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# Review On The Role Of Carbon Fibre Reinforced Polymer (CFRP) Composites In Sustainable Construction In Africa

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***Abstract***
*The construction industry in Africa faces significant challenges in achieving sustainable development due to factors such as rapid urbanization and limited resources. One promising solution is the use of carbon fibre reinforced polymer (CFRP) composites in construction. This review paper aims to provide a comprehensive analysis of the role of CFRP composites in sustainable construction in Africa. It explores the current state of CFRP applications, the potential benefits, and the challenges associated with their implementation. The review highlights the effectiveness of CFRP in strengthening and retrofitting reinforced concrete structures, improving their flexural, shear, and compressive performance. CFRP composites also have the potential to enhance the seismic resilience of buildings. Recycling and reuse of CFRP composites are crucial for sustainable construction, with various recycling methods being explored. The incorporation of recycled CFRP materials in concrete and mortar mixes has shown promising results in terms of improved mechanical properties. The review also examines the use of other sustainable composite materials, such as recycled glass fibre reinforced polymer (GFRP) and basalt fibre reinforced polymer (BFRP), in construction applications. Sustainable construction techniques, including the use of alternative binders like geopolymer, are also discussed. Challenges such as cost, lack of awareness, durability concerns, and the need for recycling infrastructure and regulatory frameworks are addressed. The opportunities presented by CFRP composites, including improved resilience, reduced maintenance, and the potential for a circular economy, are also highlighted.*
***Keywords:*** *Sustainable construction, CFRP composites, Recycling, Retrofitting, Geopolymer*

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## I. Introduction

The construction industry in Africa faces significant challenges in achieving sustainable development due to factors such as rapid urbanization, limited resources, and the need for affordable and durable infrastructure (Hadigheh et al., 2022). According to a study by Hadigheh et al. (2022), the rapid urbanization in many African countries has led to a surge in construction activities, placing a heavy demand on natural resources and creating a need for more sustainable construction practices. Furthermore, the limited availability of traditional construction materials, such as steel and cement, has hindered the development of affordable and long-lasting infrastructure in the region (Hadigheh et al., 2022). One promising solution to address these challenges is the use of carbon fibre reinforced polymer (CFRP) composites in construction (Aktas & Gunaslan, 2017; Jaiswal et al., 2017; Karzad et al., 2019; Kishore, 2017; Lingga, 2016). CFRP composites offer several advantages, including a high strength-to-weight ratio, corrosion resistance, and the potential for reduced environmental impact through recycling and reuse (Carrillo et al., 2020; Hadigheh et al., 2016; Talaeitaba et al., 2019).

This review paper aims to provide a comprehensive analysis of the role of CFRP composites in sustainable construction in Africa. It explores the current state of CFRP applications, the potential benefits, and the challenges associated with their implementation (Al-Rousan, 2022; Al-Rousan, 2022; Al-Rousan, 2020). The review also examines the latest advancements in CFRP recycling and reuse, as well as the integration of CFRP with other sustainable construction materials and techniques (Asokan et al., 2009; Correia et al., 2011; Farinha et al., 2019; Mastali et al., 2016, 2017, 2018; Rodin III et al., 2018; Tittarelli & Moriconi, 2010; Tittarelli & Shah, 2013; Tittarelli et al., 2010).

## II. Sustainability

**Strengthening and Retrofitting of Concrete Structures**

CFRP composites have been extensively used for the strengthening and retrofitting of reinforced concrete (RC) structures in Africa. Studies have shown that CFRP can effectively increase the flexural and shear capacity of RC beams (Aktas & Gunaslan, 2017; Jaiswal et al., 2017; Karzad et al., 2019; Kishore, 2017; Lingga, 2016). For example, Aktas and Gunaslan (2017) conducted an experimental study on the use of CFRP laminates to strengthen RC beams. They found that the flexural capacity of the beams was significantly enhanced, with the CFRP-strengthened beams exhibiting a 30-40% increase in ultimate load-carrying capacity compared to the control specimens. Similarly, Jaiswal et al. (2017) investigated the effect of CFRP length and beam size on the performance of strengthened RC beams. Their results showed that the use of CFRP can lead to substantial improvements in the flexural and shear behavior of the beams, with the degree of enhancement depending on the CFRP length and beam size. Karzad et al. (2019) also reported that CFRP strengthening can effectively enhance the shear capacity of RC beams, particularly for those with shear deficiencies.

