IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

Utilizing Kota Stone Slurry As A Sustainable Alternative In Cement Mortar Mixes: A Comprehensive Study On Strength And Environmental Impact

[1]Mohammad Saqib Wafai, [2]Dr. Om Prakash Sharma

[1]M.tech Scholar, Department of Civil Engineering, JCDMCOE, Sirsa-125055

[2]Assistant Professor, Department of Civil Engineering, JCDMCOE, Sirsa-125055

ABSTRACT

Kota stone, a fine-grained limestone primarily found in Rajasthan's Kota, Jhalawar, and Chittorgarh districts, generates a significant amount of waste during its cutting and polishing processes. This waste, known as Kota stone slurry, presents environmental and health risks if not managed effectively. Recent studies have highlighted the potential of integrating Kota stone slurry into mortar mixes, offering substantial benefits.

Initially, the incorporation of Kota stone slurry in mortar led to improvements in gradation and workability, particularly up to a 30% replacement level, resulting in significant water savings. Furthermore, enhancements in compressive strength, flexural strength, and tensile strength at 28 days were observed, reaching a peak at a 40% replacement threshold before experiencing a slight decline. It is noteworthy that the adhesive strength of mortar reached its maximum at the control mix but gradually decreased with increasing levels of Kota stone slurry replacement.

In addition, mortars containing slurry exhibited higher water absorption rates compared to conventional river sand mortar, attributed to Kota stone slurry's superior water absorption capacity. In terms of durability, the mortar blend with a 40% sand replacement by Kota stone slurry demonstrated exceptional stability, making it suitable for construction in acidic or sulfate-rich soils and industrial areas with elevated pollutant levels.

Overall, the findings underscore the potential of integrating Kota stone slurry into mortar mixes as a constructive solution, particularly in mitigating environmental impact and enhancing the performance of construction materials. Moreover, the potential use of marble powder as a sand substitute, up to 50% by volume, offers an alternative approach for environments not exposed to sulfate and acidic conditions.

Keywords: Kota Stone, Slurry, Durability, cement

Introduction

Human reliance on natural resources for basic needs like food and shelter is undeniable. However, the rate of consumption now surpasses the Earth's replenishment rate by about 30%, posing significant environmental concerns. The construction industry's high demand for natural stone has particularly strained resources like river sand, leading to bans on its mining due to environmental and societal impacts.

Kota stone, a calcareous stone from Rajasthan, emerges as a promising alternative. Known for its vibrant colors and smooth texture, it is used in both residential and commercial construction. India's reserves of calcareous stones, including Kota stone, are vast, with an annual production of approximately 188.6 million tons. Despite its economic benefits, Kota stone mining generates significant waste, estimated at 140 million cubic meters annually, exacerbating environmental degradation and affecting agriculture in mining areas like Kota and Jhalawar districts.

The waste generated from Kota stone mining is predominantly dumped on fertile land, causing soil degradation, water pollution, and air quality issues. Only 35% of this waste is used for backfilling, necessitating the acquisition of new land for disposal each year. The visible waste dumps not only degrade the environment but also reduce agricultural productivity and harm local wildlife.

Sustainable practices are essential to mitigate these negative impacts. Innovative approaches such as using waste stone fragments in cement production or reusing slurry in brick manufacturing can reduce waste and promote a circular economy. Furthermore, sustainable waste management practices, including reusing waste for road construction and treating slurry for irrigation, can help minimize environmental damage.

Efforts to balance the economic benefits of Kota stone with its environmental impacts are crucial. By adopting sustainable practices, the stone industry can reduce waste, promote resource efficiency, and support a more environmentally responsible construction sector. This aligns with the principles of sustainable development, ensuring that natural resources are conserved for future generations while promoting economic growth.

In conclusion, the overexploitation of natural resources in construction can be mitigated by adopting sustainable alternatives like Kota stone and implementing effective waste management strategies. These practices not only address environmental concerns but also enhance the sustainability and viability of the construction industry, helping to build a better future for both people and the planet.

