Chapter 2

Evaluation of Corundum and Rock Dust Waste as Cement-Based Concrete Material

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Abstract

This study focuses on the recovery and reuse of corundum and rock dust waste generated as by-products during abrasion tests using the Bohme abrasion device. These tests, commonly applied to assess the wear resistance of natural stones, produce significant amounts of corundum and rock dust waste. Improper disposal of these fine particulate wastes may cause environmental problems such as air and soil pollution. To address this issue within the framework of sustainable construction practices, waste particles sized between 200 and 500 μm were ground in a laboratory rod mill for 10 minutes to obtain finer fractions ranging from 75 to 150 μm. The resulting powder was mixed with Portland cement at fixed water-to-cement ratio of 0.45 and cement contents of 5%, 7%, and 10%. Concrete specimens were produced and tested for physical and mechanical properties including dry density (ρd), porosity (n), Leeb rebound hardness (LRH), uniaxial compressive strength (UCS), and point load strength (PLT). The results showed improved mechanical performance with increasing cement content. Dry density ranged from 2.45 to 2.48 g/cm^3, while porosity slightly decreased from 34.78% to 33.52%. LRH increased from 170.08 to 211.70, UCS rose from 3.00 MPa to 7.55 MPa, and PLT improved from 0.21 MPa to 0.50 MPa. These findings suggest that corundum and rock dust waste can enhance the performance of cementitious composites and be effectively utilized as secondary raw materials. This study highlights a sustainable approach to recycling abrasive waste materials in construction applications.

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1. Introduction

Corundum (synthetic alumina, Al_2O_3) powder is widely utilized across various industrial applications due to its exceptional hardness and chemical resistance. With a Mohs hardness rating of 9.0, it is considered one of the hardest naturally occurring minerals, following diamond and silicon carbide. This remarkable hardness makes corundum an effective abrasive material, particularly in grinding, cutting, and polishing operations. Today, it is commonly employed in sandpapers, grinding wheels, and abrasive blasting systems. Furthermore, its high melting point (~2050 °C) and thermal stability render it a critical component in the manufacture of refractory materials. In this context, corundum-based refractory bricks and ceramics are frequently used as linings in furnaces and reactors operating under high temperatures in the metallurgy, glass, and cement industries [1]. In addition, corundum powder plays a significant role in surface preparation and coating applications; it is effectively used in abrasive blasting for cleaning and roughening metal surfaces, and it is also preferred in creating anti-slip, wear-resistant surfaces [2].

Corundum is widely utilized in the fields of rock mechanics and construction materials due to its high hardness and uniform abrasive performance, making it a preferred medium for surface abrasion testing. In particular, the use of synthetic corundum is mandated in the Bohme abrasion test, as defined by the EN 14157 standard, to ensure reliable and repeatable evaluation of the abrasion resistance of natural stones [3]. Similarly, corundum or equivalent abrasive materials are employed in the Wide Wheel abrasion test, which is based on the EN 1341 standard, to simulate severe wear conditions typically encountered in the performance assessment of paving stones [4]. In addition, corundum-based abrasive wheels such as H-18 or CS-17 are commonly used in the Taber abrasion test, performed under ASTM D1044 and ASTM C1353 standards, to assess wear resistance on stone and concrete surfaces [5,6]. High-hardness corundum powder or similar abrasives are also recommended in tests conducted in accordance with ASTM C779, which evaluates the effects of multiple abrasive mechanisms, as well as in the historically significant Dorry abrasion test, to study surface degradation under controlled conditions [7,8].

Corundum powder, commonly used in industrial abrasion tests, generates a substantial amount of dust waste that can pose significant environmental risks. The uncontrolled release of these residues into the environment may lead to irreversible ecological damage and stands in conflict with contemporary sustainability goals. In recent years, increasing emphasis has been placed on the reutilization of such industrial by-products to create both economic and environmental value. Particularly in the construction industry, the incorporation of recovered materials as raw inputs contributes to the conservation of natural resources and the enhancement of waste management practices.

