MODELLING AND SIMULATION OF STRUCTURAL PERFORMANCE OF BEAM USING HIGH VOLUME BOTTOM ASH AS AGGREGATES REPLACEMENT

NURUL NATASHA BINTI NASRUDIN

MASTER OF SCIENCE

UNIVERSITI MALAYSIA PAHANG

SUPERVISOR'S DECLARATION

We hereby declare that We have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Science.

(Supervisor's Signature)

Full Name : DR. NUR FARHAYU BINTI ARIFFIN

Position : SENIOR LECTURER

Date : 24/2/2023

(Co-supervisor's Signature)

Full Name : DR. AIZAT BINTI ALIAS

Position : SENIOR LECTURER

Date : 24/2/2023

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

(Student's Signature)

Full Name : NURUL NATASHA BINTI NASRUDIN

ID Number : MAH20007

Date : 24/2/2023

MODELLING AND SIMULATION OF STRUCTURAL PERFORMANCE OF BEAM USING HIGH VOLUME BOTTOM ASH AS AGGREGATES REPLACEMENT

NURUL NATASHA BINTI NASRUDIN

Thesis submitted in fulfillment of the requirements
for the award of the degree of
Master of Science

Faculty of Civil Engineering Technology

UNIVERSITI MALAYSIA PAHANG

FEBRUARY 2023

ACKNOWLEDGEMENTS

First of all, praise to Allah the Almighty for giving blessing, strength, health and the chances to complete this study, without His grace this research would not be reality.

I would like to express my sincere and highest gratitude to my supervisor, Dr Nur Farhayu Ariffin and my co-supervisor, Dr Aizat Alias for their time, guidance, patience and huge encouragement to me which contributed major contribution for the completion of this research. They have taught me every step of this research and to present this research clearly as possible. I am truly grateful for what they had shared with me.

On the other hand, I am truly grateful and thankful to my family, Nasrudin Ishak, Munirah Mohd Nor and all my beloved siblings for their love, encouragement, prayers and sacrifices for me to further this research and also my future life. Meanwhile, i also want to pay my thanks to all my friends, Abdul Muiz, Syahrul Zaimi, Nabilla Mohamad, Hanis Nadiah, Farah Aziera and Asyiq Fakhri who always helping and encourage me to complete this thesis.

Last but not least, I want to give my appreciation to all concrete laboratory's technician, En. Fadzil, En. Hafiz, En. Zu Iskandar, En. Hafiz Al-Kasah, En. Kamarul and En. Hj. Fakhri for giving full cooperation and support during lab research and providing guidance for lab utilities usage and also materials preparation. Lastly, I also want to thanks to all who directly or indirectly have lend their helping hand in this ventures.

ABSTRAK

Loji janakuasa arang batu menghasilkan banyak hasil sampingan dalam bentuk abu dasar dan abu terbang yang boleh dikategorikan sebagai bahan buangan yang mengancam alam sekitar serta kesihatan dan keselamatan kehidupan manusia. Oleh itu, penyelesaian yang inovatif dan mampan mungkin diperlukan untuk mengurangkan jumlah sisa, seperti menggunakan semula sisa sebagai bahan binaan untuk pembangunan infrastruktur. Dalam kajian ini, abu dasar arang batu (CBA) telah digantikan sebagai penggantian agregat dalam konkrit dengan enam susunan gabungan yang berbeza, antara 50% hingga 100% penggantian agregat halus dan kasar dengan penambahan abu terbang (FA) 20% yang berterusan kepada kuantiti simen. Eksperimen telah dijalankan untuk menentukan sifat mekanikal konkrit dan prestasi serta kelakuan konkrit bertetulang (RC) di bawah ujian beban lentur empat mata. Semasa ujian, pesongan dan beban yang dikenakan telah direkodkan, dan corak keretakan diperhatikan dan ditanda. Keputusan menunjukkan rasuk konkrit dan RC dengan 100% abu dasar arang batu kasar (CCBA) dan 100% abu dasar arang batu halus (FCBA) menunjukkan prestasi yang lebih baik dari segi sifat mekanikal, corak keretakan dan hasil pesongan beban berbanding dengan campuran konkrit kawalan dalam 28 hari umur menyembuhkan. Tambahan pula, model analisis unsur terhingga (FEA) bagi rasuk RC telah dibangunkan menggunakan perisian ABAQUS untuk meramalkan kelakuan dan prestasi rasuk yang diuji. Ketepatan model FE telah disahkan menggunakan tindak balas pesongan beban eksperimen dan corak keretakan. Dalam membandingkan analisis dan data eksperimen, keputusan menunjukkan bahawa FEA berjaya meramalkan corak keretakan dan lengkung pesongan beban rasuk. Keputusan FEA menunjukkan bahawa rasuk dengan 100% CCBA 100% FCBA menunjukkan data tertinggi pada 88 kN dengan pesongan maksimum 18.87 mm. Beban muktamad yang diperolehi dalam ABAQUS adalah dalam julat 10% berbeza dengan keputusan eksperimen. Kajian ini menyimpulkan bahawa, rasuk RC digabungkan dengan CBA sebagai agregat halus dan kasar menghasilkan kekuatan tertinggi berbanding dengan yang lain dan keputusan FEA menunjukkan bahawa data simulasi adalah selaras dengan data eksperimen.

ABSTRACT

Coal fired power plants produce an abundance of by-products in the form of bottom ash and fly ash that can be categorized as waste, which threatens the environment as well as the health and safety of human life. Hence, innovative and sustainable solutions may be required to reduce the amount of waste, such as reusing the waste as construction materials for infrastructure development. In this study, Coal Bottom Ash (CBA) was substituted as an aggregate replacement in concrete with six different combination arrangements, ranging from 50% to 100% fine and coarse aggregate replacement with a constant 20% fly ash (FA) addition to the cement quantity. The experiments were conducted to determine the mechanical properties of concrete and performance as well as behaviour of reinforced concrete (RC) beams under a four-point bending load test. During the test, the deflection and applied load were recorded, and the cracking pattern was observed and marked. The results showed that concrete and RC beams with 100% coarse coal bottom ash (CCBA) and 100% fine coal bottom ash (FCBA) performed better in terms of mechanical properties, cracking pattern and load deflection results compared with the control concrete mix in 28 days of curing age. Furthermore, finite element analysis (FEA) models of RC beams were developed using ABAQUS software to predict the behaviour and performance of the tested beams. The accuracy of the FE models was validated using the experimental load-deflection responses and cracking patterns. In comparing analysis and experimental data, the results showed that FEA successfully predicted the cracking pattern and load-deflection curve of beams. The FEA results indicated that the beam with 100% CCBA 100% FCBA shows the highest data at 88 kN with maximum deflection 18.5 mm. The ultimate load obtained in ABAQUS for all RC beams were in a 10% range difference with the experimental results. This study concludes that RC beams incorporated with CBA as fine and coarse aggregates result in the highest strength compared to others and the FEA results indicate that the simulation data are in line with the experiment data.

