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Use of dredged material in cement bricks manufacturing

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Abstract : The rapid depletion of natural river sand, combined with the environmental challenges associated with the disposal of dredged material, has created an urgent need for sustainable alternatives in the construction industry. This study investigates the feasibility of utilizing dredged material as a partial and full replacement for fine aggregate in the production of cement bricks. Cement bricks were manufactured by replacing natural sand with dredged material at varying proportions. The bricks were cast in standard moulds and cured for 7 and 28 days under controlled conditions. Water absorption tests were conducted to evaluate the durability characteristics of the bricks. The results indicate that bricks incorporating dredged material initially exhibited a reduction in water absorption due to improved particle packing and reduced voids, followed by an increase at higher proportions owing to the finer particle size and higher porosity of the dredged material. The study concludes that dredged material can be effectively utilised for non-structural applications, thereby contributing to sustainable construction practices and environmentally responsible waste management.

Keywords : Dredged material, cement bricks, fine aggregate replacement, sustainable construction.

I.INTRODUCTION

The construction industry is one of the largest consumers of natural resources, particularly natural river sand, which is widely used as fine aggregate in concrete and masonry works. Rapid urbanisation, population growth and infrastructure development have significantly increased the demand for sand, leading to excessive extraction and serious environmental issues such as riverbank erosion, disruption of aquatic ecosystems, depletion of groundwater levels and long-term ecological imbalance. In response to these challenges, the identification of sustainable and environmentally responsible alternatives to natural sand has become essential in civil engineering practice. At the same time, large quantities of dredged material are generated annually from the maintenance of rivers, ports, harbours and navigation channels. Although dredging is necessary for maintaining navigable water depths, the disposal of dredged material presents considerable environmental and logistical challenges, as it is often treated as waste and disposed of in landfills or designated dumping areas, resulting in inefficient land use and potential environmental impacts. However, when properly processed and characterised, dredged material may possess physical properties similar to natural sand, making it a viable alternative for construction applications.

Cement bricks are widely used in non-load-bearing applications such as partition and boundary walls and provide a suitable medium for incorporating alternative materials due to their relatively simple manufacturing process. The utilisation of dredged material in cement brick production offers dual benefits by reducing dependence on natural sand and addressing waste disposal concerns. Although previous studies have explored the use of alternative fine aggregates, limited research has focused on evaluating dredged material in cement bricks based on durability aspects. Therefore, this study aims to investigate the feasibility of using dredged material as a partial and full replacement for natural sand in cement brick manufacturing by analysing its water absorption characteristics after curing.

III.RESEARCH METHODOLOGY

3.1 Literature review

Bhairappanavar et al. (2021) investigated the feasibility of using sieved dredged material as a replacement for conventional river sand in cement-stabilised bricks. The study aimed to reduce the excessive extraction of natural sand while promoting the beneficial reuse of dredged sediments. Different brick mixes containing 8–12% cement as a stabilizing agent were prepared and tested for compressive strength, water absorption, and durability under freeze–thaw cycles. The results showed that the bricks achieved compressive strengths ranging from 10.3 to 17.2 MPa, meeting the requirements for construction applications. Water absorption remained within acceptable limits, and the bricks exhibited good resistance to freeze–thaw damage. A life cycle assessment also revealed lower embodied energy and reduced carbon dioxide emissions compared with conventional bricks, highlighting the environmental advantages of using dredged material.

Nguyen et al. (2024) developed non-fired bricks using stabilised dredged material combined with fly ash, lime, and cement. The objective was to produce sustainable construction materials while reducing energy consumption associated with fired brick production. Various combinations of stabilizing materials were evaluated, and the bricks were cured for periods ranging from 7 to 28 days. Mechanical and durability tests demonstrated that the bricks attained the required strength and exhibited satisfactory durability after curing. The incorporation of fly ash and lime enhanced the binding properties of the mix, resulting in improved strength and stability. The study also highlighted that the use of dredged material in non-fired bricks reduces the consumption of natural resources and minimizes the environmental impacts associated with sediment disposal. The study concluded that stabilised dredged material can be successfully used for manufacturing non-fired bricks suitable for erosion control structures and other civil engineering applications, thereby supporting sustainable waste management.