Therefore, the structural suitability of waste materials must be ensured in order to maintain material quality, which is of critical importance. The literature contains numerous studies on the use of various industrial wastes—such as fly ash, blast furnace slag, mine tailings, foundry sand, cement kiln dust, wood ash, waste glass powder, marble dust, scrap tires, construction and demolition waste, zeolite, and waste paper industry ash—as well as agricultural wastes including rice husk ash, sugarcane bagasse ash, palm oil shell, corn stalk ash, and olive oil residues in concrete production [9–26]. However, research on the reuse of waste materials such as corundum and rock dust generated from abrasion tests remains highly limited [27–29].

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This study aims to produce concrete by incorporating waste dust generated from the Bohme Abrasion Resistance (BAR) test, which was processed through particle size reduction in the laboratory and subsequently mixed with cement in varying proportions. The environmental suitability of the resulting recycled products was evaluated through physical and mechanical tests to assess their potential application as construction materials.

2. Study Methodology

In this study, the utilization of waste dust generated after BAR tests, comprising a mixture of corundum and rock particles, was investigated. To this end, the waste dust was ground and mixed with cement at varying proportions (5%, 7%, and 10%) along with a controlled amount of water to produce concrete blocks. The resulting samples were then subjected to a series of physico-mechanical tests to systematically evaluate their strength properties. Figure 1 presents a schematic illustration of the process, from grinding the waste dust to its incorporation in concrete production, as well as the physical and mechanical tests performed on the produced concrete specimens.

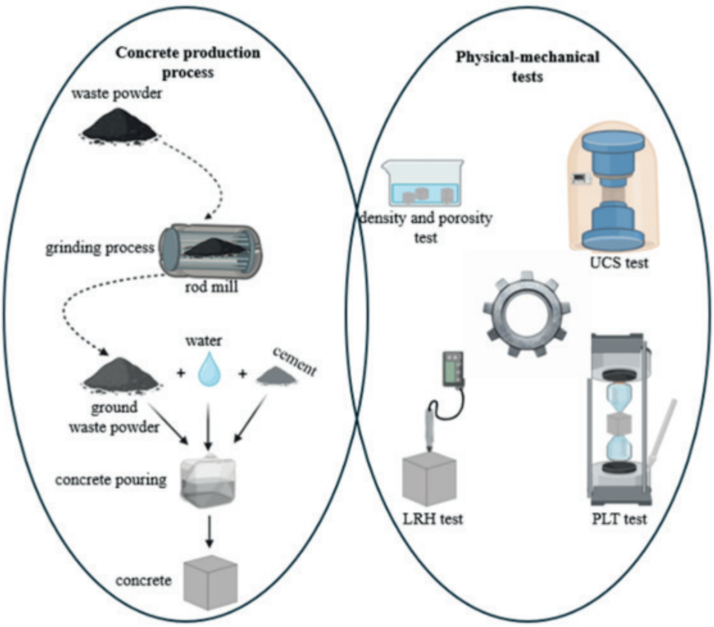

Fig. 1 A schematic representation of the process in which waste dust is ground and utilized for concrete production, along with the physico-mechanical tests applied to the produced concrete specimens

2.1 BAR Test

Tests aimed at determining frictional wear loss were conducted in accordance with the EN 14157 standard [3]. For this purpose, cube-shaped specimens with edge lengths of 71 mm were prepared. The surfaces of the specimens in contact with the abrasive belt were arranged to be flat. During the test, 20 grams of corundum powder was spread over the abrasive strip, and a constant load of 294 N was applied using a steel lever mechanism. Each test cycle consisted of 22 revolutions, after which the disc automatically stopped, and the accumulated corundum and specimen debris were cleaned from the surface. Subsequently, another 20 grams of corundum powder was applied, the specimen was rotated 90° around its vertical axis, and the procedure was repeated. This cycle was performed 16 times for each specimen. Upon completion of the test, specimens were carefully cleaned, and the mass losses caused by abrasion were determined using a precision balance.