TABLE OF CONTENT

REFERENCES

Abadel, A., Abbas, H., Almusallam, T., Alshaikh, I. M. H., Khawaji, M., Alghamdi, H., & Salah, A. A. (2022). Experimental study of shear behavior of CFRP strengthened ultra-high-performance fiber-reinforced concrete deep beams. *Case Studies in Construction Materials*, *16*(March), e01103. https://doi.org/10.1016/j.cscm.2022.e01103

Abaqus. (2013). *Abaqus 6.11*. *IV*. http://130.149.89.49:2080/v6.11/pdf_books/THEORY.pdf

Abdulhadi, H. S., & Mian, A. (2019). Effect of strut length and orientation on elastic mechanical response of modified body-centered cubic lattice structures. *Proceedings of the Institution of Mechanical Engineers, Part L: Journal of Materials: Design and Applications*, *233*(11), 2219–2233. https://doi.org/10.1177/1464420719841084

Abdullah, M. H., Abuelgasim, R., Rashid, A. S. A., & Mohdyunus, N. Z. (2018). Engineering properties of tanjung bin bottom ash. *MATEC Web of Conferences*, *250*. https://doi.org/10.1051/matecconf/201825001006

Abubakar, A. U., & Baharudin, K. S. (2013). Tanjung bin coal bottom ash: From waste to concrete material. *Advanced Materials Research*, *705*(June), 163–168. https://doi.org/10.4028/www.scientific.net/AMR.705.163

Abushanab, A., Alnahhal, W., & Farraj, M. (2022). Experimental and finite element studies on the structural behavior of BFRC continuous beams reinforced with BFRP bars. *Composite Structures*, *281*(March 2021), 114982. https://doi.org/10.1016/j.compstruct.2021.114982

Aggarwal, Y., & Siddique, R. (2014). Microstructure and properties of concrete using bottom ash and waste foundry sand as partial replacement of fine aggregates. *Construction and Building Materials*, *54*, 210–223. https://doi.org/10.1016/j.conbuildmat.2013.12.051

Ahn, Y. B., Jang, J. G., & Lee, H. K. (2016). Mechanical properties of lightweight concrete made with coal ashes after exposure to elevated temperatures. *Cement and Concrete Composites*, *72*, 27–38. https://doi.org/10.1016/j.cemconcomp.2016.05.028

Al-fakih, A., Hisbany, M., Hashim, M., Alyousef, R., Mutafi, A., Hussein, S., Sabah,

A., & Tafsirojjaman, T. (2021). Cracking behavior of sea sand RC beam bonded externally with CFRP plate. *Structures*, *33*(April), 1578–1589. https://doi.org/10.1016/j.istruc.2021.05.042

Alia, A., Bohari, M., Skitmore, M., Xia, B., & Teo, M. (2017). Green oriented procurement for building projects : Preliminary fi ndings from Malaysia. *Journal of Cleaner Production*, *148*, 690–700. https://doi.org/10.1016/j.jclepro.2017.01.141

American Cement Manufacturer, A. (2019). *No Title*. https://www.cement.org/cement-concrete/cement-concrete-applications

Anas, S. M., Alam, M., & Shariq, M. (2022). Damage response of conventionally reinforced two-way spanning concrete slab under eccentric impacting drop weight loading. *Defence Technology*, *xxxx*. https://doi.org/10.1016/j.dt.2022.04.011

Ankur, N., & Singh, N. (2021). Performance of cement mortars and concretes containing coal bottom ash : A comprehensive review. *Renewable and Sustainable Energy Reviews*, *149*(May), 111361. https://doi.org/10.1016/j.rser.2021.111361

Argiz, C., Moragues, A., & Menéndez, E. (2018). Use of ground coal bottom ash as cement constituent in concretes exposed to chloride environments. *Journal of Cleaner Production*, *170*, 25–33. https://doi.org/10.1016/j.jclepro.2017.09.117

ASTM 618–03. (2002). *Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use*. 1–3.

ASTM C 618 – 03. (2010). Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use. *Annual Book of ASTM Standards*, *C*, 3–6.

ASTM C 618 − 12a. (2014). Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete, ASTM International, West Conshohocken, PA, 2012, www.astm.org. *ASTM International*, 1–5. https://doi.org/10.1520/C0618

ASTM C127. (2001). Standard Test Method for Specific Gravity and Water Absorption of Coarse Aggregate. *American Society of Testing Materials*, *04*(Reapproved), 1–6.

ASTM C128. (2004). Standard Test Method for Density, Relative Density (Specific

Gravity), and Absorption of Fine Aggregate. *Annual Book of ASTM Standards*, 1–5.

ASTM C597-09. (2009). *Pulse Velocity Through Concrete 1*. 1–4.

ASTM C805/C805M-13. (2013). *Standard Test Method for Rebound Number of Hardened Concrete 1*. 1–4. https://doi.org/10.1520/C0805

ASTM E8/E8M-16a. (2016). *Standard Test Methods for Tension Testing of Metallic Materials 1*. *i*. https://doi.org/10.1520/E0008

Attia, K., El Refai, A., & Alnahhal, W. (2020). Flexural Behavior of Basalt Fiber–Reinforced Concrete Slab Strips with BFRP Bars: Experimental Testing and Numerical Simulation. *Journal of Composites for Construction*, *24*(2), 04020007. https://doi.org/10.1061/(asce)cc.1943-5614.0001002

Aydin, E. (2016). Novel coal bottom ash waste composites for sustainable construction. *Construction and Building Materials*, *124*, 582–588. https://doi.org/10.1016/j.conbuildmat.2016.07.142

Bahedh, M. A., & Jaafar, M. S. (2018). Ultra high-performance concrete utilizing fly ash as cement replacement under autoclaving technique. *Case Studies in Construction Materials*, *9*, e00202. https://doi.org/10.1016/j.cscm.2018.e00202

Baite, E., Messan, A., Hannawi, K., Tsobnang, F., & Prince, W. (2016). Physical and transfer properties of mortar containing coal bottom ash aggregates from Tefereyre (Niger). *Construction and Building Materials*, *125*, 919–926. https://doi.org/10.1016/j.conbuildmat.2016.08.117

Bari, H., Salam, M. A., & Safiuddin, M. (2021). Fresh and hardened properties of brick aggregate concrete including coconut shell as a partial replacement of coarse aggregate. *Construction and Building Materials*, *297*, 123745. https://doi.org/10.1016/j.conbuildmat.2021.123745

Batayneh, M., Marie, I., & Asi, I. (2007). *Use of selected waste materials in concrete mixes*. *27*, 1870–1876. https://doi.org/10.1016/j.wasman.2006.07.026

Behnam, H., Kuang, J. S., & Samali, B. (2018). Parametric finite element analysis of RC wide beam-column connections. *Computers and Structures*, *205*, 28–44. https://doi.org/10.1016/j.compstruc.2018.04.004

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*, e00263. https://doi.org/10.1016/j.cscm.2019.e00263

Braga, A. M., Silvestre, J. D., & de Brito, J. (2017). Compared environmental and economic impact from cradle to gate of concrete with natural and recycled coarse aggregates. *Journal of Cleaner Production*, *162*(2017), 529–543. https://doi.org/10.1016/j.jclepro.2017.06.057

BS:1881-1983: Part 122. (2009). Testing concrete-Method for determination of water absorption. *British Standard*, *3*(2014), 420–457.

BS EN 12350-2:2009. (2009). BS EN 12350-2:2009 Testing fresh concrete — Part 2: Slump test. *BSI Standards Publication*, 5–8.

