International Journal of Applied Engineering & Technology

THE INFLUENCE IN PROPERTIES OF CONCRETE DUE TO PARTIAL REPLACEMENT OF SAND WITH SUSTAINABLE MATERIALS: A REVIEW

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ABSTRACT
The utilization of stone dust as a partial replacement for sand in concrete has garnered significant attention in recent years due to its potential to address both environmental concerns and the need for sustainable construction practices. This review paper aims to provide a comprehensive analysis of the effect of incorporating stone dust and waste material in concrete mixtures. It explores various aspects including the properties of stone dust, its influence on the fresh and hardened properties of concrete, and its impact on the durability and sustainability of concrete structures. By synthesizing existing research findings, this paper offers insights into the opportunities and challenges associated with using stone dust as a supplementary material in concrete production.

Keywords: Stone dust, marble powder, bottom ash, silica fume,

1. INTRODUCTION
Globally the binding agent used for the construction is cement which is further used to make concrete comes with significant environmental consequences, particularly due to the extraction and consumption of natural resources like sand. The depletion of natural sand resources & hazards from the environment related with its withdrawal led to researchers to explore substitute material that can partially substitute sand in concrete mixtures. Stone dust is a co-product of stone obtained by crushing, has emerged as a promising candidate in this purpose. This paper delves into the potential benefits and drawbacks of incorporating stone dust and waste material by replacing sand in concrete mixes.

1.2. PROPERTIES OF STONE DUST
Stone dust is a fine material obtained during the crushing of stones in quarries or stone crushing units. Its properties vary depending on the type of parent rock, crushing process, and grading. Typically, stone dust consists of particles ranging from fine sand-sized to dust-sized particles. It possesses angular and irregular shapes, and its chemical composition varies based on the source rock. The physical and chemical properties of stone dust play a crucial role in determining its suitability as a partial replacement for sand in concrete.

1.3 Influence on Properties of fresh concrete
The addition of stone dust in mixtures contains various fresh concrete properties such as workability, consistency, and setting time. Studies have shown that replacing a portion of sand with stone dust can lead to a reduction in workability due to its angular and rough texture. However, the application of water-reducing admixtures or adjusting the mix proportions can mitigate this issue. The time at which the concrete set can also be influenced by the presence of stone dust, necessitating adjustments in mix design to maintain desired setting characteristics.

1.4 Influence on Properties of hard concrete
The addition of stone dust in concrete can significantly impact the hardened properties of concrete, including compressive strength, flexural strength, and durability. Research findings have been mixed regarding the stone dust behavior on the strength of concrete, studies reporting developments while others indicate reductions compared to conventional concrete. Reason such as the particle size distribution, grading, and curing conditions play a vital role in determining the strength properties of concrete containing stone dust. Moreover, the inclusion of stone dust may influence other properties such as shrinkage, permeability, and abrasion resistance, which are critical for the high performance of concrete structures.

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1.5 Durability and Sustainability Considerations

One of the key motivations behind the use of stone dust in concrete is its potential to enhance the durability and sustainability of concrete structures. Stone dust, when properly graded and processed, can improve the microstructure of concrete, thereby reducing permeability and enhancing resistance to environmental factors such as freeze-thaw cycles, chloride ingress, and sulfate attack. Furthermore, by utilizing stone dust as a partial replacement for sand, the demand for natural sand can be reduced, mitigating the environmental impact of sand mining and promoting sustainable construction practices.

2.1 Review based on Sand Replacement using waste material

Chindaprasirt and Chareerat (2007) investigates the strength and water penetration resistance of lightweight concrete incorporating bottom ash aggregates. Lightweight concrete is crucial in construction due to its reduced density and enhanced properties. The researchers focused on bottom ash, a waste product from coal combustion, as an alternative aggregate material. They examined its effects on concrete properties, particularly compressive strength and resistance to water penetration.

Ismail, Al-Hashmi, and Al-Harthy investigated the impact of incorporating silica sand as a fine material in concrete. Their research focused on analyzing how the inclusion of silica sand influenced various properties of concrete, including compressive strength, workability, and durability. By examining these factors, the study aimed to provide insights into the suitability of silica sand as a component in concrete mixtures. This research contributes valuable information for optimizing concrete mix designs and enhancing the performance of concrete structures in construction projects.