To determine the BAR value of a specific rock type, three cube-shaped specimens with edge lengths of 71 mm were prepared, and individual BAR tests were carried out on each. The average BAR value for the rock was calculated by taking the meaning of the three test results along with the standard deviation. Based on these procedures, approximately 960 ± 48 grams of corundum powder was consumed to determine the BAR value of a single rock type. The amount of material worn from the rock specimens during the Bohme test ranged from 4 to 60 grams on average, depending on the type and density of the rock [29, 30]. Figure 2 illustrates a sample of the waste powder generated following Bohme abrasion tests using the Bohme abrasion apparatus.

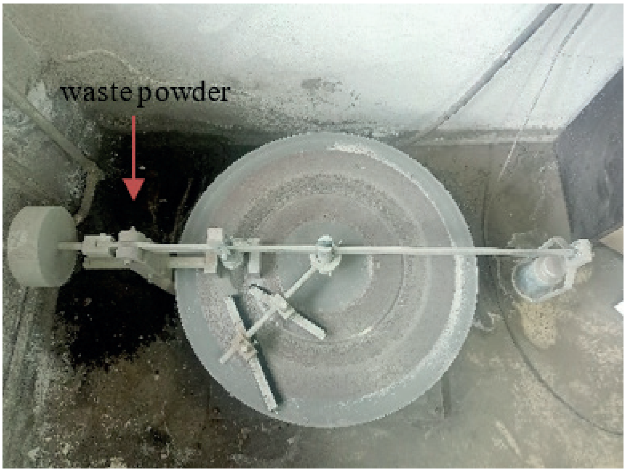

Fig. 2 Waste dust resulting from Bohme abrasion test

2.2 Concrete production from waste powder

It was determined that the particle size of the waste powder obtained after the BAR test ranged approximately between 170 and 600 μm. Concrete blocks were initially produced using the waste powder in this size range; however, it was observed that the bonding between the cement and the waste powder was insufficient, resulting in the formation of cracks in the specimens and inadequate strength properties. To overcome these issues, a particle size reduction process was applied to the waste powder. In this context, the powder was ground for 15 minutes using a laboratoryscale rod mill. As a result of the grinding process, the particle size was successfully reduced to the range of 75 to 150 μm. Figure 3 presents a visual representation of the rod mill used for the grinding of the waste powder.

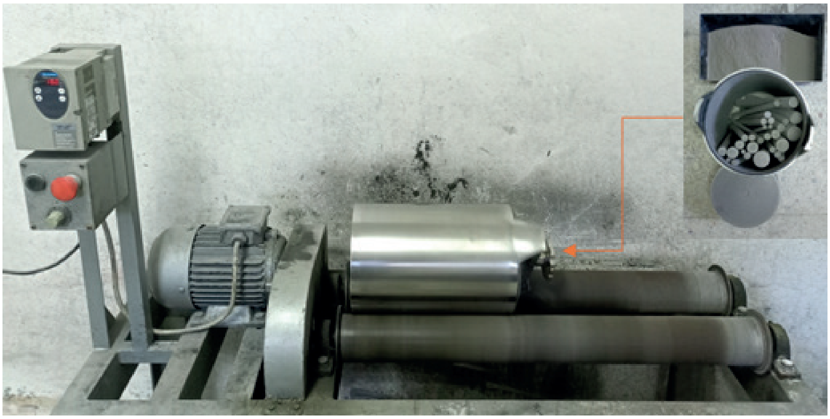

Fig. 3 Grinding process of the waste powder

Figure 4 illustrates the corundum abrasive, the residual powder produced following BAR tests, and the waste material after the grinding process.

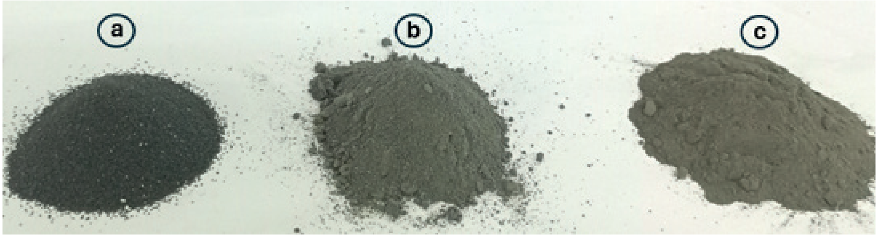

Fig. 4 a) Corundum abrasive, b) BAR test-derived waste powder, c) its ground form

Ground waste powder was mixed with white cement at proportions of 5% (S1), 7% (S2), and 10% (S3), and water was added at a water-to-cement ratio of 0.45 in accordance with TS EN 206 standards to prepare mortar. The mixtures were then cast into molds measuring 10 × 10 × 15 cm. To prevent cracking caused by water evaporation, plastic shrinkage, and delayed hydration during the initial setting and curing phases, the concrete samples were subjected to water curing for 28 days [31–33]. Figure 5 presents the blocks produced with 5%, 7%, and 10% cement additions to the waste powder.

