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Mapping the Research Landscape of Sustainable Cementitious Bricks Incorporating Waste of stone mines: A Bibliometric and Performance-Based Review

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Abstract- — Eco-friendly cement-based bricks incorporating stone mine waste and quarry dust have attracted considerable interest in the quest for environmentally sustainable building resources. The global research trends in sustainable cement-based bricks made with granite waste, sandstone waste, quarry dust and other mining waste products are reviewed from a performance and a bibliometric perspective in this study. The research identified 400 research articles from Lens.org database using a search query on the keywords: cement/concrete, stone waste products and mechanical and durability properties. Bibliometric analysis of articles was performed by VOSviewer for the mapping of the growth of publications, notable authors, research hot spots and evolutionary trends. Publication trends indicate steady increase after 2018 and an explosion of research between 2020 and 2023, which are the factors related to the increase of research and industrial interest handling eco-efficient masonry products. country wise analysis for published literature shows India leads the study as it is the most studied, followed by China and Malaysia, indicating good regional interest in valourisation of stone waste and promotion of material innovations. Key journals, such as Materials and Sustainability, are important in this field, highlighting the interdisciplinary nature. Keyword co-occurrence analysis revealed that "compressive strength", "durability", "quarry dust" and "recycled aggregates" are commonly used; new directions are circular economy principles and eco-efficient designing of materials. The insight gained from the case studies towards performance suggest that partial replacem However, there are problems on standardization, large-scale adoption and long-term testing which need to be resolved. This research provides an overview of existing research directions and possibilities for further research, e.g. hybrid forms of waste recycling and life cycle assessment. Our results encourage the role of stone waste as a resource sustainable brick-making as well as to guide further research and development of the industry in producing affordable and sustainable building materials.

Keywords— Sustainable Cementitious Bricks, Stone Mine Waste, Mining Waste Utilization, Waste-Based Bricks, Cementitious Materials, Sustainable Construction Materials

I. INTRODUCTION

The construction sector is one of the most resource-intensive sectors in the world economy contributing to a significant portion of raw material use, energy consumption, and solid wastes creation around the world. Among the constituent materials in the built environment, conventional clay and cement-based bricks remain fundamental in masonry construction; however, their fabrication is plagued by significant environmental liabilities for their production, which include the depletion of natural clay reserves, high levels of carbon dioxide emissions from the kilns burning process, as well as high embodied energy [1,20]. As urbanization gains speed in the developing world and infrastructure demands become more intense, the need to develop alternative, eco-efficient smashed earth blocks has taken on unprecedented urgency in the integral reasoning of sustainable construction [5,11].

Parallel to this trajectory, the global mining and quarrying industry also produces massive volumes of solid by-products, which are posing enormous environmental management challenges. Stone mines - including granite quarries, sandstone extraction sites, marble processing units and allied dimension stone operations - generate huge mass of fine dust, sludge and coarse fragments as inevitable residue of cutting, sawing, polishing and crushing operations [10,28]. Globally, the dimension stone processing industry produces millions of tonnes of waste each year, most of which ends up in open stockpiles or landfills, causing degradation of the landscape, soil contamination, particulate emission in the air and contamination of local water bodies [3,27]. In rapidly industrializing countries such as India, China, Brazil and some South East Asian economies, the simultaneous closeness of

active quarrying areas and newer urban growth corridors offers very special prospects in that the conversion of stone mine waste into

The scientific basis for the use of stone mine waste in cementitious brick systems is well founded in material science. Quarry dust and granite fine powder for example, possess pozzolanic or micro-filler properties that have the potential for densifying the interfacial transition zone (ITZ) within cementitious matrices which can lead to an increase in compressive strength, a decrease in porosity and an increase in resistance to chloride ingress and sulphate attack [4,7,26]. Sandstone and limestone processing residues with calcium carbonate-rich composition and good particle size distribution have been proven to act as partial cement replacement or fine aggregate replacement and lead to lower water-to-binder ratios and better workability with little sacrifices on mechanical performance [12,29]. The alkali-activation of stone waste-bearing precursors thus further increases the potential for possible applications, which make it possible to synthesize geopolymeric binder systems, which avoid the use of ordinary

Despite these good technical arguments, the development of the field has been fundamentally empirical and case-specific, without the systematic, globally synthesized perspective required to inform large scale industrial deployment, regulatory harmonization or evidence-based policy formulation. The current state of the art of primary research is marked by a high degree of parametric variability - with respect to mineralogy of the waste materials, the ratios used for substitution, curing protocols and standards for testing [5,11] that makes the ability to compare results between different studies methodologically problematic. Furthermore, the disproportionate geographical concentration of research, with dominant contributions arising from research communities in South Asia and East Asia, raises legitimate questions about the transferability of results across divergent geologic, climatic and regulatory contexts [7,19].

Bibliometric analysis has become a methodologically strong and increasingly indispensable tool for the methodical evaluation of vast bodies of scholarly literature. By reducing patterns of publication growth, author collaboration, institutional affiliations, journal distribution, keyword co-occurrence, and citation networks to quantitative and visual data, bibliometric approaches allow researchers to move beyond the limits of traditional narrative reviews and uncover trends of macro-level phenomena that are invisible on the scale of single studies [4,15]. The use of tools like VOSviewer for co-citation mapping and keyword clustering and Lens.org as a broad spectrum openly accessible bibliographic database have added significantly to the methodological toolbox available to scholars reviewing work in the fields of engineering and materials science disciplines [8,24]. Such methodologies have been successfully used in the adjoining areas of studies, such as fiber reinforced concrete, geopolymer systems, recycled