Bortali et al. (2023) evaluated harbour dredged sediments to determine their suitability for reuse in construction materials. Detailed laboratory investigations, including grain size distribution, organic matter content, and contaminant analysis, were conducted to assess the physical and chemical characteristics of the sediments. The findings indicated that, after appropriate treatment and quality control, the dredged sediments could be safely incorporated into construction products without posing significant environmental risks. The study suggested that proper processing techniques can improve the quality and consistency of dredged sediments for construction use. It also highlighted the importance of regular monitoring to ensure compliance with environmental standards. The study emphasized the importance of sediment characterization and treatment in promoting sustainable waste valorisation and reducing dependence on natural construction materials.

Hussain et al. (2022) explored the production of sustainable adobe bricks using harbour and river dredged sediments. Dynamic compaction techniques and natural fibres were incorporated into the brick manufacturing process to improve mechanical performance. The bricks underwent controlled drying before testing for compressive strength, toughness, and fibre distribution. The results demonstrated that the inclusion of natural fibres enhanced crack resistance and toughness, while controlled drying improved overall structural integrity. The manufactured bricks exhibited satisfactory engineering properties for low-cost construction applications. The study also demonstrated that combining dredged sediments with natural fibres enhances the sustainability of adobe brick production. The study highlighted the potential of dredged sediments as environmentally friendly raw materials for adobe brick production, reducing landfill disposal and encouraging resource recovery.

Yang et al. (2021) investigated the production of non-sintered permeable bricks using lightweight aggregates manufactured from dredged sediments. The objective was to produce permeable paving materials capable of improving urban drainage while utilizing waste sediments. The bricks were tested for compressive strength, water permeability, and freeze–thaw resistance. The results showed that the bricks possessed adequate mechanical strength, excellent water permeability, and good durability under freeze–thaw conditions. The permeable structure of the bricks makes them suitable for pavements and other stormwater management applications. The study demonstrated that dredged sediments can be effectively converted into value-added construction materials with minimal environmental impact. The study demonstrated that dredged sediment-based lightweight aggregates can be effectively used to manufacture environmentally sustainable permeable bricks.

Srushti et al. (2022) assessed the suitability of dredged material collected from the New Mangalore Port for clay brick manufacturing. The physical, chemical, and mineralogical properties of the dredged material were characterized using Scanning Electron Microscopy (SEM) and X-ray Diffraction (XRD). The analyses confirmed that the material contained mineral constituents compatible with conventional clay used in brick production. The characterization results indicated that the dredged material possessed favourable properties for partial replacement of natural clay. The study also highlighted the environmental benefits of utilizing port dredged material instead of disposing of it as waste. Based on the experimental findings, the researchers concluded that dredged material could serve as a sustainable alternative raw material for manufacturing clay bricks, thereby reducing environmental impacts associated with sediment disposal.

Solanki et al. (2023) presented a comprehensive review of dredged material management, focusing on its sources, characteristics, environmental concerns, and utilization strategies. The review discussed the application of dredged materials in construction, agriculture, ecosystem restoration, land reclamation, and coastal protection. It also examined regulatory frameworks, material characterization methods, and technological challenges associated with sediment reuse. The study highlighted that proper classification and treatment of dredged materials are essential to ensure their safe and effective utilization. It also emphasized the need for collaboration among researchers, industries, and policymakers to encourage large-scale implementation of sustainable dredged material management practices. The authors concluded that appropriate treatment technologies, supportive government policies, and public awareness are essential for promoting the sustainable utilization of dredged materials and minimizing disposal-related environmental impacts.

