Pertanika J. Sci. & Technol. 33 (5): 2207 - 2236 (2025)

PERTANIKA JOURNALS

SCIENCE & TECHNOLOGY

Journal homepage: http://www.pertanika.upm.edu.my/

Review Article

A Systematic Literature Review on Factors Affecting the Compatibility of Natural Fibre as Cement Board Reinforcement

Hasniza Abu Bakar, Lokman Hakim Ismail*, Emedya Murniwaty Samsudin, Nik Mohd Zaini Nik Soh, Siti Khalijah Yaman and Hannifah Tami

Faculty of Civil Engineering and Built Environment, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Johor Darul Takzim, Malaysia

ABSTRACT

The compatibility of natural fibres in cement composite is a significant concern, primarily due to their inherent incompatibility with the cement matrix. Fibre's intrinsic extractive presence cannot be used solely as a primary material for cement board (CB). Therefore, this study aims to conduct a systematic literature review (SLR) to identify the main factors that affect the compatibility between natural fibre and CB products. The review processes were based on Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and were conducted through identification, screening, eligibility, and data extraction procedures. From an intensive literature review, the compatibility of natural fibre with cement was determined to be primarily influenced by its chemical composition. As such, this aspect must be thoroughly examined before producing fibre-cementitious composites due to the varying chemical arrangement of the chemical composition of natural fibres, ranging from cellulose content (22-79.3%), followed by hemicellulose (6.9-48%) and lignin (2.44-29%). Previous studies have revealed that cellulose is the primary structural component of cell walls. The elevated cellulose content in processed fibre mainly influences its strength. This is accomplished by employing treated fibres that eliminate contaminants, leading to void circular cavities or increased pore dimensions. Notably, the approach elevates the cellulose content, diminishes the fibre diameter, augments the tensile strength, and concurrently improves the performance of the CB. The analysis of variance (ANOVA) test demonstrated a significant *P*-value of less than 0.05 ($P < 0.05$), suggesting that the increase in cellulose content significantly affects the tensile

ARTICLE INFO

Article history:
Received: 10 November 2024
Accepted: 17 April 2025
Published: 28 August 2025

DOI: https://doi.org/10.47836/pjst.33.5.08

E-mail addresses:
hasniza@uthm.edu.my (Hasniza Abu Bakar)
lokman@uthm.edu.my (Lokman Hakim Ismail)
emedya@uthm.edu.my (Emedya Murniwaty Samsudin)
nikzaini@uthm.edu.my (Nik Mohd Zaini Nik Soh)
khalijah@uthm.edu.my (Siti Khalijah Yaman)
hannifah@uthm.edu.my (Hannifah Tami)
* Corresponding author

e-ISSN: 2231-8526

strength of the fibre. Therefore, this study reveals the importance of cellulose content and its impact on the performance of CB. Thus, it can be concluded that natural fibre possesses considerable potential as a sustainable material for CB composite reinforcement.

Keywords: Compatibility, cement board reinforcement, natural fibre

---

INTRODUCTION

Over the past few decades, cement has rapidly increased its use of wood as a natural fibre reinforcement. According to Aras et al. (2022), wood is one of the raw materials used to make CB. Nowadays, the use of CB has gained interest among construction practitioners in Malaysia as one of the industrial building systems (IBS) components. The application of CB in construction projects as IBS components, such as wall siding, façades, and roof panels (Hasan et al., 2021b). The United Nations (2022) highlights the growing focus on green building initiatives to enhance resource efficiency, reduce waste, and promote a circular economy. However, the use of wood as a fibre reinforcement raises forest resource demand (Maynet et al., 2021). Previously, asbestos fibres (Momoh & Osofero, 2020) and synthetic fibres (Futami et al., 2021; Mawardi et al., 2022) were generally used for building construction material. But the use of these cement composites poses risks to health exposure (Momoh & Osofero, 2020), discharging plenty of carbon dioxide, high cost, and not biodegradable (Futami et al., 2021; Hasan et al., 2021b). To address these issues, non-wood materials can be used with cement matrices for construction materials. Therefore, most of the researchers are now investigating new alternatives to other non-wood lignocellulose materials such as palm fibres (Abrha et al., 2024), kenaf fibres (Amel et al., 2020; Amiandamhen & Osadolor, 2020; Malik et al., 2021), coconut and oil palm fibres (Futami et al., 2021), rice husk fibres (Jiang et al., 2020; Xie & Li, 2021), pineapple fibres (Syduzzaman et al., 2020), coir fibre (Budiman et al. 2021; K. J. Rao et al., 2024; Kochova, Gauvin, et al., 2020; Stapper et al., 2021; Zhang et al., 2022), empty fruit bunches (EFB) fibres (Iskandar et al., 2021; Maynet et al., 2023; Peter et al., 2020; Ridzuan et al., 2023), bamboo fibres (Taiwo et al., 2024), and others to replace wood fibres in the natural fibre composite products.

On top of that, the construction industries are going to turn to the implementation of cement-based products in green building materials and construction technology to meet the Sustainable Development Goals (SDGs). Previous research has explored the natural fibre in polymer composites for the production of micro-perforated panels, particle boards, and medium-density fibre boards (Rao & Ramakrishna, 2022). The utilization of natural fibre in cement composites is very less compared with epoxy composites, however, few researchers enhancing composite products as fibre reinforcement that can be used for indoor and outdoor building materials like concrete (Futami et al., 2021; Houda et al., 2024), fibre cement flat sheets (Taiwo et al., 2024), roof tile (Rao et al., 2024; Momoh & Osofero, 2020), brick (Momoh & Osofero, 2020), cement boards (Budiman et al., 2021; Maynet et al., 2023; Peter et al., 2020; Ridzuan et al., 2023), building claddings and facades (Momoh & Osofero, 2020).

Furthermore, the issue of compatibility is a significant challenge in the manufacturing of fibre-cement products (Aras et al., 2022; Hasan et al., 2020, 2021; Xie & Li, 2021). The aspect of compatibility between natural fibres and cement has been emphasised in numerous studies that examined the utilisation of bio-composites. Based on research by Hasan et al. (2021), the cement becomes compatible with the fibre if there is no or little disturbance during the chemical reaction of cement board formations. Conversely, the cement could be incompatible with wood or fibre substances if any imperfection occurred during the CB fabrication process, especially at the hardening stage of the cement. El Hamri et al. (2024) indicate that the presence of hemicellulose, starch, sugar, tannins, and lignin in fibre-cement composites leads to compatibility issues that significantly hinder the cement hydration process. Consequently, this primarily influences the mechanical strength of fibre-cement composites (Hasan et al., 2020; Maynet et al., 2021). Furthermore, to improve the compatibility between the fibre and the cementitious material, it is essential to perform fibre modification before its application (Jiang et al., 2020; Maynet et al., 2021). The modifications were made to improve board properties by removing certain extractives to expedite the cement setting and hardening process (El Hamri et al., 2024). Therefore, it is important to identify the key factors of compatibility between the fibre and cement that can significantly impede the hardening process. The significance of these aspects is paramount in the production of cement composites. According to recent research, there is insufficient comprehensive information regarding the primary factors influencing the compatibility of natural fibre as a reinforcement in composite materials.

This systematic review was performed in accordance with the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist. A SLR serves as a robust method for acquiring comprehensive insights into the most relevant research findings pertaining to a specific inquiry (Alaloul et al., 2021). SLR is a systematic approach that thoroughly identifies and integrates relevant research while adhering to structured, transparent, and reproducible methods at every stage of the process. The review procedures, encompassing identification, screening, eligibility, and data extraction, have not been sufficiently addressed. This gap highlights concerns about transparency and bias in traditional literature review practices. Moreover, numerous authors often select articles that support their research findings (Shaffril et al., 2020). Such a system would present a significant challenge for future scholars in replicating the study, validating the interpretations, or assessing the study's comprehensiveness. The present study seeks to perform an SLR that specifically examines the compatibility of natural fibre with cement, addressing the identified gap in the existing literature. During the review process, the authors focused on the primary research question: "What are the factors affecting the compatibility of natural fibre in a cement matrix?". The primary emphasis of this paper is on the key factors that influence the performance of CB. Therefore, this study aimed to find the main factor that contributes to the compatibility between natural fibres and cement in the cement board, which primarily influences the fibre's strength and simultaneously improves the performance of the CB.

METHODOLOGY

Systematic Literature Review

The SLR was performed by examining electronic databases and bibliographies of published research and reviews (Mhd Noor et al., 2023). This method was used as a comprehensive tool based on the PRISMA framework diagram. Previously, PRISMA was frequently employed in the field of environmental management. Nevertheless, since its introduction, the review approach has garnered much attention and has been widely utilised by many researchers. For instance, Thompson et al. (2025) applied the method in the field of civil engineering, and Alaloul et al. (2021) utilised it in the context of construction materials investigations. Meanwhile, according to Shaffril et al. (2021), PRISMA's primary focus is on randomised trials, and it may also serve as a guide for systematic reviews in any field of research that incorporates intervention evaluations. The current study employed the PRISMA framework, which encompasses three distinct domains of inquiry: environmental science, material sciences, and engineering. The analysis utilised two main scholarly databases as recommended by Thompson et al. (2025), which are Scopus and the Web of Science (WoS). The databases were selected because both are the most prominent databases in the context of an SLR. The advantages of these resources include advanced search tools, extensive coverage, rigorous quality control measures for articles, and a multidisciplinary focus that includes studies on environmental management and related fields (Gusenbauer & Haddaway, 2020).

Systematic Review Process

The current research utilised three systematic methodologies to gather pertinent publications: identification, screening, eligibility, and data abstraction, as recommended by Shaffril et al. (2020, 2021). This study effectively used these methodologies to identify and integrate relevant research in order to facilitate a systematic and clear SLR. The SLR method consists of four distinct phases, as outlined by Shaffril et al. (2021): (i) identification, (ii) screening, (iii) eligibility, and (iv) data extraction. Figure 1 illustrates the four phases of the SLR method utilised in the paper.