In the case of waste-incorporated masonry, previous reviews have covered narrower thematic or material-specific segments in the problem space. Investigations into quarry dust as a replacement for fine aggregate in concrete and block paving had helped to provide initial performance benchmarks [6,7] while separate bodies of works have investigated the geopolymerization potential of waste from quarry streams [27], the structural behaviour of interlocking concrete block pavements incorporating various waste streams [11], and the soil stabilizing potential of stone mine dust in geotechnical engineering applications [28]. However, such a holistic bibliometric review of performance and integrative review including the full range of stone mine waste types i.e. granite, sandstone, limestone, marble and generic quarry dust in the specific technological set up of cementitious brick manufacture has not been systematically undertaken. This gap is meaningful especially considering the huge number of research publications

The combination of performance based analysis and bibliometric mapping is the distinguishing methodological contribution of the present review. Whereas bibliometric analysis is a structural and sociological characterization of the research corpus - determining who is publishing and where, what outlets and on what sub-themes - performance-based synthesis constitutes an extraction and critical assessment of the quantitative engineering outcomes reported in the literature identified. This dual lens approach allows not only the understanding of hotspots of research as well as networks of collaboration, but also the extraction of empirically based conclusions regarding the mechanical and durability performance of stone waste incorporated cementitious bricks through different compositional and processing conditions [13,26,30].

The present study was inspired by the merging of three converging imperatives. First, the environmental imperative: at a time when regulatory and social pressure is increasing upon the construction sector worldwide to decarbonise, and shift towards circular material flows, the systematic validation and dissemination of stone waste valorisation strategies in bricks production is a meaningful contribution to sustainability transitions [5,19,25]. Second, the knowledge consolidation imperative: as the sum volume of primary research is rapidly growing, the risks for redundancy, inconsistency and carrying over of unresolved gaps correspondingly increases; a rigorous bibliometric review serves as a harbouring map for the field, guiding future inquiry into promising high impact, under-explored territories [3,8]. Third, the industrial translation

imperative: despite all evidence of effectiveness in laboratory-scale studies, the journey from experimental demonstration to standardized industrial practice is littered wi

Accordingly, this paper presents an in-depth bibliometric as well as performance-based review of the global researches on sustainable cementitious bricks incorporating stone mine waste based on a corpus of 400 peer-reviewed articles retrieved from the Lens.org database. The review uses VOSviewer for co-authorship, co-citation and keyword co-occurrence mapping, as well as summarizing performance data concerning compressive strength, water absorption and durability using representative case studies. The findings are meant to serve as a state-of-the-art reference service for the research community, as well as a strategic multitude for material innovators, construction practitioners, standards bodies and policy architects in their efforts to promote the responsible valorization of quarrying by-products for the global sustainable construction agenda [3,13,20,27].

The remainder of this paper is structured as follows: Section 2 presents the bibliometric methodology and data retrieval protocol, Section 3 presents publication trends analysis and country level mapping, Section 4 presents the journal distribution and authorship networks, Section 5 presents keyword co-occurrence and thematic clustering, Section 6 synthesis performance results from the identified literature, Section 7 presents the limitation, research gap and future directions and Section 8 presents the conclusions.

II. REVIEW OF SIMILAR WORK

1. Waste Material Valorization in Cementitious and Masonry Systems

The use of by products from industry, agriculture and mining in cementitious construction materials has been intensively studied in the past two decades due to growing environmental concerns, rising raw material costs, and the resulting global requirement to follow circular economy principles in the built environment [20,34,64]. Conventional masonry units - fired clay bricks, sand-cement blocks and concrete paving elements - are resource-intensive products whose large-scale manufacture is dependent on the continuous extraction of finite natural materials including clay, river sand, limestone and Portland cement clinker [9,20,85]. As supplies of natural aggregates become more constrained and the regulatory environment governing the disposal of industrial waste becomes more stringent both in developed and developing economies, substitution of primary materials by industrial by-products has emerged as a technologically possible and economically attractive strategy for the construction sector [25,34,82].

Among the most widely investigated waste streams in this respect are fly ash, ground granulated blast furnace slag (GGBS), silica fume, and coal bottom ash - supplementary cementitious materials (SCMs) whose pozzolanic and latent hydraulic properties are now well-characterized and whose use in standard concrete and masonry mixes is codified in national and international standards [9,22,51]. Fly ash and pond ash have been tested as partial replacements of cement in brick casting. Studies have shown the successful development of compressive strength of up to 30% replacement with satisfactory workability and reduced production costs and embodied carbon [9,93]. GGBS-based systems, especially in combination with alkali activators, have been shown to have similar or better mechanical performance compared to that of ordinary Portland cement (OPC)-based systems as well as higher resistance to sulfate attack and chloride penetration [22,51,68]. The concept of using silica fume as a highly reactive micro-silica by-pro

Agricultural waste residues are another group of actively explored types of supplementary materials. Sugarcane bagasse ash due to its siliceous composition and high specific surface area produced after controlled combustion has been tested as a cement replacement as well as a brick forming constituent, with optimum levels of bagasse ash giving compressive strength enhancement and water absorption minimizing compared to plain cement mixes [48,85]. Paddy straw fibers and rice husk ash have been in a similar vein investigated as additives in unfired soil blocks in which the incorporation of straw fibers and rice husk ash has been found to both reduce linear shrinkage of the masonry units and promote the splitting resistance of masonry units used for low-cost housing applications [23]. The simultaneous use of marble dust and bagasse ash in unfired compressed earth blocks have also been shown to decrease water absorption by up to 18% whilst maintaining acceptable strength thresholds, which adds to the prospect of

