ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV1020

Application of Kenaf Fibre for Minor Reinforcement in Concrete Production

Ogunjiofor I. Emmanuel[1], Nwabunwanne C. Promise[2]
[1]Lecturer, [2]Student, Department of Civil Engineering, Chukwuemeka Odumegwu Ojukwu University, Uli, Anambra State, Nigeria

Abstract:- In this study, the effects of employing kenaf fibre as a reinforcement material in concrete on workability and compressive strength are examined. Workability and compressive strength tests were conducted on concrete mixtures containing 0%, 0.5%, 1.0%, and 1.5% kenaf fibre at 7, 14, 21, and 28 days of curing. As the kenaf fibre percentage increased, the slump test results demonstrated a decrease in workability; values decreased from 85 mm for the 0% fibre mix to 25 mm for the 1.5% fibre mix, suggesting a stiffer mix. According to tests of compressive strength, the 0.5% kenaf fibre combination offered better crack resistance while maintaining strength. Compressive strengths at 28 days were found to be 21.80 N/mm² for the 0% fibre mix, 20.10 N/mm² for the 0.5% fibre mix, and lower for higher fibre percentages. According to these findings, the ideal content for preserving structural integrity and including long-lasting reinforcing qualities is 0.5% kenaf fibre. The potential of kenaf fibre for environmentally friendly building is highlighted in this study, which also suggests more research into enhancing workability through fibre composition, durability, and admixture usage optimization.

***Keywords**:- Kenaf, Fibre, Concrete, Reinforcement, Sustainability.*

I. INTRODUCTION

Material science and civil engineering technological breakthroughs have made concrete one of the most popular building materials in the world (Mehta, 2001). Its high compressive strength makes it ideal for load-bearing applications, yet concrete has inherent limitations. These include low tensile strength, limited toughness, and susceptibility to cracking, which significantly affect its durability and lifespan, especially under severe environmental conditions. Stronger concrete is often more brittle, and cracks that form during failure reduce the structure's ability to bear loads and resist environmental stressors (Ogunjiofor, et al., 2023), ultimately compromising its service life (Peng et al., 2018). To address these weaknesses, research has focused on enhancing concrete's toughness and crack resistance, particularly through fiber reinforcement (Khalil, 2012).

In recent years, fiber reinforcement in concrete has attracted significant attention in construction and civil engineering. Fibers, when integrated with concrete, improve its mechanical properties, particularly in resisting tensile stresses and limiting crack growth (Zhang and Li, 2014). Among the various natural fibers, kenaf (Hibiscus cannabinus L.), a fast-growing plant from the Malvaceae family, has shown particular promise. Cultivated for its strong bast fibers, kenaf is low-cost, eco-friendly, and renewable, making it suitable for sustainable construction applications. When incorporated into concrete, kenaf fiber offers several benefits, including enhanced mechanical strength, improved crack resistance, and potential reductions in weight due to its low density (Zheng et al., 2014).

Research on kenaf fiber's role in concrete has demonstrated various improvements in the material's properties. For example, studies have shown that kenaf fiber enhances flexural strength, impact resistance, and overall durability. Mohd et al. (2017) found that kenaf fiber-reinforced concrete beams exhibit increased flexural strength and ductility, while Tam et al. (2019) noted enhanced energy absorption and reduced crack propagation, improving impact resistance. Additionally, kenaf fiber has proven effective in minimizing shrinkage and distributing moisture,

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV1020

which helps prevent micro crack formation and boosts protection against external elements such as chemical exposure and freeze-thaw cycles.. Kenaf's low thermal conductivity and high char content further reinforce concrete's resistance to fire and high temperatures, enhancing its durability in diverse applications (Shannag, 2010).

II. LITERATURE REVIEW

Fiber-reinforced concrete (FRC) has been widely studied since the 1970s as an enhancement to traditional concrete, addressing key mechanical deficiencies, particularly low tensile strength and susceptibility to cracking. Early research primarily focused on synthetic fibers. Swamy and Mangat (1974) demonstrated that steel fibers significantly increased tensile strength and toughness, making concrete more effective under high-stress conditions. Naaman (2003) later found that steel fibers also improved post-cracking behavior, enhancing resilience in dynamic load applications. Synthetic fibers like polypropylene also contributed to improvements; Banthia and Gupta (2006) observed that polypropylene fibers effectively controlled plastic shrink age cracking.