Shetty and Parvez (2015) explored the impact of bottom ash as a substitute of fine aggregate in concrete. The author investigated how substituting fine aggregate with bottom ash influenced various properties of concrete. The researchers likely assessed factors such as compressive strength, workability, and durability to understand the feasibility and effectiveness of utilizing bottom ash in concrete production. Their findings contribute valuable insights into sustainable practices in concrete manufacturing and the utilization of industrial by-products in construction materials.

Duan, Shui, and Chen (2016) investigated the utilization of marble powder in the brick manufacturing. Their study focused on exploring the feasibility and effectiveness of incorporating marble powder into brick production processes. The researchers likely examined the impact of waste marble powder on various properties of bricks, such as compressive strength, durability, and environmental sustainability. By evaluating the waste marble powder in the brick industry, this research contributes to the growth of cost-effective construction materials.

Dinda, Prakash, and Das (2016) investigated the utilization of waste glass powder as a partial replacement for cement in concrete. Published in the Journal of Cleaner Production, their study aimed to explore the feasibility and effectiveness of incorporating waste glass powder into concrete mixtures. The researchers likely examined the influence of waste glass powder on various properties of concrete, including compressive strength, workability, and durability. By evaluating the use of waste glass powder as a cement replacement, this research contributes to sustainable practices in concrete production and waste management.

Nagaraj and Banu (2017) conducted a study on the partial replacement of sand with foundry sand in concrete. Published in the International Research Journal of Engineering and Technology, their research aimed to investigate the feasibility and effects of substituting conventional sand with foundry sand in concrete mixtures. The study likely examined the impact of foundry sand on various properties of concrete, including strength, workability, and durability. By evaluating the use of foundry sand as a sand replacement, this research contributes to sustainable practices in concrete production and waste utilization in the foundry industry.

Siddique and Singh (2012) explored the utilization of combustion by coal residues in workable materials used for construction. The research investigated the potential of incorporating coal combustion residues into concrete production to reduce environmental impact.

Dehwah, Al-Dulaijan, and Maslehuddin (2010) explored the utilization of plastic in concrete mixtures as an aggregate replacement. The research aimed to assess the feasibility of incorporating waste plastic into concrete production to address environmental concerns.

Ramezanianpour and Mahdikhani (2012) reviewed the pozzolanic behavior of nano silica (NS) in concrete. Published in Construction and Building Materials, the review synthesized existing research on the nano silica as a pozzolanic material in concrete production.

Rana and Tatineni (2017) studied the utilization of recycled coarse aggregates and ceramic tiles waste in concrete. Published in the International Journal of Engineering Science Invention, the research aimed to assess the feasibility of incorporating recycled coarse aggregates and ceramic tiles waste into concrete production.

2.2 Review based on sand replacement using dust

Siddique, R., & Khan, M. I. (2011) studies about the delves into the world of supplementary cementing materials (SCMs), which are substances added to concrete to improve its properties or to reduce the amount of cement required. SCMs such as fly ash, slag, silica fume, and rice husk ash are extensively discussed in this book, covering their types, properties, effects on concrete performance, and sustainability aspects. The authors provide valuable insights into the use of SCMs in concrete production, making it an essential reference for researchers, engineers, and practitioners in the field of concrete technology and construction materials.

Palanivel, R., Kandasamy, K., & Babu, G. K. (2018) investigates the substitute of sand which would be effective for use in concrete mix feasibly. Stone dust, a co-product of stone crushing operations, is evaluated for its potential to substitute sand in concrete, aiming to reduce the demand for natural sand and alleviate environmental concerns associated with its extraction. The findings contribute valuable insights into sustainable concrete production practices and alternative materials utilization.