CFRP strengthening has also been used to improve the compressive performance of RC columns (Carrillo et al., 2020; Hadigheh et al., 2016; Talaeitaba et al., 2019). Carrillo et al. (2020) evaluated the compressive behaviour of square and low-strength concrete columns retrofitted with externally-bonded CFRP. They found that the CFRP wrapping significantly enhanced the axial load capacity and ductility of the columns, with the strengthened columns exhibiting up to a 60% increase in ultimate compressive strength compared to the unstrengthen control columns. Additionally, Hadigheh et al. (2016) conducted a case study on the resilience and performance of CFRP-strengthened buildings subjected to earthquakes. Their study highlighted the potential of CFRP composites in enhancing the seismic resistance of RC structures, as the CFRP-strengthened buildings demonstrated improved behaviour and reduced damage under simulated earthquake loading.

The durability of CFRP-strengthened structures is a critical concern, and researchers have investigated the long-term behaviour of CFRP-strengthened RC structures under various environmental conditions. Lu et al. (2020) studied the durability of flexurally strengthened RC beams with prestressed CFRP sheets under wet-dry cycling in a chloride-containing environment. Their findings showed that the CFRP-strengthened beams maintained their enhanced flexural performance over the long term, even in the presence of chloride-induced corrosion. Hadigheh et al. (2020, 2021) developed a 3D acid diffusion model and investigated the long-term durability of CFRP-strengthened structures under acid exposure. Their research provided valuable insights into the performance and service life of CFRP-strengthened structures in acidic environments, which are common in some regions of Africa. These studies have collectively highlighted the importance of addressing the durability aspects of CFRP-strengthened structures to ensure their long-term performance and sustainability in the African context.

**Recycling and Reuse of CFRP Composites**

The recycling and reuse of CFRP composites have become increasingly important in the pursuit of sustainable construction. Several studies have explored different recycling methods, including pyrolysis (Lucile et al., 2016; Meyer et al., 2009; Sun et al., 2015), solvolysis (Oliveux et al., 2011; Pinglai et al., 2013), and fluidized bed processing (Pender & Yang, 2019). These recycling techniques have the potential to recover valuable fibres and resin materials, which can then be reused in various construction applications.

For example, Lucile et al. (2016) developed a semi-continuous flow recycling method for CFRP composites using near- and supercritical solvolysis. Their process was able to achieve high-quality fibre recovery, with the recovered fibres exhibiting properties comparable to those of virgin fibres. Meyer et al. (2009) investigated the optimization of a pyrolysis-based CFRP recycling process, focusing on parameters such as heating rate, temperature, and residence time to maximize the recovery of the carbon fibres. Sun et al. (2015) also explored the use of pyrolysis for CFRP recycling and reported that the recovered fibres could be effectively reused in the production of new CFRP composites. These studies demonstrate the feasibility of recovering CFRP materials through various recycling approaches, which can contribute to the development of a more sustainable construction industry.

Researchers have also investigated the incorporation of recycled CFRP fibres and powders in concrete and mortar mixes, demonstrating their potential to enhance the mechanical properties of these materials (Asokan et al., 2009; Correia et al., 2011; Farinha et al., 2019; Mastali et al., 2016, 2017, 2018; Rodin III et al., 2018; Tittarelli & Moriconi, 2010; Tittarelli & Shah, 2013; Tittarelli et al., 2010). Farinha et al. (2019), for instance, assessed the use of recycled GFRP waste as a filler in mortars and found that it can improve the mechanical properties of the mortar, such as compressive and flexural strength, by up to 20% compared to control mortar mixes. Correia et al. (2011) also reported that the incorporation of recycled GFRP fibres in concrete mixes can lead to enhanced mechanical performance and reduced environmental impact. The reuse of CFRP composites in construction not only reduces waste but also contributes to the development of a circular economy, aligning with the principles of sustainable construction.

**Sustainable Composite Materials**

In addition to CFRP, other sustainable composite materials have been explored for construction applications in Africa. These include the use of recycled glass fibre reinforced polymer (GFRP) composites (Correia et al., 2011; Farinha et al., 2019; Mastali et al., 2016) and basalt fibre reinforced polymer (BFRP) composites (Fan et al., 2021; Kufel et al., 2021).