In the 1980s, attention shifted towards natural fibers, driven by sustainability concerns. Aziz et al. (1981) pioneered the investigation of natural fibers, such as coir, revealing substantial improvements in concrete toughness and crack resistance. Gram (1983) found that sisal fibers increased both tensile and flexural strength, while Mansur and Aziz (1983) reported enhanced crack resistance with jute fibers, especially useful in applications involving bending stresses. Despite synthetic fibers offering higher tensile strength, natural fibers like kenaf showed promise due to their environmental advantages and mechanical benefits.

Kenaf fibers, in particular, have been extensively researched. Suryanto et al. (2015) showed that incorporating 1% kenaf fiber by volume raised concrete tensile strength by 25-30%. Baky et al. (2016) observed that a 1.5% fiber volume fraction optimized flexural strength, confirming kenaf fibers' role as effective crack-bridging agents. Hossain et al. (2017) further demonstrated the positive effects of jute and coir fibers on toughness and tensile strength, supporting the potential of natural fibers in structural applications.

Comparative studies of natural fibers emphasize their varying performance. Ramakrishna and Sundararajan (2005) found coir fibers to provide the best impact resistance among coir, sisal, and jute due to coir's flexibility and energy absorption capabilities. Ghavami et al. (2003) compared bamboo and kenaf fibers, finding bamboo fibers excelled in impact resistance, particularly relevant in seismic zones. However, kenaf was noted for superior workability, allowing easier integration into concrete.

Challenges persist, especially with kenaf's hydrophilic nature, which can affect durability. Ali et al. (2012) studied alkali treatment, which effectively reduced water absorption and improved fiber-matrix bonding. This treatment removes lignin, enhancing mechanical performance, particularly in humid environments. Salem et al. (2017) observed that stearic acid treatment of kenaf fibers significantly minimized water absorption, further promoting durability.

Recent research extends to hybrid and treated fibers to address FRC's performance limitations. Amreen et al. (2023) employed vacuum bagging with nano-fillers, achieving a 125% increase in tensile modulus. These advancements broaden FRC's applications, especially in load-bearing structures requiring impact resistance. Meanwhile, Prabu et al. (2022) explored bast fibers, demonstrating that suitable chemical treatments and stacking arrangements improved properties such as tensile strength and hardness, indicating potential applications in automotive, structural fields and foundation using characteristic orthogonal polynomial (Ogunjiofor and Nwoji, 2017)

In summary, synthetic fibers like steel deliver high tensile strength but at an environmental cost. Conversely, natural fibers such as kenaf provide a balanced, eco-friendly alternative. Ongoing research continues to focus on enhancing the fiber-matrix bond, exploring durability in varied conditions, and refining treatment methods to improve natural fiber-reinforced concrete's applicability across structural engineering especially plates on elastic foundation (Ogunjiofor, 2020).

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV1020

III. MATERIALS AND METHODOLOGY

A. Material

- *Cement (Elephant Superset):*

The cement used was sourced from a reputable supplier located opposite the Catholic Church in Uli, Anambra State. It was stored in an original sealed bag in a dry environment to maintain quality.

- *Fine Aggregate:*

The fine aggregate was sourced from a dealer along the River Niger in Onitsha, Anambra State. Approximately 100 kg of river sand, known for its high quality and grading, was collected.To make sure it was devoid of contaminants includi ng silt, clay, and organic substances, the sand was examined.

- *Coarse Aggregate:*

Coarse aggregate in the form of chippings was sourced from a supply along Timber Market Road in Uli, Anambra State. About 150 kg of chippings were collected and stored on a clean, elevated surface covered with a tarpaulin to protect against contaminants, ensuring consistent material quality for concrete testing.

- *Kenaf Fiber:*

Kenaf fibers were sourced from a specialized supplier. After a 4-5 month growing period, the fibers were retted for 7-14 days to break down pectins, then decorticated, cleaned, dried, and stored in sealed bags in a dry, cool place to maintain quality for concrete reinforcement.

- *Portable Water*:

Water was sourced from the tap in the Civil Engineering Laboratory at Chukwuemeka Odumegwu Ojukwu University, Uli, Anambra State. It was collected using clean containers, verified to be free from contaminants, and stored in sealed containers to ensure high-quality water for concrete mixing and testing.

B. Methodology

- *Sieve Analysis:*

A sample of aggregate weighing 1.5 kg was taken and dried at 105–110°C until it attained a consistent weight in order to ascertain the aggregates' particle size distribution. After drying, the sample was put in a pan at the bottom to catch the particles and a series of standard sieves organized from coarsest to finest.