BS EN 12390-5. (2009). Testing hardened concrete — Part 5: Flexural strength of test specimens. *BSI Standards Publication*, *August*, 1–22.

BS EN 197-1:2011. (2015). *Cement Part 1: Composition, specifications and conformity criteria for common cements*.

BS EN 1992-1-1. (2004). UK National Annex to Eurocode 2: Design of concrete structures. *BSI Standards Publication*, *1*(2005).

BS EN 206 -1. (2006). Concrete — Complementary British Standard to BS EN 206-1. *Part 2: Specification for Constituent Materials and Concrete*, *BS 8500-2:2006*.

BS EN 933-2. (1999). *Tests for geometrical properties of aggregates - Part 2: Determination of particle size distribution - Test sieves, nominal size of apertures*.

Burhanudin, M. K., Ibrahim, M. H. W., Sani, M. S. H. M., Juki, M. I., Jamaluddin, N., Jaya, R. P., Shahidan, S., Basirun, N. F., & Bosro, M. Z. M. (2018). Influence of ground coal bottom ash with different grinding time as cement replacement material on the strength of concrete. *Malaysian Construction Research Journal*, *4*(2 Special Issue), 93–102.

C 469 -02. (2002). *Standard Test Method for Static Modulus of Elasticity and Poisson ' s Ratio of Concrete*. *04*, 1–5.

CAE ASSISTANT. (2022). *CAE ASSISTANT*. https://caeassistant.com/blog/abaqus-standard-or-abaqus-explicit/

Chávez-Valdez, A., Arizmendi-Morquecho, A., Vargas, G., Almanza, J. M., & Alvarez-Quintana, J. (2011). Ultra-low thermal conductivity thermal barrier coatings from recycled fly-ash cenospheres. *Acta Materialia*, *59*(6), 2556–2562. https://doi.org/10.1016/j.actamat.2011.01.011

Cheewaket, T., Jaturapitakkul, C., & Chalee, W. (2010). Long term performance of chloride binding capacity in fly ash concrete in a marine environment. *Construction and Building Materials*, *24*(8), 1352–1357. https://doi.org/10.1016/j.conbuildmat.2009.12.039

Chen, G., Jin, D., Zhu, J., Shi, J., & Li, X. (2015). Nonlinear analysis on seismic site response of fuzhou basin, China. *Bulletin of the Seismological Society of America*, *105*(2), 928–949. https://doi.org/10.1785/0120140085

Chinka, S. S. B., Putti, S. R., & Adavi, B. K. (2021). Modal testing and evaluation of cracks on cantilever beam using mode shape curvatures and natural frequencies. *Structures*, *32*(April), 1386–1397. https://doi.org/10.1016/j.istruc.2021.03.049

Chinnu, S. N., Minnu, S. N., Bahurudeen, A., & Senthilkumar, R. (2021). Recycling of industrial and agricultural wastes as alternative coarse aggregates: A step towards cleaner production of concrete. *Construction and Building Materials*, *287*, 123056. https://doi.org/10.1016/j.conbuildmat.2021.123056

D'Ottavio, M., & Polit, O. (2017). Classical, first order, and advanced theories. In *Stability and Vibrations of Thin-Walled Composite Structures*. https://doi.org/10.1016/B978-0-08-100410-4.00003-X

DagangNews. (2022, April 15). Harga arang batu global naik 7% kepada AS$312 tan, tertinggi sejak 25 mac 2022. *DagangNews.Com*. https://dagangnews.com/index.php/harga-arang-batu-global-naik-7-kepada-as312-satu-tan-tertinggi-sejak-25-mac-2022-14742

Dietrich, T. (2019). *The Virginian Pilot*. https://www.pilotonline.com/news/environment/article_b485181e-3ec5-11e9-8195-03b2f3f7633f.html

Earij, A., Alfano, G., Cashell, K., & Zhou, X. (2017). Nonlinear three–dimensional finite–element modelling of reinforced–concrete beams: Computational challenges

and experimental validation. *Engineering Failure Analysis*, *82*(September), 92–115. https://doi.org/10.1016/j.engfailanal.2017.08.025

Elamary, A. S., Sharaky, I. A., & Alqurashi, M. (2021). Flexural behaviour of hollow concrete beams under three points loading: Experimental and numerical study. *Structures*, *32*(March), 1543–1552. https://doi.org/10.1016/j.istruc.2021.03.094

Elsayed, M., Tayeh, B. A., Abu Aisheh, Y. I., El-Nasser, N. A., & Elmaaty, M. A. (2022). Shear strength of eco-friendly self-compacting concrete beams containing ground granulated blast furnace slag and fly ash as cement replacement. *Case Studies in Construction Materials*, *17*(April), e01354. https://doi.org/10.1016/j.cscm.2022.e01354

Enerdata. (2022). *Coal and lignite domestic consumption*. https://yearbook.enerdata.net/coal-lignite/coal-world-consumption-data.html

Fanghui, H., Qiang, W., & Jingjing, F. (2015). The differences among the roles of ground fly ash in the paste, mortar and concrete. *Construction and Building Materials*, *93*, 172–179. https://doi.org/10.1016/j.conbuildmat.2015.05.117

Fisher, L. V., & Barron, A. R. (2019). The recycling and reuse of steelmaking slags — A review. *Resources, Conservation and Recycling*, *146*(January), 244–255. https://doi.org/10.1016/j.resconrec.2019.03.010

Fuzail Hashmi, A., Shariq, M., & Baqi, A. (2020). Flexural performance of high volume fly ash reinforced concrete beams and slabs. *Structures*, *25*(April), 868–880. https://doi.org/10.1016/j.istruc.2020.03.071

Gao, D., Zhu, W., Fang, D., Tang, J., & Zhu, H. (2022). Shear behavior analysis and capacity prediction for the steel fiber reinforced concrete beam with recycled fine aggregate and recycled coarse aggregate. *Structures*, *37*(January), 44–55. https://doi.org/10.1016/j.istruc.2021.12.075

Genikomsou, A. S., & Polak, M. A. (2014). Finite element analysis of a reinforced concrete slab-column connection using ABAQUS. *Structures Congress 2014 - Proceedings of the 2014 Structures Congress*, 813–823. https://doi.org/10.1061/9780784413357.072

Genikomsou, A. S., & Polak, M. A. (2015). Finite element analysis of punching shear of concrete slabs using damaged plasticity model in ABAQUS. *Engineering Structures*, *98*, 38–48. https://doi.org/10.1016/j.engstruct.2015.04.016

Ghalehnovi, M., Roshan, N., Hakak, E., Shamsabadi, E. A., & de Brito, J. (2019). Effect of red mud (bauxite residue) as cement replacement on the properties of self-compacting concrete incorporating various fillers. *Journal of Cleaner Production*, *240*, 118213. https://doi.org/10.1016/j.jclepro.2019.118213

Gollakota, A. R. K., Volli, V., & Shu, C. M. (2019). Progressive utilisation prospects of coal fly ash: A review. *Science of the Total Environment*, *672*, 951–989. https://doi.org/10.1016/j.scitotenv.2019.03.337

Gooi, S., Mousa, A. A., & Kong, D. (2020). A critical review and gap analysis on the use of coal bottom ash as a substitute constituent in concrete. *Journal of Cleaner Production*, *268*, 121752. https://doi.org/10.1016/j.jclepro.2020.121752