Fig. 1 *Stone Dust*

Dehwah, H. A. F., Al-Dulaijan, S. U., & Maslehuddin, M. (2010) explores the application of waste plastic materials as a replace for conventional aggregates in mixtures. With the increasing concern over plastic waste management and its environmental impact, finding sustainable ways to incorporate waste plastics into construction materials is of great importance. The research investigates the mechanical properties, workability, and durability of concrete incorporating waste plastic particles, aiming to mitigate the environmental burden of plastic waste while enhancing the performance of concrete.

Fig. 2 *Marble Powder*

Siddique, R., & Singh, G. (2011) evaluates the performance of concrete mixtures containing commercially produced RCA as a replacement for natural coarse aggregate. RCA is obtained from demolished concrete structures and processed for reuse in new concrete, offering potential benefits in terms of resource conservation and waste reduction. The research investigates the properties, durability, and continuing performance of concrete incorporating RCA, aiming to assess its suitability for various construction applications. The findings provide valuable insights into the use of recycled materials for concrete production with their impact on concrete performance and sustainability.

Fig. 3 *Coarse Recycled Aggregate*

Bhanja, S., & Routara, B. C. (2016) investigates the influence of marble dust, a waste by-product from marble processing industries, on the engineering properties of expansive soils. The study examines the effects of incorporating marble dust into expansive soils on parameters such as compaction characteristics, swell potential, shear strength, and permeability. By mitigating the expansive behavior of soils and improving their engineering properties, marble dust shows promise as a soil stabilizer and construction material additive. The findings contribute to the understanding of sustainable soil improvement techniques and alternative materials utilization in geotechnical engineering applications.

Wang, H. Y., Zhang, L. H., & Li, H. Q. (2018) investigates the impact of different cementitious materials on the carbonation process of concrete. Carbonation is a reaction between CO_2 in the atmosphere and hydrated cement phases in concrete, which effect the durability & performance of structures. The research evaluate the Portland

cement, fly ash, slag to understand their influence on the rate and depth of carbonation in concrete. The findings provide insights into optimizing concrete mix designs for enhanced carbonation resistance, contributing to the development of more durable and sustainable concrete structures.

Ahmed et.al (2018) investigates the effect of incorporating limestone powder as a partial replacement for crushed quarry sand in self-compacting repair mortars. Self-compacting repair mortars are specially formulated materials used for repairing and retrofitting concrete structures without the need for vibration. The research examines the workability, and durability of restoration of mortars having varying proportions of limestone powder, aiming to enhance their performance and sustainability. The findings offer valuable insights into optimizing repair mortar compositions for effective repair and maintenance of concrete structures.

Cheng, T. W., & Lin, T. K. (2014) investigates the early hydration characteristics of PPC in the presence of stone powder, a by-product stone crushing operation. Hydration is the reaction between cement and water, which forms the binding matrix in concrete. Understanding the early hydration process is crucial for predicting the setting time, strength development, and overall performance of concrete. The research examines the impact of stone powder on the hydration kinetics and microstructure evolution of cement mortar, providing insights into the possible use of stone powder as a supplementary binding material. The findings contribute to optimize the concrete mix design.

Dhinakaran, G., & Ravichandran, P. T. (2014) worked on the stone dust made by crushing and utilized for the replace of sand in concrete. Fine aggregate, typically sand, plays a crucial role in concrete mixtures by providing workability, cohesiveness, and volume stability. However, the increasing demand for sand in construction has led to environmental concerns related to its extraction. The research investigates the mechanical properties, workability, and durability of concrete incorporating stone dust as a fine aggregate replacement, aiming to mitigate the environmental impact of sand mining while maintaining concrete performance. The findings provide valuable insights into sustainable concrete production practices and alternative materials utilization.

Ganesan, N., & Rajagopal, K. (2008) investigates the feasibility of partially replacing cement with quarry dust, a by-product of stone quarrying operations, in concrete mixtures. Cement, as the binding agent in concrete, significantly contributes to its environmental footprint due to the energy consumption & emissions by carbon associated within the production. The research explores the properties of concrete incorporating varying proportions of dust as a cement replace, aiming to minimize the impact done by environmental of concrete production while maintaining performance.

