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Review paper

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APPLICATION OF LAMINATED COMPOSITES IN THE AUTOMOTIVE, AVIATION AND MARINE INDUSTRY

ABSTRACT: The paper presents the application of laminated composites in the automotive, aerospace and marine industries. Laminated composites are characterised by a high strength–to–weight ratio, durability, corrosion resistance and the ability to tailor properties by designing the laminate structure. In the automotive industry, they are used to produce body elements, chassis structures and suspension components, contributing to weight reduction while maintaining the required mechanical properties and safety. In the aerospace industry, they are used in wings, fuselage structures, unmanned aerial vehicles, hybrid laminated composites and multifunctional composite systems. In the marine industry, laminated composites are used in hull and sandwich structures due to their low weight, corrosion resistance and favourable behaviour under fatigue loading. Despite these advantages, wider application remains limited by high production costs, repair complexity, degradation during long–term operation and recycling challenges. Future development will be directed towards optimising the laminate structure, improving production technologies, developing hybrid and multifunctional structures, and increasing recycling capabilities.

KEYWORDS: laminated composites, CFRP, automotive industry, aviation industry, marine industry

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PRIMENA LAMINATNIH KOMPOZITA U AUTOMOBILSKOJ VAZDUHOPLOVNOJ I POMORSKOJ INDUSTRIJI

REZIME: U radu je prikazana primena laminatnih kompozita u automobilskoj, vazduhoplovnoj i pomorskoj industriji. Laminatne kompozite karakterišu visok odnos čvrstoće i mase, trajnost, otpornost na koroziju i mogućnost prilagođavanja svojstava projektovanjem strukture laminata. U automobilskoj industriji se primenjuju za izradu elemenata karoserije, struktura šasije i delova sistema oslanjanja, doprinoseći smanjenju mase uz zadržavanje zahtevanih mehaničkih svojstava i bezbednosti. U vazduhoplovnoj industriji se primenjuju za izradu krila, konstrukcije trupa bespilotnih letelica, hibridnih laminatnih kompozita i multifunkcionalnih kompozitnih sistema. U pomorskoj industriji laminatni kompoziti se primenjuju za izradu konstrukcije trupa i sendvič panela zbog male mase, otpornosti na koroziju i dobre otpornosti na zamorno opterećenje. I pored navedenih prednosti, njihova šira primena i dalje je ograničena visokim troškovima proizvodnje, složenošću popravke, degradacijom tokom dugotrajne eksploatacije i izazovima reciklaže. Budući razvoj biće usmeren ka optimizaciji strukture laminata, unapređenju proizvodnih tehnologija, razvoju hibridnih i multifunkcionalnih struktura i povećanju mogućnosti reciklaže.

KLJUČNE REČI: laminatni kompoziti, CFRP, automobilska industrija, avio industrija, pomorska industrija

INTRODUCTION

The development of modern transportation systems is conditioned by increasingly stringent requirements in terms of weight reduction, increased safety, energy efficiency and reduced environmental impact. In this context, advanced materials, and in particular laminated composites, occupy an important place in the construction of vehicles, primarily in the automotive industry.

Laminated composites enable the design of lightweight and mechanically efficient structures, where the desired properties are achieved by controlling the orientation of the fibres, the choice of the matrix and the application of appropriate production technologies. Thanks to their high specific strength, corrosion resistance and energy absorption capacity, these materials are increasingly used in structural and semi–structural components of vehicles (Fatima et al. 2025; Jovanović et al. 2025; Mohammadi et al. 2022).

In the modern automotive industry, the application of composite materials such as carbon fibre reinforced plastic-CFRP and glass fibre reinforced polymer–GFRP is becoming increasingly important due to the need to reduce weight and improve mechanical properties. Spasenović and Blagojević indicate that CFRP and GFRP contribute to reducing weight and increasing energy efficiency of vehicles, while maintaining adequate stiffness and resistance to loads (Spasenović & Blagojević, 2021).