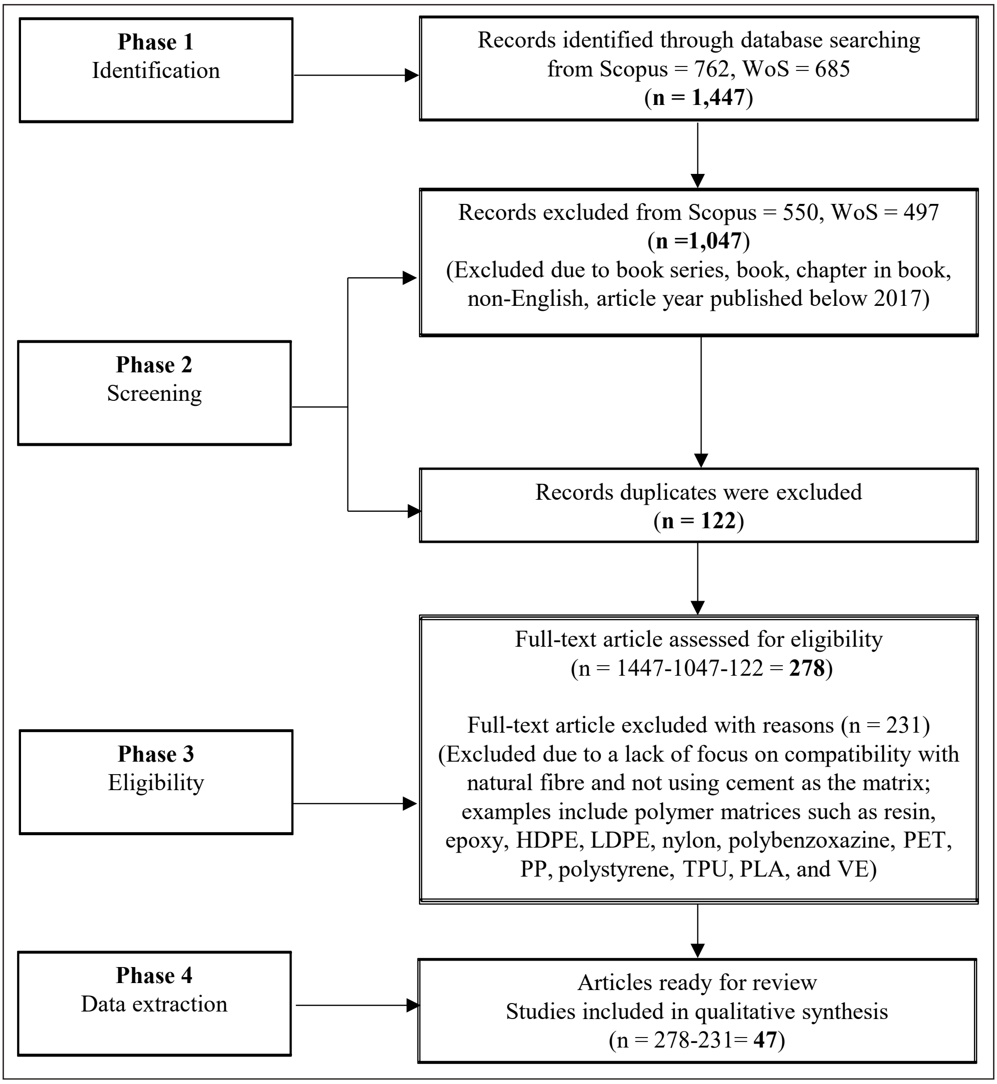


Figure 1. PRISMA diagram (Alaloul et al., 2021)
Note. PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analyses; WoS = Web of Science; HDPE = High-density polyethylene; LDPE = Low-density polyethylene; PET = Polyethylene terephthalate; PP = Polypropylene; TPU = Thermoplastic polyurethane; PLA = Polylactic acid; VE = Vinyl ester

Phase 1: Identification

The initial stage consisted of identifying the keywords used in the search process. Three primary keywords were identified according to the defined research questions: compatibility, natural fibre, and CB. To enhance the richness of these keywords, a thorough search for synonyms, related phrases, and variations was performed. This was accomplished by utilising an online thesaurus, specifically thesaurus.com, and referencing the keywords used in prior research. Additionally, the keywords recommended by Scopus were considered, and input from experts in the field was solicited. This procedure involved the examination of several terms associated with CB, including composite, bio-composite, biocomposite, cement composite, cement board, cementboard, cement-bonded board, particleboard, particle board, cement-bonded, cement-based product, fiberboard, and fibre board. The search functions employed for processing keyword combinations comprised field code functions, phrase searching, wildcards, truncation, and Boolean operators within Scopus databases (Table 1). A total of 762 records were identified through database searching in Scopus, while 685 records were identified in Web of Science, covering a duration of 6 years. The search methodology utilised a human approach known as "handpicking" from reputable databases, including Google Scholar. The search efforts yielded a total of 1,447 potential articles from the selected databases, as depicted in Figure 1.

Table 1
The search string used for the systematic review process

Database	**String**
Scopus	TITLE-ABS-KEY ((_"compatibility"_) AND (_"natural fib*"_) AND (_"composite*"_ OR _"biocomposite*"_ OR _"bio composite*"_ OR _"bio-composite*"_ OR _"cement"_ OR _"cement composite*"_ OR _"cementboard*"_ OR _"cement board*"_ OR _"cement bonded board*"_ OR _"particleboard*"_ OR _"particleboard*"_ OR _"cement bonded"_ OR _"cement-bonded"_ OR _"cement based product*"_ OR _"fib*board*"_ OR _"fib* board*"_))
Web of Science	(("compatibility") AND ("natural fib*") AND ("composite*" OR "biocomposite*" OR "bio composite*" OR "bio-composite*" OR "cement" OR "cement composite*" OR "cementboard*" OR "cement board*" OR "cement bonded board*" OR "particleboard*" OR "particle board*" OR "cement bonded" OR "cement-bonded" OR "cement based product*" OR "fib*board*" OR "fib* board*"))

Phase 2: Screening

The second step in the process was screening, wherein publications were evaluated for their inclusion or exclusion from the study. The process was executed using either database assistance or manual screening performed by the authors. The inclusion or exclusion of articles was determined by a specific set of criteria, as detailed in Table 2. By the notion of "research field maturity" highlighted by Kraus et al. (2020), this study has restricted the screening procedure to encompass only publications published from 2020 onwards. Furthermore, the selection of this timeline was based on the number of published papers required for a comprehensive review. The authors decided to focus on empirical research publications, as these provide the necessary source data for an in-depth examination. It is worth noting that, to prevent any potential misinterpretation, only texts written in the English language were taken into consideration. Given that the purpose of the SLR pertains to material studies, the selection of material science, environmental science, and engineering as the subject areas was deemed to enhance the likelihood of obtaining a greater number of articles relevant to the study. At this juncture, among the pool of 1,047 articles deemed suitable for review, a cumulative count of 122 items exhibiting duplication was excluded.

Table 2
Inclusion and exclusion criteria

Criterion	**Inclusion**	**Exclusion**
Timeline	2020 and 2025	< 2020
Document type	Articles	Book chapter, book series
Language	English	Non-English
Subject area	Material science, Environmental science, Engineering	

Phase 3: Eligibility

The third phase entails the assessment of eligibility, during which all the articles were obtained for further analysis. The authors conducted a manual examination of the remaining papers to assess their relevance, employing methods such as reading the title, abstract, or the complete text. The initial review of the abstracts was followed by a comprehensive examination of all the articles to identify relevant themes or factors influencing the compatibility of natural fibres. Following the completion of the evaluation process, a cumulative count of 231 articles was deemed ineligible for inclusion due to their lack of emphasis on the compatibility of natural fibre, CB, or cement composite. These articles were excluded due to a lack of focus on the compatibility of natural fibre and insufficient emphasis on the use of cement, including polymer matrices such as resin, epoxy, and others.

Phase 4: Data Extraction

The final round of the evaluation process for data extraction yielded a total of 47 articles.

RESULTS

Descriptive Information

Based on the provenance of the articles, out of the 47 articles, a significant portion, nine papers (19%), originated from Malaysia. This was followed by the Netherlands, which contributed six papers (13%), and four papers (9%) were from the United Kingdom and Hungary, as illustrated in Figure 2. The interest might be ascribed to the abundant availability of significant quantities of natural fibres within these nations.

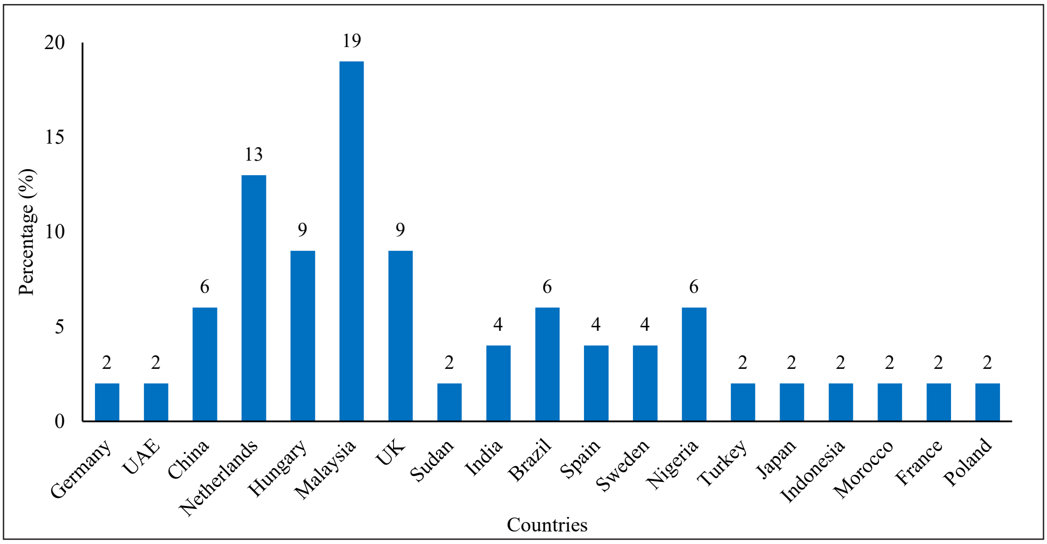


Figure 2. Distribution of research based on origin
Note. UAE = United Arab Emirates; UK = United Kingdom

Factors Affecting the Compatibility of Natural Fibre as CB Reinforcement

The present study involved the examination of 47 specifically chosen items, leading to the identification of two primary factors: (1) Fibre strand and (2) CB. Subsequently, each factor was categorised into three sub-factors, as shown in Table 3. The main research question

Table 3
Factors affecting the compatibility of natural fibre in cement board

No.	**Authors**	**Type of natural fibre**	**Fibre strand**			**Cement board**		
			Fibre properties	**Fibre treatment**	**Cement hydration**	**Density**	**Cement–fibre ratio**	**Water content**
1	Kochova, Caprai, et al. (2020)	Wood fibre	√		√			√
2	Kochova, Gauvin, et al. (2020)	Coir fibre	√					
3	Amel et al. (2020)	Kenaf fibre			√		√	
4	Jiang et al. (2020)	Straw fibre		√	√			√
5	Peter et al. (2020)	EFB fibre		√		√	√	√
6	Hasan et al. (2020)	Hungarian plant	√		√			
7	Bonnet-Masimbert et al. (2020)	Oil palm fibre	√	√	√			