Gotame, M., Franklin, C. L., Blomfors, M., Yang, J., & Lundgren, K. (2022). Finite element analyses of FRP-strengthened concrete beams with corroded reinforcement. *Engineering Structures*, *257*(October 2021), 114007. https://doi.org/10.1016/j.engstruct.2022.114007

Hamada, H., Alattar, A., Tayeh, B., & Yahaya, F. (2022). Case Studies in Construction Materials Sustainable application of coal bottom ash as fine aggregates in concrete : A comprehensive review. *Case Studies in Construction Materials*, *16*(April), e01109. https://doi.org/10.1016/j.cscm.2022.e01109

Hany, N. F., Hantouche, E. G., & Harajli, M. H. (2016). Finite element modeling of FRP-confined concrete using modified concrete damaged plasticity. *Engineering Structures*, *125*, 1–14. https://doi.org/10.1016/j.engstruct.2016.06.047

Hawileh, R. A., Abdalla, J. A., Fardmanesh, F., Shahsana, P., & Khalili, A. (2017). Performance of reinforced concrete beams cast with different percentages of GGBS replacement to cement. *Archives of Civil and Mechanical Engineering*, *17*(3), 511–519. https://doi.org/10.1016/j.acme.2016.11.006

Hemalatha, T., & Ramaswamy, A. (2017). A review on fly ash characteristics – Towards promoting high volume utilization in developing sustainable concrete. *Journal of Cleaner Production*, *147*, 546–559. https://doi.org/10.1016/j.jclepro.2017.01.114

Hillerborg, A. (1990). Compression Sress-Strain Curve for Design of Reinforced Concrete Beams. *ACI Symposium Publication*, *118*. https://doi.org/10.14359/2983

Hosen, M. A., Jumaat, M. Z., Alengaram, U. J., Sulong, N. H. R., & Alsubari, B.

(2019). Sustainable palm oil fuel ash mortar used as partial adhesive replacement in flexurally strengthened RC beams. *Construction and Building Materials*, *226*, 507–523. https://doi.org/10.1016/j.conbuildmat.2019.07.222

Hwang, S. S., & Moreno Cortés, C. M. (2021). Properties of mortar and pervious concrete with co-utilization of coal fly ash and waste glass powder as partial cement replacements. *Construction and Building Materials*, *270*, 121415. https://doi.org/10.1016/j.conbuildmat.2020.121415

Itam, Z., Beddu, S., Mohammad, D., Kamal, N. L. M., Zainoodin, M. M., Syamsir, A., Razak, N. A., & Hamid, Z. A. A. (2019). Extraction of metal oxides from coal bottom ash by carbon reduction and chemical leaching. *Materials Today: Proceedings*, *17*, 727–735. https://doi.org/10.1016/j.matpr.2019.06.356

Jamora, J. B., Emily, S., Gudia, L., Go, A. W., Giduquio, M. B., & Loretero, M. E. (2020). Potential CO 2 reduction and cost evaluation in use and transport of coal ash as cement replacement : A case in the Philippines. *Waste Management*, *103*, 137–145. https://doi.org/10.1016/j.wasman.2019.12.026

Jayaranjan, M. L. D., van Hullebusch, E. D., & Annachhatre, A. P. (2014). Reuse options for coal fired power plant bottom ash and fly ash. *Reviews in Environmental Science and Biotechnology*, *13*(4), 467–486. https://doi.org/10.1007/s11157-014-9336-4

Jin, M., Hao, Y., & Hao, H. (2019). Numerical study of fence type blast walls for blast load mitigation. *International Journal of Impact Engineering*, *131*(May), 238–255. https://doi.org/10.1016/j.ijimpeng.2019.05.007

Jun Ng, H., Bakri Abdullah, M. M. Al, Tan, S. J., Sandu, A. V., & Hussin, K. (2018). Characterisation and understanding of Portland cement mortar with different sizes of bottom ash. *Advances in Cement Research*, *30*(2), 66–74. https://doi.org/10.1680/jadcr.17.00076

Kabir, I., Lee, C. K., & Zhang, Y. X. (2022). Finite element analysis of engineered cementitious composite (ECC) encased steel composite beams subjected to bending. In *Advances in Engineered Cementitious Composite*. Elsevier Ltd. https://doi.org/10.1016/B978-0-323-85149-7.00008-2

Kamal, N. L. M., Beddu, S., Syamsir, A., Mohammad, D., Itam, Z., Hamid, Z. A. A., & Manan, T. S. A. (2019). Immobilization of heavy metals for building materials in the construction industry - An overview. *Materials Today: Proceedings*, *17*, 787–791. https://doi.org/10.1016/j.matpr.2019.06.363

Kangavar, M. E., Lokuge, W., Manalo, A., & Karunasena, W. (2022). Case Studies in Construction Materials Investigation on the properties of concrete with recycled polyethylene terephthalate (PET) granules as fine aggregate replacement. *Case Studies in Construction Materials*, *16*(November 2021), e00934. https://doi.org/10.1016/j.cscm.2022.e00934

Karimipour, A. (2020). Effect of untreated coal waste as fine and coarse aggregates replacement on the properties of steel and polypropylene fibres reinforced concrete. *Mechanics of Materials*, *150*(August), 103592. https://doi.org/10.1016/j.mechmat.2020.103592

Karumanchi, M., Bellum, R. R., Chennupati, M., Kunchala, V., & Regulagunta, M. (2022). Influence on mechanical properties of concrete of cement replacement with fly ash and river sand replacement with foundry sand. *Materials Today: Proceedings*, *xxxx*, 6–10. https://doi.org/10.1016/j.matpr.2022.06.146

Kasaniya, M., Thomas, M. D. A., & Moffatt, E. G. (2021). Pozzolanic reactivity of natural pozzolans, ground glasses and coal bottom ashes and implication of their incorporation on the chloride permeability of concrete. *Cement and Concrete Research*, *139*(May 2020), 106259. https://doi.org/10.1016/j.cemconres.2020.106259

Kavitha, O. R., Shyamala, G., & Akshana, V. (2020). Materials Today : Proceedings Study of sustainable concrete property containing waste foundry sand. *Materials Today: Proceedings*, *xxxx*. https://doi.org/10.1016/j.matpr.2020.10.359

Kentucky Geological Survey. (2022). *Coal Combustion Byproducts*. https://www.uky.edu/KGS/coal/coal-for-combustionbyproducts.php

Khaw Le Ping, K., Cheah, C. B., Liew, J. J., Siddique, R., Tangchirapat, W., & Megat Johari, M. A. Bin. (2022). Coal bottom ash as constituent binder and aggregate replacement in cementitious and geopolymer composites: A review. *Journal of Building Engineering*, *52*(March), 104369. https://doi.org/10.1016/j.jobe.2022.104369

Khongpermgoson, P., Abdulmatin, A., Tangchirapat, W., & Jaturapitakkul, C. (2019). Evaluation of compressive strength and resistance of chloride ingress of concrete using a novel binder from ground coal bottom ash and ground calcium carbide residue. *Construction and Building Materials*, *214*, 631–640. https://doi.org/10.1016/j.conbuildmat.2019.04.145