Research by Mititelu et al. focuses on multi–criteria evaluation of the behaviour of CFRP laminated composites in car frames, emphasising the importance of mechanical testing and analysis in the design of structural elements (Mititelu et al. 2022).

In the aerospace industry, CFRP composites are widely used in aircraft load–bearing structures due to their high specific modulus and specific strength, which is confirmed through systematic literature reviews on the global application of CFRP in aero–structures (Zhang et al. 2023). Contemporary reviews also emphasise the importance of integrated design and manufacturing technologies of CFRP structural parts in aerospace, with a focus on process optimisation and structural development of high–performance materials (Bai et al. 2025).

The application of laminated composites in the automotive industry has gained increasing attention in recent decades, primarily due to the need for vehicle weight reduction, increased energy efficiency and reduced emissions of harmful gases. Materials such as carbon and glass fibre reinforced composites exhibit an extremely favourable strength–to–weight ratio, as well as good resistance to corrosion and fatigue, which makes them suitable for use in load–bearing and safety–critical vehicle components. Research shows that the use of CFRP materials can lead to a 30–40% reduction in the mass of vehicle structural parts, while simultaneously improving mechanical performance (Faizal Herum Ibrahim et al. 2025).

This review aims to analyse the application of laminated composites in modern transportation systems, with a special focus on the automotive, aerospace and marine industries. The paper covers the basic types of laminated composites, relevant materials and production technologies, as well as key challenges and future trends in their application in modern transportation technologies.

LAMINATED COMPOSITES

Laminated composites are layered composite materials composed of multiple individual layers (laminae), whose properties largely depend on the stacking order, fibre orientation, layer thickness, and type of materials used. Figure 1 shows a laminate composite. Due to their low density, high specific strength and stiffness, as well as good resistance to corrosion and fatigue, laminated composites have significant applications in transportation systems (Kreculj, 2013).

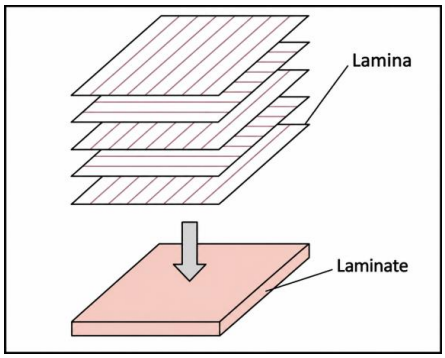


Figure 1 Laminated composite (Mitrović, 2024)

The lamina is the basic structural layer of a composite, in which the fibres can be unidirectional oriented or arranged in multiple directions. By combining multiple laminae of different orientations, a laminate is formed. The total thickness and mechanical properties of laminate depend on the number, orientation and order of the layers. The orientation of the fibres plays a key role in load transfer, as layers with unidirectional oriented fibres exhibit high strength and stiffness in the fibre direction, but significantly lower properties in the transverse direction. By appropriately arranging the layers oriented at angles of 0°, ±45° and 90°, a quasi–isotropic laminate can be formed, which exhibits approximately uniform mechanical properties in the plane of the laminate, which makes it suitable for use in structural components (Campbell, 2010; Kreculj, 2013; Mitrović, 2024).

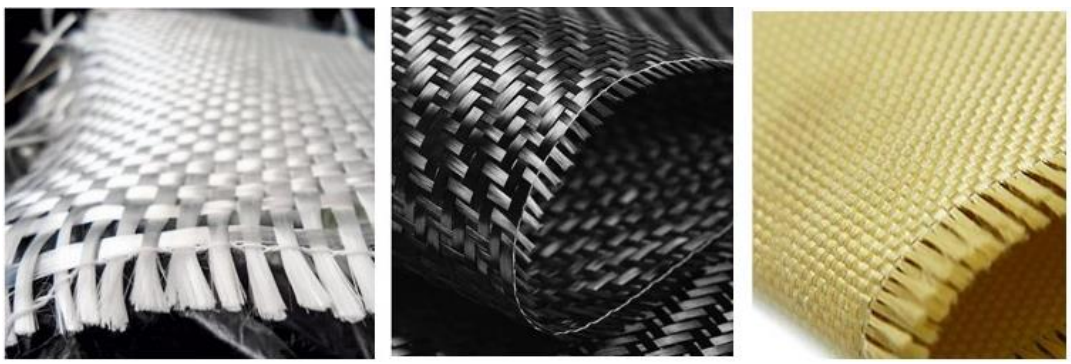
Reinforcement of Laminated Composites – Fibres