Table 3 *(continue)*

No.	**Authors**	**Type of natural fibre**	**Fibre strand**			**Cement board**		
			Fibre properties	**Fibre treatment**	**Cement hydration**	**Density**	**Cement–fibre ratio**	**Water content**
8	Owoyemi et al. (2020)	*Gmelina arborea* (Roxb.)		√		√	√	
9	Momoh and Osofero (2020)	Oil palm fibre	√		√			
10	Momoh et al. (2020)	Oil palm broom	√	√				
11	Sahu and Gupta (2020)	-		√				
12	Najeeb et al. (2020)	Pineapple leaf fibres	√					
13	Amiandamhen and Osadolor (2020)	Kenaf fibres					√	
14	Berger et al. (2020)	Spruce wood	√		√			
15	Mirski et al. (2020)	Sawdust				√		
16	Mucsi et al. (2020)	Coconut husk, Reed straw				√		
17	Xie and Li (2021)	Rice straw fibre	√	√	√			
18	Adelusi et al. (2021)	Corn Cob, *G. arborea* Sawdust		√		√		
19	Futami et al. (2021)	EFB fibre	√					
20	Maynet et al. (2021)	EFB fibre		√	√			√
21	Iskandar et al. (2021)	EFB fibre	√	√				
22	Malik et al. (2021)	Kenaf fibre	√					
23	Hasan et al. (2021b)	Wood fibre	√			√	√	√
24	Hasan et al. (2021a)	Lignocellulosic fibre		√	√	√		
25	Stapper et al. (2021)	Coir fibre		√				
26	Amiandamhen et al. (2021)	*Ceiba pentandra* (L.) Gaertn. and *G. arborea* (Roxb.)					√	
27	Vitrone et al. (2021)	Lignocellulosic fibre	√					
28	Kabir et al. (2021)	Hemp fibre	√					
29	Castellano et al. (2021)	Opuntia fibre	√	√				
30	Budiman et al. (2021)	Coconut coir	√	√		√		
31	Wu et al. (2022)	*Miscanthus* x *giganteus*	√					
32	Zhang et al. (2022)	Coir fibre	√		√			√
33	Aras et al. (2022)	Olive oil fibre				√	√	
34	Chougan et al. (2022)	Wheat straw						√
35	Maynet et al. (2023)	EFB fibre	√	√	√	√	√	

Table 3 *(continue)*

No.	**Authors**	**Type of natural fibre**	**Fibre strand**			**Cement board**		
			Fibre properties	**Fibre treatment**	**Cement hydration**	**Density**	**Cement–fibre ratio**	**Water content**
36	Lima et al. (2023)	Malva fibre	√		√			
37	Ridzuan et al. (2023)	EFB fibre				√	√	√
38	Song et al. (2023)	Hemp fibers	√					
39	El Hamri et al. (2024)	Cedar Sawdust	√			√		
40	Kolajo et al. (2024)	EFB fibre		√				
41	Silva et al. (2024)	Eucalyptus fibers	√		√			
42	Taiwo et al. (2024)	Bamboo fibre	√					
43	Azmi et al. (2024)	-		√		√	√	
44	K. J. Rao et al. (2024)	Coir fibre	√					
45	Abrha et al. (2024)	Palm fibre	√					
46	Aaron and Carsten (2024)	Softwood fibre	√		√			
47	Fioroni et al. (2025)	Bamboo fibre, pine fibre	√					
	Total		**29**	**17**	**15**	**13**	**10**	**8**

Note. EFB = Empty fruit bunches

addressed in this SLR was "What are the factors affecting the compatibility of natural fibre in the cement matrix?" The study's results identified two primary factors, along with six sub-factors: fibre properties, treatment, cement hydration, density, cement-to-fibre ratio, and water content. These factors collectively provided insights into the research question. Furthermore, the primary factors emphasised in this study pertain to the evaluation of fibre strands about CB performance. Therefore, the priority of this study was to focus on the highest scoring factor, fibre properties (29), as the main criterion, compared to fibre treatment (17) and cement hydration (15), which were not elaborated.

Properties of Natural Fibre as CB Reinforcement

Generally, the most important factors considered by many to influence the strength of composites as construction materials are the mechanical and physical properties of EFB fibre (Bonnet-Masimbert et al., 2020). Nonetheless, in actuality, the chemical properties play the most crucial role in enhancing the compatibility between fibre and cement. A fluid matrix effectively restricts sugar levels at the fibre's surface without interfering with the cement hydration, which, in turn, enhances the properties of the interface (Bonnet-Masimbert et al., 2020). Previous researchers have conducted distinct studies on the chemical, physical, and mechanical properties of fibres, as illustrated in Table 4. Currently, there is insufficient discourse concerning how the interaction of chemical, physical, and mechanical properties of natural fibre influences the performance of CB. Therefore, this study aims to identify the key factors in fibre properties that enhance the compatibility of CB composites.

Table 4 provides a detailed review of articles examining the chemical, physical, and mechanical properties of fibre strands. The tabulated information showed that chemical composition (CC), scanning electron micrograph (SEM), and tensile (T) are the main fibre properties tested, with 18, 14, and 8 articles, respectively, addressing each property. However, there is limited number of studies that investigate the impact of fibre properties that are significant for supplementary testing, including micro duplet (MD), moisture content (MC), attenuated total reflection (ATR), Fourier Transformed Infrared Spectroscopy (FTIR), thermogravimetric analysis (TGA), X-Ray diffraction (XRD), energy dispersive X-ray (EDX) and pull out (PO). Therefore, this paper focused on recent studies regarding CC, SEM, and T properties, which are important for future researchers or industries when fabricating CB.

Table 4
Articles reviewed for fibre properties

References	**Fibre properties**										
	Chemical properties	**Physical properties**								**Mechanical properties**	
	CC	**SEM**	**MD**	**MC**	**ATR**	**FTIR**	**TGA**	**XRD**	**EDX**	**T**	**PO**
Momoh et al. (2020)		√		√				√		√	
Kochova, Caprai, et al. (2020)	√	√									
Kochova, Gauvin, et al. (2020)	√	√				√		√	√	√	√
Peter et al. (2020)	√	√									
Hasan et al. (2020)		√									
Bonnet-Masimbert et al. (2020)	√	√				√				√	√
Momoh and Osofero (2020)	√	√									
Najeeb et al. (2020)	√				√		√	√	√	√	
Futami et al. (2021)	√	√	√							√	
Iskandar et al. (2021)		√				√				√	
Xie and Li (2021)	√	√				√					
Hasan et al. (2021b)		√				√	√				
Vitrone et al. (2021)	√										
Kabir et al. (2021)	√	√									
Castellano et al. (2021)	√										

Table 4 *(continue)*

References	**Fibre properties**										
	Chemical properties	**Physical properties**								**Mechanical properties**	
	CC	**SEM**	**MD**	**MC**	**ATR**	**FTIR**	**TGA**	**XRD**	**EDX**	**T**	**PO**
Budiman et al. (2021)	√										
Wu et al. (2022)						√		√			
Zhang et al. (2022)				√							
Maynet et al. (2023)	√	√		√						√	
Lima et al. (2023)	√										
Song et al. (2023)	√	√				√		√			
El Hamri et al. (2024)	√										
Silva et al. (2024)	√										
Abrha et al. (2024)											√
Aaron and Carsten (2024)	√									√	
Fioroni et al. (2025)	√					√					
Total	**18**	**14**	1	3	1	8	2	5	2	**8**	3

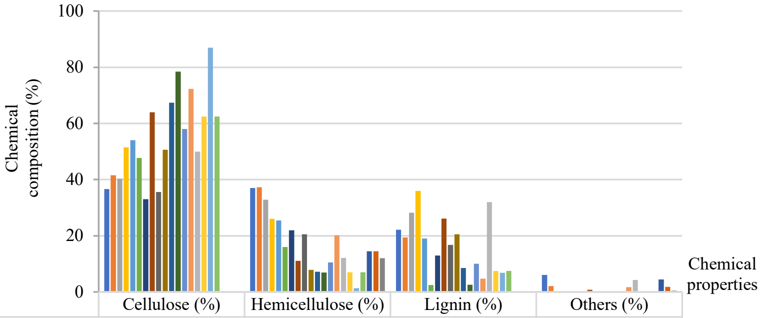
Note. CC = Chemical composition; SEM = Scanning electron micrograph; T = Tensile; MD = Micro duplet; MC = Moisture content; ATR = Attenuated total reflection; FTIR = Fourier Transformed Infrared Spectroscopy; TGA = Thermogravimetric analysis; XRD = X-Ray diffraction; EDX = Energy dispersive X-ray; PO = Pull out

Effect on the Chemical Properties of Natural Fibre as CB Reinforcement

The properties of natural fibres are mainly influenced by the chemical composition of the plant sources from which they are derived (Malik et al., 2021; Xie & Li, 2021). Fibre properties such as hemicellulose, cellulose, lignin and other impurities significantly influence the normal setting process and contribute to the prolonged setting time of the cement matrix (El Hamri et al., 2024; Hasan et al., 2021b; Maynet et al., 2023). The presence of residual oil disrupts the binding agent, preventing the immediate use of natural fibre in the cement matrix (Maynet et al., 2021). Research by Hasan et al. (2020), Maynet et al. (2021), and Wu et al. (2022) indicates that plant fibres, which are composed of various chemical compounds, including sugar and tannin, play a significant role in inhibiting the hydration of wood fibre and cement, thereby affecting the strength. This finding is in agreement with that reported by Silva et al. (2024), that untreated eucalyptus fibres produced higher impurities, hemicellulose (65.6%), lignin (23%) and extractive (10.9%). The amount and types of fibre extractives in contact with the cement matrix water can potentially inhibit the hydration of the cement composite setting. Similarly, Ridzuan et al. (2023) discovered that untreated fibre yielded lower results, falling below the minimum standard requirement for the physical and mechanical properties of a standard CB. This research obtained low results for thickness swelling (TS, 1.82%), modulus of elasticity (MOE, 1398 N/mm^2), modulus of rupture (MOR, 3.51 N/mm^2) and internal bonding (IB, 0.164 N/mm^2) due to incompatibility between the cement and the untreated fibre. Consequently, raw fibre needs to be processed to remove the impurities due to its original conditions, which might cause difficulties in establishing good bonding between the fibre-cement matrix and produce low performance of CB.

Cellulose serves as the primary component in the cell wall of natural fibre, contributing to its toughness (Momoh & Osofero, 2020; Xie & Li, 2021). Additionally, cellulose functions as a crucial element that affects the mechanical properties of fibres and their interaction with matrices. Moreover, hemicellulose and lignin, which serve as bonding agents for cellulose, are non-crystalline and dissolve within the cement paste (Bonnet-Masimbert et al., 2020; Hasan et al., 2021a; Kabir et al., 2021; Kochova, Caprai, et al., 2020). Figure 3 illustrates the chemical composition of the natural fibre identified in previous research. It has been demonstrated that cellulose constitutes the primary component of the chemical composition of natural fibres, ranging from 33-78.5%, followed by hemicellulose (6.9-37.3%), lignin (2.6-36%) and others (0.1-6.1%). This finding proved that the values of composition indicated that cellulose content possesses the highest percentage and suggesting its potential use in the composite. This statement was agreed by Maynet et al. (2023) and Futami et al. (2021) that high cellulose is crucial for fibre reinforcement in cement board materials and acts as a viable alternative to wood fibre in cement boards. Fioroni et al. (2025) proved that higher cellulose content (87%) of bamboo fibre produced high performance of cement composites (MOE, 7710 N/mm^2 and MOR, 16.50 N/mm^2). Therefore, the cellulose content contributes to the structural integrity and stiffness of the composite. This is particularly beneficial in construction materials like cement boards, where rigidity is essential for structural performance.