Table 1 presents the properties of the corundum powder used in the Bohme tests and the cement employed for concrete production.

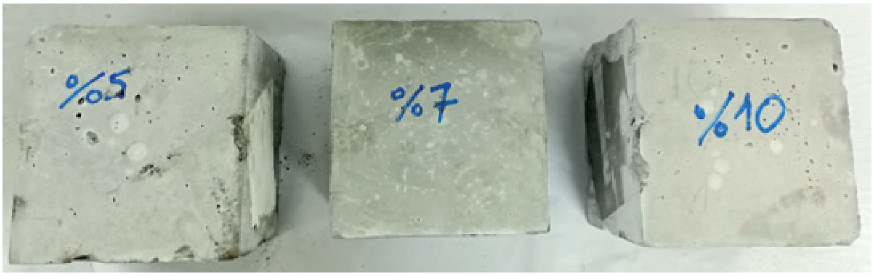

Fig. 5 ***Blocks produced by adding 5%, 7%, and 10% cement to the waste powder***

Table 1 Some Properties of Corundum Powder and Cement Used in Concrete Block Production [34, 35]

Properties of Corundum Powder		Technical Properties of Cement	
Component	Amount (%)	Component	Value (%)
SiO_2	40–60	SiO_2	21.6
Al_2O_3	10–20	Al_2O_3	4.05
Fe_2O_3	5–13	Fe_2O_3	0.28
CaO	5–13	CaO	65.7
MgO	5–13	MgO	1.30
Na_2O	<4	Na_2O	0.30
K_2O	<4	K_2O	0.35
TiO_2	<3	Na_2O	0.30
Loss on Ignition (LOI)	1–5	Loss on Ignition (LOI)	3.50
Density	3.9 – 4.20 g/cm³	Density	3.06 g/cm³
Grain Shape	Angular	Blaine Fineness	4600 cm²/g
Hardness	6.5–7 Mohs	Whiteness (Hunter Lab Y value)	≥85.5%
Color	Brown / Black	Compressive Strength (28 days)	60.0 MPa

2.3 Physico-mechanical tests

The three types of produced concrete blocks were cut and sized according to specific standards, and the samples were subjected to tests for dry density (ρd), porosity (n), Leeb rebound hardness (LRH), point load test (PLT), and uniaxial compressive strength (UCS).

2.3.1 Determination of dry density (ρd) and porosity (n)

In this experiment, the volumes of the samples were first determined, followed by the measurement of their dry weights. Subsequently, the samples were saturated in water for 48 hours to achieve full saturation, after which both their saturated weights and submerged weights were recorded. Using these values, the n and ρd of the samples were calculated. The procedure was carried out in accordance with the guidelines specified in TS EN 1936 [36].

2.3.2 Leeb Rebound Hardness (LRH) test

Since there is no standardized procedure for LRH testing on rocks and concrete specimens, the LRH measurements in this study were conducted based on the methods proposed by İnce and Bozdağ [37]. The LRH values were obtained using an Insize ISH-PHB testing device equipped with a D-type probe (Figure 6a). The technical specifications of the device include a measurement range of 0 to 999 HL, an impact energy of 11 Nmm, and an accuracy of ±6 HL. Prior to the measurements, the device was calibrated, and twenty evenly distributed impact points were selected on the surface of a cubic specimen with 70 mm edge length. The arithmetic mean of these measurements was taken as the HL value of the specimen.