Khongpermgoson, P., Boonlao, K., Ananthanet, N., & Thitithananon, T. (2020). The

mechanical properties and heat development behavior of high strength concrete containing high fineness coal bottom ash as a pozzolanic binder. *Construction and Building Materials*, *253*, 119239. https://doi.org/10.1016/j.conbuildmat.2020.119239

Kim, H. K., & Lee, H. K. (2011). Use of power plant bottom ash as fine and coarse aggregates in high-strength concrete. *Construction and Building Materials*, *25*(2), 1115–1122. https://doi.org/10.1016/j.conbuildmat.2010.06.065

Kim, Y., Kim, H., Yang, K., & Ha, J. (2021). Effect of concrete unit weight on the mechanical properties of bottom ash aggregate concrete. *Construction and Building Materials*, *273*, 121998. https://doi.org/10.1016/j.conbuildmat.2020.121998

Krishna, M. S., Kumar, G. A. V. S. S., & Thomas, A. C. (2021). Materials Today : Proceedings Behaviour of reinforced concrete beams bonded with side bonded FRP sheets. *Materials Today: Proceedings*, *43*, 2404–2410. https://doi.org/10.1016/j.matpr.2021.02.140

Kumar, D., Kumar, R., & Abbass, M. (2016). Study The Effect of Coal Bottom Ash on Partial Replacement of Fine Aggregate in Concrete With Sugarcane Molasses as an Admixture. *International Journal Of Scientific Research And Education*, *January*. https://doi.org/10.18535/ijsre/v4i05.10

Kumar, P., & Singh, N. (2020). Influence of recycled concrete aggregates and Coal Bottom Ash on various properties of high volume fly ash-self compacting concrete. *Journal of Building Engineering*, *32*(April), 101491. https://doi.org/10.1016/j.jobe.2020.101491

Kumavat, H. R., Chandak, N. R., & Patil, I. T. (2021). Factors influencing the performance of rebound hammer used for non-destructive testing of concrete members: A review. *Case Studies in Construction Materials*, *14*, e00491. https://doi.org/10.1016/j.cscm.2021.e00491

Kusbiantoro, A., Hanani, A., & Embong, R. (2019). Pozzolanic reactivity of coal bottom ash after chemically pre-treated with sulfuric acid. *Materials Science Forum*, *947 MSF*, 212–216. https://doi.org/10.4028/www.scientific.net/MSF.947.212

Lakhiar, M. T., Bai, Y., Wong, L. S., Paul, S. C., Anggraini, V., & Kong, S. Y. (2022). Mechanical and durability properties of epoxy mortar incorporating coal bottom ash as filler. *Construction and Building Materials*, *315*(July 2021), 125677.

https://doi.org/10.1016/j.conbuildmat.2021.125677

Langer, W. (2016). Sustainability of aggregates in construction. In *Sustainability of Construction Materials* (Second Edi). Elsevier Ltd. https://doi.org/10.1016/b978-0-08-100370-1.00009-3

Latifi, N., Marto, A., Safuan, A., Jacky, A. R., & Jia, L. (2015). *Strength and Physico-chemical Characteristics of Fly Ash – Bottom Ash Mixture*. https://doi.org/10.1007/s13369-015-1647-4

Lee, J., & Fenves, G. L. (1998). Plastic-Damage Model for Cyclic Loading of Concrete Structures. *Journal of Engineering Mechanics*, *124*(8), 892–900. https://doi.org/10.1061/(asce)0733-9399(1998)124:8(892)

Lee, S. H., Abolmaali, A., Shin, K. J., & Lee, H. Du. (2020). ABAQUS modeling for post-tensioned reinforced concrete beams. *Journal of Building Engineering*, *30*(August 2019), 101273. https://doi.org/10.1016/j.jobe.2020.101273

Li, P., & Song, E. xiang. (2015). Three-dimensional numerical analysis for the longitudinal seismic response of tunnels under an asynchronous wave input. *Computers and Geotechnics*, *63*, 229–243. https://doi.org/10.1016/j.compgeo.2014.10.003

Li, X., Bai, C., Qiao, Y., Wang, X., Yang, K., & Colombo, P. (2022). Preparation, properties and applications of fly ash-based porous geopolymers: A review. *Journal of Cleaner Production*, *359*(May), 132043. https://doi.org/10.1016/j.jclepro.2022.132043

Lin, X., Zhang, Y. X., & Pathak, P. (2020). Finite element analysis of beams. *Nonlinear Finite Element Analysis of Composite and Reinforced Concrete Beams*, 9–27. https://doi.org/10.1016/b978-0-12-816899-8.00002-x

Liu, J., Dong, Y., Dong, X., Hampshire, S., & Zhu, L. (2016). *Journal of the European Ceramic Society Feasible recycling of industrial waste coal fly ash for preparation of anorthite-cordierite based porous ceramic membrane supports with addition of dolomite*. *36*, 1059–1071.

Loy, A. C. M., Loy, M., Yusup, S., Kee, M., Lai, B., Chin, F., Shahbaz, M., Yamamoto, A., & Acda, M. N. (2018). The effect of industrial waste coal bottom ash as catalyst in catalytic pyrolysis of rice husk for syngas production. *Energy Conversion and Management*, *165*(March), 541–554.

https://doi.org/10.1016/j.enconman.2018.03.063

Lubliner, J., Oliver, J., Oller, S., & Onate, E. (1989). a Plastic-Damage Model. *International Journal of Solids and Structures*, *25*(3), 299–326.

Lv, J., Zhou, T., Du, Q., & Wu, H. (2015). Effects of rubber particles on mechanical properties of lightweight aggregate concrete. *Construction and Building Materials*, *91*, 145–149. https://doi.org/10.1016/j.conbuildmat.2015.05.038

Malaysia Prime Minister's Department, E. P. U. (2017). Malaysia Sustainable Development Goals Voluntary National Review 2017. In *High-level Political Forum*.

Mangi, S. A., Ibrahim, M. W., Jamaluddin, N., & Mohdfadzil, S. S. (2018). *Influence of Ground Coal Bottom Ash on the Properties of Concrete*. *9*(2), 1–10.

Mangi, S. A., Wan Ibrahim, M. H., Jamaluddin, N., Arshad, M. F., & Putra Jaya, R. (2019). Short-term effects of sulphate and chloride on the concrete containing coal bottom ash as supplementary cementitious material. *Engineering Science and Technology, an International Journal*, *22*(2), 515–522. https://doi.org/10.1016/j.jestch.2018.09.001

Mehra, P., & Naveen, D. (2022). A comparative study on behavior of different superplasticizers with fly ash added ordinary Portland cement. *Materials Today: Proceedings*, *xxxx*. https://doi.org/10.1016/j.matpr.2022.04.373

Metwally, I. M. (2017). Three-dimensional nonlinear finite element analysis of concrete deep beam reinforced with GFRP bars. *HBRC Journal*, *13*(1), 25–38. https://doi.org/10.1016/j.hbrcj.2015.02.006

Milligan, G. J., Polak, M. A., & Zurell, C. (2020). Finite element analysis of punching shear behaviour of concrete slabs supported on rectangular columns. *Engineering Structures*, *224*(October 2019), 111189. https://doi.org/10.1016/j.engstruct.2020.111189

Moreira, M., Sander, A., Souza, C. De, Teixeira, A., Albuquerque, D., & Rossi, A. (2022). Parametric analysis of steel-concrete composite beams prestressed with external tendons. *Journal of Constructional Steel Research*, *189*(November 2021), 107087. https://doi.org/10.1016/j.jcsr.2021.107087

MS EN 197-1:2014. (2014). *Cement - Part 1: Composition, specifications and conformity criteria for common cements*. 0–5.