Besides, the chemical composition of fibre is influenced by various factors such as age, location, growth stage, environment, and land conditions (Malik et al., 2021). Sahu and Gupta (2020) indicated that the inconsistency in natural fibre properties arises from factors such as their origin, climate, and growth duration. Similarly, Momoh and Osofero (2020) stated that other factors that have an impact include the age of the fibre source, diverse experimental techniques, various fibre sources, and treatments. Previous studies have shown that different varieties of plants yield different properties of the fabricated CB. Studies by Najeeb et al. (2020) proved that pineapple leaf fibre (PALF)-Yankee leaf fibre had a higher cellulose content compared to Josapine's PALF. The cellulose of PALF- Yankee leaf fibre and Josapine's PALF was 47.74 and 33%, respectively. This finding proved that different types of PALF resulted in different chemical compositions. Similar studies by El Hamri et al. (2024) highlighted that the challenges in the advancement of wood-cement composites for different wood species compatibility with cement constituents and their inhibitory impact on cement hydration. Other than that, findings from Momoh and Osofero (2020) proved that the removal of impurities on the different parts of the oil palm tree through pre-treatment resulted in different chemical compositions. The results proved that EFB fibre contained higher cellulose, 38-65%, compared to oil palm frond (OPF) fibre and oil palm trunk (OPT) fibre, which were 40-50% and 29-47%, respectively. Meanwhile, different treatments also significantly affect the chemical composition of fibre. Xie and Li (2021) demonstrated that various treatments led to different conclusions, with twice-bleached rice straw fibres (RF4) achieving an optimal cellulose content of 78.5%, surpassing other treatments, such as steam explosion, hydrogen peroxide immersion, and bleaching. In summary, determining the chemical composition of natural fibres after treatment is essential for optimizing their properties, ensuring quality, and expanding their potential applications. Therefore, it is very important to determine the chemical composition of natural fibres after the treatment process before they can be used for the next stage.



	Cellulose (%)	Hemicellulose (%)	Lignin (%)	Others (%)
■ Kochova et al. (2020)-Coir fibre	36.6	37	22.2	6.1
■ Kochova et al. (2020)-Spruce fibre	41.6	37.3	19.4	2.1
■ Peter et al. (2020)-EFB fibre	40.35	32.82	28.26	
■ Momoh and Osofero (2020)-EFB fibre	51.5	26	36	
■ Bonnet-Masimbert et al. (2020)-Oil palm fibre	54	25.5	19	
■ Najeeb et al. (2020)-PALF, Yankee	47.74	15.98	2.44	
■ Najeeb et al. (2020)-PALF, Josapine	33	22	13	
■ Aaron and Carsten (2024) -Softwood fibre	64	11.1	26.1	0.8
■ Xie and Li (2021)-Rice straw fibre, RF1	35.6	20.5	16.8	
■ Xie and Li (2021)-Rice straw fibre, RF2	50.6	7.9	20.5	
■ Xie and Li (2021)-Rice straw fibre, RF3	67.4	7.2	8.5	0.1
■ Xie and Li (2021)-Rice straw fibre, RF4	78.5	6.9	2.6	
■ Castellano et al. (2021)-Opuntia fibre	58	10.5	10	
■ Song et al. (2023) - Hemp fibre	72.3	20.15	4.7	1.7
■ Anas et al. (2024)-Cedar sawdust	50	12.1	32	4.24
■ Lima et al (2023)-Malva fibre	62.5	7	7.5	
■ Carlos et al. (2025)-Bamboo fibre	87	1.38	6.8	
■ Lima et al. (2023)-Malva fibre	62.5	7	7.5	
■ Budiman et al. (2021)-Coir fibre (untreated)		14.5		4.5
■ Budiman et al. (2021)-Coir fibre (cold water)		14.5		1.8
■ Budiman et al. (2021)-Coir fibre (hot water)		12		0.5

Figure 3. Main percentages of chemical composition of the natural fibres
Note. EFB = Empty fruit bunches; PALF = Pineapple fibre

Effect on the Physical Properties of Natural Fibre as CB Reinforcement

Many researchers used surface morphology analysis (SEM) to observe changes on the fibre surface after pre-treatment. A study conducted by Peter et al. (2020) investigated how the impurities attached to the surface of untreated EFB fibre influenced the bonding characteristics between EFB fibre and the cement matrix. Similar studied by Maynet et al. (2023), that mentioned high amount of silica body were attached on the fibre surface before treatment, as shown in Figure 4a. While, Figure 4b shows that natural impurities and silica bodies were eliminated from the fibre's surface, leading to an increased pore size and a rougher surface after sodium hydroxide (NaOH) pre-treatment (Bonnet-Masimbert et al., 2020). In summary, the consensus among previous studies suggests that the removal of impurities (silica bodies) from the fibre surface results in the formation of empty circular craters or larger pore sizes (Bonnet-Masimbert et al., 2020; Peter et al., 2020), an increase in cellulose content (Maynet et al., 2023), reduced fibre's diameter (Maynet et al., 2021), improved tensile strength (Maynet et al., 2023) and better compatibility between fibre and cement matrix (Xie & Li, 2021).

Nonetheless, a high chemical concentration or an excessive solution would certainly degrade the fibre. Research done by Jiang et al. (2020) proved that the fibre begins to sustain damage and deform at a concentration of 4% NaOH and affected of the boundary layers of the EFB fibre, leading to a deterioration of the fibre particles, as illustrated in Figure 4c. Furthermore, based on findings from Kabir et al. (2021), it was observed that high concentrations of NaOH treatment (6-10%) led to a weakening and breakage of hemp fibre, as illustrated in Figure 4d. In addition, the application of hot water treatment at a temperature of 100°C for a duration of 2 h resulted in damage to the fibre, attributed to excessive delignification and radial cracking (Momoh et al., 2020).

Additionally, Maynet et al. (2021) indicated that the diameter of the fibre influenced its properties, in which when the diameter was decreased, the strength of the fibre also increased. Previous findings stated that fibre diameter in range 0.03 to 0.57 mm as shown in Table 5. Others than that, the physical properties of natural fibres that consist of length (1-200 mm), moisture content (5-43.51%), and density (0.07-1.51 g/cm^3). Nevertheless, moisture content should be a priority, but lack of research were not included these properties. Maynet et al. (2021) proved that 5% moisture content produced CB with meet the minimum standard for physical properties with density CB of 1309 kg/m^3 and TS value of 0.65%. They argued that the moisture content of the fibre must be controlled at approximately ±5%. It is because the interaction between natural fibres and the material matrix and fibres can be influenced by fibre hydrophilicity and hydrophobicity.

Recent findings by Maynet et al. (2023) revealed that the length of the fibres significantly influences the strength of the CB composite. EFB fibres at different lengths were utilised according to the mesh retained sizes of R7M (5 mm), R14M (3 mm), and R30M (1 mm).

The findings show that the ideal fibre length recommended for the fabrication of CB composites is the processed fibres that retain on the R14M sieve, averaging 3 mm in length. Nonetheless, shorter particles tend to bypass significant voids and irregularities in CB, whereas longer fibre lengths, particularly those retained at R7M, result in a composite with lower density, which consequently increases the number of voids. The result from this study agrees with Momoh and Osofero (2020) who commended the fibre length of 3 cm and should not be greater than 50 mm since longer lengths create "balling" of the fibres in cement matrix. Therefore, the potential natural fibres physical properties for the suitability in cement board primarily influence by diameter fibre in range 0.03 to 0.57 mm, fibre length of 3 mm and moisture content of 5%, would significantly enhanced the interlocking at the interface in CB composite.

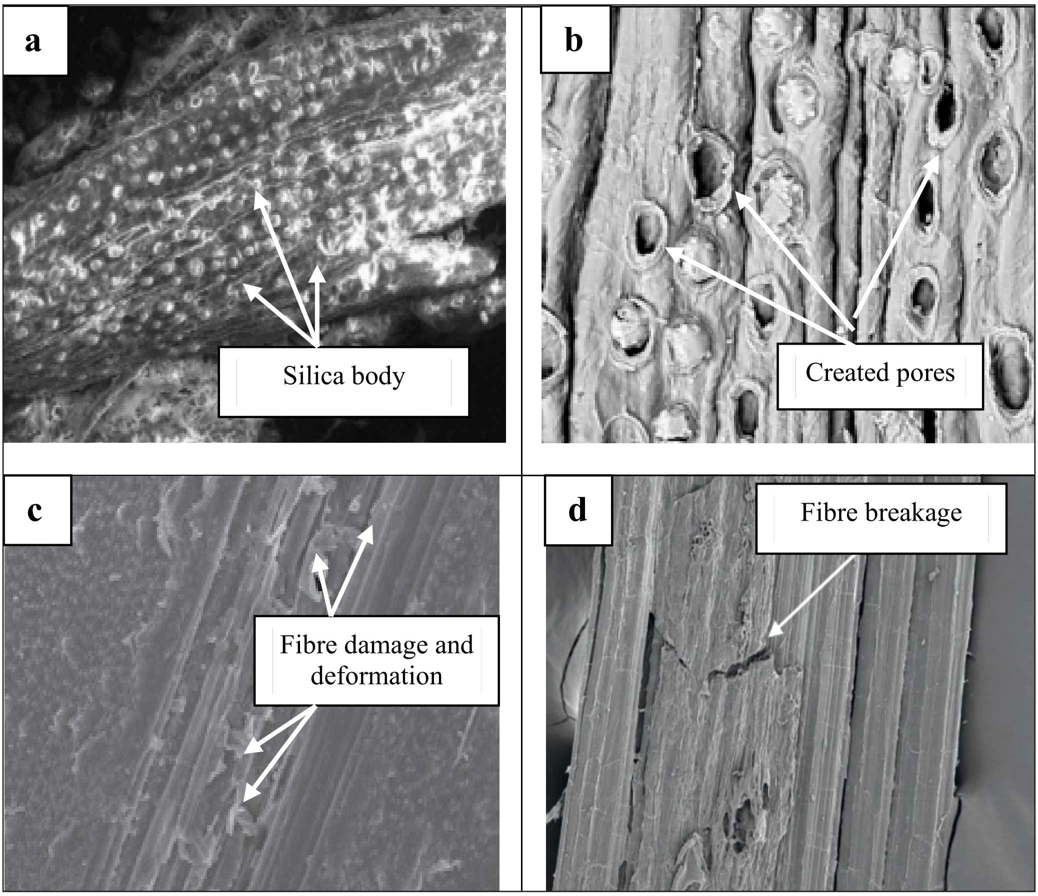


Figure 4. Scanning electron microscope images: (a) Silica body on the fibre surface before treatment (empty fruit bunches [EFB] fibre); (b) Pore or empty circular crater on the fibre surface after treatment (EFB fibre); (c) Fibre damage and deformation; and (d) Fibre breakage - 8% sodium hydroxide (Hemp fibre)
Source: Bonnet-Masimbert et al. (2020), Jiang et al. (2020), Kabir et al. (2021), and Maynet et al. (2023)