Fibre material

In transportation applications, glass, carbon and aramid fibres are most commonly used (Figure 2). Glass fibres are characterised by a favourable price–to–mechanical properties ratio, good corrosion resistance and relatively simple processing, which is why they are widely used in the automotive and marine industries.

Aramid fibres are characterised by low density, high tensile strength and pronounced impact resistance, which makes them suitable for passive safety system components, although their application is limited by their higher cost and more complex production (Dharmavarapu & M.B.S, 2022; Đorđević, n.d.).

Carbon fibres have extremely high specific strength and stiffness, as well as good fatigue resistance, which is why they are increasingly used in the automotive industry, especially in body parts, chassis, suspension systems and drivetrain elements (Huang, 2009).



a) b) c)

Figure 2 Comparative presentation of fibres made from different materials: a) glass fibres, b) carbon fibres, c) aramid fibres (Carbon Fiber Reinforced Plastic Tank Repair in OH – RAK, 2024; What's Fiberglass, and How Does the Delicate Material Reinforce Thousands of Products?, 2024)

Fibre shape

Fibres are used in the production of laminated composites in the form of unidirectional oriented bundles, as well as in the form of various types of weaving. The choice of fibre shape depends on the requirements in terms of mechanical properties, the complexity of the geometry and the applied production technology.

Unidirectional weaves allow for maximum strength and stiffness in a particular direction, while weaves with multidirectional fibre orientation provide more balanced properties and better adaptability to complex shapes. Knitted and randomly oriented fabrics are mainly used for less loaded or non–structural elements (Campbell, 2010; Đorđević, n.d.; Hall & Javanbakht, 2021).

Types of Matrices

The matrix in laminated composites has the role of fibre connection, load transfer, and protection of the reinforcement from external influences. Thermosetting matrices, primarily epoxy, phenolic and polyester resins, are widely used in transportation applications. Epoxy resins are characterised by good mechanical resistance, low shrinkage and good fatigue resistance, which makes them suitable for highly loaded structural components in the automotive industry (Jin et al., 2015; Saba et al., 2016). Phenolic resins have good resistance to high temperatures and flame, while polyester resins are mainly used in less demanding and more economically accessible solutions (Asim et al., 2018; El-Din Saleh, 2012).

Fabrication Methods of Laminated Composites

The production of laminated composites can include various open and closed mould techniques. The choice depends on the type of material, the component geometry, the required quality and the production volume. In the transportation industry, closed mould processes, such as Resin Transfer Moulding (RTM), High–Pressure RTM and pressing processes, are of particular importance, as they enable controlled quality, high repeatability and integration into mass production (Biswas & Anurag, 2019; Campbell, 2010; Hall & Javanbakht, 2021; Mitrović, 2024).The choice of process depends on the requirements in terms of mechanical properties, repeatability, production cycle and cost–effectiveness.

APPLICATION OF LAMINATED COMPOSITES

Due to increasingly stringent requirements for weight reduction, increased energy efficiency and reduced emissions, laminated composites are becoming important materials in transportation systems. Their application is particularly pronounced in the automotive, aerospace and marine industries, where they contribute to the reduction of structural weight, safety improvement and reduced maintenance costs.

In modern vehicles, laminated composites, especially CFRP and GFRP, are used in various structural components such as body panels, supporting beams, floor structures and parts of the suspension system. These materials are often used due to their high strength–to–weight ratio, which allows a significant reduction in vehicle weight while maintaining mechanical strength and resistance (Spasenović & Blagojević, 2021). Composite structures show favourable behaviour in terms of energy absorption during impact, which makes them suitable for use in elements that contribute to the passive safety of vehicles (Lukaszewicz, 2013). Furthermore, advanced reviews indicate that properly designed composites allow for optimisation of fibre orientation, thickness, and layer sequence to achieve the required mechanical properties and performance in specific automotive parts (Khan et al., 2025a).