Correia et al. (2011) investigated the use of recycled GFRP waste in concrete mixtures and found that the incorporation of GFRP fibres and powders can improve the mechanical properties of concrete, such as compressive and flexural strength, by up to 20% compared to control mixes. Farinha et al. (2019) also reported similar findings, demonstrating the potential of recycled GFRP waste as a filler material in mortar mixes.

Researchers have also explored the use of BFRP composites in construction applications. Fan et al. (2021) studied the shear behaviour of inorganic polymer concrete beams reinforced with basalt FRP bars and stirrups. Their results showed that the BFRP-reinforced beams exhibited improved shear performance and ductility compared to control beams. Kufel et al. (2021) investigated the use of hybrid composites, combining BFRP and CFRP, to optimize the performance and sustainability of construction materials. The incorporation of these recycled and alternative fibre-reinforced composites in concrete and mortar mixes has shown promising results in terms of improved mechanical properties and environmental benefits.

The exploration of these sustainable composite materials, in addition to CFRP, highlights the diverse range of solutions being investigated to address the challenges faced by the construction industry in Africa. The integration of these materials with other sustainable construction techniques, such as the use of alternative binders like geopolymers, further contributes to the development of a more sustainable and resource-efficient built environment.

**Sustainable Construction Techniques**

Beyond the use of CFRP and other composite materials, sustainable construction techniques have also been explored in the African context. These include the use of alternative binders, such as geopolymer (Hadigheh et al., 2022), and the integration of CFRP with geopolymer concrete for improved durability and performance.

Researchers have also investigated the potential of using recycled materials, such as waste glass (Guo et al., 2020; Harrison et al., 2020; Paul et al., 2018) and end-of-life wind turbine blade materials (Deeney et al., 2021; Herman et al., 2021; Mattsson et al., 2020; Nagle et al., 2020; Oliveira et al., 2020), in construction applications. These efforts contribute to the development of more sustainable and resource-efficient construction practices in Africa.

## III. Challenges

The following are challenges of CCRP composites:

(i) Cost and Availability: The higher initial cost of CFRP composites compared to traditional construction materials can be a barrier to their widespread adoption in Africa, particularly in regions with limited financial resources. Hadigheh et al. (2022) highlighted that the cost of CFRP composites is a significant challenge, as many African countries face financial constraints. Overcoming this barrier will require innovative financing mechanisms, such as government subsidies or public-private partnerships, to make CFRP more accessible and affordable for construction projects in Africa.

(ii) Lack of Awareness and Technical Knowledge: There is a need to increase awareness and build technical expertise among construction professionals in Africa to effectively design, install, and maintain CFRP-strengthened structures. Al-Rousan (2022) and Al-Rousan (2020) emphasized the importance of developing technical knowledge and skills to properly implement CFRP strengthening techniques. Capacity-building programs, training workshops, and collaboration with international experts can help bridge this gap and enable African construction professionals to leverage the benefits of CFRP composites.

(iii) Durability Concerns: The long-term durability of CFRP-strengthened structures in the African environment, which may include exposure to high temperatures, UV radiation, and harsh weather conditions, requires further investigation and monitoring. Hadigheh et al. (2020, 2021) highlighted the need for addressing the durability aspects of CFRP-strengthened structures, particularly in acidic environments, to ensure their long-term performance and sustainability. Continued research and field monitoring will be crucial to address these concerns and provide reliable data on the durability of CFRP-strengthened structures in the African context.

(iv) Recycling Infrastructure: The development of efficient recycling infrastructure and technologies for CFRP and other composite materials is still relatively limited in many African countries, hindering the circular economy approach. Lucile et al. (2016), Meyer et al. (2009), and Sun et al. (2015) have explored various recycling methods for CFRP composites, but the implementation of these technologies in Africa remains a challenge. Investing in the establishment of recycling facilities and promoting the integration of recycled CFRP materials in construction can contribute to the development of a more sustainable and circular construction industry.

(v) Regulatory and Policy Frameworks: The lack of comprehensive regulatory and policy frameworks to support the use of sustainable construction materials and techniques, including CFRP composites, can hamper their widespread adoption in the African construction industry. Hadigheh et al. (2022) emphasized the need for the adoption of supportive policies, regulations, and incentives to encourage the use of CFRP composites and other sustainable construction materials in Africa. The development of clear guidelines, standards, and certification schemes can provide a framework for the safe and effective implementation of CFRP-strengthened structures.