Table 5
Physical properties of different natural fibres

Type of fibre	**Physical properties**				**References**
	Diameter (mm)	**Length (mm)**	**Moisture content (%)**	**Density (g/cm^3)**	
Coir fibre	-	40-50	-	-	Kochova, Gavin, et al. (2020)
	-	1-2	-	-	Budiman et al. (2021)
	0.20-0.50	8	-	0.07	Zhang et al. (2022)
	0.10-0.20	150-200	10.50	1.40	K. J. Rao et al. (2024)
Spruce wood	-	-	-	-	Kochova, Caprai, et al. (2020)
Oil palm fibre	-	60	-	0.70-1.51	Bonnet-Masimbert et al. (2020)
	-	-	-	-	Momoh et al. (2020)
EFB fibre	-	3	-	-	Momoh and Osofero (2020)
	0.22-0.57	17-47.70	13-43.51	-	Peter et al. (2020)
	-	1, 3, 5	5	-	Maynet et al. (2023)
	-	-	-	-	Iskandar et al. (2021)
Pineapple leaf fibre	-	-	-	-	Najeeb et al. (2020)
Rice straw fibre	0.06-0.07	0.354-0.578	-	-	Xie and Li (2021)
Hemp fibre	0.25	4.23	-	1.34	Song et al. (2023)
Bamboo fibre	0.03	5.30	-	-	Taiwo et al. (2024)
Palm fibre	0.171	12	-	0.723	Abrha et al. (2024)

Note. EFB = Empty fruit bunches

Effect on the Mechanical Properties of Natural Fibre as CB Reinforcement

Previous studies demonstrated that natural fibre can serve as reinforcement for CB based on its mechanical strength. Figure 5 shows the previous findings on tensile strength, which ranges from 200-663 N/mm^2. Findings from Momoh and Osofero (2020), and Xie and Li (2021) showed that the elimination of contaminants from EFB fibre through pre-treatment improved the chemical composition. Momoh and Osofero (2020) showed that EFB fibre possesses the highest cellulose content after it has undergone NaOH treatment. This study also revealed that a higher cellulose content correlates with enhanced strength in treated fibre. Similar with Bonnet-Masimbert et al. (2020) confirmed that fibre treatment such as NaOH solution (2, 4, 6, 10%), Silane (1, 3%) and hot water (1-2 hr soaking time) improved fibre surface by indicating the presence of empty circular craters or larger pore sizes, significantly improve the tensile strength of the fibres. This study resulted in the tensile strength of oil palm fibre improving, ranging from 220 to 395 N/mm^2 at 2-4% NaOH, respectively. Furthermore, the tensile strength of 3% silane treatment increased compared to 1% silane, with achieved optimal values of 484 and 316 N/mm^2, respectively.

Meanwhile, hot water treatment one soaking hour higher than 2 hour at strength value of 404 and 347 N/mm^2. The reason of an increament of strength due to fibre treatment that successfully removes impurities, hemicellulose, lignin, and waxy substances from fibre surfaces, exposing more cellulose fibrils with higher tensile strength and improving mechanical properties.

A prior study by Najeeb et al. (2020) demonstrated that different types of plants possessed different properties. The percentages of cellulose of PALF-Yankee leaf fibre and Josapine's PALF, which were 47.74 and 33%, produced different tensile strength results of 390 and 295 N/mm^2, respectively. The strength of Yankee's PALF is higher than Josapine's PALF due to higher crystallinity, which enhances the strength of the fibre. Furthermore, a higher concentration of chemicals or an overly prolonged treatment would certainly degrade the fibre (Bonnet-Masimbert et al., 2020). Their findings show that tensile strength decreased from 6-10% NaOH (334-288 N/mm^2). In a similar sense, hot water treatment at 100°C with 2 hours of soaking time may also result in fibre degradation due to severe delignification and radial cracking, causing the tensile strength of the fibre to decrease (Momoh et al., 2020) and fibre to fracture (Kabir et al., 2021). Therefore, exposure to higher chemical concentrations, temperature, and prolonged soaking durations can be considered to hurt the tensile strength of the fibre due to lignocellulose degradation and surface rupture.

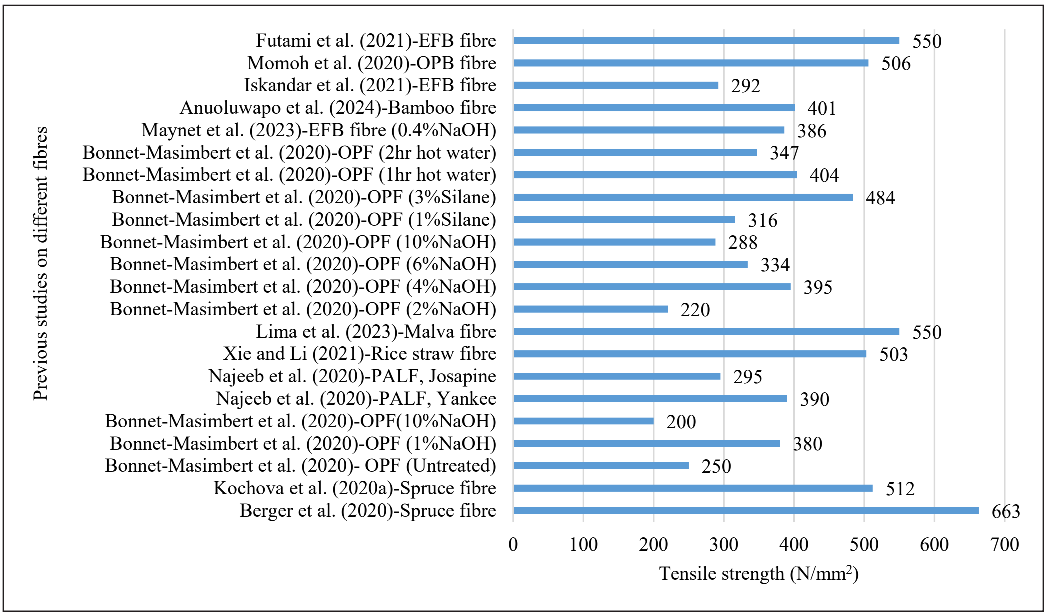


Figure 5. The fibre strength of natural fibre
Note. EFB = Empty fruit bunches; OPB = Oil palm broom; OPF = Oil palm fibre ; PALF = Pineapple fibre; NaOH = Sodium hydroxide

Relationship Between Chemical, Physical and Mechanical Properties of Natural Fibre Towards CB Reinforcement

As mentioned earlier, cellulose serves as the primary structural component in cell walls. Consequently, numerous findings reported that pre-treatment of fibre is effective in removing impurities, increasing the cellulose content, improving the tensile strength and simultaneously enhancing the compatibility between fibre and cement matrix (Iskandar et al., 2021; Maynet et al., 2023). Najeeb et al.'s (2020) research found that PALF-Yankee leaf fibre had a higher cellulose content (47.74%) than Josapine's PALF (33%), and tensile strength measurements were 390 and 295 N/mm^2. The reason for the strength of Yankee's PALF was higher than that of Josapine's PALF because of its elevated crystallinity, which contributes to the higher strength of the fibre. As a summary, higher crystallinity generally correlates with higher tensile strength due to the more organised and deformation-resistant nature of crystalline regions.

Furthermore, the percentage of cellulose examined by Kochova, Gauvin, et al. (2020), Peter et al. (2020), Xie and Li (2021), Castellano et al. (2021), El Hamri et al. (2024), Aaron and Carsten (2024), fall within the ranges reported by earlier studies, specifically, 37, 40, 57, 58, 50, 64%, respectively. All of these compositions prove the potential for outstanding fibre strength of cellulose. Nonetheless, researchers including Bonnet-Masimbert et al. (2020), Momoh et al. (2020), Futami et al. (2021), Iskandar et al. (2021), Maynet et al. (2023) and Taiwo et al. (2024), merely cited the chemical composition values from previous studies, with the tensile strength was found to be within a favourable range of 220-550 N/mm^2. Therefore, a lack of study reported that both chemical composition and tensile strength are necessary to be determined. Somehow, it can predict earlier the performance of cement board.

As such, higher cellulose content holds great significance, as this material is the most robust and stiffest in organic fibres. In contrast, hemicellulose lacks the same impactful properties due to its solubility in water and high water absorption. Meanwhile, lignin primarily serves as a bonding agent, functioning as the matrix within this cellulose composite. Moreover, the impact of cellulose on fibre strength is illustrated in Figure 6. The figure shows that the elimination of natural impurities and silica bodies from the fibre's surface leads to the formation of larger pore sizes and rougher surfaces. This, in turn, enhances cellulose content, reduces fibre diameter, increases tensile strength, and simultaneously improves the compatibility between fibre and the cement matrix. Research conducted by Bonnet-Masimbert et al. (2020), and Xie and Li (2021) confirmed this finding, indicating that the presence of empty circular craters or larger pore sizes can improve the tensile strength of the fibres. Table 6 shows the findings from a one-way analysis of variance (ANOVA) examining the relationship between cellulose content and fibre tensile strength. Since the p-value was below 0.05, the ANOVA test indicates a statistically significant result.

Thus, it can be concluded that the increase in cellulose content has influenced the fibre's tensile strength. The reason is that higher cellulose content contributes to better strength and simultaneously higher compatibility of fibre when incorporated in the cement matrix as a form of reinforcement. The relatively low tensile strength can be attributed to the lower content of cellulose in untreated fibre. This demonstrates the importance of cellulose content, as it is the primary molecule in the cell wall of natural fibre and plays a crucial role in providing toughness, thereby enabling the full potential of the fibre to be harnessed.