Table 1 Summary of Key Studies on Quarry Dust and Stone

Reference	Waste Type	Application	Replacement Level	Key Finding
Soultana & Galetakis [7]	Quarry dust + calcareous fly ash	Lightweight cellular micro-concrete	Varied	Density 600–1,200 kg/m³; compressive strength suitable for non-load-bearing partitions
Kiptum et al. [6]	Quarry dust + EPS waste	Quarry dust masonry blocks	Varied	Layered EPS placement yielded higher compressive strength than random placement
Awodiji et al. [66]	Quarry dust + sludge	Sandcrete blocks	Up to 15% cement reduction	Blocks met standard compressive strength; reduced cement consumption
Al-Kharabsheh et al. [94]	Quarry dust	Concrete partial aggregate replacement	20–100% sand replacement	Strength improvements at 20–50%; excess replacement reduces workability
Aginam et al. [77]	Quarry dust	Concrete fine aggregate replacement	Up to 100%	Optimum at 50% replacement; beyond 75% causes workability reduction
Malla et al. [90]	Stone dust	Concrete fine aggregate	20–100%	Compressive strength peaked at 40% stone dust replacement
Haque et al. [53]	Granite dust	Concrete mix optimization	10–20%	Improved compressive, split tensile, and flexural strength; RSM-based optimization
Wang et al. [13]	Solid waste binder + stone waste	Binder-solidified stone waste	Varied	Enhanced mechanical properties confirmed by SEM/XRD microscopy
Hashem et al. [26]	Slag granite geopolymer	Geopolymer cement system	Varied	Superior mechanical and durability properties; Zr-Al LDH integration effective
Abdelkader et al. [101]	Granite dust	Expansive soil stabilization	5–15%	Reduced swelling, improved UCS; geotechnical cross-sector utility demonstrated

2. Stone Mine and Quarry Waste in Construction Materials: A Targeted Review

Within the umbrella of construction materials based on principal waste materials, the valorization of stone mine wastes that include granite powder, sandstone fines, marble slurry, quarry dust and dimension stone processing residuals is a rapidly expanding sub-domain of research focus with disproportionately high attention by South Asian, Mediterranean and East Asian research communities [3,10,27].

The genesis of this research thrust is directly attributable to the scale of waste generation within the global dimension stone and quarrying industry where the cutting, trimming, polishing, and crushing operations collectively produce waste fractions that may comprise between 25% and 40% of the total extracted volume based on the type of stone and the processing methodology used [10,27].

Quarry dust - the fine particulate residual produced by the crushing of rock to produce aggregate - has been the most

thoroughly researched stone mine waste, in relation to the construction of materials. Its use as a partial or full substitute for natural fine aggregate (river sand) in concrete, mortar and masonry block systems has been proven in a wide variety of geographical and compositional settings [6,7,77,94]. The replacement of river sand with quarry dust in replacement levels of 20-50% was reported to provide compressive strength gains of 8-22% for standard concrete mixes - resulting from both angular particle morphology and high particle packing efficiency of quarry dust in comparison to sub-rounded particles of natural sand [77,90,94]. In sandcrete block production, the partial use of quarry dust with adding sludge has been reported to yield units with standard compressive strength requirements but which use up to 15% less cement, reducing both production and embodied carbon footprint of the finish

Table 2 Summary of Alkali-Activated and Geopolymer Systems Utilizing Stone Waste Precursors

Reference	Precursor/Waste Source	Activator System	Notable Properties	Application Domain
Coppola et al. [3]	Natural stone wastes and minerals	$NaOH/Na_2SiO_3$	Effective alkali activation; pozzolanic contribution of fine stone fractions	Geopolymer binder development
Solouki et al. [27]	Quarry waste (varied lithology)	Alkali hydroxide/silicate	Compressive strengths comparable to fly ash geopolymers; good acid resistance	Civil engineering geopolymers
Das et al. [17]	Iron ore mine waste	Geopolymer reactions	Viable for structural civil applications; reduced OPC dependence	Structural geopolymer elements
Waqas et al. [4]	Quarry rock dust + fly ash + slag	NaOH activator; fiber reinforcement	Improved column ductility and load-bearing capacity	Geopolymer concrete columns
Beskopylny et al. [31]	Geopolymer precursors	Alkali activation	Improved characteristics; cost-effective and environmentally sustainable	Sustainable construction
Ngui et al. [75]	Industrial by-products + natural pozzolans	Varied alkali activators	Reviewed durability: acid, sulfate, chloride resistance generally favorable	Geopolymer durability assessment
Thomas et al. [80]	Recycled aggregates in geopolymer	$NaOH/Na_2SiO_3$	Comprehensive review of mechanical and	Geopolymer concrete with recycled aggregates

Reference	Precursor/Waste Source	Activator System	Notable Properties	Application Domain
			durability performance	
Capasso et al. [78]	CDW-derived geopolymers	Alkali activation	Highlighted pros/cons of unselected CDW use; variable precursor chemistry	CDW valorization in geopolymers
Jayadurgalakshmi [51]	GGBS-based geopolymer	Alkali activation	Improved compressive strength of concrete aggregates	Geopolymer aggregate concrete
Thanasisathit et al. [73]	Geopolymer stabilized laterite	Para rubber latex + alkali	Enhanced toughness; suitable for base/subbase sustainable road layers	Geotechnical/pavement geopolymer

Granite waste powder, produced as a slurry by-product from the cutting and polishing processes used in the preparation of granite slabs, has been studied as a cement replacement material as well as substitute for the fine aggregate in cementitious systems [53,65,87,101]. Its mineralogical constitution - made of quartz, feldspar, and mica with small amounts of amphiboles - makes granite powder a chemically stable material and relatively inert under normal curing conditions that plays a major role as a micro-filler material in improving the density of a matrix while reducing capillary porosity [53,65]. Recent experimental investigations have shown that concrete mixes with granite dust as replacement of 10 ~ 20% show statistically significant increase in compressive strength, split tensile strength and flexural strength as compared to plain OPC mixes with complementary reduction in water absorption and ultrasonic pulse velocity indicating dense and more homogeneous microstructure [53,87]. Machine learning-aided