## IV. Opportunities

The following are opportunities offers by CFRP composites:

(i) Improved Resilience and Longevity: The high strength-to-weight ratio and corrosion resistance of CFRP composites make them well-suited for the construction of durable and resilient infrastructure in Africa, which can withstand natural disasters and environmental stresses. Carrillo et al. (2020) and Hadigheh et al. (2016) demonstrated the potential of CFRP composites in enhancing the seismic resistance and resilience of reinforced concrete structures, which is particularly important in the African context, where natural disasters are a common occurrence.

(ii) Reduced Maintenance and Life-Cycle Costs: The reduced need for maintenance and extended service life of CFRP-strengthened structures can lead to long-term cost savings and improved overall sustainability. Lu et al. (2020) found that CFRP-strengthened beams maintained their enhanced flexural performance even under harsh environmental conditions, suggesting the potential for reduced maintenance requirements and extended service life of CFRP-strengthened structures in Africa.

(iii) Waste Reduction and Circular Economy: The development of effective CFRP recycling and reuse techniques can contribute to the reduction of construction and demolition waste, aligning with the principles of a circular economy. Farinha et al. (2019), Correia et al. (2011), and Mastali et al. (2016, 2017, 2018) have demonstrated the successful incorporation of recycled GFRP and CFRP materials in concrete and mortar mixes, highlighting the potential for creating a closed-loop system in the African construction industry.

(iv) Collaboration and Knowledge Sharing: Increased collaboration among African countries, as well as with international partners, can facilitate the exchange of knowledge, best practices, and technological advancements in the use of CFRP and other sustainable construction materials. Such collaborative efforts can help address the challenges faced by individual countries and promote the widespread adoption of CFRP composites and other sustainable solutions in the African construction industry.

(v) Policy and Regulatory Initiatives: The adoption of supportive policies, regulations, and incentives can encourage the widespread use of CFRP composites and other sustainable construction materials in Africa, driving the transition towards a more sustainable built environment. Hadigheh et al. (2022) emphasized the importance of developing comprehensive regulatory and policy frameworks to support the adoption of sustainable construction materials and techniques, including CFRP composites, in the African context.

## V. Conclusion

The use of CFRP composites in sustainable construction offers significant potential for Africa to address the challenges of rapid urbanization, limited resources, and the need for durable infrastructure. Hadigheh et al. (2022) emphasized that the rapid urbanization in many African countries has led to a surge in construction activities, placing a heavy demand on natural resources and creating a need for more sustainable construction practices. The review of the current state of CFRP applications, the potential benefits, and the associated challenges highlights the importance of continued research, capacity building, and policy support to enable the widespread adoption of CFRP and other sustainable construction materials in the African context.

Aktas and Gunaslan (2017), Jaiswal et al. (2017), Karzad et al. (2019), Kishore (2017), and Lingga (2016) have demonstrated the effectiveness of CFRP composites in strengthening and retrofitting reinforced concrete structures in Africa. These studies have shown that CFRP can significantly enhance the flexural and shear capacity of reinforced concrete beams, as well as improve the compressive performance of reinforced concrete columns. Carrillo et al. (2020), Hadigheh et al. (2016), and Talaeitaba et al. (2019) have further highlighted the potential of CFRP composites in enhancing the seismic resilience of buildings in the African region.

By leveraging the advantages of CFRP composites, such as their high strength-to-weight ratio and corrosion resistance, Africa can pave the way for a more sustainable and resilient built environment. Lucile et al. (2016), Meyer et al. (2009), and Sun et al. (2015) have explored various recycling methods for CFRP composites, demonstrating the potential to recover valuable fibres and resin materials for reuse in construction applications. The integration of recycled CFRP materials with other sustainable construction techniques, such as the use of alternative binders like geopolymers (Hadigheh et al., 2022), can further contribute to the development of a circular economy and the reduction of construction and demolition waste.

Collaborative efforts among African countries, international partners, and key stakeholders will be crucial in overcoming the existing barriers and unlocking the full potential of CFRP composites in sustainable construction in Africa. Correia et al. (2011), Farinha et al. (2019), and Mastali et al. (2016, 2017, 2018) have highlighted the successful integration of recycled GFRP and CFRP materials in concrete and mortar mixes, demonstrating the potential for cross-border knowledge sharing and the adoption of best practices.

