The SWOT discussion on the Advanced Materials in Civil Engineering, Vietnam

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ABSTRACT

Current construction projects in Vietnam are focusing on and prioritizing the use of ‚advanced materials‘ to improve performance, quality, and sustainability. However, the application of these materials still faces certain limitations and challenges. This study discusses the research of some typical advanced materials such as High-performance concrete, Polymer composites, and Lightweight materials. Then, a SWOT discussion was presented to evaluate the ‘strengths’, ‘weaknesses’, ‘opportunities’, and ‘threats’ from government, businesses, and scientific materials research development perspectives. Despite strengths such as growing construction demand, abundant resources, and government support, the industry faces numerous challenges. Weaknesses include limited research capacity, high production costs, and lack of stringent standards. Nevertheless, opportunities arise from sustainable construction demands, international collaboration, and emerging green transition trends. Conversely, the industry currently faces threats such as competition from traditional materials, a shortage of highly skilled technical workforce, and limited awareness of advanced materials’ benefits. This study contributes to filling the knowledge gap in the context of strategic planning and indicates significant implications for managers, potentially enhancing their strategic decision-making in Vietnam.

Keywords: *Advanced materials, High-performance Concrete, Lightweight Material, Polymer Composite Material, SWOT.*

1. INTRODUCTION

Using “advanced materials” has transformed the traditional construction approach, creating new options and increasing labor efficiency (Daneshvar et al. [1]; Spagnuolo et al. [2]) Application of advanced materials is considered one of the factors determining the quality, cost, construction time, and sustainability of the project. For example, construction materials frequently account for a significant fraction of the entire construction cost, particularly at rates of 75–80% for civil and industrial projects, 70–75% for traffic, and 50–55% for irrigation works.

The research on advanced materials has grown extensively; however, its wide use in many different types of structures and contexts has limited the ability to develop a comprehensive review of advanced materials in civil engineering. Furthermore, the construction materials field aims to use modern technologies in production according to “Construction Materials Development Strategy for The Period 2021–2030, with An Orientation Toward 2050” (No. 1266/QĐ-TTg) [3]. The goal is to propose strategic planning for developing new materials that are more sustainable and efficient.

Therefore, a SWOT analysis is useful for strategic planning (Valentin [4]; Dickson [5]; Panagiotou [6]). Most organizations today engage in strategic planning. Strategic planning is a method of assisting an organization in being more productive by guiding the allocation of resources in order to achieve goals. In fact, strategic planning is essential for effective strategic management. Thus, this study aimed to access, analyze, and synthesize the literature to provide an overview of the advanced materials in construction based on SWOT analysis. The main objective of this paper is to categorize the available literature (analytical/experimental). The discussion remains descriptive, and the reader is recommended to consult the cited references for specifics on parameters and mathematical models. Three phases were adopted to conduct this literature review: (a) conducting the review, (b) conducting the analysis, and (c) writing up the review.

2. METHODOLOGY

This study was conducted following the process shown in Figure 1.

It begins with a review approach. Integrative reviews assess, critique, and combine the literature on a study issue to establish new theoretical viewpoints and frameworks. Based on this, the integrative review strategy was used as the research methodology in this study.

SWOT analysis is a tool used in organizations for strategic planning and management. External and internal analysis, often known as SWOT analysis, is the next step in the strategic management process. An organization can identify essential challenges and opportunities in its competitive environment by conducting an external analysis. It also investigates how competition in this environment is expected to evolve and the implications of that evolution for the threats and opportunities an organization faces. While external analysis focuses on threats and opportunities, internal analysis assists an organization in identifying its organizational strengths and weaknesses. It also assists an organization in determining which of its resources and competencies are likely to provide a competitive advantage and which are less likely to do so.

Based on SWOT analysis, organizations can select the most appropriate strategy. Strategic choice is related to the organization's vision, mission, objectives, and external and internal analysis.