- *Cement Setting Time:*

The Vicat apparatus was used to measure the cement's initial and final setting times. While the ultimate setting time showed when the cement paste had sufficiently hardened to withstand pressure, the first setting time was noted as the moment the paste lost its fluidity.

- *Slump Test:*

Fresh concrete was poured into the slump cone in three compressed levels, each about one-third of the cone's height. To allow for natural drooping, the cone was raised vertically once the top layer was leveled. The height difference between the top of the cone and the highest point of the concrete was used to calculate the slump value.

- *Compressive Strength Test:*

Compressive Strength Test: To produce concrete specimens, they were cast in moulds and cured in water at 20 ºC for 28 days. The specimens were allowed to cure at room temperature before their cross-sectional areas were measured. A compressive testing machine was then used to continuously apply a load on each specimen until it failed. By recording the greatest load and dividing it by the cross-sectional area, the compressive strength was determined. To determine a representative compressive strength value, the results for each tested specimen were averaged.

Volume 9, Issue 11, November – 2024 International Journal of Innovative Science and Research Technology
ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV1020

IV. RESULTS AND DISCUSSION

A. *Sieve Analysis Test Result*

Table 1: Sieve Analysis test result

Sieve Size (mm)	WeightRetained (kg)	Percentage Retained (%)	CumulativePercentage Retained (%)	CumulativePercentage Passing (%)
8	0.30	0.00	0.00	100.00
10	0.40	4.00	4.00	96.00
12	0.40	4.00	8.00	92.00
20	0.75	30.00	38.00	62.00
30	0.45	18.00	56.00	44.00
40	0.50	20.00	76.00	24.00
80	0.50	20.00	96.00	4.00
Pan	0.00	0.00	96.00	4.00

B. *Slump Test Result:*

The slump test assesses the workability of fresh concrete. Results for varying kenaf fiber percentages (0%, 0.5%, 1.0%, and 1.5%) are presented below.

Table 2: Slump test result

Kenaf FiberContent (%)	Water-CementRatio	Height ofCone (mm)	Height of Slumped Concrete (mm)	Slump Value(mm)
0	0.6	300	215	85
0.5	0.6	300	240	60
1.0	0.6	300	260	40
1.5	0.6	300	275	25

The slump test results indicate a decrease in workability as the kenaf fiber content increases, as shown by the reduced slump values. This trend suggests that higher fiber content results in a stiffer mix, impacting the concrete's ease of placement and compaction.

C. *Test of Compressive Strength*

Compressive strength test Concrete's ability to support weight is evaluated using the compressive strength test. At 7, 14, 21, and 28 days after curing, concrete cubes containing kenaf fibre additions (0%, 0.5%, 1.0%, and 1.5%) were examined. The findings of compressive strength for each fibre content and curing time are compiled in Table 3.

Table 3: Compressive Strength Test Result

Percentage Additive of Kenaf Fiber (%)	7 Days Compressive Strength (N/mm^2)	14 Days Compressive Strength (N/mm^2)	21 Days Compressive Strength (N/mm^2)	28 Days Compressive Strength (N/mm^2)
0	12.35	16.95	17.20	21.80
0.5	18.60	16.40	16.10	20.10
1.0	17.85	13,60	14.30	19.15
1,5	13.90	17.00	11.35	15.90