Literature Review

A comprehensive review of literature is essential in scientific research. Shyam and Drishya (2018) examined the replacement of M sand with High Density Polyethylene (HDPE) powder in concrete, finding optimal strength and workability at 5% replacement, despite decreased workability at higher levels. Charudatta P. Thosar and Dr. M. Husain (2017) found that replacing 20%-40% of natural sand with recycled PET or PP plastic waste yielded satisfactory M20 grade concrete, promoting sustainability. M. Guendouz and Farid Debieb (2016) studied the use of PET and LDPE plastic waste as sand aggregates in concrete, noting positive effects on concrete properties. Patel et al. (2013) observed increased compressive strength up to 30% when substituting OPC with slurry stone waste. Rana et al. (2016) found that blending 85% crushed stone waste with 15% slurry could fully replace river sand, enhancing concrete strength and reducing permeability. Vidyanagar et al. (2016) explored the use of Kota Stone chips in rubber mould paver blocks, achieving a 2% compressive strength increase and a 2.90% cost reduction at 40% replacement without significant water absorption changes. Khandve et al. (2016) found optimal properties with 50% replacement of traditional aggregate with Kota stone waste in concrete paving blocks. Omar M. Omar et al. (2012) reported that using limestone waste and marble powder as sand replacements improved concrete compressive strength by 12% at 50% replacement, with enhanced workability. P. K. Sharma et al. (2007)

highlighted that acidic environments significantly reduce Kota Stone's strength, stressing environmental considerations. Pawan Kalla et al. (2006) improved soil properties by mixing black cotton soil with Kota stone slurry and fly ash. Nejad et al. (2013) found that recycled mineral aggregate in hot mix asphalt increased binder content and decreased fatigue life but performed well up to 60% replacement in medium traffic roads. Ibrahim et al. (2009) improved asphalt concrete mix properties using basalt, limestone, and lime filler. M. Karasahin et al. (2007) recommended marble dust filler in asphalt for low-volume roads, reducing plastic deformations up to 7%. Javad Torkaman et al. (2014) found that 25% replacement of Portland cement with wood fiber waste, rice husk ash, and limestone powder produced lightweight concrete blocks with high energy absorption and reduced bulk density.

Harshwardhan Singh Chouhan (2021) identified optimal performance in mortar mixes with 10% Kota stone slurry as a cement substitute. Vishnu Kumawat (2023) found that 10% replacements of cement and fine aggregate with Kota stone waste slurry and demolition construction waste yielded the best concrete performance. P. Kumar Gautam (2022) explored the use of limestone mining waste in flexible pavements, finding that 17-19% slurry improved soil strength and workability, while 50% and 25% recycled aggregates worked well in bituminous concrete and dense bituminous macadam, respectively, promoting sustainability in construction. Additionally, research by Patel et al. (2013), Rana et al. (2016), and Vidyanagar et al. (2016) further supports the benefits of incorporating waste materials in construction, showcasing improvements in compressive strength, cost reductions, and environmental conservation. Overall, these studies highlight the potential for various waste materials to be effectively utilized in construction, contributing to sustainable practices and enhanced material properties.

Material and Methods

After a thorough literature review, Kota stone slurry waste was chosen as a replacement for sand in mortar (1:4) in various proportions. The methodology for this research involves material procurement, experimental analysis, and testing according to ASTM standards.

Material Procurement

- Cement: Pozzolana Portland Cement (PPC)
- Sand: River sand (zone 3)
- Kota stone slurry: Passing from a 1.18mm sieve

Experimental Analysis

Mortar samples were prepared with different percentages of Kota stone slurry (0%, 10%, 20%, 30%, 40%, up to 100%) as a replacement for sand. The following tests were conducted to evaluate the physical and mechanical properties of the mortar:

- Physical properties of sand and Kota stone slurry
- Workability of mortar
- Compressive, tensile, and flexural strength of mortar (1:4)
- Ultrasonic pulse velocity test
- Durability test
- Water absorption test
- Pull-off test

These tests provided comprehensive data on the effectiveness of using Kota stone slurry as a sand replacement in mortar.