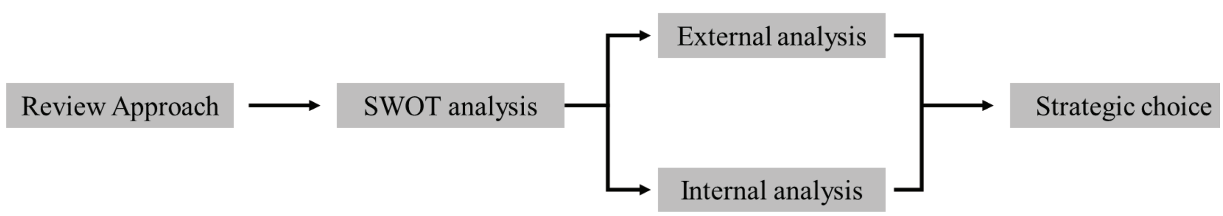

Figure 1. Research workflow

3. RESULTS AND DISCUSSION

3.1. General information

This study reviewed advanced materials such as high-performance concrete (HPC), polymer composites (FRP), and lightweight materials.

3.1.1. High-performance concrete (HPC)

High-performance concrete (HPC) improves ordinary concrete in terms of characteristics and constructability. These particularly developed concretes must meet a combination of performance standards and are made with both ordinary and special materials. Special mixing, laying, and curing techniques may be required to make and manage high-performance concrete. Because of its strength, endurance, and high modulus of elasticity, high-performance concrete has been chiefly employed in tunnels, bridges, and tall buildings. It has also been used to repair shotcrete, poles, parking garages, and agricultural uses.

Figure 2 shows the significant concrete technology achievements from the 1900s to the 2000s. The graph shows concrete technology advanced slowly during the 1960s, with maximum compressive strengths ranging from 15 to 50 MPa. In general, the evolution of HPC can be divided into four stages: 1980s, 1990s, and after 2000. In the 1980s; micro defect free cement (MDF) was invented (Azmee and Shafiq, 2018). Polymers are used in the MDF technique to seal the pores and erase all imperfections in the cement paste.

MDF concrete has compressive strengths ranging from 50 to 100 MPa. However, its uses were limited because of the high cost of raw materials, the complicated preparation method, substantial creep, and brittleness. In the 1990s, Richard and Cheyrezy [7] developed reactive powder concretes (RPC) using components with improved fineness and reactivity. RPC is the most often employed type of HPC in laboratory and field tests, and it is distinguished by a high binder content, a very high cement content, the use of silica fume (SF), fine quartz powder, quartz sand, and steel fibers. RPC has a compressive strength between 120 to 200 MPa. Since the year 2000, significant progress has been achieved in the development of HPC. Supplementary cementitious materials like fly ash (FA), ground granulated blast furnace slag (GGBS), and rice husk ash (RHA) are utilized to replace some of the cement in the production of sustainable HPC and to reduce its existing cement usage. Furthermore, it has been reported that HPC can be made using standard temperature curing without affecting its characteristics. Because of the emergence of environmentally benign HPC at a reasonable cost, HPC applications are gaining popularity.

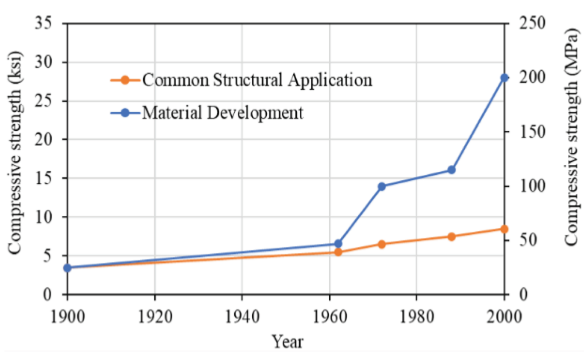

***Figure** 2. The development of concrete compressive strength (modified from Azmee and Shafiq [8]).*

3.1.2. Polymer composite materials (FRP)

Polymers have been widely used in advanced applications (Figure 3.).