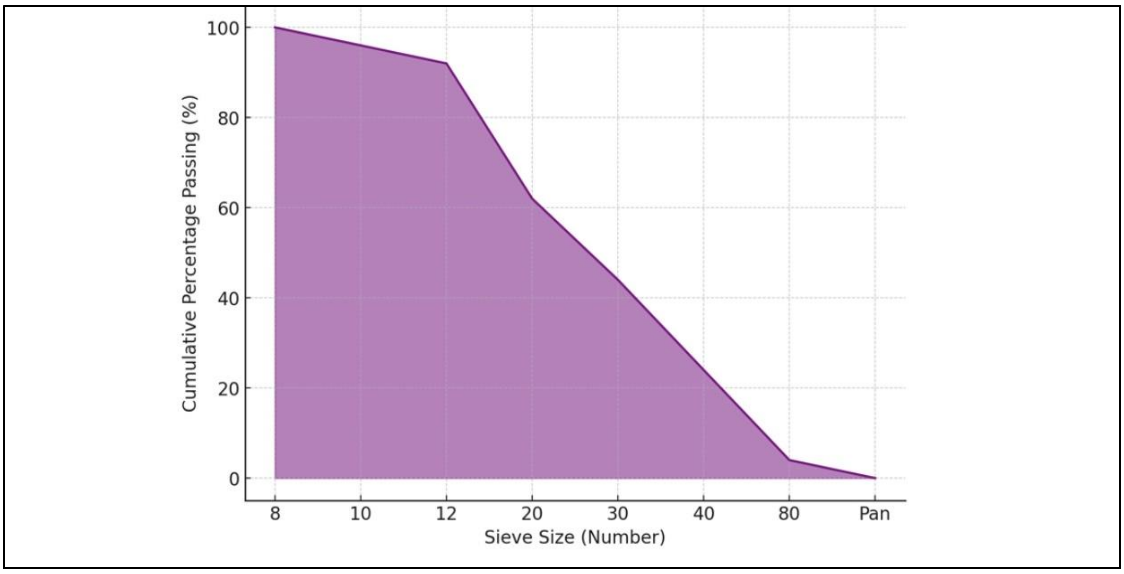

Fig. 1: Sieve Analysis Result

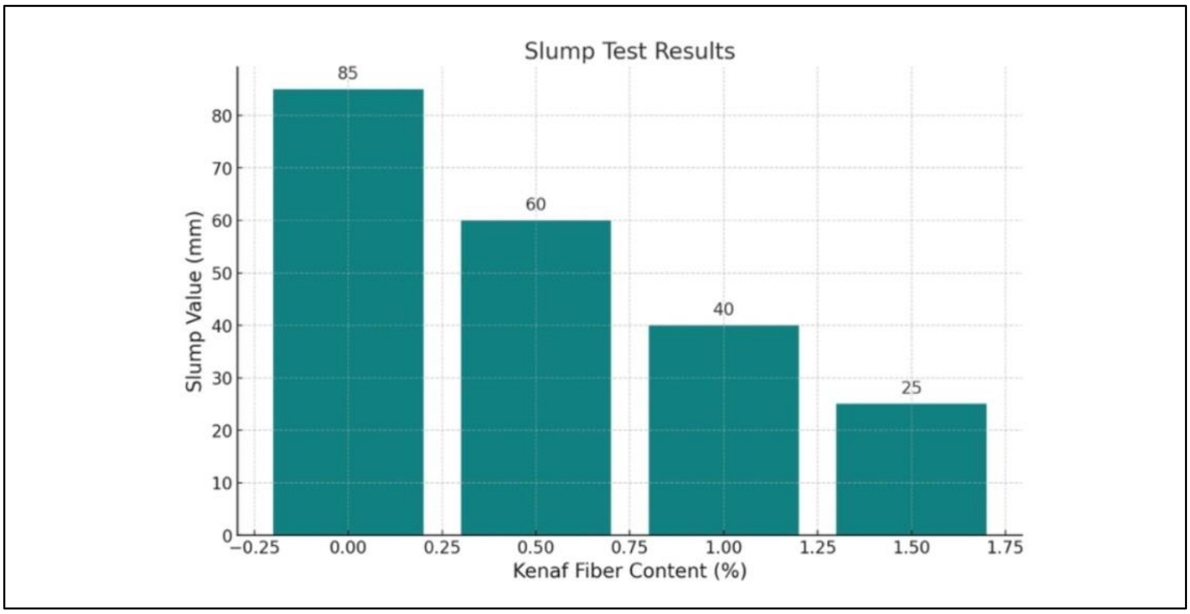

Fig 2: Slump Test Result

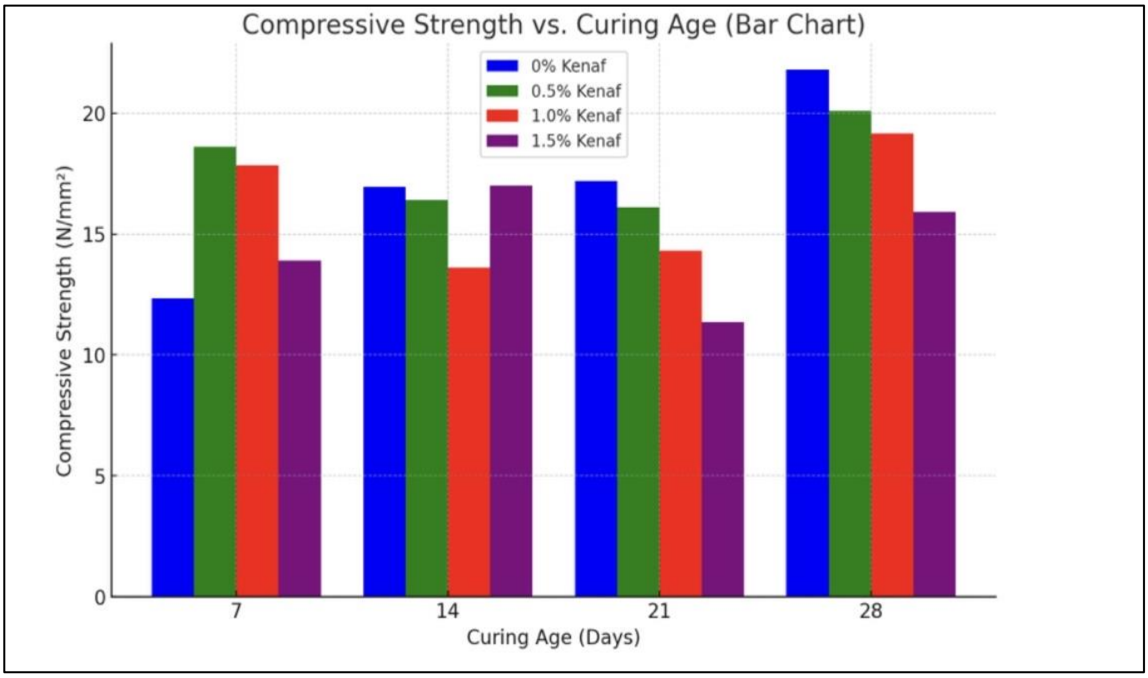

Fig 3: Compressive Strength Test Result

V. CONCLUSION

This study tested the effects of adding different fibre contents (0%, 0.5%, 1.0%, and 1.5%) of kenaf fibre as reinforcement in concrete on workability and compressive strength. The workability of concrete declined with increasing kenaf fibre concentration, as seen by reduced slump values, especially at 1.5% fibre content, according to the results. Testing for compressive strength showed that 0.5% fibre content kept strength near the control, whereas larger fibre percentages resulted in strength decreases because of potential matrix disturbance. In order to balance improved fracture resistance with preserved structural integrity, the ideal fibre content for reinforcing concrete was found to be 0.5%. Furthermore, because kenaf fibre is a renewable and biodegradable resource, its use supports sustainability by encouraging the creation of eco-friendly building materials.

VI. RECOMMENDATION

- Optimize Fiber Content: Further studies should refine the optimal kenaf fiber percentage, testing intermediate levels (e.g., 0.25% and 0.75%) for balanced performance.
- Long-Term Performance: Conduct durability studies under environmental variations (freeze-thaw cycles, moisture exposure) to assess long-term viability.
- Chemical Admixtures: Use super plasticizers to counter workability issues at higher fiber contents, maintaining fluidity without sacrificing reinforcement benefits.
- Hybrid Fiber Reinforcement: Explore combinations of kenaf with fibers like steel or polypropylene to enhance both tensile and compressive strengths.
- Pilot Applications: Apply a 0.5% kenaf fiber mix in sustainable construction pilots to assess practicality in real-world scenarios.
- Standards and Guidelines: Develop standardized methods and guidelines for natural fiber-reinforced concrete, facilitating broader industry adoption.

REFERENCES

[1]. Ali, M., Liu, A., Sou, H., and Chouw, N., “Mechanical and dynamic properties of coconut fiber-reinforced concrete,” Construction and Building Materials, vol. 30, pp. 814-825, 2012.

[2]. Amreen, M., Ghouri, A.A., and Kumar, V., “Enhancement of fiber-reinforced concrete properties with vacuum bagging and nano-fillers,” Materials Today: Proceedings, vol. 62, pp. 895-900, 2023.