2.3.3 Uniaxial compressive strength

The UCS tests were performed on cubic specimens with 50 mm edge length by following the procedures outlined in the ASTM standard [38]. A 3000 kN capacity UTEST testing machine was used for this purpose (Figure 6b). During the UCS testing, the loading rate was set to 0.25 ± 0.05 MPa/s. Each specimen was tested five times, and the average UCS value was determined from these measurements.

2.3.4 Point load test (PLT)

The PLT test can be conducted using core, block, or irregularly shaped specimens. In this study, block specimens measuring 50×40×30 mm were used for the PLT test. The reading unit of the PLT device employed in the tests was calibrated and digitized (Figure 6c). The procedure was carried out in accordance with ISRM standards [39]. For each of the three different concrete block types, 10 specimens were prepared, and the average of the test results was taken to determine the PLT values.

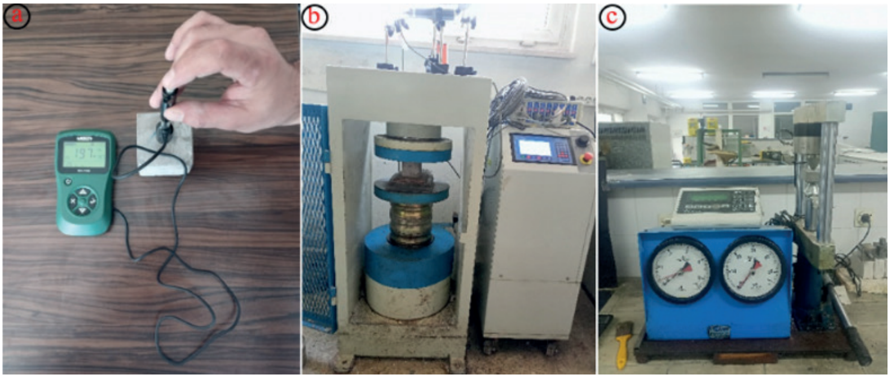

Fig. 6 a) LRH test, b) UCS test, c) PLT test

3 Result and Discussion

Table 2 presents the physico-mechanical properties of the concrete specimens produced in this study. The highest density was recorded in the S2 sample, while the lowest was observed in the S3 sample. The porosity values of the concrete blocks were considerably high and relatively similar across all specimens. The LRH, UCS, and PLT values increased proportionally with the cement content in the mixtures, with the S3 specimen exhibiting the highest strength among the produced blocks.

Table 2 Physico-mechanical properties of the produced concrete specimens

Sample	ρd (g/cm³)	n (%)	LRH	UCS (MPa)	PLT (MPa)
S1	2.46	34.78	170.08	3.00	0.21
S2	2.48	34.72	195.72	5.63	0.36
S3	2.45	33.52	211.70	7.55	0.50

The uniaxial compressive strength (UCS) of concrete is closely related to its microstructural properties. In the literature, it is emphasized that the balance between porosity and the amount of cementitious binder is a key factor in determining concrete strength [32, 33]. In this study, the porosity levels of the analyzed specimens were found to be around 33–35%, which are considered relatively high. Increased porosity leads to a greater number of weak zones within the concrete matrix, facilitating crack initiation and propagation under load, thereby limiting strength. Conversely, an increase in cement content enhances the integrity of the binder matrix, partially compensating for the negative effects of porosity and thereby improving compressive strength.

This is clearly observed in the S3 specimen, which exhibited the highest UCS value (7.55 MPa), as it contained the highest cement content among all specimens. However, despite the increased cement content, the high porosity restricts the strength from rising indefinitely. For this reason, although the S3 specimen demonstrated the highest strength, the resulting compressive strength values remain significantly below those required for conventional structural concrete (typically ≥20 MPa).

Within the scope of this study, the mechanical performance of the concrete was shaped by the complex interaction between porosity and cement content. While increasing the cement content positively influenced strength, high porosity remained the main limiting factor for overall compressive strength. Additionally, the literature classifies concrete strength based on application areas and states that strength values below 3 MPa are unsuitable for use as building materials, whereas strengths in the range of 5–10 MPa are considered acceptable for backfill and light structural applications [32].