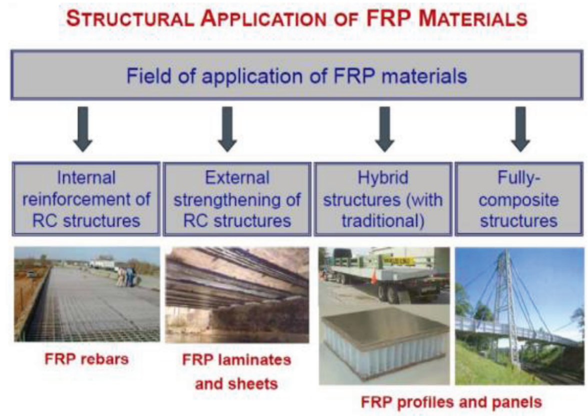

***Figure** 3. Structural application of FRP materials (Pendhari et al. [9]).*

They are adaptable materials that can be easily shaped to fit any application. Polymer composites are polymer materials with reinforcement in which the polymer functions as a matrix resin that penetrates and bonds to the reinforcement bundles. Potential advantages commonly expounded by proponents of RPC materials include high specific strength, high specific stiffness, tailorable durability, good fatigue performance, adaptable construction, and decreased maintenance costs (Pendhari et al., 2008 [10]). As a result, reinforced polymer composites are being researched as an alternative reinforcement for concrete and, in rare situations, whole fiber composite structures.

3.1.3. Lightweight materials

Advanced manufacturing sectors that create structural components are working on reducing energy consumption by replacing normally heavy materials with lighter ones, such as lightweight alloys, polymers, and composites. Lightweight alloys and composites allow structural components to meet stringent weight-reduction standards. For roadway construction, a lightweight embankment minimizes the vertical or horizontal loads and thrusts delivered to the embankment's support or containment, whether soil, pipes, or above-ground and underground structures. The usage of EPS geofoam (Figure 4.) is becoming more widely acknowledged as a critical strategy for lowering overall highway costs through "accelerated construction."

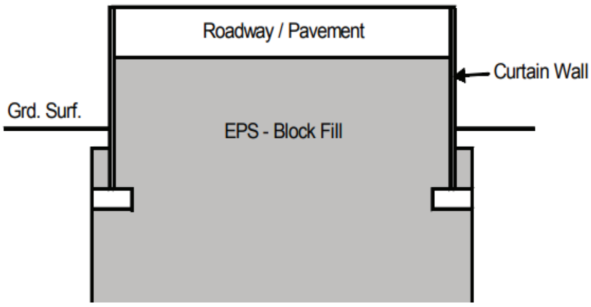

Figure 4. EPS-geofoam fills embankment supports the overall roadway structure and the walls of architectural curtains (Riad et al., [11]).

3.2. Overview of research on Advanced Materials applications in the world and Vietnam

3.2.1. High-performance concrete (HPC)

Over the last twenty years, remarkable advances have taken place in the research and application of high-performance concrete (HPC), which exhibits excellent rheological behaviors that include workability, durability, structural lightness, speed of execution, sustainability, economic savings due to reduced structure maintenance, improved mechanical and durability performance with very high compressive strength, and non-brittleness behavior. Advanced materials are increasingly being used in the Construction and Civil Engineering field, particularly in the context of Industry 4.0, which aims to enhance the efficiency and sustainability of construction projects. Numerous scientific studies have highlighted the significant role and advantages of employing advanced materials in the industry. These materials include high-performance concrete (HPC), composite materials, and lightweight materials, among others, within the construction domain.

Numerous studies have focused on the research, development, and optimization of concrete's mechanical, physical, and chemical properties to meet the demanding requirements for the performance and sustainability of building structures. For instance, Mosi [12] reported on education strategies for a sustainable HPC ecosystem. Additionally, studies by Tsung-Yueh Tu et al. [13], Oke et al. [14], Gonzalez-Corominas and Etxeberria [15], and Hasan Mostafaei et al. [16] have explored the use of recycled materials and innovative HPC formulations to enhance durability and reduce environmental impact.