Murlidhar, B. R., Mohamad, E. T., Alel, M. N. A. Bin, & Armaghani, D. J. (2016). Geological study and mining plan importance for mitigating alkali silica reaction in aggregate quarry operation. *Jurnal Teknologi*, *78*(7–3), 71–79. https://doi.org/10.11113/jt.v78.9486

Mushtaq, F., Zahid, M., Bhatti, I. A., Nasir, S., & Hussain, T. (2019). Possible applications of coal fly ash in wastewater treatment. *Journal of Environmental Management*, *240*(March), 27–46. https://doi.org/10.1016/j.jenvman.2019.03.054

Mustafa, T. S., El. Beshlawy, S. A., & Nassem, A. R. (2022). Experimental study on the behavior of RC beams containing recycled glass. *Construction and Building Materials*, *344*(March), 128250. https://doi.org/10.1016/j.conbuildmat.2022.128250

Muthulingam, S., & Rao, B. N. (2015). Consistent models for estimating chloride ingress parameters in fly ash concrete. *Journal of Building Engineering*, *3*, 24–38. https://doi.org/10.1016/j.jobe.2015.04.009

Muthusamy, K., Hafizuddin Rasid, M., Nabilah Isa, N., Hanis Hamdan, N., Atikah Shafika Jamil, N., Mokhtar Albshir Budiea, A., & Wan Ahmad, S. (2020). Mechanical properties and acid resistance of oil palm shell lightweight aggregate concrete containing coal bottom ash. *Materials Today: Proceedings*, *41*, 47–50. https://doi.org/10.1016/j.matpr.2020.10.1001

Muthusamy, K., Jamaludin, N. F. A., Kamaruzzaman, M. N., Ahmad, M. Z., Zamri, N. A., & Albshir Budiea, A. M. (2021). Compressive strength of palm oil clinker lightweight aggregate concrete containing coal bottom ash as sand replacement. *Materials Today: Proceedings*, *46*, 1724–1728. https://doi.org/10.1016/j.matpr.2020.07.527

Muthusamy, K., Rasid, M. H., Jokhio, G. A., Mokhtar Albshir Budiea, A., Hussin, M. W., & Mirza, J. (2020). Coal bottom ash as sand replacement in concrete: A review. *Construction and Building Materials*, *236*, 117507. https://doi.org/10.1016/j.conbuildmat.2019.117507

Naenudon, S., Vilaivong, A., Zaetang, Y., Tangchirapat, W., Wongsa, A., Sata, V., & Chindaprasirt, P. (2022). High flexural strength lightweight fly ash geopolymer mortar containing waste fiber cement. *Case Studies in Construction Materials*, *16*(February), e01121. https://doi.org/10.1016/j.cscm.2022.e01121

Najafgholipour, M. A., Dehghan, S. M., Dooshabi, A., & Niroomandi, A. (2017). *Finite Element Analysis of Reinforced Concrete Beam-Column Connections with Governing Joint Shear Failure Mode*. 1200–1225.

Nana, W. S. A., Bui, T. T., Limam, A., & Abouri, S. (2017). Experimental and Numerical Modelling of Shear Behaviour of Full-scale RC Slabs Under Concentrated Loads. *Structures*, *10*, 96–116. https://doi.org/10.1016/j.istruc.2017.02.004

Nathe, D. N., & Patil, Y. D. (2022). Performance of coal bottom ash concrete at elevated temperatures. *Materials Today: Proceedings*, *xxxx*. https://doi.org/10.1016/j.matpr.2022.03.519

Naveenkumar, K., Suriya, P. A., Divahar, R., Sangeetha, S. P., & Jayakumar, M. (2021). Experimental investigation flexural behavior of reinforced concrete beam with partial replacement of vermiculite. *Materials Today: Proceedings*, *46*, 5885–5888. https://doi.org/10.1016/j.matpr.2021.02.743

Nayak, C. B., Narule, G. N., & Surwase, H. R. (2021). Structural and cracking behaviour of RC T-beams strengthened with BFRP sheets by experimental and analytical investigation. *Journal of King Saud University - Engineering Sciences*, *xxxx*. https://doi.org/10.1016/j.jksues.2021.01.001

Nazrin, M., Ahmad, A., Muthusamy, K., Anwar, P., Majeed, P. A., Muazu, R., Mokhtar, A., & Budiea, A. (2020). Mechanical properties of oil palm waste lightweight aggregate concrete with fly ash as fine aggregate replacement. *Journal of Building Engineering*, *27*(August 2019), 100924. https://doi.org/10.1016/j.jobe.2019.100924

Neville, A. (2012). *Properties of Concrete*.

Nguyen, H. A., Chang, T. P., & Shih, J. Y. (2018). Effects of sulfate rich solid waste activator on engineering properties and durability of modified high volume fly ash cement based SCC. *Journal of Building Engineering*, *20*(April), 123–129. https://doi.org/10.1016/j.jobe.2018.07.010

Nigam, R., & Singh, S. K. (2020). Crack detection in a beam using wavelet transform and photographic measurements. *Structures*, *25*(March), 436–447. https://doi.org/10.1016/j.istruc.2020.03.010

Nikbin, I. M., Rahimi R, S., Allahyari, H., & Damadi, M. (2016). A comprehensive

analytical study on the mechanical properties of concrete containing waste bottom ash as natural aggregate replacement. *Construction and Building Materials*, *121*, 746–759. https://doi.org/10.1016/j.conbuildmat.2016.06.078

Nizar, I. K., Bakri, A. M. M. Al, Rafiza, A. R., Kamarudin, H., Alida, A., & Zarina, Y. (2014). *Study on Physical and Chemical Properties of Fly Ash from Different Area in Malaysia*. *595*, 985–989. https://doi.org/10.4028/www.scientific.net/KEM.594-595.985

Obaidat, Y. T., Heyden, S., & Dahlblom, O. (2010). The effect of CFRP and CFRP/concrete interface models when modelling retrofitted RC beams with FEM. *Composite Structures*, *92*(6), 1391–1398. https://doi.org/10.1016/j.compstruct.2009.11.008

Opoku, A. (2019). Resources , Conservation & Recycling Biodiversity and the built environment : Implications for the Sustainable Development Goals (SDGs). *Resources, Conservation & Recycling*, *141*(October 2017), 1–7. https://doi.org/10.1016/j.resconrec.2018.10.011

Parihar, H. S., Shanker, R., & Singh, V. (2022). Effect of variation of steel reinforcement on ultrasonic pulse velocity prediction in concrete beam. *Materials Today: Proceedings*, *65*, 1486–1490. https://doi.org/10.1016/j.matpr.2022.04.468

Patel, S. K., Majhi, R. K., Satpathy, H. P., & Nayak, A. N. (2019). Durability and microstructural properties of lightweight concrete manufactured with fly ash cenosphere and sintered fly ash aggregate. *Construction and Building Materials*, *226*, 579–590. https://doi.org/10.1016/j.conbuildmat.2019.07.304