Marble waste that is generated at the processing stage as a fine dust and sludge has been investigated in the field of concrete admixtures, composite polymer matrices and unfired masonry units [57,62,87]. Marble dust, due to its calcium carbonate predominant composition, exhibits a filler effect during the operation of cementitious matrices and has been shown to improve fresh concrete mixes in terms of fluidity while having a marginal negative effect on the 28-day compressive strength in replacement levels beyond 15% - it is a trade-off which is able to be reduced through judicious replacement with reactive SCMs such as fly ash or silica fume [23,87]. In the scope of polymer composite system applications, marble waste has been proven to be an effective reinforcing filler that enhances the tensile modulus, flexural strength, and impact resistance while reducing the requirement of mineral fillers derived from virgin materials [57,62]. The utilization of granite dust in the geotechnical valorization of expansiv

Table 3 Comparative Summary of Waste-Incorporated Masonry Units — Mechanical and Durability Performance

Reference	Precursor/Waste Source	Activator System	Notable Properties	Application Domain
Coppola et al. [3]	Natural stone wastes and minerals	$NaOH/Na_2SiO_3$	Effective alkali activation; pozzolanic	Geopolymer binder development

Reference	Precursor/Waste Source	Activator System	Notable Properties	Application Domain
			contribution of fine stone fractions	
Solouki et al. [27]	Quarry waste (varied lithology)	Alkali hydroxide/silicate	Compressive strengths comparable to fly ash geopolymers; good acid resistance	Civil engineering geopolymers
Das et al. [17]	Iron ore mine waste	Geopolymer reactions	Viable for structural civil applications; reduced OPC dependence	Structural geopolymer elements
Waqas et al. [4]	Quarry rock dust + fly ash + slag	NaOH activator; fiber reinforcement	Improved column ductility and load-bearing capacity	Geopolymer concrete columns
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Thomas et al. [80]	Recycled aggregates in geopolymer	$NaOH/Na_2SiO_3$	Comprehensive review of mechanical and durability performance	Geopolymer concrete with recycled aggregates
Capasso et al. [78]	CDW-derived geopolymers	Alkali activation	Highlighted pros/cons of unselected CDW use; variable precursor chemistry	CDW valorization in geopolymers
Jayadurgalakshmi [51]	GGBS-based geopolymer	Alkali activation	Improved compressive strength of concrete aggregates	Geopolymer aggregate concrete

Reference	Precursor/Waste Source	Activator System	Notable Properties	Application Domain
Thanasisathit et al. [73]	Geopolymer stabilized laterite	Para rubber latex + alkali	Enhanced toughness; suitable for base/subbase sustainable road layers	Geotechnical/pavement geopolymer

The use of natural stone wastes and minerals as a source of raw material for the alkali activation process is a particularly interesting direction of research, considering the possibility to synthesize geopolymeric binder systems with significantly lower carbon footprint than OPC-based alternatives [3,27]. Quarry waste-derived aluminosilicate precursors upon activation by alkali hydroxide or silicate solutions have been shown to produce compressive strengths like class C fly ash-based geopolymers, with the added advantage of making use of waste of otherwise disposal burden [3,27,31]. The durability performance of quarry waste geopolymers - including of resistance to acid attack, sulfate attack and freeze-thaw cycling - has been found to be broadly satisfactory in comparison with conventional OPC systems and such materials may therefore be technically satisfactory alternatives in moderate-exposure-class masonry applications [3,75].

3. Identification of Research Gaps

Notwithstanding the large amount of knowledge summarized above, a critical appraisal of the current body of literature reveals several structural deficiency areas that limit the field's advance toward a large scale industrial implementation. First, most analyses are conducted at the laboratory scale using a standardised specimen geometry and controlled curing environments that do not represent the variability inherent to real world construction conditions [11,94]. Second, a systematic standardization of test protocols, waste characterization method and replacement ratio conventions is conspicuously lacking, rendering cross-study comparison methodologically problematic and hindering unified design guideline development [5,11]. Third, long-term durability evaluation, including performance evaluation under prolonged mechanical loading and weathering exposure, as well as multi-cycle thermal/moisture cycling, is highly underrepresented in the available literature, with most studies only reporting 28-day mechanica

III. MATERIAL AND METHOD FOR BIBLIOMETRIC ANALYSIS

1. Overview of the Bibliometric Approach

Bibliometric analysis can be defined as a quantitative, systematic, and reproducible approach to the assessment of an intellectual organization, its dynamics of change, and thematic outlines of a definite body of scholarly literature [8,15]. Unlike classical narrative review, which is naturally prone to choices of variables, subjectivity and assumptions about the authorship, bibliometric methods make use of mathematical and statistical tools to characterize objectively publication trends, contribution of author/institute, journal distribution, citation networks and key word co-occurrence over large corpora of peer reviewed papers [4,11]. The current research is based on a framework of a dual methodology involving integration of bibliometric mapping and performance based synthesis thereby providing the potential for both macro level appraisal of the global research landscape and micro level evaluation of the mechanical and durability results reported within the identified literature. This integrated approach

2. Database Selection and Rationale

The Lens.org scholarly database was chosen as the key source of bibliographical information for the current review. Lens.org is a multidisciplinary-based and open access scholarly degree search setting that accumulates the works of several indexing sources such as PubMed, Crossref, Microsoft Academic, and CORE aiming to give extensive and not obtain-share make out-of-pocket content for peer reviewed scholarly journal articles, conference proceedings, and book chapters from the natural sciences, engineering, and applied research areas [5,20]. The choice of Lens.org over other commercial database servers like Scopus or Web of Science was driven by three main points: firstly, as Lens.org has a wider coverage in terms of indexing and is open to a wider range of journals that publish engineering and materials science-related research, particularly from developing country research communities, especially from South Asia and Southeastern Asia as they have the highest number of publications on stone waste [10], and