Researchers have also investigated the application of HPC in precast concrete, such as the feasibility of replacing traditional steel wires with Glass Fiber fiber-reinforced polymer (GFRP) composite bars for pre-tensioning (Spagnuolo et al., 2023 [17]), and the effectiveness of HPC in designing standard prestressed concrete beams (Weigel et al. [18]). Furthermore, studies have proposed innovative design methods for precast prestressed concrete girder bridges using ultra-high-performance concrete (UHPC) (Almansour and Lounis [19]). These advanced HPC materials have piqued the interest of researchers worldwide, encouraging exploration and application in construction. These studies have contributed substantially to developing and applying HPC in the Construction industry, enhancing the quality, efficiency, and effectiveness of construction projects in the era of Industry 4.0.

Additionally, Vietnamese researchers such as Nguyen Van Ngon et al. [20] have focused on producing high-strength concrete M60 using local materials and proposing optimal mix designs for high-strength concrete (HSC) with R28 = 60 MPa, providing a practical basis for construction projects. Ta Bien Cuong [21] investigated the production technology for high-strength concrete with a strength of up to 65 MPa for irrigation works in Vietnam using Pooc Leng blended cement PCB 40. Nguyen Viet Duc [22] proposed a novel method to enhance the mix design process of high-strength concrete. Nguyen Cong Thang et al. [23] examined the use of fast-setting calcium aluminate (ACA) admixtures to produce high-flow, high-early-strength, ultra-high-performance concrete.

These studies collectively showcase the

potential and effectiveness of HPC technology in modeling, analyzing, and designing building structures, thereby enhancing the quality and efficiency of construction projects. Furthermore, they underscore the keen interest of Vietnamese scientists in applying HPC in the construction industry, a trend that is expected to continue and contribute to the industry's sustainability and modernization.

3.2.2 Polymer composites (FRP)

In the field of Research and application of composite materials, there have been many notable Research works worldwide. Sandeep S. Pendhari et al. [24] assessed various applications of fiber-reinforced polymer composites (FRPCs) in external strengthening in civil construction. This study focused on experimental as well as analytical and numerical studies. Major structural components like beams, columns, and beam-column joints were considered and evaluated for structural behavior. P. D. Pastuszak et al. [25] presented an overview of composite material applications, including distinguishing specific characteristics and advantages of composite materials compared to traditional materials. A project by Mertz, D R, et al. [26] evaluated the feasibility of using advanced composite materials in rehabilitating damaged steel bridge components.

In Vietnam, researchers have also shown a keen interest in applying composite materials within the construction domain. For instance, Truong Hoai Chinh [27] investigated the load-bearing capacity of bamboo mats (composite) and proposed their use as formwork panels in building construction. Tran Hoai Anh et al. [28] conducted experimental Research to evaluate the effectiveness of flexural strengthening of corroded reinforced concrete beams using CFRP composite plates. Duong Xuan Hoa [29] explored the production technology and application of dispersed steel fiber-reinforced composite materials. Furthermore, Nguyen Binh Ha et al. [30] researched the feasibility of employing geopolymer concrete in designing and constructing prestressed concrete continuous span beams. These studies collectively contribute to the advancement and practical application of composite materials in construction globally and within the context of Vietnam.

3.2.3. Lightweight materials

Regarding ultra-light materials: Ultra-lightweight materials are extensively researched and applied in many industrial fields. Mugahed Amran et al. [31] comprehensively reviewed raw materials, production processes, properties of foamed concretes, types, and applications of ULCC, particularly in geotechnical applications. Additionally, limitations and gaps in ULCC application in road construction were emphasized, and suggestions regarding improving its usage and performance were provided. Mazaheripour, Ghanbarpour et al. [32] evaluated the Lightweight Expanded Clay Aggregate Self Compacting Concrete (LLSCC) produced by the Nan-Su method, in which the Packing Factor (PF) of the mix design method was modified and improved. This study analyzed the impact of polypropylene fibers on the fresh properties and mechanical characteristics of LLSCC in the hardened state. Another study by He Pan [33] reviewed the performance, alloy composition, and development of advanced lightweight, high-strength materials such as high-strength steels, high-strength aluminum alloys, high-strength magnesium alloys, and titanium alloys. Gloria M. Cuenca-Moyano [34] used bottom ash from raw ash and processed fly ash in the production of lightweight concretes, replacing sand (15% - 25%) and expanded clay (25% - 35%). After processing the fly ash through grinding, it was added to the concrete as a partial cement replacement. It provides detailed information about current trends in lightweight material applications in the defense sector. The review also includes historical and current perspectives on defense technologies. It discusses using lightweight materials such as metal matrix alloys, polymer matrix alloys, ceramic matrix alloys, and fiber alloys in defense fields. Finally, the review also highlights potential military applications of lightweight materials.