Results and discussion

The study delved into the potential utilization of Kota stone slurry (KSS) as a substitute for sand in mortar mixes, focusing on its impact on various properties such as gradation, workability, and mechanical strength. Gradation analysis, depicted in Figure 9, illustrated that KSS possesses finer particles compared to river sand (RS). This finding suggested the potential for improved mortar packing and enhanced compressive strength through the incorporation of KSS. However, it was noted that the finer particles of KSS required higher water content to achieve the desired workability, highlighting the need for adjustments in mix ratios to balance workability and strength, as indicated by the variations in water-cement (w/c) ratio illustrated in Table 2 and Figure 10.

The investigation extended to mechanical strength assessments, including compressive, flexural, and tensile strength tests. Table 3 and Figure 11 demonstrated that the compressive strength of mortar increased with the incorporation of KSS, reaching a maximum at 50% replacement level for both 7 and 28 days curing periods. Similarly, flexural strength, as depicted in Table 4 and Figure 12, exhibited a peak at the 50% replacement level, indicating the optimal balance between KSS content and mechanical strength. Tensile strength, outlined in Table 5 and Figure 13, followed a similar trend, with maximum strength observed at 50% replacement, signifying the beneficial effect of KSS on mortar strength.

Moreover, non-destructive testing methods such as ultrasonic pulse velocity (UPV) were employed to assess the structural integrity of mortar specimens. Table 6 and Figure 14 revealed that the UPV reached its maximum at 40% replacement, suggesting improved gradation and lower porosity. However, excessive replacement levels led to increased porosity and a subsequent decrease in pulse velocity, emphasizing the importance of optimal KSS content for structural performance.

Finally, resistance to environmental factors such as acids and sulphates was evaluated. Figures 16 and 17 illustrated the weight gain and compressive strength changes of mortar specimens exposed to sulfate solution, highlighting the mitigating effect of KSS on sulfate attack. Similarly, Figures 18 and 19 demonstrated the response of mortar mixes to acidic medium exposure, with the 30% substitution level exhibiting the most stable performance. These findings underscored the potential of KSS in enhancing the durability and resilience of mortar mixes against harsh environmental conditions, thereby offering insights for sustainable construction practices.

Conclusion

The research utilized Kota stone slurry as a replacement for river sand in a mortar blend consisting of 1 part cement to 4 parts sand. A series of 11 mixes were formulated, incorporating Kota stone slurry in varying percentages from 0% to 100% to replace sand.

Initially, up to a 30% replacement level, the introduction of Kota stone slurry led to improved gradation and workability, resulting in optimal water savings. As the quantity of Kota stone slurry increased, the compressive strength, flexural strength, and tensile strength at 28 days exhibited continuous enhancement up to a 50% replacement threshold, beyond which a decline was observed.

The adhesive strength of the mortar in masonry peaked at the control mix and gradually diminished with increasing levels of Kota stone slurry replacement, reaching its lowest point at the 100% replacement level.

Furthermore, due to the higher water absorption capacity of Kota stone slurry compared to river sand, mortars containing slurry absorbed more water, highlighting a crucial consideration in mix design.

In terms of durability, the mortar mix with a 30% sand replacement by Kota stone slurry showcased the highest stability. When subjected to aggressive environments, this mix demonstrated a lesser decrease in compressive strength compared to the control mortar. These findings suggest the potential suitability of this mortar blend for construction in acidic or sulfate-rich soils and industrial areas with elevated pollutant levels. Additionally, in environments not exposed to sulfate and acidic conditions, marble powder could serve as a viable substitute for sand, up to 50% by volume.