Manni et al. (2021) investigated the replacement of natural clay with dredged sediments at proportions ranging from 10% to 50% in fired clay bricks. The study evaluated thermal properties, colour characteristics, and environmental impacts of the produced bricks. The results indicated that incorporating dredged sediments had minimal influence on thermal performance, while higher sediment contents caused noticeable changes in brick colour and increased surface reflectance. The physical and mechanical properties of the bricks remained suitable for practical applications despite these changes. The use of dredged sediments also reduced the demand for natural clay, supporting resource conservation and sustainable construction practices. Environmental assessments demonstrated reduced resource consumption and lower environmental impacts compared with conventional clay bricks, indicating the sustainability of sediment incorporation.

Zhang et al. (2024) examined the influence of cement content, moisture content, and curing age on the engineering properties of non-sintered bricks manufactured from dredged silt. Experimental results showed that increasing cement content and extending curing duration significantly improved compressive strength. However, excessive cement content resulted in increased brittleness of the bricks. The study also found that proper moisture content was essential for achieving good compaction and effective cement hydration. These findings helped identify the optimum mix design for producing durable and cost-effective non-sintered bricks. The study established optimal combinations of cement content and curing conditions for producing durable and environmentally friendly dredged silt bricks suitable for construction purposes.

Božić et al. (2023) investigated the use of sediments from the Drava River as partial replacements for clay in brick production, with replacement levels ranging from 10% to 50%. Laboratory tests showed that increasing sediment content increased porosity and slightly reduced compressive strength. However, all brick specimens satisfied the relevant construction standards. The researchers concluded that the bricks were suitable for general construction applications despite the slight reduction in strength. The reuse of river sediments also helped reduce waste disposal and conserve natural clay resources. A Life Cycle Assessment (LCA) further demonstrated reductions in environmental impacts, confirming that the reuse of river sediments in brick manufacturing is both technically feasible and environmentally beneficial. The study also emphasized compliance with existing regulatory requirements for sustainable construction materials.

3.2 Materials

Cement:

Ordinary Portland Cement (OPC) of grade 53 was used as the binding material, conforming to relevant Indian Standards.

Table. 1 Characteristics of cement

Standard Consistency (%)	28
Fineness of cement (%)	3
Initial setting time (min)	87
Final setting time (min)	272
Specific gravity	3.15

Fine Aggregate (Natural Sand):

River sand was used as the control fine aggregate. It was clean, well-graded, and free from organic impurities.