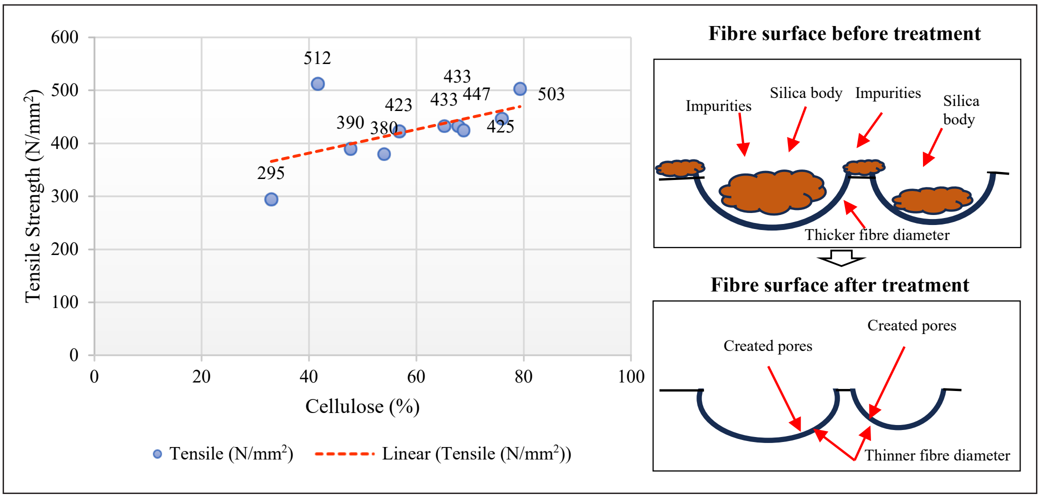


Figure 6. Effect of cellulose on the fibre strength as a reinforcement for cement board

Table 6

Analysis of variance test for the effect of cellulose on the fibre strength as a reinforcement for cement board

Source of variation	SS	df	MS	*F*	*P*-value	*F* crit
Between groups	666435.3	1	666435.3	329.0484	5.16E-13	4.413873
Within groups	36456.14	18	2025.341			
Total	702891.4	19				

Future Perspectives on Improving the Drawbacks of Natural Fibre

Fibre Surface Modification of Natural Fibre

Fibre surface modification improves fibre integrity in cement composites (Momoh & Osofero, 2020). Factors like extractives hinder cement hydration, setting, and strength development, affecting the physical and mechanical properties (Hasan et al., 2021b, 2020; Momoh et al., 2020). According to Iskandar et al. (2021), Bonnet-Masimbert et al. (2020) and Aruna et al. (2020) have addressed the improvement of fibre cement compatibility through surface treatment of fibre, such as physical and chemical treatments. Figure 7 (a-f) shows the effect of fibre treatment, such as hot water, alkaline, thermal, and untreated, on the physical (TS, water absorption [WA], and density) and mechanical properties (MOE, MOR, IB) of CB. Ridzuan et al. (2023) proved that untreated fibre produced low performance of physical and mechanical properties of cement board with optimum value of TS (1.82%), density (1313 kg/m^3), MOE (1398 N/mm^2), MOR (3.51 N/mm^2), and IB (0.164 N/mm^2).

Previous studies were mainly conducted on the chemical method, such as Maynet et al. (2023) and Peter et al. (2020) used a lower concentration of NaOH (0.4 and 1%), resulting in physical and mechanical properties below the minimum requirement. However, the study indicates that heat thermal pre-treatment of the fibre significantly eliminates residual and impurities compared to NaOH pre-treatment with optimum value of MOE (4699 N/mm^2), MOR (9.1 N/mm^2) and IB (0.53 N/mm^2). Therefore, low concentrations are not suggested, but high concentrations of chemical treatments can damage fibres, affecting their mechanical properties and affecting the health implications.

However, the knowledge of the impact of physical treatments like hot water treatment on the compatibility of cement composites is limited. Adelusi et al. (2021) found that pre-treatment of maize cob and sawdust fibre with hot water at 100°C for an hour produced stronger, stiffer, and more stable cement boards, resulting in higher MOE and MOR values of 10,797 and 8.42 N/mm^2, respectively, and lowest TS and WA after 24 hours (0.3-1.15%). This is due to many void spaces being filled, which helps achieve a thorough and homogenous mix of the cement bonded board. Similar to Owoyemi et al. (2020), who conducted a study using hot water treatment at 90°C for 30 minutes, produced the highest MOE value of 4164 N/mm^2. The study reveals that higher cement and corn cob particle mixing ratios improve composite board resistance, stiffness, and breaking strength. Therefore, surface modification treatment can enhance surface roughness, remove impurities, and incorporate new functional groups to improve bonding between the fibre surface and the matrix.

In conclusion, hot water treatment is seen as the right approach to improve the drawbacks of natural fibre as a cement board reinforcement. This treatment has good potential from other methods in some benefits, such as being non-chemical or environmentally friendly, cheaper than alkalization and salinization (Momoh et al., 2020; Stapper et al., 2021), increasing mechanical properties and improving thermal stability (Nordin et al., 2020).

Compatibility Method of Fibre and Cement Matrix

The combination of materials in cement can lead to degradation of natural fibres, causing disintegration within the cement matrix and reducing the structural integrity of composites. Silva et al. (2024) highlight that plant fibers' incompatibility with cement is due to dissolved extractives' impact on cement hydration and the presence of numerous hydroxyl groups in cell walls, which negatively affect the physical and mechanical properties of the composites. According to Amel et al. (2020), Aaron and Carsten (2024), and Silva et

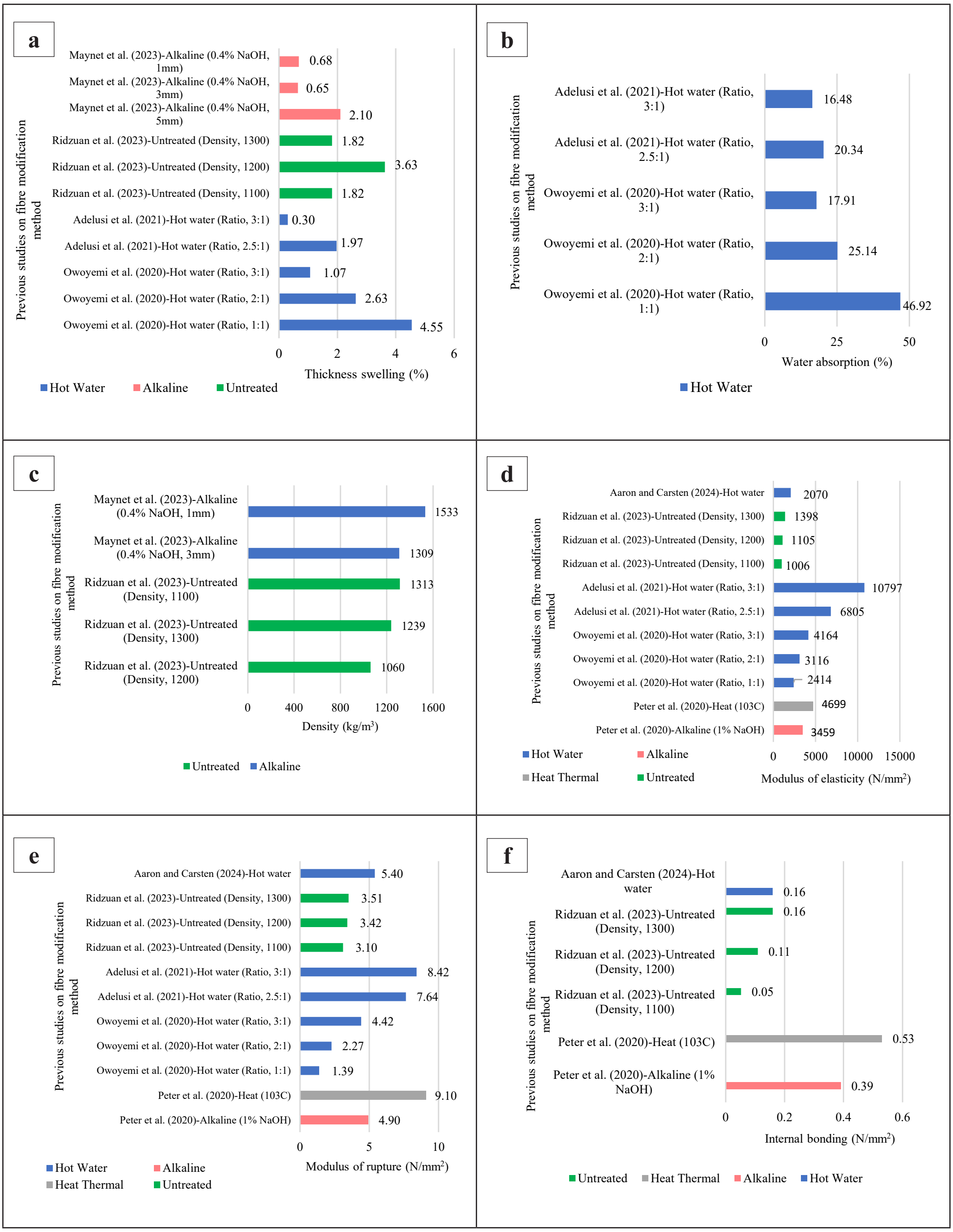


Figure 7. Effect of fibre treatment on the physical and mechanical properties of cement board: (a) Thickness swelling; (b) Water absorption; (c) Density; (d) Modulus of elasticity; (e) Modulus of rupture; (f) Internal bonding

al. (2024), a hydration test was conducted to assess the compatibility of wood particles or fibres on the setting of cement. Their findings show that increased fibre content influences the hydration of anhydrous cement.

Previous studies have shown that fibre treatments such as cold water (Kochova, Caprai, et al., 2020), NaOH (Bonnet-Masimbert et al., 2020; Jiang et al., 2020; Lima et al., 2023; Maynet et al., 2023), and hot water (Aaron & Carsten, 2024) produced medium inhibition grade (Table 7). This phenomenon is due to the poor setting of fibre treatment,

Table 7

Effect of fibre treatment on the compatibility of fibre-cement matrix

References	**Type of fibre**	**Treatment / Concentration**	**T (°C)**	**H (hr)**	***I* (%)**	**Grade of inhibition**
Kochova, Caprai, et al. (2020)	Spruce wood wool	CW-A	-	-	85	Medium
		CW-B	-	-	75	Medium
Amel et al. (2020)	Kenaf fibre	-	67.8	6	-	-
Jiang et al. (2020)	Straw fibre	3%NaOH (4hours)	15.8	1.5	91.72	-
Bonnet-Masimbert et al. (2020)	Oil palm fibre	1 NaOH	-	-	91.5	Medium
		10% NaOH	-	-	93.2	Medium
Xie and Li (2021)	Rice straw fibres	S (97.5OPC-2.5RF1)	-	-	2.606	Low
		S (95OPC-5RF1)	-	-	25.58	Medium
		S (92.5OPC-7.5RF1)	-	-	112.68	Extreme
		S (90OPC-10RF1)	-	-	Infinate	Extreme
		S+HPA (95OPC-5RF22	-	-	0.027	Low
		S+HPA (92.5OPC-7.5RF2)	-	-	1.168	Low
		S+HPA (90OPC-10RF2)	-	-	14.55	Medium
		S+HPA+B 1x (95OPC-5RF3)	-	-	0.027	Low
		S+HPA+B 1x (90OPC-10RF3)	-	-	1.943	Low
		S+HPA+B 2x (95OPC-5RF4)	-	-	0.02	Low
		S+HPA+B 2x (90OPC-10RF4)	-	-	2.222	Low
Lima et al. (2023)	Malva fibre	5% NaOH (30 min)	-	-	80	Medium
Maynet et al. (2023)	EFB fibre	U	45.9	10.5	-	-
		0.4% NaOH (24 hr)	47	11.2	-	-
Aaron and Carsten (2024)	Softwood fibre	HW (5 hr)	-	-	18.1	Medium
Silva et al. (2024)	Eucalyptus fibers	NB	36	-	34.52	Medium

Note. CW = Cold water; NaOH = Sodium hydroxide; S = Steam; HPA = Hydrogen peroxide aqueous; B = Bleaching; U = Untreated; HW = Hot water; NB = Non bleached; RF = Rice straw fibers; OPC = Ordinary Portland cement which causes an amount and types of fibre extractives in contact with the cement matrix that can potentially disintegrate within the cement matrix or inhibit hydration. They have shown that the interfacial bond strength between wood fibres and cement matrix can be increased with fibre treatment. Nevertheless, Silva et al. (2024) mentioned that untreated Eucalyptus fibres also produced moderate inhibition of the cementitious matrix. This happened due to the type of fibre, which had fewer impurities, resulting in better inhibition of the composite. Similar findings with Lima et al. (2023) resulted in a high concentration of 5% NaOH solution. Soaking for 30 minutes produced a medium inhibition grade for Malva fibre. Similar to Xie and Li (2021), who found that adding rice straw (RF1) from 2.5-10 wt.% significantly slowed cement hydration. It may be due to a high amount of impurities, which reduces and delays the hydration process, forming a thin permeable layer around the cement grains. Other than that, a shorter length of the treated fibre produced a higher hydration temperature. Maynet et al. (2023) found that cement mixed with EFB fibre increased the hydration rate for R14M, reaching 44.9°C for treated fibre and 43.8°C for untreated fibre. Shorter treated fibres improved interfacial bond, load transfer, and crack resistance. Therefore, the treated fibre removes impurities, resulting in increased cellulose content, improved strength, and significantly enhanced hydration rate.