Although there has been much progress in the Research and application of ultra-lightweight materials, many challenges still need to be addressed to optimize their applications and ensure safety and sustainability in real-world applications. However, with the potential of ultra-lightweight materials, they are expected to play an essential role in improving performance and sustainability across many industrial sectors.

Researchers in Vietnam, such as Nguyen Trong Lam et al. [35], studied overcoming these limitations to improve the efficiency of AAC use in high-rise building construction in Vietnam. Nguyen Cong Thang et al. [36] provided initial results on the use of recycled polystyrene hollow aggregates in lightweight concrete production. Bui Le Anh Tuan, et al. [37] studied the production of artificial lightweight aggregates (LWA) from local materials and fly ash from thermal power plants in the Mekong Delta region using the cold bonding method. Through the analysis and evaluation of LWA properties and self-compacting lightweight concrete produced in the study, it can be demonstrated the potential for applying fly ash to LWA production and application to self-compacting lightweight concrete combined with mineral admixtures (Fly ash, silica fume) replacing cement in the study to improve concrete properties significantly.

These studies demonstrate the interest of the research community in Vietnam in the application of ultra-lightweight materials in the construction field. Although limited by information in international databases, these studies have contributed to the exploitation and development of ultra-lightweight materials to improve features and efficiency in the construction of residential, transportation, and infrastructure projects in Vietnam. Progress in this field will also help reduce environmental impacts and enhance efficiency in the construction process.

3.3. SWOT Discussion on the advanced material applications in Vietnam

In recent times, Vietnam has witnessed a significant increase in research and application of advanced materials in the construction industry. Important construction projects such as high-rise buildings, bridges, and roads are gradually switching to using high-performance concrete construction materials, ultra-lightweight materials, etc., to improve the performance and sustainability of the project. The application of advanced materials is a modern trend, and there is an urgent need to meet sustainable and energy-saving construction standards. This change also creates favorable conditions for Vietnam to enter the world of more innovative and more advanced construction, contributing to improving the quality and class of construction projects in the country.

In this study, SWOT (Strengths, Weaknesses, Opportunities, Threats) was based to discuss on the application of advanced construction materials. The SWOT discussion will help us better understand the strengths, weaknesses, opportunities, and challenges facing the construction industry in Vietnam. Here is a fundamental SWOT analysis:

3.3.1. Strengths

- Growing demand: Vietnam is witnessing rapid development in the construction sector, especially in the construction of high-rise buildings, bridges, and roads. The need to build sustainable, energy-saving, and environmentally friendly buildings has created a great opportunity to apply advanced materials in the construction industry.

- Abundant natural resources: Vietnam has abundant natural resources such as soil, sand, stone, and recycled materials. This facilitates the development of advanced construction materials from these resources, helping to reduce dependence on imports and enhance the sustainability of the construction industry.

- Government support and incentive policies: The Vietnamese government has promoted sustainable construction and energy savings by introducing policies to support and encourage using advanced materials. Incentive programs and financial support for sustainable construction projects have created favorable conditions for the application of advanced materials in the construction market in Vietnam.

- Ability to make an impact in reducing carbon emissions: Advanced construction materials such as lightweight concrete and heat and sound insulation have the ability to reduce carbon emissions during production and use. Using these materials helps reduce the impact of climate change and contributes to Vietnam's carbon emission reduction goals in the construction industry.