Rahmad, R. et.al (2016) investigates the effect of incorporating fly ash and quarry dust, two industrial by-products, on the properties of concrete. Fly ash, a residue from coal combustion, and quarry dust, a by-product of stone quarrying operations, are commonly used as supplementary cementitious materials and fine aggregate replacements, respectively, in concrete production. The research evaluates the workability, and durability containing varying combinations such as fly ash and quarry dust, aiming to optimize their synergistic effects on concrete performance. The findings contribute to the development of sustainable concrete mix designs.

***Fig. 4** Quarry Dust*

Safiuddin, M., West, J. S., & Soudki, K. A. (2016) investigates the influence of replacing cement with limestone powder on the properties of concrete. Limestone powder, a finely ground form of limestone, is increasingly used as a supplementary cementitious material in concrete production due to its pozzolanic and filler effects. The study examines the mechanical properties, durability, and microstructural characteristics of concrete containing various proportions of limestone powder as a cement replacement. The findings provide insights into the effects of limestone powder on concrete performance, including its impact on strength, workability, and durability properties. The research contributes to the optimization of concrete mix designs and the utilization of limestone powder as a sustainable alternative to cement in concrete production.

Hameed Shahul et.al (2012) investigates the green concrete incorporating quarry dust and marble sludge powder in replace of fine aggregate. Green concrete, also known as eco-friendly or sustainable concrete, is characterized by reduced environmental impact and improved sustainability compared to conventional concrete. The research evaluates the mechanical properties, workability, and durability of green concrete mixtures containing varying proportions of quarry rock dust and marble sludge powder, aiming to optimize their performance and sustainability.

***Fig. 5** Sludge Powder*

Zhang, M. H., & Malhotra, V. M. (1995) investigates the incorporation of rice husk ash (RHA) as a supplementary cementitious material in high-performance concrete (HPC). The study explores the properties, durability, microstructural details of HPC containing varying proportions of RHA, aiming to enhance concrete performance and sustainability. The findings provide valuable insights into the effects of RHA on HPC properties, including its impact on strength, and durability. The research contributes to the development of sustainable concrete mix designs and the utilization of agricultural waste materials in construction.

***Fig. 6** Rice Husk Ash*

Yüksel, İ., & Sarıdemir, M. (2019) examines the impact of adding marble dust to cement mortars on their mechanical properties and shrinkage behavior. Marble dust, a by-product of marble processing, is investigated for its potential to enhance the performance of cement mortars. The research evaluates the strength and shrinkage characteristics of cement mortars containing varying proportions of marble dust. By analyzing the mechanical behavior and shrinkage properties of marble dust-modified mortars, the study provides valuable insights into optimizing mortar compositions for improved performance and durability.

Singh, M., & Gupta, S. K. (2013) assesses the suitability of a mixture of marble dust and fly ash as a cost-effective alternative for concrete production. Marble dust and fly ash, both industrial by-products, are investigated for their potential to replace conventional aggregates and cement, respectively, in concrete mixtures. The study evaluates the properties by mechanical equipment, workability, and durability of concrete incorporating marble dust and fly ash, aiming to develop low-cost concrete mix designs without compromising performance. The findings contribute valuable insights into utilizing industrial by-products in concrete production and reducing construction costs while maintaining concrete quality.

Patel, R., & Mehta, P. K. (2018) investigates the impact in durability of concrete paving blocks when marble dust is present in it. Concrete paving blocks are commonly used in various outdoor applications, including sidewalks, driveways, and pavements, where durability and resistance to environmental factors are crucial. The research examines the abrasion resistance, water absorption, and freeze-thaw durability of concrete paving blocks containing marble dust. By assessing the performance of marble dust-modified paving blocks under different environmental conditions, the study provides valuable insights into enhancing the durability and longevity of concrete infrastructure using marble dust.

Ramachandran, S., & Ramamurthy, K. (2015) investigates the effect of marble powder on the characteristics of mortar and concrete mixes. Marble powder, a waste material from marble processing industries, is evaluated for its potential to improve the qualtiy of mortar and concrete mixtures. The research examines the workability, compressive strength, and durability of mortar and concrete containing varying proportions of marble powder. By

analyzing the effects of marble powder on mortar and concrete properties, the study provides valuable insights into optimizing mix designs for enhanced performance and sustainability in construction applications.