Application of Laminated composites in the Automotive Industry

In the modern automotive industry, laminated composites play a significant role in reducing vehicle weight while simultaneously meeting requirements for strength, stiffness, and safety. They are most commonly used in the manufacture of body parts such as hoods, bumpers, doors, roofs, and spoilers, as well as certain chassis elements, suspension systems, and drive components.

A typical example of the application of laminated composites is the hood of a vehicle. By using CFRP laminated composites, it is possible to achieve a weight reduction of up to about 30% compared to metal alternatives, while maintaining the required strength and stiffness (Khan et al., 2025b). In a light electric vehicle, Bere et al. showed that the use of CFRP can lead to an even more significant weight reduction: the tested composite hood was approximately 2.5 times lighter than a corresponding steel structure, with an increase in lateral and torsional stiffness (Bere et al., 2021).

Laminated composites are increasingly used in the manufacture of vehicle chassis, where they contribute to improved handling, reduced overall weight and fuel consumption, increased resistance to corrosion and fatigue. A particular advantage of these materials is their ability to dampen vibrations and maintain long–term structural stability.

Laminated composites also have significant applications in passive safety systems, primarily in bumpers. Materials such as CFRP and GFRP have shown good energy absorption capabilities during low–speed collisions, thereby reducing vehicle damage and increasing passenger safety. In a recent study, an optimised CFRP bumper beam achieved a 57.18% weight reduction compared to the initial aluminium version, while meeting the crashworthiness requirements (Dai et al., 2024).

In addition, laminated composites are used to produce leaf springs, which, compared to steel ones, have lower weight, longer service life, better corrosion resistance, and improved shock and vibration damping (Khan et al., 2025b). In one experimental study, an optimised GFRP leaf spring had a weight of approximately 9.75 kg, compared to 31.24 kg for the corresponding steel structure, which represents a weight reduction of approximately 69% while meeting the requirements for bending stiffness and strength. In addition to the significant weight reduction, the design of the GFRP leaf spring can be adapted to the requirements of the suspension system by appropriately adjusting the geometry and structure of the laminate. The position of the composite leaf spring in a vehicle and its typical construction is shown in Figure 3.



Figure 3 Location and typical construction of a GFRP composite leaf spring (Ma et al., 2021)

Typical examples of the application of laminated composites in the automotive industry are shown in Figure 4.



a) b) c)

Figure 4 Application of laminated composites in the automotive industry: a) Air filter housing, b) Hood, c) Spoiler (*Corvette Stingray C8 2020-2023 Tuning Kit*, n.d.; Gao et al., 2018; Sedlacek & Lasova, 2017)

Sedlacek et al. (Sedlacek & Lasova, 2017) used numerical analysis and the finite element method to design and optimise an air filter housing for a racing motorcycle. The goal was to reduce mass by 70% while maintaining stiffness and strength. The models included fibre orientation and overlap, cut and splice locations, and a prototype was fabricated from impregnated carbon fibres.

Gao et al. (Gao et al., 2018) investigated a CFRP hood, optimising the orientation and thickness of the layers for maximum stiffness and minimum mass. ABAQUS and FEM software were used, and the DMTO method was used for optimisation. The prototype was fabricated using the VARTM method, and experimental test results confirmed the numerical analysis.

The examples show that the application of laminated composites in the automotive industry is based on the simultaneous optimisation of fibre orientation, layer thickness, and production process to achieve minimal mass while meeting strength and stiffness requirements.