In this study, the PLT values of the produced concrete specimens ranged from 0.21 MPa to 0.50 MPa. These values clearly indicate that the mechanical strength of the specimens is limited. From the perspective of PLT, the results fall within the low-strength category, suggesting that such materials are not suitable for structural applications. In this context, the obtained PLT results demonstrate that the specimens are more appropriate for use in backfill and lightweight structural applications. Furthermore, while PLT values increased with higher cement content, it was also observed that high porosity restricted the improvement in strength. This finding implies that when waste powder is utilized in concrete production, the mechanical performance may remain limited, and additional enhancement strategies would be necessary before considering these materials for structural use.

3 Conclusion

In this study, the use of waste powders obtained from the BAR test in artificial concrete production was investigated by mixing them with varying proportions of cement. The physical and mechanical properties of the produced concrete specimens were examined in detail, and the technical suitability of the waste powders as a construction material was evaluated with respect to environmental sustainability. The main findings are summarized as follows:

- The porosity levels measured in the concrete specimens ranged between 33% and 35%, indicating relatively high values. This elevated porosity emerged as one of the primary factors limiting the mechanical strength of the concrete.
- Increasing the cement content improved the integrity of the binder matrix, leading to enhanced UCS and PLT values. The highest compressive strength (7.55 MPa) was recorded in the S3 specimen, which contained the largest proportion of cement. However, due to the persistently high porosity, the strength improvement remained limited, and the resulting values fell considerably below those typical of standard structural concretes, which usually exceed 20 MPa.
- An increase in cement content also resulted in higher LRH values, indicating that the incorporation of waste powders in cement-based concrete contributed positively to both hardness and mechanical resistance.
- Although the concrete specimens did not achieve sufficient strength for structural applications, they were considered suitable for use in backfilling and lightweight structural purposes.

This study demonstrates that waste powders from the BAR test hold significant potential for recovery and the development of environmentally friendly construction materials. Nevertheless, additional efforts are needed to reduce porosity to enhance mechanical performance. While combining waste powders with cement improves strength, the high porosity prevents the material from reaching standard strength levels required for load-bearing applications. Therefore, these materials are more suitable for lightweight structural uses or as fill material and should be considered within the broader context of sustainable construction material development.

References

1. Zhang, Z., Yu, L., Zhang, Y., Cui, K., Zhang, C., Shen, X. "Enhancement, application, and challenges of chromium–corundum high-temperature refractories", International Journal of Applied Ceramic Technology, 21(6), pp. 3717–3734, 2024. https://doi.org/10.1111/ijac.14815
2. Bogatu, N., Muresan, A. C., Mardare, L., Ghisman, V., Ravoiu, A., Dima, F. M., Buruiana, D. L. "The influence of different type materials of grit blasting on the corrosion resistance of S235JR carbon steel", Inventions, 8(1), pp. 39, 2023. https://doi.org/10.3390/inventions8010039
3. European Committee for Standardization (CEN) "EN 14157:2017 Natural stone test methods – Determination of abrasion resistance", CEN, Brussels, 2017. https://doi.org/10.3403/30344412
4. European Committee for Standardization (CEN) "EN 1341:2012 Natural stone test methods – Determination of resistance to surface abrasion using the rotating disc method", CEN, Brussels, 2012.
5. ASTM International "Standard Test Method for Resistance of Transparent Plastics to Surface Abrasion", ASTM International, West Conshohocken, PA, 2013.
6. ASTM International "Standard Test Method for Abrasion Resistance of Stone Subjected to Foot Traffic Using a Rotary Platform Abraser", ASTM International, West Conshohocken, PA, 2020.
7. ASTM International "Standard Test Method for Abrasion Resistance of Horizontal Concrete Surfaces", ASTM International, West Conshohocken, PA, 2017. https://doi.org/10.1520/c0779_c0779m-00
8. British Standards Institution (BSI) "BS 812 Part 112: Testing aggregates – Method for determination of resistance to surface wear", BSI, London, 1985.
9. Yousuf, A., Manzoor, S. O., Youssouf, M., Malik, Z. A., Khawaja, K. S. "Fly ash: production and utilization in India-an overview", J. Mater. Environ. Sci, 11(6), pp. 911–921, 2020.
10. Özbay, E., Erdemir, M., Durmuş, H. İ. "Utilization and efficiency of ground granulated blast furnace slag on concrete properties–A review", Construction and Building Materials, 105, pp. 423–434, 2016. https://doi.org/10.1016/j.conbuildmat.2015.12.153
11. Memon, M. J., Jhatial, A. A., Murtaza, A., Raza, M. S., & Phulpoto, K. B. (2021). Production of eco-friendly concrete incorporating rice husk ash and polypropylene fibres. *Environmental Science and Pollution Research*, *28*, 39168-39184.https://doi.org/10.1007/s11356-021-13418-3
12. Bahurudeen, A., Vaisakh, K. S., Santhanam, M. "Availability of sugarcane bagasse ash and potential for use as a supplementary cementitious material in concrete", Indian Concrete Journal, 89(6), pp. 41–50, 2015.