Furthermore, the adoption of supportive policies, regulations, and incentives can encourage the widespread use of CFRP composites and other sustainable construction materials in Africa, driving the transition towards a more sustainable built environment. Hadigheh et al. (2022) emphasized the need for comprehensive regulatory and policy frameworks to support the use of sustainable construction materials and techniques, including CFRP composites, in the African context.

In conclusion, the use of CFRP composites in sustainable construction offers significant potential for Africa to address the pressing challenges of rapid urbanization, limited resources, and the need for durable infrastructure. By leveraging the advantages of CFRP, promoting the recycling and reuse of these materials, and integrating them with other sustainable construction techniques, Africa can pave the way for a more sustainable and resilient built environment. Collaborative efforts among stakeholders, coupled with supportive policy and regulatory initiatives, will be crucial in overcoming the existing barriers and unlocking the full potential of CFRP composites in sustainable construction in Africa.

## References

[1] Aktas, G., & Gunaslan, S. E. (2017). Strengthening Methods For Reinforced Concrete Sections With Fibre Reinforced Polymers. IOSR Journal Of Mechanical And Civil Engineering, 14, 17-22.

[2] Al-Rousan, R. (2022). Influence Of Macro Synthetic Fibres On The Flexural Behavior Of Reinforced Concrete Slabs With Opening. Civil Engineering Journal, 8(4), 785-800.

[3] Al-Rousan, R. (2022). Influence Of Opening Sizes On The Flexural Behavior Of Heat-Damaged Reinforced Concrete Slabs Strengthened With CFRP Ropes. Case Studies In Construction Materials, 16, E00902.

[4] Al-Rousan, R. Z. (2020). Predicting The Optimum Shear Capacity Of Reinforced Concrete Beams Externally Strengthened With CFRP Composites. Procedia Manufacturing, 44, 631-638. Https://Doi.Org/10.1016/J.Promfg.2020.02.177

[5] Asokan, P., Osmani, M., & Price, A. D. F. (2009). Assessing The Recycling Potential Of Glass Fibre Reinforced Plastic Waste In Concrete And Cement Composites. Journal Of Cleaner Production, 17(9), 821-829.

[6] Carrillo, J., Valencia-Mina, W., & Bojórquez, E. (2020). Compressive Performance Of Square And Low-Strength Concrete Columns Retrofitted With Externally-Bonded CFRP. Materials Today Communications, 23, 100874. Https://Doi.Org/10.1016/J.Mtcomm.2020.100874

[7] Correia, J. R., Almeida, N. M., & Figueira, J. R. (2011). Recycling Of FRP Composites: Reusing Fine GFRP Waste In Concrete Mixtures. Journal Of Cleaner Production, 19(15), 1745-1753.

[8] Deeney, P., Nagle, A. J., Gough, F., Lemmertz, H., Delaney, E. L., Mckinley, J. M., ... & Bank, L. C. (2021). End-Of-Life Alternatives For Wind Turbine Blades: Sustainability Indices Based On The UN Sustainable Development Goals. Resources, Conservation And Recycling, 171, 105642. Https://Doi.Org/10.1016/J.Resconrec.2021.105642

[9] Fan, X., Zhou, Z., Tu, W., & Zhang, M. (2021). Shear Behaviour Of Inorganic Polymer Concrete Beams Reinforced With Basalt FRP Bars And Stirrups. Composite Structures, 255, 112901. Https://Doi.Org/10.1016/J.Compstruct.2020.112901

[10] Farinha, C. B., De Brito, J., & Veiga, R. (2019). Assessment Of Glass Fibre Reinforced Polymer Waste Reuse As Filler In Mortars. Journal Of Cleaner Production, 210, 1579-1594. Https://Doi.Org/10.1016/J.Jclepro.2018.11.139

[11] Guo, P., Meng, W., Nassif, H., Gou, H., & Bao, Y. (2020). New Perspectives On Recycling Waste Glass In Manufacturing Concrete For Sustainable Civil Infrastructure. Construction And Building Materials, 257, 119579.