In conclusion, many factors contribute to the incompatibility caused by the various chemical compositions affecting the hydration of cement setting. Therefore, this hydation test can be used to assess the suitability of compatibility for cement-fibre composite before production, either under low, medium, or extreme inhibition grade. Furthermore, inhibition index is a suitable method for evaluating the compatibility of fibre and cement matrix before the CB fabrication process (Hasan et al., 2021b; Maynet et al., 2021). Thus, mostly previous researcher have not studied the chemical composition with the performance of physical and mechanical CB. Therefore, this pre-checking of the hydration test could know the suitability of fibre and predict the performance of CB before it can be proceeded to the fabrication.

CONCLUSION

The compatibility of natural fibre with cement is primarily determined by the properties of the fibre. Through an intensive literature review, the physical, chemical and mechanical properties of natural fibre influence to the performance of the cement board. The potential natural fibres physical properties for the suitability in cement board are primarily influence by diameter fibre in range 0.03 to 0.57 mm, fibre length of 3 mm and moisture content of 5%, would significantly enhanced the interlocking at the interface in CB composite. Meanwhile, the chemical composition contains of cellulose is the main factor of the structural component in cell walls and its contribure the compatibility in the CB composite. During the fibre treatment could eliminates an impurities, resulting in empty circular craters or larger pore sizes. Notably, it increases the cellulose content, decreases the fibre diameter, enhances the mechanical strength of tensile, and simultaneously improves the performance of the CB. Furthermore, there are still lacking of study on the effect of hot water treatment on the hydration rate of the EFB fibre-cement mix. This pre-checking of the hydration test could know the suitability of fibre and predict the performance of cement board before it can be proceeded to the fabrication. In summary, natural fibre is promising as a sustainable construction material for reinforcing cement matrices, potentially replacing synthetic fibres and asbestos for CB reinforcement.

ACKNOWLEDGEMENTS

The authors gratefully acknowledged support from the Malaysian Ministry of Higher Education (MOHE) and Universiti Tun Hussein Onn Malaysia (UTHM) through FRGS-RACER grant No. K159.

REFERENCES

Aaron K. M., & Carsten, M. (2024). Basalt grid reinforcement of cement-bonded particleboards. *Construction and Building Materials*, *410*, 134168. https://doi.org/10.1016/j.conbuildmat.2023.134168

Abrha, S. F., Shiferaw, H. N., & Kanakubo, T. (2024). Bridging behavior of palm fiber in cementitious composite. *Journal of Composite Science*, *8*(9), 361. https://doi.org/10.3390/jcs8090361

Adelusi, E. A., Olaoye, K. O., Adelusi, F. T., & Adedokun, S. A. (2021). Physico-mechanical properties of cement-bonded boards produced from mixture of corn cob particles and *Gmelina arborea* sawdust. *Journal of Forest and Environmental Science*, *37*(1), 79-89, https://doi.org/10.7747/JFES.2021.37.1.79

Alaloul, W. S., Salaheen, M. A., Malkawi, A. B., Alzubi, K., Al-Sabaeei, A. M., & Musarat, M. A. (2021). Utilising of oil shale ash as a construction material: A systematic review. *Construction and Building Materials*, *299*, 123844. https://doi.org/10.1016/j.conbuildmat.2021.123844

Amel, B. A., Paridah, M. T., Rahim, S., & Hussein, A. S. (2020). Effects of kenaf bast fibre and silica fume content on bending strength and dimensional stability of cement bonded kenaf composite boards. *Journal of Engineering Science and Technology*, *15*(2), 1124–1138.

Amiandamhen, S. O., & Osadolor, S. O. (2020). Recycled waste paper–cement composite panels reinforced with kenaf fbres: Durability and mechanical properties. *Journal of Material Cycles and Waste Management*, *22*, 1492-1500. https://doi.org/10.1007/s10163-020-01041-2

Amiandamhen, S. O., Agwu, C. U., & Ezenwaegbu, P. N. (2021). Ezenwaegbu, evaluation of cement-bonded particleboards produced from mixed sawmill residues, *Journal of the Indian Academy of Wood Science*, *18*(1), 14–19. https://doi.org/10.1007/s13196-021-00273-5

Aras, U., Kalaycıoğlu, H., Yel, H., & Kuştaş, S. (2022). Utilisation of olive mill solid waste in the manufacturing of cement-bonded particleboard, *Journal of Building Engineering*, *49*, 104055. https://doi.org/10.1016/j.jobe.2022.104055

Azmi, N. H, Nik Soh, N. M. Z., & Abu Bakar, H. (2024). The compatibility of cement bonded fibreboard through dimensional stability analysis: A review. *Pertanika Journal of Science and Technology*, *32*(5), 1979-1996. https://doi.org/10.47836/pjst.32.5.03

Berger, F., Gauvin, F., & Brouwers, H. J. H. (2020). The recycling potential of wood waste into wood-wool/cement composite. *Construction and Building Materials*, *260*, 119786. https://doi.org/10.1016/j.conbuildmat.2020.119786

Bonnet-Masimbert, P. A., Gauvin, F., Brouwers, H. J. H., & Amziane, S. (2020). Study of modifications on the chemical and mechanical compatibility between cement matrix and oil palm fibres. *Results in Engineering*, *7*, 100150. https://doi.org/10.1016/j.rineng.2020.100150

Budiman, I., Sumarno, A., Triastuti, Prasetyo, A. M., Maidina, Widodo, E., Akbar, F., Subiyanto, B., & Nugroho, A. (2021). The properties of cement boards reinforced with coconut coir fiber (*Cocos nucifera*) as building materials. In *IOP Conference Series: Earth and Environmental Science* (Vol. 762, No. 1, p. 012074). IOP Publishing. https://doi.org/10.1088/1755-1315/762/1/012074

Castellano, J., Marrero, M. D., Ortega, Z., Romero, F., Benitez, A. N. & Ventura, M. R. (2021). *Opuntia* spp. fibre characterisation to obtain sustainable materials in the composites field. *Polymers*, *13*(13), 2085. https://doi.org/10.3390/polym13132085

Chougan, M., Ghaffar, S. H., Sikora, P., Mijowska, E., Kukułka, W., & Stephan, D. (2022). Boosting Portland cement-free composite performance via alkali-activation and reinforcement with pre-treated functionalised wheat straw. *Industrial Crops and Products 178*, 114648. https://doi.org/10.1016/j.indcrop.2022.114648

El Hamri, A., Mouhib, Y., Ourmiche, A., Chigr, M., & El Mansouri, N. E. (2024). Study of the effect of cedar sawdust content on physical and mechanical properties of cement boards. *Molecule*, *29*(18), 4399. https://doi.org/10.3390/molecules29184399

Fioroni, C. A., Kadivar, M., do Amaral, L. M., Ezugwu, E. K., Calabria-Holley, J., & Savastano Junior, H. (2025). Sol-gel treated pulp and accelerated carbonation curing: A novel approach for high-performance bamboo fibre cement composites. *Construction and Building Materials*, 458, 139487. https://doi.org/10.1016/j.conbuildmat.2024.139487

Futami, E., Shafigh, P., Katman, H. Y., & Ibrahim, Z. (2021). Recent progress in the application of coconut and palm oil fibres in cement-based materials, *Sustainability*, *13*(22), 12865. https://doi.org/10.3390/su132212865

Gusenbauer, M. & Haddaway, N. R. (2020). Which academic search systems are suitable for systematic reviews or meta-analyses? Evaluating retrieval qualities of Google Scholar, PubMed, and 26 other resources. *Research Synthesis Methods*, *11*(2), 181–217. https://doi.org/10.1002/jrsm.1378

Hasan, K. M. F., Brahmia, F. Z., Bak, M., Peter, G. H., Levente, D., & Tibor, A. (2020). Effects of cement on lignocellulosic fibres. In R. Nemeth, P. Redemacher, C. Hansman, M. Bak, & M. Bader (Eds.), *9th Hardwood Proceedings Part I: With Special Focus on "An Underutilized Resource: Hardwood Oriented Research"* (pp. 99–103). University of Sopron Press.