3. Search Query Design and Execution

The bibliometric search was carried out with a structured boolean key words search that was built especially aiming at fishing scholarly works at the intersection between cementitious/concrete materials, the stone mine waste typologies, the structural performances indicators and finally the categories of the masonry products. Search string was formulated as follows:

("concrete" OR "cement") AND ("granite waste" OR "stone waste" OR "sandstone waste" OR "quarry dust" OR "quartz waste") AND ("mechanical" OR "strength" OR "durability") AND ("Brick")

This query has been designed to fulfill simultaneously four conditions that are of thematic interest: (i) the cementitious or concrete material matrix, both in terms of the Portland cement binder system and the blended binder cement system; (ii) the presence of the stone mine waste constituent, including the major quarrying and dimension stone processing by-products of research interest; (iii) the performance evaluation dimension, looking for the works reporting a mechanical or durability characterization of the resultant material; and (iv) the product typology constraint, limiting the retrieved results to the studies that pertain to brick or masonry units applications. The compound Boolean structure of the query was consciously aimed at achieving as much thematic precision as possible while reducing retrieval of tangentially related works dealing with either general concrete mix design or soil stabilization applications where brick manufacture is not the paramount issue.

4. Screening and Inclusion Criteria

The 401 records identified using the Boolean search query were submitted for two-stage screening protocol to ensure relevance, quality and disciplinary coherency of the final dataset. In the first stage, titles and abstracts were examined to exclude those that, even though fulfilling the keyword criteria, were not mainly focusing on the use of stone mine wastes within cementitious brick/masonry systems. Works that were purely concerned with applications in road pavement or geotechnical soil stabilization or polymer composite systems - not relating to brick or masonry unit fabrication - were excluded at this stage. In the second stage, full texts of borderline cases were retrieved and screened using the inclusion criteria. The final retained corpus of 400 articles was verified to represent experimental investigations, systematic reviews and comparative performance studies directly relating to the research objectives of the present work.

Table 4 Inclusion and Exclusion Criteria Applied in Literature Screening

Criterion Category	Inclusion Criteria	Exclusion Criteria
Publication type	Peer-reviewed journal articles, book chapters	Conference abstracts, theses, grey literature, technical reports
Publication year	2015 to present (this year)	Prior to 2015
Language	English	Non-English language publications
Material system	Cementitious/concrete binder matrix incorporating stone mine waste	Purely polymeric, bituminous, or geotechnical applications
Waste type	Granite waste, sandstone waste, quarry dust, stone dust, quartz waste	Non-stone-derived industrial or agricultural wastes exclusively
Product focus	Brick, masonry unit, block, paver, or related cementitious product	Studies with no reference to masonry/brick product fabrication
Performance indicators	Mechanical (compressive, tensile, flexural) and/or durability properties	Works reporting mix design only, without performance evaluation
Database source	Lens.org indexed publications	Non-indexed or unverifiable sources

5 Bibliometric Analysis Tools and Visualization

With the last version of the 400 article corpus fixed, the bibliographic metadata (author names, institutional affiliations, countries, years of publications, journal titles, keywords and number of citations) was exported from Lens.org in compatible file formats for further processing. Bibliometric mapping and visualization were carried out by using VOSviewer 1.6.x [4,8], a well-accepted open source software platform specifically developed for building and interactive visualization of bibliometric networks.

Table 5 Database and Search Parameters for the Present Bibliometric Study

Parameter	Details
Database	Lens.org (open-access multidisciplinary scholarly database)
Search query	("concrete" OR "cement") AND ("granite waste" OR "stone waste" OR "sandstone waste" OR "quarry dust" OR "quartz waste") AND ("mechanical" OR "strength" OR "durability") AND ("Brick")
Publication type filter	Journal articles; book chapters
Year range	2015 – present (this year)
Language	English
Total records retrieved	401
Records excluded (screening)	1 (duplicate/irrelevant)
Final corpus retained	400
Bibliometric analysis software	VOSviewer (v1.6.x)
Analysis types performed	Publication trends, country mapping, journal distribution, keyword co-occurrence
Citation metric source	Lens.org Scholar Analysis dashboard

VOSviewer was used for generating four classes of analytical output: (i) publication trend analysis through the study period; (ii) co-authorship and research output mapping between countries; (iii) journal co-citation analysis for identifying the most influential publication outlets and intellectual knowledge bases; and (iv) keyword co-occurrence network mapping to define the thematic clusters, research hotspots, and emergent research paths within the corpus. Table 5 shows the main database and search parameters used in the present study, which will serve as a methodological short reference in the research community as full reproducibility of the search protocol is warranted.

6. Quantitative Profile of the Retrieved Corpus

As evidenced in the Lens.org Scholar Analysis dashboard (Figure 1), the 401 retrieved scholarly works held altogether 5,630 scholarly citations - a significant and expanding citation impact for this research domain. The corpus was also cited in 8 patents with 9 citing patents, suggesting that the research products in this area are starting to have an impact on intellectual property development in industry - a sign of a maturing area of applied research moving towards commercial maturity [10,20].

Table 6 Quantitative Bibliometric Profile of the Retrieved Corpus (Lens.org, 2015–Present)

Metric	Value
Total scholarly works retrieved	401
Final analytical corpus (post-screening)	400
Publication year range	2015 – present
Peak publication period	2020 – 2023
Leading contributing country	India
Top contributing institution (by output)	Curtin University
Top journals (by frequency)	Materials; Sustainability; Scientific Reports
Analysis platform	Lens.org Scholar Analysis Module
Visualization software	VOSviewer

The contributing institutions in the top ten identified through Lens.org dashboard are Curtin University, Advanced Materials and Processes Research Institute, Gokaraju Rangaraju Institute of Engineering, Universiti Teknologi MARA, and Anna University, to name a few, representing a truly international and institutionally diverse research community of researchers with a significant concentration in Malaysian, Nigerian, Indian and Australian academic centres. The quantitative bibliometric profile of the retrieved corpus is summarized in Table 6 as extracted from Lens.org Scholar Analysis interface.