3. CONCLUSION

In conclusion, the incorporation of dust as a partial substitution of sand in concrete shows promise as a sustainable alternative that can address environmental concerns and contribute to the development of durable and high-performance concrete structures. While challenges exist in terms of variability and compatibility, ongoing research efforts are advancing our understanding of the properties and behavior of concrete containing stone dust. By overcoming these challenges and leveraging its potential benefits, stone dust has the potential to play a significant role in the future of sustainable construction practices.

REFERENCES

1) Chindaprasirt, P., & Chareerat, T. (2007). Strength and water penetration resistance of lightweight concrete containing bottom ash aggregates. Cement and Concrete Composites, 29(3), 224-229.

2) Ismail, Z., Al-Hashmi, E. A., & Al-Harthy, A. S. (2003). Effect of use of silica sand as fine material in concrete. Journal of Materials in Civil Engineering, 15(5), 443-447.

3) Shetty, M. S., & Parvez, I. (2015). Effect of bottom ash as replacement of fine aggregate in concrete. International Journal of Scientific and Research Publications, 5(7), 1-4.

4) Duan, P., Shui, Z. H., & Chen, W. Y. (2016). Use of waste marble powder in brick industry. Construction and Building Materials, 128, 53-59.

5) Dinda, S., Prakash, R., & Das, S. K. (2016). Utilization of waste glass powder as a partial replacement of cement in concrete. Journal of Cleaner Production, 116, 65-74.

6) Nagaraj, T. S., & Banu, Z. (2017). Study on partial replacement of sand with foundry sand in concrete. International Research Journal of Engineering and Technology, 4(2), 2188-2191.

7) Kaur, S., Singh, S., & Gupta, T. (2018). Strength and durability study of concrete using marble powder as replacement of cement and sand. International Journal of Research in Engineering and Technology, 7(6), 66-70.

8) Siddique, R., & Singh, G. (2011). Performance of concrete made with commercially produced coarse recycled concrete aggregate. Cement and Concrete Research, 41(3), 235-248.

9) Siddique, R., & Singh, G. (2012). Utilization of coal combustion residues in sustainable construction materials. Resources, Conservation and Recycling, 66, 1-2.

10) Li, J., & Zhang, Z. (2018). Effect of using stone powder as a partial replacement of sand on the properties of concrete. Journal of Materials in Civil Engineering, 30(10), 04018342.

11) Siddique, R., & Singh, G. (2012). Effect of fine aggregate replacement with Class F fly ash on the mechanical properties of concrete. Cement and Concrete Research, 42(3), 554-559.

12) Dehwah, H. A. F., Al-Dulaijan, S. U., & Maslehuddin, M. (2010). Use of waste plastic in concrete mixture as aggregate replacement. Waste Management, 30(11), 2255-2261.

13) Ramezanianpour, A. A., & Mahdikhani, M. (2012). Pozzolanic behavior of nano silica (NS) in concrete: A review. Construction and Building Materials, 29, 573-581.

14) Sheral, S., & Jothi, R. K. (2016). Experimental investigation on partial replacement of sand by quarry dust in concrete. International Journal of Innovative Research in Science, Engineering and Technology, 5(8), 15102-15110.

15) Ling, T. C., Poon, C. S., & Lam, W. H. (2016). Use of recycled aggregates in molded concrete bricks and blocks. Construction and Building Materials, 111, 112-118.

16) Zhang, M. H., & Malhotra, V. M. (1995). High-performance concrete incorporating rice husk ash as a supplementary cementing material. ACI Materials Journal, 92(6), 664-671.

17) Parande, A. K., & Devkar, A. V. (2015). Experimental investigation on partial replacement of natural sand by waste foundry sand. International Journal of Advanced Research in Science and Technology, 4(2), 50-56.

18) Topçu, İ. B., & Sarıdemir, M. (2007). Properties of concrete containing waste glass. Cement and Concrete Research, 37(6), 951-957.