In summary, the application of advanced materials in construction in Vietnam has many strengths, especially in meeting the needs of sustainable, energy-saving, and environmentally friendly construction. The development of the construction industry and support from the government also create favorable conditions for developing and applying advanced materials in Vietnam's construction industry.

3.3.2. Weaknesses

- Limited research and development capacity: The field of research and development of advanced materials in construction at universities and research institutes in Vietnam is still limited. Lack of investment and interest from businesses has made research capacity in this field not really developed, making it challenging to come up with new and advanced material solutions.

- High production costs: Although advanced construction materials have many outstanding advantages, production costs are still higher than those of traditional construction materials. This increases construction costs and limits the widespread application of advanced materials in construction projects in Vietnam.

- Regulations and standards: Currently, quality control and evaluation of advanced construction materials are not strictly implemented in Vietnam. Lack of clear regulations and standards on quality and inspection has reduced the reliability and trust of investors and contractors, while also affecting the development of the construction industry.

- Competition from traditional construction materials: Traditional construction materials such as regular concrete are still a popular and cheap choice. This competition makes changing and converting to using advanced materials difficult, especially in convincing investors and contractors to accept higher prices.

- Natural resource shortages: Exploiting natural resources to produce advanced construction materials can cause resource shortages, especially when there is rising construction demand. This shortage can increase costs and affect the sustainability of the construction industry.

In summary, although the application of advanced materials in construction in Vietnam has many strengths, many limitations still need to be overcome to promote the sustainable development of the construction industry, future construction, and the confidence of investors and contractors.

3.3.3. Opportunities

- Demand for sustainable and energy-efficient construction: Vietnam has a growing demand for sustainable and energy-efficient construction. Advanced materials such as lightweight concrete, thermal and acoustic insulation, and recycled materials meet this requirement and have the potential to help reduce the consumption of natural materials and CO_2 emissions during construction.

- Cooperation with international companies and research institutes: Cooperation with international companies and research institutes in the field of advanced construction materials helps promote technology transfer and improve research capacity. Save Vietnam. This helps open up opportunities to access advanced technologies and optimize the construction material production process.

- Trend of transition to sustainable construction: awareness of the importance of sustainable and environmentally friendly construction is increasingly emphasized in the construction community in Vietnam. Therefore, investors, contractors, and project developers are looking for sustainable and energy-efficient construction solutions, and advanced materials are an attractive and valuable option to meet this bridge's needs.

In summary, the current state of applying advanced materials in construction in Vietnam is bringing many promising opportunities, from diverse and increasing market demand to abundant natural resources to support from the government. Government and the trend toward transitioning to sustainable construction. Taking advantage of and developing these opportunities will contribute to the sustainable development of the construction industry in Vietnam.

3.3.4. Threats

- High costs and competitiveness with traditional materials: The production costs of advanced construction materials are still higher than those of traditional materials, such as conventional concrete. This makes it difficult to compete and convince investors and contractors to accept higher prices to use advanced materials in construction projects.

- Technical capacity and professional labor: Production and application of advanced construction materials require high technical capacity and professional labor. The lack of highly qualified human resources has limited the production scale and quality of advanced materials in Vietnam.

- Ability to utilize natural resources: Exploiting natural resources to produce advanced construction materials can cause resource shortages, especially when increasing construction demand. This shortage can increase costs and affect the sustainability of the construction industry.

- Challenges in awareness and awareness of using advanced materials: Some businesses and investors still lack awareness of the benefits of using advanced construction materials. Manufacturing process changes and new material applications require long-term commitment and investment from stakeholders.

- Competition from countries producing advanced materials: The production and import of advanced construction materials from countries with technical capacity and long-term experience is also challenging for the Vietnamese construction industry. Countries producing advanced materials have competed directly with businesses and products in the construction market.

In summary, although the application of advanced materials in construction in Vietnam has many promising opportunities, it also faces many challenges and threats. There is a need for investment and support from the government, and it is necessary to promote cooperation and technology transfer to promote the sustainable development of the construction industry in Vietnam.

3.4. A proposed solution for strategic choice

The above SWOT analysis proposes groups of solutions from government, cooperation, and research.