13. Manso, J. M., Gonzalez, J. J., Polanco, J. A. "Electric arc furnace slag in concrete", Journal of Materials in Civil Engineering, 16(6), pp. 639–645, 2004.https://doi.org/10.1061/(asce)0899-1561(2004)16:6(639)
14. Manoharan, T., Laksmanan, D., Mylsamy, K., Sivakumar, P., Sircar, A. "Engineering properties of concrete with partial utilization of used foundry sand", Waste Management, 71, pp. 454–460, 2018.https://doi.org/10.1016/j.wasman.2017.10.022
15. Siddique, R. "Utilization of industrial by-products in concrete", Procedia Engineering, 95, pp. 335–347, 2014. https://doi.org/10.1016/j.proeng.2014.12.192
16. Wang, W., Wei, W., Gao, S., Chen, G., Yuan, J., Li, Y. "Agricultural and aquaculture wastes as concrete components: A review", Frontiers in Materials, 8, pp. 762568, 2021. https://doi.org/10.3389/fmats.2021.762568
17. Aliabdo, A. A., Abd Elmoaty, M., Aboshama, A. Y. "Utilization of waste glass powder in the production of cement and concrete", Construction and Building Materials, 124, pp. 866–877, 2016. https://doi.org/10.1016/j.conbuildmat.2016.08.016
18. Dhoka, M. C. "Green concrete: using industrial waste of marble powder, quarry dust and paper pulp", Int. J. Eng. Sci. Invent, 2(10), pp. 67–70, 2013.
19. Alabdulkarim, A., El-Sayed, A. K., Alsaif, A. S., Fares, G., Alhozaimy, A. M. "Behavior of lightweight self-compacting concrete with recycled tire steel fibers", Buildings, 14(8), pp. 2463, 2024. https://doi.org/10.3390/buildings14082463
20. Vongole, R. M., Nagraj, Y., Naganna, S. R., Mailar, G., Yaseen, Z. M. "Valorization of incinerator bottom ash for the production of resource-efficient eco-friendly concrete: Performance and toxicological characterization", arXiv preprint arXiv:2104.12497, 2021. https://doi.org/10.1007/s44150-021-00006-9
21. Calvo, J. G., Carballosa, P., Padilla, I., Jarabo, R., Romero, M., López-Delgado, A. "Use of industrial waste-based zeolites in the fabrication of cementitious materials", Materiales de Construcción, 74(356), pp. e358–e358, 2024. https://doi.org/10.3989/mc.2024.390024
22. Martínez-Lage, I., Velay-Lizancos, M., Vázquez-Burgo, P., Rivas-Fernández, M., Vázquez-Herrero, C., Ramírez-Rodríguez, A., Martín-Cano, M. "Concretes and mortars with waste paper industry: Biomass ash and dregs", Journal of Environmental Management, 181, pp. 863–873, 2016. https://doi.org/10.1016/j.jenvman.2016.06.052
23. Shafigh, P., Jumaat, M. Z., Mahmud, H. "Oil palm shell as a lightweight aggregate for production high strength lightweight concrete", Constructi-

on and Building Materials, 25(4), pp. 1848–1853, 2011. https://doi.org/10.1016/j.conbuildmat.2010.11.075