Table. 2 Characteristics of sand

IS Classification	SW
Specific Gravity	2.65
Bulking of sand (%)	28.33

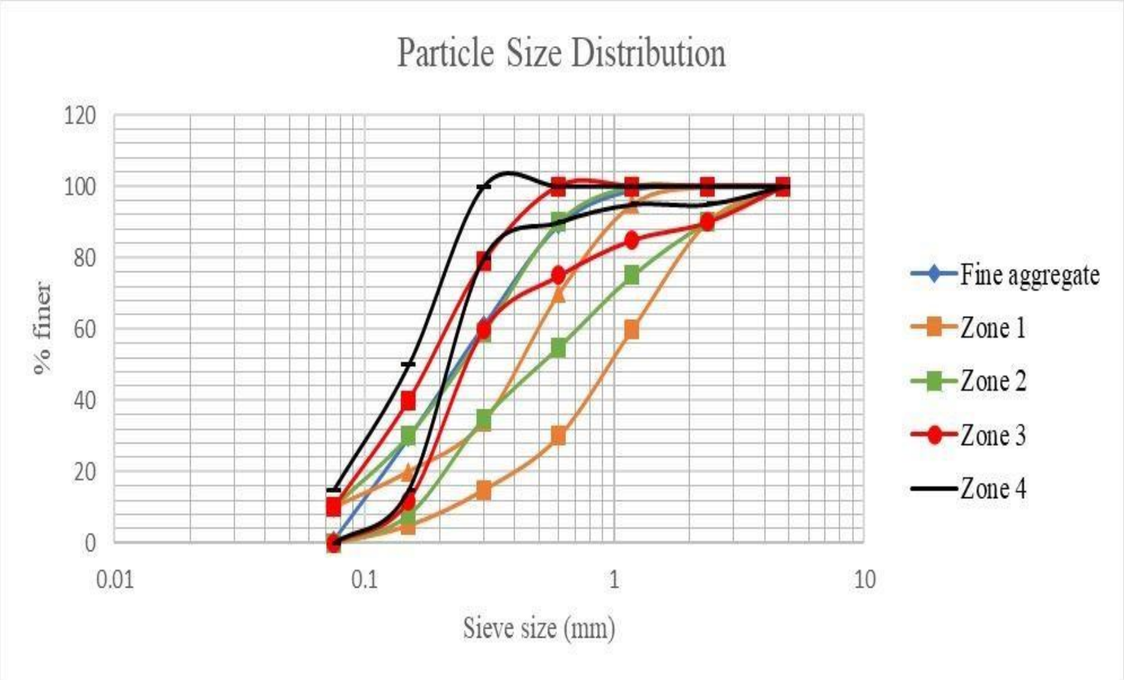

Fig. 1 Particle size distribution curve of sand

Table. 3 Result obtained from sieve analysis

Effective size,D10	0.2
Uniformity coefficient, (D10/D60)	0.3
Fineness modulus	3.201
Grading zone	III

According to IS 383:2016, the aggregate corresponds to Grading Zone III, which is suitable for concrete and masonry works.

Dredged material:

Dredged material was collected from cheruvathur harbour was air-dried, sieved, and processed to remove oversized particles and impurities before use as a fine aggregate replacement.

Table. 4 Characteristics of dredged material

IS Classification	SP
Specific Gravity	2.54
pH	7
Organic content (%)	0.5

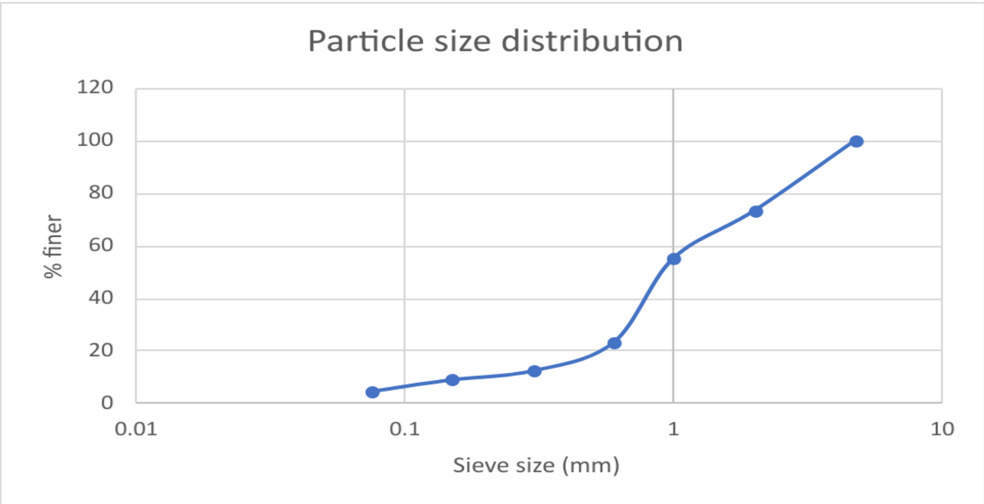

Fig. 2 Particle size distribution curve of dredged material

Since Cu = 0.137 (< 4) and Cc = 0.84 (not between 1 and 3), the soil is poorly graded . As the particle sizes are below 4.75 mm, The sample is sandy soil .The dredged soil is a poorly graded fine sand (SP type as per IS classification).

3.3 Collection and processing of dredged material

Dredged material was collected from Cheruvathur harbour, kasaragod district. The collected material was initially air-dried to remove excess moisture. After drying, it was sieved to eliminate oversized particles, shells, organic matter, and other foreign impurities. The processed dredged material was then stored in dry conditions until use. This preparation ensured uniformity and suitability of the dredged material for use as fine aggregate in cement bricks.

