R., 2022. Geotechnical Characteristics of Fine-Grained Soils Stabilized with Fly Ash, a Review. Sustainability (Switzerland). https://doi.org/10.3390/su142416710

Uzarowicz, L., Zagorski, Z., 2015. Mineralogy and chemical composition of technogenic soils (Technosols) developed from fly ash and bottom ash from, dalam: Soil Science Annual. De Gruyter Open Ltd, hlm. 82–91. https://doi.org/10.1515/ssa-2015-0023

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Violleta, P.T., 2026. KLH perkirakan 12,6 juta-25,2 ton abu FABA dihasilkan PLTU pada 2025 [WWW Document]. https://www.antaranews.com/berita/5376890/klh-perkirakan-126-juta-252-ton-abu-faba-dihasilkan-pltu-pada-2025.

Wang, J., Yan, H., 2012. DEM analysis of energy dissipation in crushable soils. Soils and Foundations 52, 644–657. https://doi.org/10.1016/j.sandf.2012.07.006

Wang, J.-J., Cheng, Y.-Z., Zhang, H.-P., Deng, D.-P., 2015. Effects of particle size on compaction behavior and particle crushing of crushed sandstone–mudstone particle mixture. Environ. Earth Sci. 73, 8053–8059. https://doi.org/10.1007/s12665-014-3961-7

Wang, J.-J., Zhang, H.-P., Deng, D.-P., 2014. Effects of Compaction Effort on Compaction Behavior and Particle Crushing of a Crushed Sandstone-Mudstone Particle Mixture. Soil Mechanics and Foundation Engineering 51, 67–71. https://doi.org/10.1007/s11204-014-9256-x

Wang, X., Zhang, J.-S., Yang, G.-Y., Chen, X.-B., 2007. Test on dynamic stress of roadbed and pavement under heavy loads. Zhendong yu Chongji/Journal of Vibration and Shock 26, 169–173.

Xing, L., Li, X., Cao, P., Luo, J., Jiang, H., 2024. Stepwise extraction and utilization of silica and alumina from coal fly ash by mild hydrothermal process. Process Safety and Environmental Protection 182, 918–929. https://doi.org/10.1016/j.psep.2023.12.035

Yang, S., 2017. Influence of heating on the weight loss and mineral phase in MSWI ash: LOI of incineration ash, dalam: IOP Conference Series: Earth and Environmental Science. https://doi.org/10.1088/1755-1315/61/1/012079

Yoon, S., Umashankar Balunaini, ;, Yildirim, I.Z., Prezzi, M., Siddiki, N.Z., 2009. Construction of an Embankment with a Fly and Bottom Ash Mixture: Field Performance Study. https://doi.org/10.1061/ASCE0899-1561200921:6271

Zein, Z., Jaber, L., Jahami, A., 2025. Comprehensive Review of Classes F and C Fly Ash Effects oClayey Soils: Geotechnical Predictive Correlations. Periodica Polytechnica Civil Engineering. https://doi.org/10.3311/PPci.37980

Zhang, W., Liu, X., Zhang, Z., Wang, Y., Xue, Y., Hao, X., Lu, Y., 2021. Circulating fluidized bed fly ash mixed functional cementitious materials: Shrinkage compensation of f-CAO, autoclaved hydration characteristics and environmental performance. Materials 14. https://doi.org/10.3390/ma14206004

Zierold, K.M., Odoh, C., 2020. A review on fly ash from coal-fired power plants: Chemical composition, regulations, and health evidence. Rev. Environ. Health. https://doi.org/10.1515/reveh-2019-0039