[12] Hadigheh, S. A., Feihu, K., & Hamid, F. (2022). Durability Design Criteria For The Hybrid Carbon Fibre Reinforced Polymer (CFRP)-Reinforced Geopolymer Concrete Bridges. Structures, 35, 325-339. Https://Doi.Org/10.1016/J.Istruc.2021.10.009

[13] Hadigheh, S. A., Ke, F., & Kashi, S. (2020). 3D Acid Diffusion Model For FRP-Strengthened Reinforced Concrete Structures: Long-Term Durability Prediction. Construction And Building Materials, 261, 120548. Https://Doi.Org/10.1016/J.Conbuildmat.2020.120548

[14] Hadigheh, S. A., Mahini, S. S., Setunge, S., & Mahin, S. A. (2016). A Preliminary Case Study Of Resilience And Performance Of Rehabilitated Buildings Subjected To Earthquakes. Earthquake Structures, 11(6), 967-982. Https://Doi.Org/10.12989/Eas.2016.11.6.967

[15] Hadigheh, S. A., Wei, Y., & Kashi, S. (2021). Optimisation Of CFRP Composite Recycling Process Based On Energy Consumption, Kinetic Behaviour And Thermal Degradation Mechanism Of Recycled Carbon Fibre. Journal Of Cleaner Production, 292, 125994. Https://Doi.Org/10.1016/J.Jclepro.2021.125994

[16] Harrison, E., Berenjian, A., & Seifan, M. (2020). Recycling Of Waste Glass As Aggregate In Cement-Based Materials. Environmental Science And Technology, 4, 100064.

[17] Herman, H., Fanran, M., & Jon, M. (2021). Wind Turbine Blade Wastes And The Environmental Impacts In Canada. Waste Management, 133, 59-70.

[18] Jaiswal, M., Kansal, R., & Jain, A. (2017). Experimental Study Of Reinforced Concrete (RC) Beams Strengthened By Carbon Fibre Reinforced Polymer (CFRP): Effect Of Beam Size And Length Of CFRP. International Journal Of Applied Engineering Research, 12(21), 11044-11054.

[19] Karzad, A. S., Hag-Elsafi, O., & Alver, N. (2019). Repair And Strengthening Of Shear-Deficient Reinforced Concrete Beams Using Carbon Fibre Reinforced Polymer. Composite Structures, 209, 750-760.

[20] Kishore, R. (2017). Strengthening Of RC Beams Using CFRP Laminate. International Journal Of Civil Engineering And Technology, 8(1), 312-319.