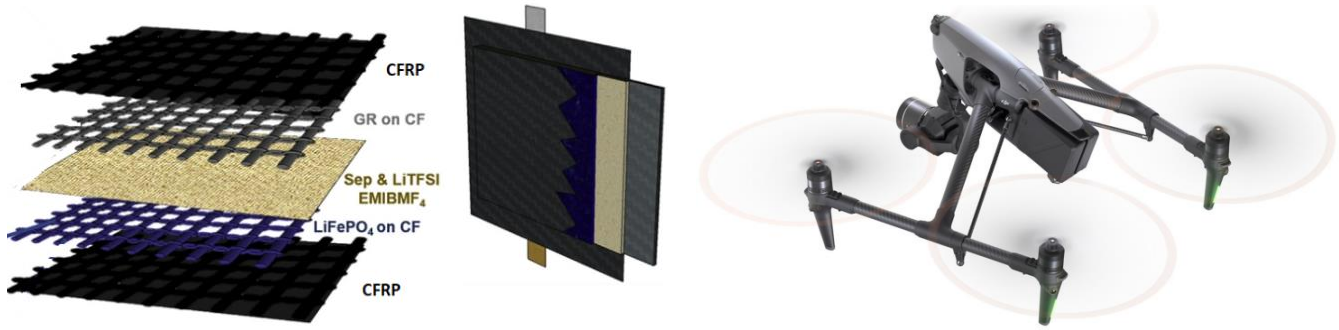
Application of Laminated Composites in the Aerospace Industry

Due to their high strength–to–weight ratio, laminated composites are widely used in the aerospace industry, for wings, fuselage sections, stabilizers, floor structures, and other load–bearing and semi–load–bearing components. As these are highly responsible structures, these materials are subjected to numerous static, dynamic, fatigue, and impact tests (Linganiso & Anandjiwala, 2016).

A typical example of the application of hybrid laminate structures is GLARE (glass–reinforced aluminium laminate), which consists of alternating thin aluminium layers and layers of glass fibres in an epoxy matrix. In the Airbus A380 aircraft, GLARE is used in the upper fuselage panels, with the total area of these structures being approx. 469 m² and comprising of 27 panels. According to Park and Choi, the use of GLARE in the A380 fuselage structure can achieve a weight reduction of approximately 794 kg, or about 10% compared to a corresponding aluminium structure. In addition to weight reduction, the importance of this material is also reflected in its favourable fatigue resistance and damage tolerance (Yoon Park & Jong Choi, 2019).

Laminated composites are also of particular interest in the development of unmanned aerial vehicles, where weight reduction is of key importance for increasing flight time and energy efficiency. In these applications, CFRP is most often used for the manufacture of wings, propellers, housings and supporting structures, where various laminate manufacturing techniques are applied.

In the aerospace industry, laminated composites are used for the manufacture of structural parts of satellites, as well as in the development of multifunctional composite batteries. Figure 5 shows examples of the application of laminated composites in the aerospace industry.



a) b)

Figure 5 Applications of laminated composites in the aerospace industry: a) CFRP–reinforced lithium battery, b) Drone (*DJI Inspire 3 – Master the Unseen*, 2024; Moyer et al., 2020)

Moyer et al. (Moyer et al., 2020) have demonstrated the production of a composite lithium battery with an epoxy matrix and woven carbon fibres as a reinforcement and collector. The lamination was performed using the “Wet lay–up” process, and the active elements of the battery were embedded in the fibre layers. The resulting plate serves both as a structural element and as a power source in cubic satellites, allowing for more rational use of space and integration of other components.

A special group of laminate materials are fibre–reinforced metal laminated composites (Fibre–Metal Laminated composites – FML), which consist of alternating thin metal layers and layers of fibre–reinforced polymer composites. The most well–known types are GLARE, ARALL and CARALL. By combining the properties of metal and composite layers, low mass, high fatigue and impact resistance, as well as good tolerance to damage are achieved. FML materials were primarily developed for aerospace structures, while their application is gradually expanding to the automotive and marine sectors (Etri et al., 2022).

Application of Laminated Composites in the Marine Industry

The application of laminated composites in the marine industry is widespread, primarily due to their corrosion resistance, low mass and good fatigue resistance. These materials are used for the manufacture of hulls, superstructures, decks, steering systems and protective domes for sonar.