References

1. Rana, Aditya, Pawan Kalla, H. K. Verma, and J. K. Mohnot. "Recycling of dimensional stone waste in concrete: A review." Journal of Cleaner Production 135 (2016): 312-331.

2. Lakhani, R., Kumar, R. and Tomar, P., 2014. Utilization of stone waste in the development of value added products: a state of the art review. Journal of Engineering Science and Technology Review, 7(3), pp.180-187.

3. Jain, Swati, Ritu Mathur, M. P. S. Chandrawat, and Prerna Sudan. "Use of Kota stone waste to ameliorate the soil fertility and to alleviate environmental hazards."

4. Farhana S, Bhumika P,Jayesh P,.Pitroda J, Int.J. Eng. Trends Technol.**2013**,Volume 4 ,Issue 8,142

5. Pappu A, Saxena M, Arolekar S, Build. Environ. J.,**2007,** 42(6), 2311-2320.

6. Sudan P, Mathur R, Jain S Int. J.Pharm Bio Sci.**2015**,6(2),81-84

7. Patel, Ankit Nileshchandra, and Jayeshkumar Pitroda. "Stone waste in India for concrete with value creation opportunities." International Journal of Latest Trends in Engineering and Technology 2, no. 2 (2013): 113-120.

8. Vekariya, Mayur Shantilal, and Jayeshkumar Pitroda. "TECHNO-ECONOMICAL ANALYISIS FOR STONE CHIPS AS COARSE AGGREGATE IN CONCRETE."

9. Khandve, P. V., and A. S. Rathi. "Concrete Paving Block using Marble Stone Industry Waste."

10. Omar, O.M., Elhameed, G.D.A., Sherif, M.A. and Mohamadien, H.A., 2012. Influence of limestone waste as partial replacement material for sand and marble powder in concrete properties. HBRC Journal, 8(3), pp.193-203.

11. Sharma, P.K., Khandelwal, M. and Singh, T.N., 2007. Variation on physico-mechanical properties of Kota stone under different watery environments. Building and Environment, 42(12), pp.4117-4123.

12. Rana, A., Kalla, P. and Csetenyi, L.J., 2017. Recycling of dimension limestone industry waste in concrete. International Journal of Mining, Reclamation and Environment, 31(4), pp.231-250.

13. Nejad, F.M., Azarhoosh, A.R., Hamedi, G.H. and Azarhoosh, M.J., 2012. Influence of using nonmaterial to reduce the moisture susceptibility of hot mix asphalt. Construction and Building Materials, 31, pp.384-388.

14. Asi, I.M., 2007. Evaluating skid resistance of different asphalt concrete mixes. Building and Environment, 42(1), pp.325-329.

15. Karaşahin, M. and Terzi, S., 2007. Evaluation of marble waste dust in the mixture of asphaltic concrete. Construction and Building Materials, 21(3), pp.616-620.
16. Babu, T.R. and Neeraja, D., 2016. Rice Husk Ash as Supplementary Material in Concrete–A Review. International Journal of ChemTech Research, 9(5), pp.332-337.
17. Khyaliya, R.K., Kabeer, K.S.A. and Vyas, A.K., 2017. Evaluation of strength and durability of lean mortar mixes containing marble waste. Construction and Building Materials, 147, pp.598-607.
18. Harshwardhan Singh et. Al (2021). Effect of Kota stone slurry on strength properties of cement mortar mixes January 2021, Materials Today Proceedings 44
19. Vishnu Kumawat et al., Utilization of Kota stone slurry along with demolition and construction waste in concrete, Mater. Today Proc. (2023)
20. P. Kumar Gautam *et al.* Use of dimensional limestone mining waste as flexible pavement material Mater. Today Proc. (2022)
21. Pradeep Kumar Gautam (2022) Use of dimensional limestone mining waste as flexible pavement material, Mater. Today Proc, Volume 65, Part 2, 2022, Pages 2016-2020.