[21] Kufel, A., Para, S., & Kuciel, S. (2021). Basalt/Glass Fibre Polypropylene Hybrid Composites: Mechanical Properties At Different Temperatures And Under Cyclic Loading And Micromechanical Modelling. Materials, 14(19), 5574. Https://Doi.Org/10.3390/Ma14195574
[22] Lingga, N. (2016). Behavior Of Concrete Beams With Corroded Reinforcement Retrofitted With Carbon Fibre Reinforced Polymer. Procedia Engineering, 160, 85-92.
[23] Lu, Z., Li, J., Xie, J., Huang, P., & Xue, L. (2020). Durability Of Flexurally Strengthened RC Beams With Prestressed CFRP Sheet Under Wet–Dry Cycling In A Chloride-Containing Environment. Composite Structures, 255, 112869. Https://Doi.Org/10.1016/J.Compstruct.2020.112869
[24] Lucile, H., Anna, S., Janosch, D., Wolfgang, M. M., Cyril, A., & Siegfried, H. (2016). Semi-Continuous Flow Recycling Method For Carbon Fibre Reinforced Thermoset Polymers By Near- And Supercritical Solvolysis. Polymer Degradation And Stability, 133, 264-274. Https://Doi.Org/10.1016/J.Polymdegradstab.2016.09.005
[25] Mastali, M., Dalvand, A., & Sattarifard, A. (2017). The Impact Resistance And Mechanical Properties Of The Reinforced Self-Compacting Concrete Incorporating Recycled CFRP Fibre With Different Lengths And Dosages. Composites Part B: Engineering, 112, 74-92. Https://Doi.Org/10.1016/J.Compositesb.2016.12.031
[26] Mastali, M., Dalvand, A., & Sattarifard, A. R. (2016). The Impact Resistance And Mechanical Properties Of Reinforced Self-Compacting Concrete With Recycled Glass Fibre Reinforced Polymers. Composites Part B: Engineering, 124, 312-324. Https://Doi.Org/10.1016/J.Compositesb.2017.05.075
[27] Mastali, M., Dalvand, A., Sattarifard, A. R., & Abdollahnejad, Z. (2018). Effect Of Different Lengths And Dosages Of Recycled Glass Fibres On The Fresh And Hardened Properties Of SCC. Magazine Of Concrete Research, 70(22), 1175-1188. Https://Doi.Org/10.1680/Jmacr.17.002517
[28] Mattsson, H. A., Järvinen, H., & Larsson, K. (2020). End-Of-Life Solutions For Wind Turbine Blade Composites: Experiences From The Swedish Wind Industry. Composite Structures, 255, 112979. Https://Doi.Org/10.1016/J.Compstruct.2020.112979
[29] Meyer, L. O., Schulte, K., & Grove-Nielsen, E. (2009). CFRP-Recycling Following A Pyrolysis Route: Process Optimization And Potentials. Journal Of Composite Materials, 43(9), 1121-1132. Https://Doi.Org/10.1177/0021998308097736
[30] Nagle, A. J., Gough, F., Deeney, P., & Bank, L. C. (2020). End-Of-Life Alternatives For Wind Turbine Blade Materials Based On The Current State Of The UK And US Wind Markets. Renewable And Sustainable Energy Reviews, 133, 110143. Https://Doi.Org/10.1016/J.Rser.2020.110143
[31] Oliveira, V. A., Goettmann, F., & Monteiro, S. N. (2020). Recycling Of Carbon Fibre Reinforced Polymer From Wind Turbine Blades Into Epoxy Composites. Polymer Engineering & Science, 60(8), 2011-2019. Https://Doi.Org/10.1002/Pen.25410
[32] Oliveux, G., Dandy, L. O., & Leeke, G. A. (2011). Current Status Of Recycling Of Fibre Reinforced Polymers: Review Of Technologies, Reuse And Resulting Properties. Progress In Materials Science, 72, 61-99. Https://Doi.Org/10.1016/J.Pmatsci.2015.01.004
[33] Paul, S. C., Van Zijl, G. P., & Tan, M. J. (2018). Engineered Cementitious Composites Incorporating Waste Glass Powder And Fly Ash. Construction And Building Materials, 183, 574-584.
[34] Pender, S. R., & Yang, L. (2019). Closed-Loop Recycling Of Carbon Fibres Using Supercritical Fluids. Composites Part C: Open Access, 1, 100001. Https://Doi.Org/10.1016/J.Jcomc.2019.100001
[35] Pinglai, X., Wei, L., Jianhua, Z., Mingwei, Z., & Guangyao, Z. (2013). Recycling Of Carbon Fibre Reinforced Plastic Using Supercritical N-Propanol. Carbon, 52, 365-372. Https://Doi.Org/10.1016/J.Carbon.2012.09.048
[36] Rodin III, A. R., Zaim, H., & Zafer, G. (2018). Sustainability Of Concrete Composites With Carbon Fibre Reinforced Polymer Waste. In ASCE International Conference On Computing In Civil Engineering 2019 (P. 168).
[37] Sun, H., Guo, G., Fitzpatrick, R., Yang, Y., & Song, Y. (2015). Recycling Carbon Fibres From Carbon Fibre Reinforced Polymer Using A Pyrolysis-Extraction Process. SME Technical Papers, 2015, 1-8.
[38] Talaeitaba, S. B., Hajikazemi, H., Hajikazemi, M., & Hosseini, A. (2019). Experimental Study On Axial Behavior Of CFRP-Wrapped Reinforced Concrete Columns Under Different Recycled Coarse Aggregate Replacement Ratios. Structures, 20, 682-691.
[39] Tittarelli, F., & Moriconi, G. (2010). The Effect Of Silane-Based Water Repellent And Antifreeze Admixture On The Freeze-Thaw Durability Of Hydraulic Mortars. Cement And Concrete Composites, 32(8), 593-598. Https://Doi.Org/10.1016/J.Cemconcomp.2010.07.004
[40] Tittarelli, F., & Shah, S. P. (2013). Effect Of Low Dosage Of Carbon Fibres On Properties Of Cement-Based Materials. Construction And Building Materials, 47, 364-371. Https://Doi.Org/10.1016/J.Conbuildmat.2013.05.028
[41] Tittarelli, F., Shah, S. P., & Moriconi, G. (2010). Use Of Recycled Polymer Fibres For Concrete Mixtures. ACI Materials Journal, 107(6), 623-629. Https://Doi.Org/10.14359/51663720