Laminated composites are particularly used in high–speed vessels, patrol and military vessels, where they contribute to weight reduction and improved performance. For smaller and medium–sized vessels, such as fishing boats, yachts and rescue boats, GFRP is most often used (Chandra Chakraborty, 2022; Rubino et al., 2020). An additional advantage of laminated composites in military applications is reflected in the ability to dampen vibrations and reduce radar visibility.

As an example of the application of GFRP laminated composites, the construction of the hull of a composite yacht can be highlighted. In the analysed vessel, individual parts of the hull are made with different numbers of laminate layers, depending on the position and expected load. The hull construction and appearance of the GFRP laminated plate are shown in Figure 6.

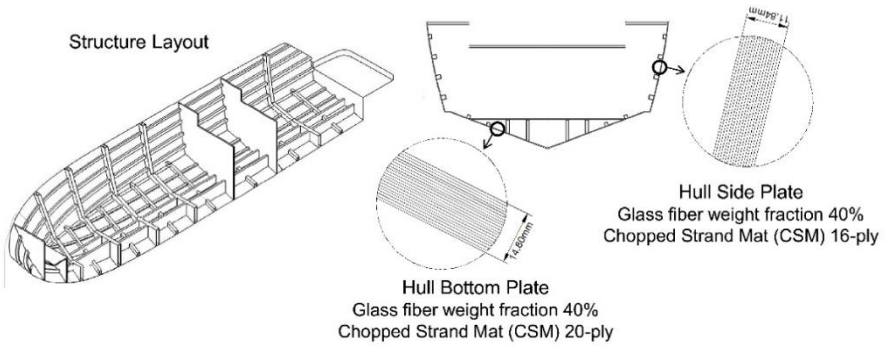


Figure 6 Hull construction and GFRP laminated panel of a composite yacht

This example shows that the laminate structure in marine structures can be adapted to local loading conditions by selecting the number and arrangement of layers. In this case, the control of the actual proportion of glass fibres and internal defects plays an important role in ensuring the required mechanical properties of the manufactured structure. One of particular importance in marine structures are sandwich laminate structures, which consist of outer load–bearing layers made of GFRP, CFRP or aramid composites and a lightweight core, most often made of polymer foam or honeycomb structure. This type of structure allows for high bending stiffness with low mass, which is why it is used in hulls, decks and superstructures of vessels. Mass reduction can contribute to increasing load capacity, reduction of fuel consumption and improvement of vessel stability (Yoon Park & Jong Choi, 2019).

A typical example of the use of sandwich–laminate structures is the Swedish Visby–class corvette, whose hull is made of sandwich panels with carbon and glass reinforcements and a polymer matrix. The use of carbon fibres has enabled a reduction in the hull mass by approximately 30%, while maintaining the necessary structural resistance and favourable characteristics for military applications (Yoon Park & Jong Choi, 2019). However, long–term exposure to seawater and moisture is a significant factor in the design of these structures, since moisture penetration into the polymer matrix and the fibre–matrix interface can lead to degradation of the mechanical properties of the laminate. Therefore, when choosing materials for marine applications, in addition to the initial mechanical properties, it is necessary to consider their long-term resistance in the marine environment (Osa–Uwagboe et al., 2024a).

Compared to aviation applications, where minimal mass and high specific stiffness are the dominant requirements, corrosion resistance, durability, and cost–effectiveness are of particular importance in marine structures.

DISCUSSION

Analysis of the presented applications shows that the main reasons for the introduction of laminated composites are similar in different transport sectors and primarily include weight reduction, high specific strength and stiffness, as well as the possibility of adapting the laminate structure to specific load conditions. The importance of individual requirements varies depending on the field of application. In the automotive industry, in addition to mechanical properties, price and short production cycle time are crucial, while in aviation, minimal weight, high specific stiffness and reliability are dominant. In marine structures, in addition to low weight, corrosion resistance, durability and stability of properties during exposure to an aggressive marine environment are of particular importance.