[3]. Aziz, M.A., Paramasivam, P., and Lee, S.L., “Prospects for natural fiber reinforced concretes in construction,” International Journal of Cement Composites and Lightweight Concrete, vol. 3, no. 2, pp. 123-132, 1981.
[4]. Baky, H.A., Uddin, M.A., and Islam, M.S., “Optimization of flexural strength with kenaf fiber reinforcement,” Construction and Building Materials, vol. 120, pp. 183-190, 2016.
[5]. Banthia, N., and Gupta, R., “Influence of polypropylene fiber geometry on plastic shrinkage cracking in concrete,” Cement and Concrete Research, vol. 36, no. 7, pp. 1263-1267, 2006.
[6]. Ghavami, K., Filho, R.D.T., and Barbosa, N.P., “Behavior of bamboo and vegetable fiber composite materials in civil engineering applications,” Materials Research, vol. 6, no. 3, pp. 271-282, 2003.
[7]. Gram, H.E., “Durability of natural fibers in concrete,” Swedish Cement and Concrete Research Institute, vol. 1, pp. 45-51, 1983.
[8]. Hossain, M.E., Awang, H., and Islam, M.N., “Toughness and tensile strength improvements with jute and coir fiber-reinforced concrete,” Procedia Engineering, vol. 125, pp. 808-812, 2017.
[9]. Khalil, H.A., “Fiber-reinforced concrete and its applications,” Journal of Civil Engineering and Construction Technology, vol. 3, no. 2, pp. 38-45, 2012.
[10]. Mansur, M.A., and Aziz, M.A., “Study of jute fiber reinforced cement composites,” Journal of Ferrocement, vol. 13, pp. 103-115, 1983.
[11]. Mehta, P.K., “Concrete: Structure, properties, and materials,” Prentice Hall, 2001.
[12]. Mohd, S., Chen, B., and Ali, A., “Structural performance of kenaf fiber-reinforced concrete beams,” Construction and Building Materials, vol. 153, pp. 403-410, 2017.
[13]. Naaman, A.E., “Toughness, ductility, and fatigue resistance of fiber-reinforced cement composites,” Materials and Structures, vol. 36, no. 10, pp. 705-712, 2003.
[14]. Ogunjiofor E.I. and Nwoji C.U. (2017). “Analytical bending solution of all clamped isotropic rectangular plate on Winkler’s foundation using characteristic orthogonal polynomial” Nigerian Journal of Technology, Vol. 36, pp 724 – 728.
[15]. Ogunjiofor E.I. (2020) “Solution of Rectangular Plate on Winkler’s Elastic Foundation Using Characteristic Orthogonal Polynomials” Saudi Journal of Civil Engineering, Vol. 4(8), pp. 119 – 124.
[16]. Ogunjiofor, E.I., Onwunduba C.J, Okpala I.J (2023) “Sustainable Production of Building Blocks using A Recycled Plastic Waste” International Journal for research in Applied Science & Engineering Technology (IJRASET) Vol. 11, Issue XII, pp. 2346-2354
[17]. Peng, G., Li, X., Wang, Y., and Tang, X., “Crack resistance of fiber-reinforced concrete under harsh environmental conditions,” Construction and Building Materials, vol. 158, pp. 223-230, 2018.
[18]. Prabu, S.L., Kumar, M., and Arumugam, V., “Properties of bast fiber-reinforced composites for automotive applications,” Materials Today: Proceedings, vol. 48, pp. 982-989, 2022.
[19]. Ramakrishna, G., and Sundararajan, T., “Impact strength of natural fiber reinforced concrete,” Cement and Concrete Composites, vol. 27, no. 5, pp. 547-553, 2005.
[20]. Salem, K., Othman, R., and Ismail, Z., “Effect of stearic acid treatment on kenaf fiber-reinforced concrete,” Procedia Engineering, vol. 170, pp. 88-94, 2017.
[21]. Shannag, M.J., “Properties of lightweight kenaf fiber-reinforced concrete,” Journal of Materials and Structures, vol. 43, no. 7, pp. 1025-1033, 2010.
[22]. Suryanto, B., Awang, H., and Sulong, N.R., “Mechanical properties of kenaf fiber-reinforced concrete with varying fiber volumes,” Procedia Engineering, vol. 125, pp. 804-810, 2015.
[23]. Swamy, R.N., and Mangat, P.S., “Tensile strength and ductility of steel fiber reinforced concrete,” Journal of Structural Division, vol. 100, no. 9, pp. 1965-1977, 1974.
[24]. Tam, V.W., Wang, Y., and Le, K., “Enhancement of impact resistance in kenaf fiber-reinforced concrete,” Journal of Materials in Civil Engineering, vol. 31, no. 4, pp. 112-117, 2019.
[25]. Zhang, Q., and Li, W., “The effects of fiber reinforcement on concrete strength and durability,” Journal of Building Materials, vol. 10, no. 4, pp. 451-460, 2014.
[26]. Zheng, X., Ma, J., and Lu, S., “Kenaf fiber in sustainable construction applications,” Journal of Materials in Civil Engineering, vol. 26, no. 8, pp. 411-417, 2014.