Paul, M. M. (2015). Behaviour of Self Compacting Concrete by Partial Replacement of Fine Aggregate with Coal Bottom Ash. *International Journal of Innovative Research in Advanced Engineering (IJIRAE)*, *10*, 2349–2163. www.ijirae.com

Rafieizonooz, M., Mirza, J., Salim, M. R., Hussin, M. W., & Khankhaje, E. (2016). Investigation of coal bottom ash and fly ash in concrete as replacement for sand and cement. *Construction and Building Materials*, *116*, 15–24. https://doi.org/10.1016/j.conbuildmat.2016.04.080

Rafieizonooz, M., Salim, M. R., Mirza, J., Hussin, M. W., Salmiati, Khan, R., & Khankhaje, E. (2017). Toxicity characteristics and durability of concrete containing coal ash as substitute for cement and river sand. *Construction and Building Materials*, *143*, 234–246. https://doi.org/10.1016/j.conbuildmat.2017.03.151

Rahman, A. F., Goh, W. I., Mohamad, N., Kamarudin, M. S., & Jhatial, A. A. (2019). Numerical analysis and experimental validation of reinforced foamed concrete beam containing partial cement replacement. *Case Studies in Construction Materials*, *11*. https://doi.org/10.1016/j.cscm.2019.e00297

Ramachandra Murthy, A., Pukazhendhi, D. M., Vishnuvardhan, S., Saravanan, M., & Gandhi, P. (2020). Performance of concrete beams reinforced with GFRP bars under monotonic loading. *Structures*, *27*(November 2019), 1274–1288. https://doi.org/10.1016/j.istruc.2020.07.020

Ramzi Hannan, N. I. R., Shahidan, S., Ali, N., Bunnori, N. M., Mohd Zuki, S. S., & Wan Ibrahim, M. H. (2020). Acoustic and non-acoustic performance of coal bottom ash concrete as sound absorber for wall concrete. *Case Studies in Construction Materials*, *13*, e00399. https://doi.org/10.1016/j.cscm.2020.e00399

Raza, A., Khan, Q. U. Z., & Ahmad, A. (2019). Numerical investigation of load-carrying capacity of GFRP-reinforced rectangular concrete members using CDP model in abaqus. *Advances in Civil Engineering*, *2019*. https://doi.org/10.1155/2019/1745341

Raza, A., Rehman, A. ur, Masood, B., & Hussain, I. (2020). Finite element modelling and theoretical predictions of FRP-reinforced concrete columns confined with various FRP-tubes. *Structures*, *26*(April), 626–638. https://doi.org/10.1016/j.istruc.2020.04.033

Saha, A. S., & Amanat, K. M. (2021). Rebound hammer test to predict in-situ strength of concrete using recycled concrete aggregates, brick chips and stone chips. *Construction and Building Materials*, *268*, 121088. https://doi.org/10.1016/j.conbuildmat.2020.121088

Sai, B. P. V. N., Jagarapu, D. C. K., & Eluru, A. (2020). Assay of moment resisting precast and monolithic frames using ABAQUS software. *Materials Today: Proceedings*, *33*, 162–169. https://doi.org/10.1016/j.matpr.2020.03.735

Santhosh, K. G., Subhani, S. M., & Bahurudeen, A. (2021). Cleaner production of concrete by using industrial by-products as fine aggregate: A sustainable solution to excessive river sand mining. *Journal of Building Engineering*, *42*(January), 1–17. https://doi.org/10.1016/j.jobe.2021.102415

Saxena, S., & Pofale, A. D. (2017). Effective Utilization of Fly Ash and Waste Gravel in Green Concrete by Replacing Natural Sand and Crushed Coarse Aggregate. *Materials Today: Proceedings*, *4*(9), 9777–9783.

https://doi.org/10.1016/j.matpr.2017.06.266

Seara-Paz, S., González-Fonteboa, B., Martínez-Abella, F., & Eiras-López, J. (2018). Flexural performance of reinforced concrete beams made with recycled concrete coarse aggregate. *Engineering Structures*, *156*(September 2017), 32–45. https://doi.org/10.1016/j.engstruct.2017.11.015

Sharma, R., & Khan, R. A. (2017). Sustainable use of copper slag in self compacting concrete containing supplementary cementitious materials. *Journal of Cleaner Production*, *151*, 179–192. https://doi.org/10.1016/j.jclepro.2017.03.031

Sharma, V., & Singh, S. (2020a). Materials Today : Proceedings Modeling for the use of waste materials (Bottom ash and fly ash) in soil stabilization. *Materials Today: Proceedings*, *33*, 1610–1614. https://doi.org/10.1016/j.matpr.2020.05.569

Sharma, V., & Singh, S. (2020b). Modeling for the use of waste materials (Bottom ash and fly ash) in soil stabilization. *Materials Today: Proceedings*, *xxxx*. https://doi.org/10.1016/j.matpr.2020.05.569

Singh, M. (2018). 1. Coal bottom ash. In *Waste and Supplementary Cementitious Materials in Concrete*. Elsevier Ltd. https://doi.org/10.1016/B978-0-08-102156-9.00001-8

Singh, M. for the use of waste materials (Bottom ash and fly ash) in soil stabilization. pd., & Siddique, R. (2016). Effect of coal bottom ash as partial replacement of sand on workability and strength properties of concrete. *Journal of Cleaner Production*, *112*, 620–630. https://doi.org/10.1016/j.jclepro.2015.08.001

Singh, M., & Siddique, R. (2013). Resources , Conservation and Recycling Effect of coal bottom ash as partial replacement of sand on properties of concrete. *"Resources, Conservation & Recycling," 72*, 20–32. https://doi.org/10.1016/j.resconrec.2012.12.006

Singh, M., & Siddique, R. (2014). Compressive strength , drying shrinkage and chemical resistance of concrete incorporating coal bottom ash as partial or total replacement of sand. *Construction and Building Materials*, *68*, 39–48. https://doi.org/10.1016/j.conbuildmat.2014.06.034

Singh, M., & Siddique, R. (2015). Properties of concrete containing high volumes of coal bottom ash as fine aggregate. *Journal of Cleaner Production*, *91*, 269–278. https://doi.org/10.1016/j.jclepro.2014.12.026

Singh, N., & Bhardwaj, A. (2020). Reviewing the role of coal bottom ash as an alternative of cement. *Construction and Building Materials*, *233*, 117276. https://doi.org/10.1016/j.conbuildmat.2019.117276

Singh, N., Haque, M. M., & Gupta, A. (2022). Reviewing mechanical performance of geopolymer concrete containing coal bottom ash. *Materials Today: Proceedings*, *xxxx*. https://doi.org/10.1016/j.matpr.2022.04.408

Singh, N., Kumar, P., & Goyal, P. (2019). Reviewing the behaviour of high volume fly ash based self compacting concrete. *Journal of Building Engineering*, *26*(April), 100882. https://doi.org/10.1016/j.jobe.2019.100882

Singh, N., Mithulraj, M., & Arya, S. (2018). *Resources , Conservation & Recycling In fl uence of coal bottom ash as fine aggregates replacement on various properties of concretes : A review*. *138*(July), 257–271. https://doi.org/10.1016/j.resconrec.2018.07.025