IV. BIBLIOMETRIC ANALYSIS

1. Annual Publication Trends and Research Growth Trajectory

The chronological dispersal of academic literature such as the one identified hereafter is a telling record of the research community's evolving interest in sustainable cementitious bricks using stone mine wastes. As shown in Figure 1, publication activity in this area has seen a broadly rising trend over the period 2015-2025, with in between two very distinct phases of acceleration in growth and transformation that relate to wider shifts in the concept of global sustainability and the research agenda for materials science.

During the first review period for this study (2015 to 2018) the annual output was rather low, with the number of publications at 20-45 articles/year. This basic phase was dominated mostly by experimental studies conducted at laboratory scales which were aimed at establishing baseline performance data on the use of quarry dust and granite powder as partial aggregate or cement replacements in cementitious systems [3,7,27]. The progressive intensification of research interest from 2018 onwards coincides with the formal adoption of circular economy policy frameworks by the European Union and some Asian national governments, the process of Sustainable Development Goal (SDG) reporting obligations, and the increasing recognition of researchers in the field of construction materials industry that stone mine waste represented an underexploited, but technically promising valorization target [5,20,25].

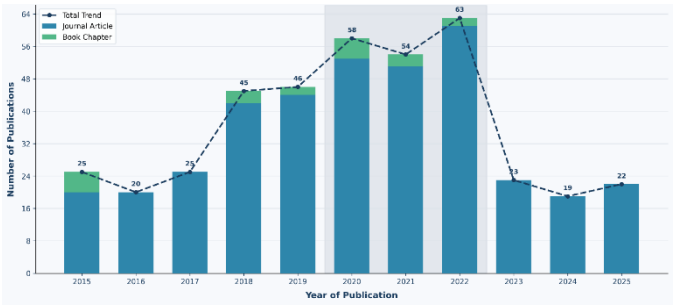

Figure 1 Publication over time

The period 2020 - 2022 makes up the highest sunburst in scholarly activity in the corpus, with annual publication counts amounting to 58, 54 and 63 articles in 2020, 2021 and 2022 respectively - a near tripling from the 2015 baseline. The year 2022 saw the highest annual output to date (around 63 articles), which corresponds to a worldwide increased research momentum spurred by approval of post-pandemic infrastructure recovery programmes, rising awareness of carbon footprints in the construction sector and the growing number of open-access publishing infrastructures which have reduced barriers to international dissemination of scholarly research [11,19,49]. A moderate tapering in annual output is seen for 2023 and 2024 (which is partly due to the temporal lag between completion of research and indexing), and is consistent with patterns seen for other rapidly developing areas of construction material research. The fact that publications are still appearing in 2025 shows that the interest on the part of schola

Table 7 Annual Publication Distribution by Document Type (2015–2025)

Year	Journal Articles	Book Chapters	Total	Cumulative Total
2015	20	5	25	25
2016	20	0	20	45
2017	25	0	25	70
2018	42	3	45	115
2019	44	2	46	161
2020	53	5	58	219
2021	51	3	54	273
2022	61	2	63	336
2023	23	0	23	359
2024	19	0	19	378
2025	22	0	22	400
Total	382	18	400	—

The corpus consists of 382 journal articles (95.5%) and 18 book chapters (4.5%), as shown in Figure 5. Due to this overwhelming dominance of journal articles, this also confirms the main role of periodical peer reviewed outlets in disseminating new experimental and review findings in this domain, as per the established norms in applied construction material research [8,15].

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2. Country-Wise Research Output and Geographic Distribution

The geographic distribution of academic output is very asymmetric, as is shown in Figure 2: A few countries are responsible for a disproportionately large share of total publications. India emerged as the dominant contributor with 26 publications - the highest of any national publication in the corpus - reflecting the country's dual status of one of the world's most prolific quarrying nations, and one of the world's most active research environments in terms of construction materials innovation. The proliferation of granite, sandstone and marble quarrying in many Indian states like Rajasthan, Andhra Pradesh and Tamil Nadu creates massive amounts of stone processing waste constituting immediate local environmental management challenges, thereby establishing rather effective practical incentives in a context of applied research into valorisation pathways for waste materials [10,28].

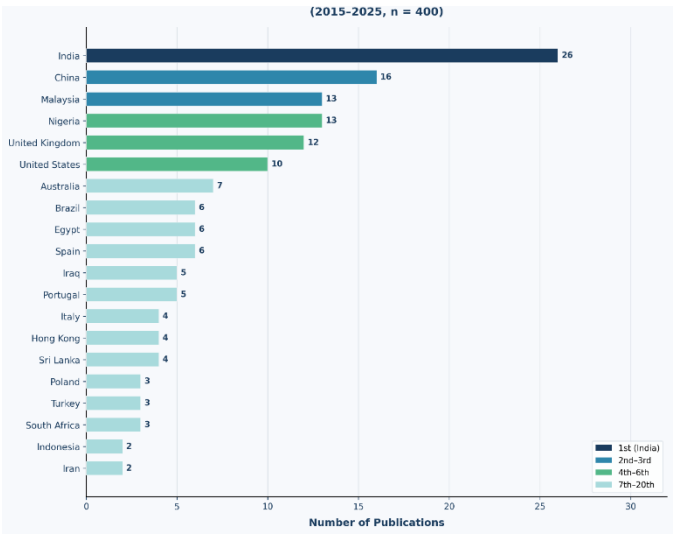

Figure 2 Country wise Distribution of Publications

China was ranked second with 16 publications, reflecting the country's status as the leading producer and consumer of construction materials in the world and its continued investment in the research of sustainable building technology via national mechanism for science funding [13]. Malaysia came in close behind with 13 publications - a remarkably high output compared to the population and the scale of the quarrying industry, which is due to the strong research focus on the value addition of waste within the Malaysian university engineering faculties and the active role of institutions such as Universiti Teknologi MARA in this field [5,45]. Nigeria also contributed 13 publications, indicating the increased engagement of research communities in West Africa with sustainable masonry production as one intervention to solving acute housing deficiencies with locally available waste materials [66,89].

