PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	Title, p. 1 - The title explicitly identifies the article as a systematic review.
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	Abstract, p. 2 - Abstract identifies the study as a systematic review and reports PRISMA 2020, Scopus, 453 records, and 45 included articles.
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	Section 1. Introduction, pp. 2–4 - Rationale, background, environmental motivation, knowledge gaps, and need for sustainable clay stabilization are described.
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Section 2.2. Research Question, p. 5 - Guiding question explicitly stated using adapted PICO/TiO.
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	Section 2.4. Inclusion and exclusion criteria, p. 5 - Peer-reviewed research/reviews, English, 2022-2026; gray literature, unindexed conference abstracts, and studies without standardized geotechnical testing excluded.
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	Section 2.3. Search Strategy, p. 5 - Scopus database; search conducted April 2026. No additional databases/repositories searched.
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Section 2.3. Search Strategy, p. 5 - Full TITLE-ABS-KEY Boolean search string is reported.
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	Sections 2.3–2.5 and 3.1, pp. 5–7 - Deduplication, title/abstract screening, full-text eligibility, and final inclusion are described. Number of reviewers/independence and automation details are not reported.
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	Section 2.6. Data Extraction, p. 6 - Data extraction variables and JBI-adapted validity assessment are

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			reported. Number of reviewers/independence and investigator contact procedures are not reported.
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	Section 2.6. Data Extraction, p. 6; Sections 3.5–3.11, pp. 12–18 - Outcomes include UCS, Atterberg limits, CBR, SEM/EDS, durability and microstructural metrics. The protocol for selecting all compatible outcome results is not explicitly reported.
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	Section 2.6. Data Extraction, p. 6; results tables, pp. 13–18 - Metadata, soil mineralogy, biopolymer type/dosage, curing conditions and performance metrics were extracted. Assumptions for missing/unclear information are not reported.
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	Section 2.6. Data Extraction, p. 6; Section 4.4.1, p. 21 - Internal validity assessed with a JBI-adapted experimental checklist for the included corpus. Reviewer number/independence are not reported.
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	Results Sections 3.5–3.12, pp. 12–20 - Outcomes/parameters are presented by biopolymer, strength, durability, microstructure, hybrid systems and sustainability. Explicit effect-measure definitions are not reported.
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	Section 3.1 and Section 2.4, pp. 5–7 - Studies were grouped for qualitative/structured synthesis according to the review questions, eligibility criteria, biopolymer type and performance themes.
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	Section 2.6, p. 6 - Narrative and structured synthesis used because of methodological heterogeneity. Specific procedures for missing summary statistics/data conversions are not reported.

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	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Results Sections 3.2–3.12, pp. 7–20 - Results are tabulated and visually displayed using tables, figures, bibliometric maps and thematic syntheses.
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	Section 2.6, p. 6; Section 3.12, pp. 18–19; Section 4.4.2, pp. 21–22 - Narrative/structured synthesis was selected because of methodological heterogeneity; quantitative meta-analysis was considered unviable. No meta-analysis model/software was reported.
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	Section 3.12, pp. 18–19; Section 4.4.2, pp. 21–22 - Sources of heterogeneity (mineralogy, polymer attributes/dosage, preparation/compaction, curing/testing standards) are discussed, but no formal subgroup/meta-regression method is reported.
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	Not reported - No formal sensitivity analysis is described.
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	Not reported - No method for assessing risk of bias due to missing results/reporting bias is described.
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	Not reported - No formal certainty/confidence assessment method (e.g., GRADE) is described.
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Section 3.1, pp. 6–7 - 453 records initially identified; screening and eligibility process described; 45 articles included. Figure 1 presents a PRISMA flow diagram.
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	Not reported - No specific list of potentially eligible but excluded studies with individual exclusion reasons is provided.
Study characteristics	17	Cite each included study and present its characteristics.	Results Sections 3.2–3.12, pp. 7–20; Tables 1–6 - Included studies are cited and their characteristics/themes

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			are presented.
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Section 2.6, p. 6; Section 4.4.1, p. 21 - JBI-adapted assessment is reported, including assessment of the included corpus; individual study risk-of-bias results are not presented in a dedicated table/figure.
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Results Sections 3.5–3.12, pp. 12–20 - Outcome ranges and representative values are reported in tables/text. Individual-study summary statistics and precision measures are not consistently reported.
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	Results Sections 3.2–3.12, pp. 7–20; Section 4.1, pp. 20–21 - Syntheses summarize findings by publication trends, biopolymer category, mechanical performance, durability, microstructure and sustainability.
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	Sections 3.6–3.12 and 4.1, pp. 13–21 - Descriptive/structured results are presented. No formal meta-analysis or pooled statistical estimate is reported.
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	Section 3.12, pp. 18–19 - Heterogeneity is described and attributed to soil mineralogy, polymer attributes/dosage, preparation/compaction, curing and testing standards; no formal heterogeneity investigation is reported.
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	Not reported - No formal sensitivity analysis results are presented.
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	Not reported - No assessment of reporting bias due to missing results is presented.
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	Not reported - No certainty/confidence assessment of the body of evidence is presented.
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	Sections 4.1-4.3, pp. 20–21 - Main findings are interpreted and

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			compared with existing/seminal evidence.
	23b	Discuss any limitations of the evidence included in the review.	Sections 4.4.3 and 4.4.2, pp. 21–22 - Limitations of the included primary studies and limitations of the review are discussed.
	23c	Discuss any limitations of the review processes used.	Section 4.4.2. Limitations of the review, pp. 21–22 - Language, time window, gray literature, heterogeneity and single-database limitations are discussed.
	23d	Discuss implications of the results for practice, policy, and future research.	Section 4.5. Implications, pp. 22–24 - Implications for practice, public policy and future research are provided.
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	Section 2.1. Protocol and Registration, p. 4 - A prospective protocol under PRISMA-P is stated; no registration name or registration number is reported.
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	Section 2.1, p. 4 - Protocol development is mentioned, but no access location for the protocol is provided.
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	Not reported - No amendments to a registration/protocol are described.
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	Not reported - No financial or non-financial supprt/funder role is stated.
Competing interests	26	Declare any competing interests of review authors.	Not reported — No competing-interest declaration is provided in the manuscript text.
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	Section 2.5, p. 6 - Screening matrix and supplementary data are stated to be hosted on Zenodo: https://zenodo.org/uploads/20314145.

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