Although laminated composites show significant advantages in terms of weight reduction, mechanical properties and performance improvement, their wider application, especially in automotive mass production, is still limited by a number of factors. First of all, the high cost of materials and manufacturing processes, as well as the complexity of forming technologies, pose a significant challenge to their economic viability. Recent reviews indicate that the lack of fast and energy–efficient manufacturing processes, the high cost of CFRP and other composite materials, and the limitations of existing tools and procedures for design and repair significantly limit their application in the automotive industry compared to conventional metals such as steel and aluminium (Sarfraz et al. 2021).

Additional limitation is the behaviour of composite structures during long–term operation. This is particularly pronounced in marine conditions, where moisture and seawater ingress can lead to matrix plasticisation, weakening of the fibre–matrix bond, and a reduction in tensile, flexural, and inter–laminar shear properties. Review of research shows that the degree of degradation depends on the type of fibre and matrix, the order of layers, the manufacturing method, the temperature and the exposure time, indicating that not only the initial mechanical properties but also their long–term stability must be considered when designing laminated composites (Osa–Uwagboe et al., 2024b).

The challenges related to recycling and end–of–life waste management represent a significant obstacle to the widespread application of laminated composites in transportation systems. Due to the use of thermosetting matrices and the combination of different materials, the separation of components during recycling remains technologically complex, and existing methods often damage the mechanical properties of the material or require energy–intensive, economically disadvantageous processes. Despite the development of several mechanical, chemical and thermal methods, the limited possibility of obtaining recycled CFRP material with properties comparable to virgin material still represents a significant challenge for integration into the circular economy and reuse in transportation applications (Aldosari et al. 2024; Butenegro et al. 2021; Spasenović & Blagojević, 2021; Zhang et al. 2020).

Sustainability issue is particularly acute for large marine structures, which often have a design life of 20–30 years. Modern approaches increasingly include the selection of alternative fibres and matrices, recycling and reuse of materials, life cycle analysis, and the development of more sustainable sandwich structures (Baley et al., 2024).

Market data indicate a continued growth in industrial interest in composite materials produced by lay-up processes. According to a report by Markets and Markets, the global lay–up composites market is estimated at USD 43.18 billion in 2024 and USD 47.23 billion in 2025. Further market growth is expected in the coming period, with its value forecast to reach approximately USD 72.87 billion by 2030, at a compound annual growth rate (CAGR) of 9.3%. In 2024, the automotive industry represented the largest end–use sector, while significant applications of these materials were also recorded in the aerospace, marine and energy industries. The main drivers of further growth are the requirements for weight reduction and the use of lightweight materials with high mechanical properties, with additional development potential in the field of electric vehicles and marine structures (Lay–up Composites Market by Fiber Type, Resin Type, End–Use Industry and Region – Global Forecast to 2030, 2026).

A special example of the modern development of laminate structures is represented by fibre-reinforced metal laminated composites (FML – Fibre–Metal Laminated composites), which combine thin metal layers and fibre–reinforced composite layers to combine the advantages of both groups of materials. The importance of FML structures is particularly pronounced in aerospace, but their application is also developing in the automotive and marine industries. The distribution of the FML materials market by application in 2024 is shown in Figure 7 (Pulidindi & Yadav, 2025).

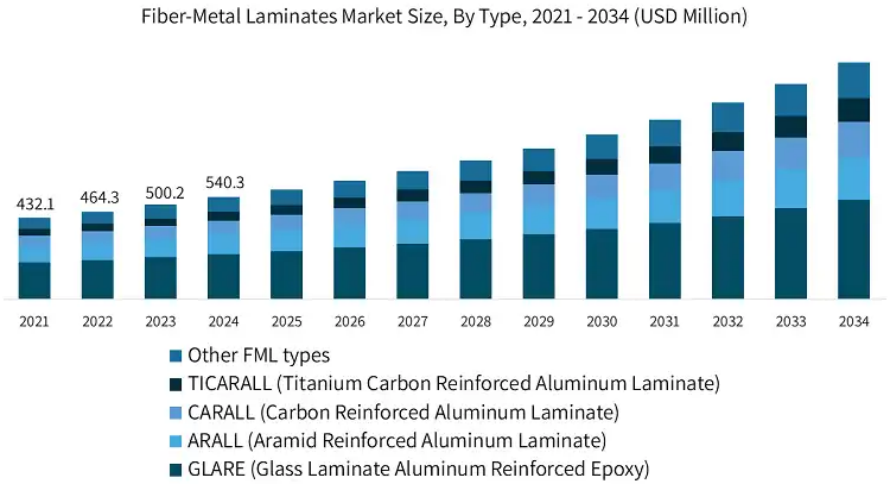


Figure 7 Market share of FML materials by application area (Pulidindi & Yadav, 2025)