Hasan, K. M. F., Horváth, P. G., & Alpár, T. (2021a). Lignocellulosic fiber cement compatibility: A state of the art review. *Journal of Natural Fibers*, *19*(13), 5409-5434. https://doi.org/10.1080/15440478.2021.1875380

Hasan, K. M. F., Horváth, P. G., & Alpár, T. (2021b). Development of lignocellulosic fiber reinforced cement composite panels using semi-dry technology, *Cellulose*, *28*, 3631–3645. https://doi.org/10.1007/s10570-021-03755-4

Houda, H., Mehrez, I., Gheith, R., & Jemni, A. (2024). Enhancing concrete properties with agave Americana fiber reinforcement. *ACS Omega*, *9*(8), 8743–8753. https://doi.org/10.1021/acsomega.3c03687

Iskandar, W. M. E., Ong, H. R., Rahman Khan, M. M., Ramli, R., & Mohamed Halim, R. (2021). Influence of ultrasound on alkaline treatment of empty fruit bunch fibre: Preliminary study. In *IOP Conference Series: Materials Science and Engineering* (Vol. 1092, No. 1, p. 012002). IOP Publishing. https://doi.org/10.1088/1757-899x/1092/1/012002

Jiang, D., An, P., Cui, S., Sun, S., Zhang, J., & Tuo, T. (2020). Effect of modification methods of wheat straw fibers on water absorbency and mechanical properties of wheat straw fiber cement-based composites. *Advances in Materials Science and Engineering*, *2020*, 8392935. https://doi.org/10.1155/2020/8392935

Kabir, M. M., Alhaik, M. Y., Aldajah, S. H., Lau, K. T., Wang, H., & Islam, M. M. (2021). Effect of hemp fibre surface treatment on the fibre-matrix interface and the influence of cellulose, hemicellulose, and lignin contents on composite strength properties. *Advances in Materials Science and Engineering*, *2021*, 9753779, https://doi.org/10.1155/2021/9753779

Kochova, K., Caprai, V., Gauvin, F., Schollbach, K., & Brouwers, H. J. H. (2020). Investigation of local degradation in wood stands and its effect on cement wood composites. *Construction and Building Materials*, *231*, 117201. https://doi.org/10.1016/j.conbuildmat.2019.117201

Kochova, K., Gauvin, F., Schollbach, K., & Brouwers, H. J. H. (2020). Using alternative waste coir fibres as a reinforcement in cement-fibre composites. *Construction and Building Materials*, *231*, 117121. https://doi.org/10.1016/j.conbuildmat.2019.117121

Kolajo, T. E., Fowowe, A. O., & Adefowope, G. (2024). Production of the structural layer of wall panels using fibres obtained from stalk of oil palm empty fruit bunch wastes. *Adeleke University Journal of Engineering and Technology*, *7*(1), 139-146.

Kraus, S., Breier, M., & Dasí-Rodríguez, S. (2020). The art of crafting a systematic literature review in entrepreneurship research. *International Entrepreneurship and Management Journal*, *16*, 1023-1042. https://doi.org/10.1007/ s11365-020-00635-4

Lima, T. E. S., Tambara Ju´nior, L. U. D., Nascimento, L. F. C., Demosthenes, L. C. C., Monteiro, S. N., & Azevedo, A. R. G. (2023). Evaluation of the feasibility application of Malva fibers in cement-basedcomposites. *Journal of Materials Research and Technology*, *23*, 6274-6286. https://doi.org/10.1016/j.jmrt.2022.11.014

Malik, K., Ahmad, F., & Gunister, E. (2021). A review on the kenaf fiber reinforced thermoset. *Applied Composite Materials*, *28*, 491-528. https://doi.org/10.1007/s10443-021-09871-5

Mawardi, I., Aprilia, S., Faisal, M., Ikramullah., & Rizal, S. (2022). An investigation of thermal conductivity and sound absorption from binderless panels made of oil palm wood as bio-insulation materials. *Results in Engineering*, *13*, 100319. https://doi.org/10.1016/j.rineng.2021.100319

Maynet, W. A., Samsudin, E. M., & Nik Soh, N. M. Z. (2023). Effects of fibre length on the physical properties of oil palm empty fruit bunch cement board (OPEFB-CB). *Pertanika Journal of Science and Technology*, *31*(3), 1279–1290. https://doi.org/10.47836/pjst.31.3.09

Maynet, W., Samsudin, E. M., & Nik Soh, N. M. Z. (2021). Physical and mechanical properties of cement board made from oil palm empty fruit bunch fibre: A review. In *IOP Conference Series: Materials*

Science and Engineering (Vol. 1144, No. 1, p. 012008). IOP Publishing. https://doi.org/10.1088/1757-899x/1144/1/012008

Mhd Noor, M. T., Shahar, H. K., Baharudin, M. R., Syed Ismail, S. N., Abdul Manaf, R., Md Said, S., Ahmad, J., & Sri Ganesh, M. (2023). A systematic review on an optimal dose of disaster preparedness intervention utilizing Health Belief Model Theory. *Pertanika Journal of Science and Technology*, *31*(1), 149-159. https://doi.org/10.47836/pjst.31.1.10

Mirski, R., Dukarska, D., Derkowski, A., Czarnecki, R., & Dziurka, D. (2020). By-products of sawmill industry as raw materials for manufacture of chip-sawdust boards. *Journal of Building Engineering*, *32*, 101460. https://doi.org/10.1016/j.jobe.2020.101460

Momoh, E. O., & Osofero, A. I. (2020). Recent developments in the application of oil palm fibers in cement composites. *Frontiers of Structural and Civil Engineering*, *14*(1), 94-108. https://doi.org/10.1007/s11709-019-0576-9

Momoh, E. O., Osofero, A. I., & Menshykov, O. (2020). Physicomechanical properties of treated oil palm-broom fibers for cementitious composites. *Journal of Materials in Civil Engineering*, *32*(10). https://doi.org/10.1061/(asce)mt.1943-5533.0003412

Mucsi, Z. M., Hasan, K. M. F., Horvath, P. G., Bak, M., Koczan, Z., & Alpar, T. (2020). Semi-dry technology mediated lignocellulosic coconut and energy reed straw reinforced cementitious insulation panels. *Journal of Building Engineering*, *57*, 104825. https://doi.org/10.1016/j.jobe.2022.104825

Najeeb, M. I., Sultan, M. T. H., Andou, Y., Shah, A. U. M., Eksiler, K., Jawaid, M., & Ariffin, A. H. (2020). Characterisation of lignocellulosic biomass from Malaysian's yankee pineapple ac6 toward composite application. *Journal of Natural Fibers*, *18*(12), 2006-2018. https://doi.org/10.1080/15440478.2019.1710655

Owoyemi, J. M., Ogunrinde, O. S., & Oyeleye, I. O. (2020). Physical and mechanical properties of cement bonded strand board produced from *Gmelina arborea* (Roxb.) harvesting residues. *African Journal of Agricultural Research*, *16*(7), 976-982. https://doi.org/10.5897/ajar2020.14809

Peter, P., Nik Soh, N. M. Z., Akasah. Z. A., & Mannan, M. A. (2020). Durability evaluation of cement board produced from untreated and pre-treated empty fruit bunch fibre through accelerating ageing. In *IOP Conference Series: Materials Science and Engineering* (Vol. 713, No. 1, p. 012019). IOP Publishing. https://doi.org/10.1088/1757-899X/713/1/012019

Rao, P. R., & Ramakrishna, G. (2022). Oil palm empty fruit bunch fiber: Surface morphology, treatment, and suitability as reinforcement in cement composites - A state of the art review. *Cleaner Materials*, *6*, 100144. https://doi.org/10.1016/j.clema.2022.100144

Rao, K. J., Sastri, M. V. S. S., Swetha, T., & Poojita, C. (2024). Optimizing roofing efficiency: Utilizing GGBS and coir fibre in cement tile production. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1409, No. 1, p. 012014). IO Publishing. https://doi.org.10.1088/1755-1315/1409/1/012014

Ridzuan, M. N., Abu Bakar, H., Samsudin, E. M., Nik Soh, N. M. Z., & Ismail, L. H. (2023). Effects of density variation on the physical and mechanical properties of empty fruit bunch cement board (EFBCB). *Pertanika Journal of Science and Technology*, *31*(3), 1157-1172. https://doi.org/10.47836/pjst.31.3.02

Sahu, P., & Gupta, M. K. (2020). A review on the properties of natural fibres and its bio-composites: Effect of alkali treatment. *Proceedings of the Institution of Mechanical Engineers, Journal of Materials, Part L: Design and Applications*, *234*(1), 198-217. https://doi.org/10.1177/1464420719875163

Shaffril, H. A. M., Ahmad, N., Samsuddin, S. F., Abu Samah, A., & Hamdan, M. E. (2020). Systematic literature review on adaptation towards climate change impacts among indigenous people in the Asia Pacific regions. *Journal of Cleaner Production*, *258*, 120595. https://doi.org/10.1016/j.jclepro.2020.120595

Shaffril, H. A. M., Samsuddin, S. F., & Abu Samah, A. (2021). The ABC of systematic literature review: The basic methodological guidance for beginners. *Quality and Quantity*, *55*, 1319-1346. https://doi.org/10.1007/s11135-020-01059-6

Silva, D. W., Bufalino, L., Alves Junior, A. T., Scatolino, M. V., Batista, F. G., de Medeiros, D. T., Mendes, L. M., & Tonoli, G. H. D. (2024). Impact of accelerated aging cycles on the performance of extruded cement-based composites reinforced with non-bleached eucalyptus fibers. *Environmental Science and Pollution Research*, *31*, 35789-35799. https://doi.org/10.1007/s11356-024-33665-4

Song, H., Liu, T., Gauvin, F., & Nrouwers, H, J. H. (2023). Improving the interface compatibility and mechanical performances of the cementitious composites by low-cost alkyl ketene dimer modified fibers. *Construction and Building Materials*, *395*, 132186. https://doi.org/10.1016/j.conbuildmat.2023.132186

Stapper, J. L., Gauvin, F., & Brouwers, H. J. H. (2021). Influence of short-term degradation on coir in natural fibre-cement composites. *Construction and Building Materials*, *306*, 124906. https://doi.org/10.1016/j.conbuildmat.2021.124906

Syduzzaman, M., Al Faruque, M. A., Bilisik, K., & Naebe, M. (2020). Plant-based natural fibre reinforced composites: A review on fabrication, properties and applications. *Coatings*, *10*(10), 973. https://doi.org/10.3390/coatings10100973

Taiwo, A. S., Ayre, D. S., Khorami, M., & Rahatekar, S. S. (2024). Optimizing the mechanical properties of cement composite boards reinforced with cellulose pulp and bamboo fibers for building applications in low-cost housing estates. *Materials*, *17*(3), 646. https://doi.org/10.3390/ma17030646

Thompson, D., Augarde, C., & Osorio, J. P. (2025). A review of chemical stabilisation and fibre reinforcement techniques used to enhance the mechanical properties of rammed earth. *Discover Civil Engineering*, *2*, 27. https://doi.org/10.1007/s44290-025-00184-1

United Nations. (2022). *Report of the secretary-general on the work of the organization*. https://www.un.org/annualreport/2022/index.html

Vitrone, F., Ramos, D., Ferrando, F., & Salvad, J. (2021). Binderless fiberboards for sustainable construction – Materials, production methods and applications. *Journal of Building Engineering*, *44*, 102625. https://doi.org/10.1016/j.jobe.2021.102625

Wu, F., Yu, Q., & Brouwers, H. J. H. (2022). Long-term performance of bio-based miscanthus mortar. *Construction and Building Materials*, *324*, 126703. https://doi.org/10.1016/j.conbuildmat.2022.126703

Xie, X. & Li, H. (2021). compatibility between rice straw fibers with different pre-treatments and ordinary Portland cement. *Materials*, *14*(21), 6402. https://doi.org/10.3390/ma14216402

Zhang, X. X., Ji, Y. L., Pel, L., Sun, Z. P., & Smeulders, D. (2022). Early-age hydration and shrinkage of cement paste with coir fibers as studied by Nuclear Magnetic Resonance. *Construction and Building Materials*, *336*, 127460. https://doi.org/10.1016/j.conbuildmat.2022.127460