3.4 Mix proportion

Cement bricks were manufactured by replacing natural river sand with dredged material in conventional brick of 1:3 at different replacement levels of 0%, 20%, 40%, 60%, 80% and 100% by weight. The mix with 0% dredged material served as the control specimen. A constant cement content was maintained for all mixes to ensure comparability of results.

3.5 Testing

Water absorption test:
The water absorption test on bricks is carried out to determine the amount of water a brick can absorb, which indicates its durability and quality.

IV. RESULTS AND DISCUSSION

1. Water absorption test:

Table 4 presents the water absorption results at 7 and 28 days for bricks manufactured with dredged material incorporated as a partial replacement for fine aggregate at varying replacement percentages
.

Table. 5 Water absorption test results

Dredged material percentages	Water absorption at 7th day (%)	Water absorption at 28th day (%)
0	0.68	0.66
20	0.75	0.68
40	0.85	0.71
60	0.64	0.56
80	0.92	0.86
100	0.93	0.9

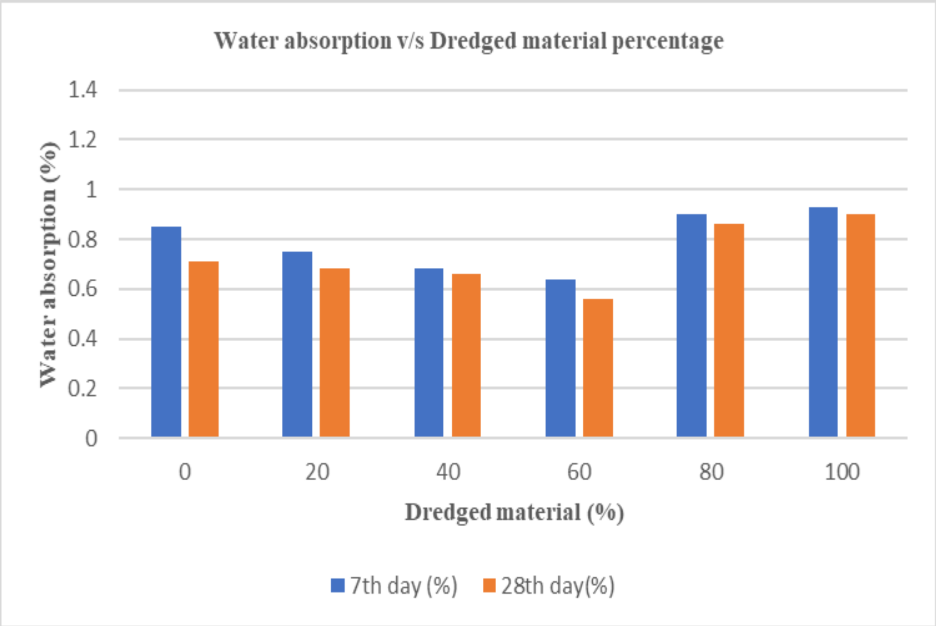

Fig. 3 Water absorption test results

The results show that water absorption decreases as the dredged material content increases up to 60%. The lowest absorption was recorded at 60% replacement with 0.64% at 7 days and 0.56% at 28 days, indicating better density and reduced porosity of the bricks.

V. CONCLUSION

This study investigated the feasibility of using dredged material as a replacement for natural river sand in cement brick manufacturing. The results demonstrated that the incorporation of dredged material significantly influences the water absorption characteristics of the bricks. Among all the mixes, the brick containing 60% dredged material exhibited the lowest water absorption values at both 7 and 28 days, indicating improved density and reduced porosity. Although water absorption increased at higher replacement levels, all mixes showed acceptable performance for non-structural applications. Therefore, dredged material can be considered a sustainable and environmentally friendly alternative to natural sand in cement brick production. Its utilisation not only reduces the depletion of natural resources but also provides an effective solution for the beneficial reuse of dredged waste, thereby contributing to sustainable construction practices.

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