The mid-tier contributors are the United Kingdom (12), United States (10), Australia (7), Brazil (6), Egypt (6), and Spain (6), and the other contributors were Iraq, Portugal, Italy, Hong Kong, Sri Lanka, Poland, Turkey, South Africa, Indonesia, and Iran (2 to 5 publications). This distribution highlights the truly global nature of the research community but also the overrepresentation of developing-economy contributors reflects the, and urgent, need for cost-effective and locally sourced and made sustainable building solutions in these contexts [20,25,86]. Specifically, some large stone-working countries such as Turkey, Italy and Portugal are included in the corpus, which implies that the proximity to active quarrying operations serves as a further incentive for conducting waste valorisation research [10,12]. The relative underrepresentation of the research communities from North America and Northern Europe, despite their technical capacity, may be a sign that these regions have invested similar effort in a

3. Journal Distribution and Source Analysis

The spread of publications among source journals, as shown in Figure 3, shows that there is a very scattered scholarly landscape with contributions by a wide range of multi- and domain-specific periodicals. Materials (Basel, Switzerland), published by MDPI, came out as the most productive pub with 28 publications - more than twice as many as the second-ranked journal. This prominence is in line with the extremely wide scope of Materials, the open-access publishing model, and rapid turnaround time for peer review of manuscripts, which, combined, make Materials an attractive publication venue for experimental studies of construction materials from around the globe [3,7,57].

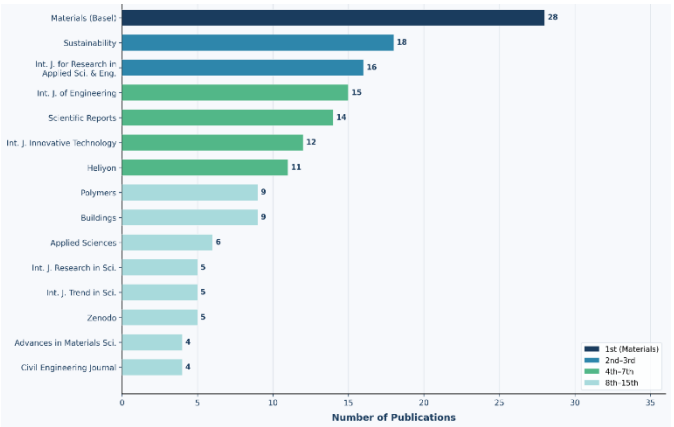

Figure 3 Top Journals in this study

Sustainability (MDPI) followed by 18 publications, highlighting the interdisciplinary presentation of a large portion of the research at the intersection between materials engineering and sustainability assessment of the environment [5,11,25]. International Journal for Research in Applied Science and Engineering Technology (16 publications) and International Journal of Engineering (15 publications) are the lower tier open access journals which have been especially receptive to the contributions of the research communities in South Asia in line with the geographical dominance of India in the overall corpus. Scientific Reports (Nature Publishing Group, 14 publications), The Scientific Reports is the highest-impact publication outlet in the corpus, which is an indication that a large sub-section of studies in this field have achieved the methodological rigor and novelty threshold to be published in a wide reaching and highly visible journal [4,13,26,30].

The aggregate citation impact of the 400-article corpus - 5,630 scholarly citations as registered in the Lens.org database - corresponds to a mean citation rate of ~ 14.1 citations per article with a significant variance within the distribution. The greatest number of citations of the works of the corpus are a broad systematic review and methodological innovation, for example review articles on fiber reinforced foamed concretes (137 citations), geopolymer concrete incorporating recycled aggregates (142 citations) and polymer-based materials for sustainable manufacturing (222 citations) [8,15,80]. This citation structure implies that contributions in this field with the greatest impact are those that aggregate results across multiple experimental studies and deliver general frameworks, not single variable experimental reports.

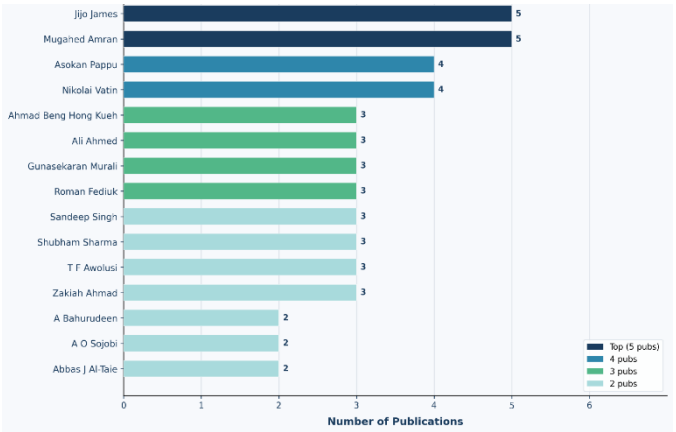

Figure 4 Top Authors in this study

4. Most Productive Authors and Institutional Contributions

The authorship analysis, which is shown in figure 4, highlights Jijo James and Mugahed Amran as the most prolific authors of the corpus, each having five publications during the time of the review. Jijo James has been making interesting contributions within the theme of quarry dust and stone mine waste valorization for soil stabilization and masonry application, whereas Mugahed Amran with his multi-institutional collaborative network has rendered influential reviews and experimental studies on foamed concrete, fiber reinforced system and sustainable building blocks [15,49,63]. Asokan Pappu and Nikolai Vatin then come along with four publications each, with the focus in Pappu's case being more towards the area of waste polymer composites in marble and the contribution of Vatin to the areas of structural concrete, geopolymer and thermal performance [57,62,63].