19) Rana, D., & Tatineni, B. (2017). Utilization of recycled coarse aggregates and ceramic tiles waste in concrete. International Journal of Engineering Science Invention, 6(6), 2319-6734.

20) Akhtar, S., Ahmad, M., & Bhattacharyya, S. K. (2016). Use of brick kiln dust as pozzolanic material in concrete: A review. Construction and Building Materials, 105, 28-42.

21) Siddique, R., & Khan, M. I. (2011). Supplementary cementing materials. Springer Science & Business Media.

22) IS 383:1970. Specification for coarse and fine aggregates from natural sources for concrete (Second Revision).

23) Palanivel, R., Kandasamy, K., & Babu, G. K. (2018). Partial replacement of sand with stone dust as fine aggregate in concrete. International Journal of Civil Engineering and Technology, 9(8), 1002-1011.

24) Dehwah, H. A. F., Al-Dulaijan, S. U., & Maslehuddin, M. (2010). Use of waste plastic in concrete mixture as aggregate replacement. Waste Management, 30(11), 2255-2261.

25) Siddique, R., & Singh, G. (2011). Performance of concrete made with commercially produced coarse recycled concrete aggregate. Cement and Concrete Research, 41(3), 235-248.

26) Bhanja, S., & Routara, B. C. (2016). Effect of marble dust on engineering properties of expansive soil. In Advances in Geotechnics (pp. 349-357). Springer, Singapore.

27) Wang, H. Y., Zhang, L. H., & Li, H. Q. (2018). Experimental study on effects of cementitious materials on carbonation of concrete. Construction and Building Materials, 172, 378-386.

28) Ahmed, A. A., & Abd-Elmoaty, A. M. (2018). Effect of limestone powder as a partial replacement of crushed quarry sand on properties of self-compacting repair mortars. Journal of Building Engineering, 20, 207-214.

29) Cheng, T. W., & Lin, T. K. (2014). Early hydration of Portland cement with stone powder. Construction and Building Materials, 66, 34-38.

30) Dhinakaran, G., & Ravichandran, P. T. (2014). Utilization of stone dust as fine aggregate replacement in concrete. ARPN Journal of Engineering and Applied Sciences, 9(3), 284-288.

31) Ganesan, N., & Rajagopal, K. (2008). Experimental study on partial replacement of cement with quarry dust. Advances in Engineering and Technology, 1(2), 99-106.

32) Rahmad, R., Azmi, S. A., Ibrahim, M. H. W., & Hussin, M. W. (2016). Effect of fly ash and quarry dust on properties of concrete. Procedia Engineering, 148, 292-296.

33) Safiuddin, M., West, J. S., & Soudki, K. A. (2016). The influence of cement replacement by limestone powder on concrete properties. Construction and Building Materials, 113, 228-236.

34) Shahul Hameed, M. S., & Sekar, A. S. S. (2012). Properties of green concrete containing quarry rock dust and marble sludge powder as a fine aggregate. ARPN Journal of Engineering and Applied Sciences, 7(9), 1154-1159.

35) Zhang, M. H., & Malhotra, V. M. (1995). High-performance concrete incorporating rice husk ash as a supplementary cementing material. ACI Materials Journal, 92(6), 664-671.

36) Yüksel, İ., & Sarıdemir, M. (2019). The effects of marble dust addition on mechanical properties and shrinkage of cement mortars. Construction and Building Materials, 196, 470-478.

37) Singh, M., & Gupta, S. K. (2013). Evaluation of marble dust and fly ash mixture for low-cost concrete. Journal of Materials in Civil Engineering, 25(7), 936-944.

38) Patel, R., & Mehta, P. K. (2018). Effect of marble dust on durability of concrete paving blocks. Journal of Cleaner Production, 182, 944-953.

39) Ramachandran, S., & Ramamurthy, K. (2015). Influence of marble powder mortar and concrete mix. The Indian Concrete Journal, 89-93.

40) Ramezanianpour, A. A., & Mahdikhani, M. (2012). Pozzolanic behavior of nano silica (NS) in concrete: A review. Construction and Building Materials, 29, 573-581.