The data presented in Figure 7 show a clear dominance of the aerospace and defence industry in the application of FML materials. In 2024, this sector had a market share of 61.5%, which corresponds to a value of approximately 332.5 million USD. This share can be associated with the requirements of aerospace structures for weight reduction, high fatigue resistance and reliability under long–term cyclic loads. At the same time, market analysis indicates the expansion of the application of FML structures in the automotive sector, especially in electric and hybrid vehicles, as well as in marine structures, where their application is associated with the requirements for weight reduction, increased corrosion resistance and durability of the structure (Pulidindi & Yadav, 2025).

The potential for further development is also confirmed by the estimate that the global FML market was worth approximately USD 540.3 million in 2024, while it is expected to reach approximately USD 1.25 billion by 2034, with a forecasted CAGR of 8.9% (Pulidindi & Yadav, 2025).

Although the above market indicators indicate significant potential for further growth and wider application of laminated composites, their future development will largely depend on overcoming the previously discussed technological, economic and environmental limitations. In this regard, research is directed towards the simultaneous improvement of materials, construction and production technologies. The development of hybrid and multifunctional structures allows for the combination of the advantages of different materials, while processes such as RTM, HP–RTM and AFP contribute to higher repeatability, automation and shortening of production cycles. At the same time,

the development of materials with lower environmental impact, improved recycling and reuse capabilities, and more reliable prediction of the long-term behaviour of laminate structures under different operating conditions are of increasing importance (Automotive Composites Market, n.d.; Osa–Uwagboe et al., 2024b; Sarfraz et al., 2021).

CONCLUSIONS

Laminated composites represent a significant group of materials in modern transportation systems, especially in the automotive, aerospace, and marine industries. Their application allows for a significant reduction in the mass of structures while maintaining or improving mechanical properties, which can improve energy efficiency, performance, and safety of transportation systems.

The analysis of the presented applications shows that their main advantage is not only in high specific strength and stiffness, but also in the ability to design the laminate structure in accordance with specific load conditions. By choosing the material, orientation, number, and sequence of layers, it is possible to adapt the mechanical behaviour of the component to the requirements of its application. This possibility of structural adaptation is one of the main reasons for the increasingly widespread use of laminated composites in the transportation industry.

However, the criteria for their application are not the same in all transport sectors. In the automotive industry, in addition to reducing weight and meeting strength and safety requirements, cost–effectiveness and the possibility of serial production play a significant role. In aerospace and space applications, the requirements for minimum weight, high specific stiffness and structural reliability dominate, while in the marine industry, corrosion and fatigue resistance, durability and stability of properties in the marine environment are particularly important. Sandwich-laminate and hybrid structures, including FML materials, show special potential, in which the combination of different materials seeks to achieve more favourable ratios of weight, mechanical properties and durability.

Although the presented applications and market trends indicate a further growth in the importance of laminated composites, their wider application is still conditioned by solving the problems of high material and production costs, the complexity of repair, recycling and preservation of mechanical properties during long-term exploitation. Future development will therefore be directed towards automation and improvement of production processes, optimization of material selection, orientation, number and sequence of layers in accordance with specific loading conditions, development of hybrid and multifunctional structures, increasing the possibilities of recycling and reuse, as well as more reliable prediction of long-term behaviour of laminated composites in different exploitation conditions. These directions of development, along with compliance with increasingly stringent industrial and environmental requirements, represent the basis for a wider and more sustainable application of laminated composites in future transport systems.

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