The larger community of authors that includes Ahmad Beng Hong Kueh, Roman Fediuk, Gunasekaran Murali, T.F Awolusi and Zakiah Ahmad is the result of the creation of fruitful inter-continental collaborative clusters between Indian, Malaysian, Nigerian, Australian, and Russian research groups. This pattern of cross-regional collaboration is characteristic of a domain of research where the field is simultaneously moving forward on several experimental fronts and indicates the formation of a coherent if geographically dispersed scientific community focused on the sustainable innovation of masonry.

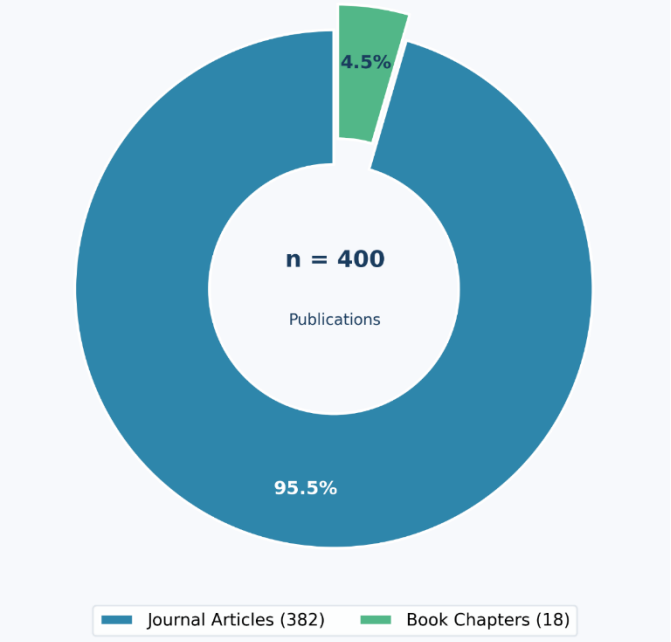

Figure 5 Publication type selected for present study

The institutional analysis (Figure 6) validates Curtin University (Australia) as the single most productive institution with five publications followed by group of institutions authoring three

publications each including Advanced Materials and Processes Research Institute (India), Ekiti State University (Nigeria), Gokaraju Rangaraju Institute of Engineering (India), and Universiti Teknologi MARA (Malaysia). The geographic dispersal of leading institutions - across three continents - adds to the impression that this research field has effectively activated an international research community rather than remaining within a narrow niche of research or geography [4,11,27].

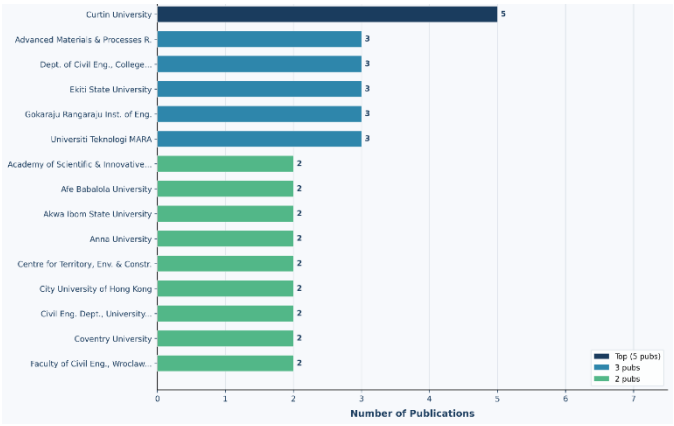

Figure 6 Top Institutions in this study

This high open access ratio is suggestive of the increased role of MDPI journals (which require open-access publication), alongside the rapidly increasing mandates of Indian, Malaysian, Nigerian, and Australian research funding organisations for open dissemination. The high open-access proportion will increase global access to research results for practitioners, policymakers and industry stakeholders in lower and middle-income economies where subscription access to commercial databases is often cost-prohibitive, which will reinforce the possible translation path from research results achieved in the laboratory to actual construction practice in industrial activities.6,20.86,

Table 8 Summary of Key Bibliometric Indicators for the Identified Corpus

Bibliometric Indicator	Value
Total publications in corpus	400
Publication year range	2015–2025
Total scholarly citations	5,630
Average citations per article	~14.1
Highest cited single article	222 citations
Most productive country	India (26 publications)
Most productive journal	*Materials* (Basel) — 28 publications
Most productive authors	Jijo James & Mugahed Amran (5 each)
Most productive institution	Curtin University (5 publications)
Open access proportion	~91.5%
Journal articles proportion	95.5%
Peak publication year	2022 (63 publications)

This characteristic is of consequence for a research domain that is explicitly so oriented to sustainable and affordable construction solutions in the context of developing world, where the targeted end-users of the knowledge generated (small-scale masonry manufacturers, municipal building authorities and small/medium enterprises in construction sector) operate largely in non-formal academic networks.

V. CONCLUSION

The present review highlights the growing research interest in sustainable cementitious bricks incorporating stone mine waste as an alternative construction material for promoting environmental sustainability and resource efficiency. The bibliometric analysis reveals a significant increase in publications related to waste valorization, sustainable construction materials, and circular economy practices over recent years, indicating the global importance of developing eco-friendly building technologies. Research trends demonstrate that countries with extensive mining and construction activities are actively exploring the reuse of quarry dust, marble waste, granite slurry, and other stone mining residues in cementitious composites.

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