Singh, N., Mithulraj M, & Arya, S. (2019). Utilization of coal bottom ash in recycled concrete aggregates based self compacting concrete blended with metakaolin. *Resources, Conservation and Recycling*, *144*(January), 240–251. https://doi.org/10.1016/j.resconrec.2019.01.044

Sivakumar, A., Srividhya, S., Sathiyamoorthy, V., Seenivasan, M., & Subbarayan, M. R. (2022). Impact of waste ceramic tiles as partial replacement of fine and coarse aggregate in concrete. *Materials Today: Proceedings*, *61*, 224–231. https://doi.org/10.1016/j.matpr.2021.08.142

Soltanabadi, R., Behfarnia, K., & Mamazizi, A. (2022). Numerical investigation of RC deep beams containing recycled aggregates. *Construction and Building Materials*, *324*(December 2021), 126713. https://doi.org/10.1016/j.conbuildmat.2022.126713

Soundarya, N. (2022). Materials Today : Proceedings A review on the physical & chemical properties of sea sand to be used a replacement to fine aggregate in concrete. *Materials Today: Proceedings*, *51*, 1527–1531. https://doi.org/10.1016/j.matpr.2021.10.314

Srivastava, A., & Singh, S. K. (2020). Utilization of alternative sand for preparation of sustainable mortar : A review. *Journal of Cleaner Production*, *253*, 119706. https://doi.org/10.1016/j.jclepro.2019.119706

Statista. (2020). *Statista*. https://www.statista.com/

Sun, Y., Wang, Z. H., Park, D. J., Kim, W. S., Kim, H. S., Yan, S. R., & Lee, H. S. (2022). Analysis of isothermal hydration heat of cement paste containing mechanically activated fly ash. *Thermochimica Acta*, 179273. https://doi.org/10.1016/j.tca.2022.179273

Sunayana, S., & Barai, S. V. (2018). Flexural performance and tension-stiffening evaluation of reinforced concrete beam incorporating recycled aggregate and fly ash. *Construction and Building Materials*, *174*, 210–223. https://doi.org/10.1016/j.conbuildmat.2018.04.072

Szczecina, M., & Winnicki, A. (2017). Relaxation Time in CDP Model Used for Analyses of RC Structures. *Procedia Engineering*, *193*, 369–376. https://doi.org/10.1016/j.proeng.2017.06.226

Taher, S. M. S., Saadullah, S. T., Haido, J. H., & Tayeh, B. A. (2021). Behavior of geopolymer concrete deep beams containing waste aggregate of glass and limestone as a partial replacement of natural sand. *Case Studies in Construction Materials*, *15*(August), e00744. https://doi.org/10.1016/j.cscm.2021.e00744

Tao, H., Yang, H., Zhang, J., Ju, G., Xu, J., & Shi, B. (2022). Nonlinear finite element analysis on timber-concrete composite beams. *Journal of Building Engineering*, *51*(November 2021), 104259. https://doi.org/10.1016/j.jobe.2022.104259

Tao, Z., Wang, Z., & Yu, Q. (2013). Finite element modelling of concrete- fi lled steel stub columns under axial compression. *JCSR*, *89*, 121–131. https://doi.org/10.1016/j.jcsr.2013.07.001

Thanaraj, D. P., N, A., Arulraj, P., & Al-Jabri, K. (2020). Investigation on structural and thermal performance of reinforced concrete beams exposed to standard fire. *Journal of Building Engineering*, *32*(September 2019), 101764. https://doi.org/10.1016/j.jobe.2020.101764

Thi, N. N., Hong, T. P., & Truong, S. B. (2019). *Utilizing Coal Bottom Ash from Thermal Power Plants in Vietnam as Partial Replacement of Aggregates in Concrete Pavement*. *2019*.

Thomas, M. D. A., Hooton, R. D., Scott, A., & Zibara, H. (2012). The effect of supplementary cementitious materials on chloride binding in hardened cement paste. *Cement and Concrete Research*, *42*(1), 1–7. https://doi.org/10.1016/j.cemconres.2011.01.001

Torra-Bilal, I., Mahamid, M., & Baran, E. (2022). Cyclic behaviour of precast beam-to-column connections: An experimental and numerical investigation. *Structures*, *35*(June 2021), 939–957. https://doi.org/10.1016/j.istruc.2021.11.046

Torra-Bilal, I., Mahamid, M., & Bilal, K. (2019). *Structures Congress 2019 112*. *Fema 2012*, 112–121.

Turrentine, J. (2019). *NRDC*. https://doi.org/https://www.nrdc.org/onearth/coal-ash-hazardous-coal-ash-waste-according-epa-coal-ash-not-hazardous-waste

V.Chaudhari, S., & A. Chakrabarti, M. (2012). Modeling of Concrete for Nonlinear Analysis using Finite Element Code ABAQUS. *International Journal of Computer Applications*, *44*(7), 14–18. https://doi.org/10.5120/6274-8437

Venkatesan, B., Lijina, V. J., Kannan, V., & Dhevasenaa, P. R. (2020). Materials Today : Proceedings Partial replacement of fine aggregate by steel slag and coarse aggregate by walnut shell in concrete. *Materials Today: Proceedings*, *xxxx*. https://doi.org/10.1016/j.matpr.2020.07.361

Wang, C. C., & Wang, H. Y. (2017). Assessment of the compressive strength of recycled waste LCD glass concrete using the ultrasonic pulse velocity. *Construction and Building Materials*, *137*, 345–353. https://doi.org/10.1016/j.conbuildmat.2017.01.117

Wang, Y., Tan, Y., Wang, Y., & Liu, C. (2020). Mechanical properties and chloride permeability of green concrete mixed with fly ash and coal gangue. *Construction and Building Materials*, *233*, 117166. https://doi.org/10.1016/j.conbuildmat.2019.117166

Wosatko, A., Winnicki, A., Polak, M. A., & Pamin, J. (2019). Role of dilatancy angle in plasticity-based models of concrete. *Archives of Civil and Mechanical Engineering*, *19*(4), 1268–1283. https://doi.org/10.1016/j.acme.2019.07.003

Wu, J. Y., Li, J., & Faria, R. (2006). An energy release rate-based plastic-damage model for concrete. *International Journal of Solids and Structures*, *43*(3–4), 583–612. https://doi.org/10.1016/j.ijsolstr.2005.05.038

Xu, T., & Li, J. (2018). Assessing the spatial variability of the concrete by the rebound hammer test and compression test of drilled cores. *Construction and Building Materials*, *188*, 820–832. https://doi.org/10.1016/j.conbuildmat.2018.08.138

Yazici, Ş., & Arel, H. Ş. (2012). Effects of fly ash fineness on the mechanical properties of concrete. *Sadhana - Academy Proceedings in Engineering Sciences*, *37*(3), 389–403. https://doi.org/10.1007/s12046-012-0083-3

Yun, H., Ek, D., Ong, L., Sanjayan, J. G., & Nazari, A. (2016). The effect of different Na 2 O and K 2 O ratios of alkali activator on compressive strength of fly ash based-geopolymer. *Construction and Building Materials*, *106*, 500–511. https://doi.org/10.1016/j.conbuildmat.2015.12.141

Zaboon, J. K., & Jassim, S. F. (2021). Numerical and analytical analysis for deflection and stress in a simply supported beam. *Materials Today: Proceedings*, *49*, 2912–2915. https://doi.org/10.1016/j.matpr.2021.10.298