24. Memon, S. A., Khan, S., Wahid, I., Shestakova, Y., Ashraf, M. "Evaluating the Effect of Calcination and Grinding of Corn Stalk Ash on Pozzolanic Potential for Sustainable Cement-Based Materials", Advances in Materials Science and Engineering, 2020(1), pp. 1619480, 2020. https://doi.org/10.1155/2020/1619480
25. Di Giacomo, G., Romano, P. "Evolution of the olive oil industry along the entire production chain and related waste management", Energies, 15(2), pp. 465, 2022. https://doi.org/10.3390/en15020465
26. Pernicova, R., Kolomaznik, T. "Recycled Nanoparticles of Artificial Corundum as Fine-Grained Addition in Concrete Mixture", In: Materials Science Forum, City of Conference, Country of Conference, 2019, pp. 217–221. ISSN: 1662-9752. https://doi.org/10.4028/www.scientific.net/msf.947.217
27. Dal Poggetto, G., D'Angelo, A., Catauro, M., Barbieri, L., Leonelli, C. "Recycling of waste corundum abrasive powder in MK-based geopolymers", Polymers, 14(11), pp. 2173, 2022. https://doi.org/10.3390/polym14112173
28. Dal Poggetto, G., Kittisayarm, P., Pintasiri, S., Chiyasak, P., Leonelli, C., Chaysuwan, D. "Chemical and mechanical properties of metakaolin-based geopolymers with waste corundum powder resulting from erosion testing", Polymers, 14(23), pp. 5091, 2022. https://doi.org/10.3390/polym14235091
29. Karakaya, E., Kekeç, B., Bilim, N. "The relationship between texture coefficient (TC) values of magmatic rocks and Böhme abrasiveness values", In: VII. International Halich Congress on Multidisciplinary Scientific Research, Istanbul, Turkey, 2024, pp. 756–768. ISBN: 978-625-367-638-4.
30. Bozdağ, A. "Doğal Yapı Taşlarının Fiziko Mekanik Özellikleriyle Böhme Aşınma Direncinin Tahmini", *Mühendislik Bilimleri ve Tasarım Dergisi*, 8(4), pp. 1062–1071, 2020. (in Turkish) https://doi.org/10.21923/jesd.771863
31. Neville, A. M. "Properties of Concrete", Pearson Education Limited, London, 2011. ISBN: 978-0273755807.
32. Mehta, P. K., Monteiro, P. J. M. "Concrete: Microstructure, Properties, and Materials", McGraw-Hill Education, 2014. ISBN: 978-0071797870.
33. American Concrete Institute (ACI). "308R-01: Guide to Curing Concrete", American Concrete Institute, Farmington Hills, Michigan, United States of America, Rep. 308R-01, 2001.
34. Aydınlar Madencilik. "Korund Ürünü Bilgileri", [online] Available at: https://www.aydinlarmadencilik.com.tr/product/korund/aydinlarmadencilik.com.tr [Accessed: 7 June 2025].

35. Çimsa Çimento Sanayi ve Ticaret A.Ş. "Çimsa Super White Cement – Technical Data Sheet", [online] Available at: https://cimsa.com.tr/en/wp-content/uploads/sites/3/2022/02/super-white-technical-sheet.pdf [Accessed: 25 May 2025].
36. Turkish Standards Institution (TSI). TS EN 1936: Natural Stone Test Methods – Determination of Real Density and Apparent Density, and Open Porosity. TSI, Ankara, Turkey, 2007. https://doi.org/10.3403/01663707u
37. İnce, İ., Bozdağ, A. "An investigation on sample size in Leeb hardness test and prediction of some index properties of magmatic rocks", Arabian Journal of Geosciences, 14, pp. 1–13, 2024. https://doi.org/10.1007/s12517-021-06478-9
38. American Society for Testing and Materials (ASTM). Committee C01 on Cement. "Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (using 2-in. or [50 mm] Cube Specimens)", ASTM International, West Conshohocken, PA, USA, 2021. https://doi.org/10.1520/c0109_c0109m-20b
39. ISRM. "Suggested method for determining point load strength," International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, vol. 22, pp. 51–60, 1985. https://doi.org/10.1016/0148-9062(85)92327-7