3.4.1. Government

- Support and incentive policies: Provide tax incentives and import tax reductions for advanced construction materials and related production technologies. Provide financial support and investment capital for the research, development, and production of advanced construction materials. Encourage the use of advanced materials in important and notable construction projects to promote their adoption and diffusion in the construction industry.

- Regulations and standards: Provide clear regulations and standards on the quality and inspection of advanced construction materials to increase reliability and ensure safety for use in construction projects. Promote the development and recognition of standards and certification for advanced construction materials in accordance with international regulations.

- Investment in research and development: Increase investment in universities, research institutes, and related organizations to increase the research and development capacity of advanced construction materials in the country. Create favorable conditions for researchers and consulting businesses to cooperate in research, technology transfer, and the application of advanced materials in construction projects.

- Training and education: Develop high-quality training programs on advanced materials applications for architects, construction engineers, and professionals in the construction industry. Offer educational programs and create instructional materials to introduce and raise awareness of the benefits and potential of using advanced construction materials.

- Support and create favorable conditions: Create a favorable environment for businesses in the field of advanced construction materials to invest, produce, and do business. Support in resolving legal issues and administrative procedures to reduce time and costs for applying and producing advanced materials.

- Cooperation: Creating favorable conditions for cooperation between businesses and research institutes in developing advanced materials. Create funding and risk-sharing mechanisms to encourage businesses to engage in research and development of advanced construction materials.

3.4.2. Cooperation

- Improve product quality: Invest in research and development to improve and optimize the quality of advanced construction materials. Launch new, high-quality products that meet international standards to increase added value and attract customers.

- Innovating production technology: Applying modern technology and automation in the production process to improve efficiency and reduce production costs. Invest in advanced equipment and machinery to improve production productivity and product quality.

- Brand building and product promotion: Building and promoting brands of advanced construction materials to enhance customer reputation and trust. Promote marketing and advertising activities to introduce and promote the use of advanced materials in construction projects.

- Cooperation: Cooperate with partners inside and outside the construction industry to share resources and techniques while promoting technology transfer and learning from experience. Build sustainable partnerships to create effective synergies and optimize mutual benefits.

- Strengthen training and human resource development: Invest in training and human resource development to improve technical capacity and professional knowledge in applying and using advanced construction materials. Build a professional working environment and promote opportunities to retain and develop talent.

- Environmental protection and sustainable development: Focus on developing advanced environmentally friendly construction materials, minimizing negative impacts on resources and the environment. Promote the use of recycled and reused materials to optimize the sustainability of the construction industry.

3.4.3. Research

- Research and development of advanced materials: Focus on research and development of new advanced construction materials, meeting performance, sustainability, and safety requirements for construction projects. Optimize the composition and structure of materials to improve their mechanical, physical, and chemical properties.

- Technology transfer and practical application: Find ways to transfer technology and apply research results to actual production and construction. Coordinate with construction businesses to carry out pilot projects and apply advanced materials to real projects.

- Performance and sustainability assessment: Conduct numerical tests and simulations to evaluate advanced construction materials' mechanical and sustainability performance under real-world conditions. Analyze the impact of environmental factors and loads on the performance and lifespan of materials.

- Training and developing human resources: Training and developing a team of highly qualified human resources in the field of research and application of advanced construction materials. Build an in-depth and multidisciplinary research environment to create favorable conditions for research and development of advanced materials.

- Cooperation: Strengthen cooperation with domestic and foreign research institutes and universities to share knowledge, experience, and research results on advanced construction materials. Build a collaborative network among researchers to optimize funding and resource sharing in research.

- Strengthen quality management and control: Develop strict quality control and testing processes to ensure the reliability and safety of advanced materials. Provide standards and regulations on quality control and inspection of advanced construction materials.

In summary, solution groups from scientific research can help promote the application of advanced materials in construction in Vietnam by focusing on research and development of new materials, technology transfer, and application. Practice, performance and sustainability assessment, training and human resource development, collaboration, knowledge sharing, and strengthening quality management and control.

CONCLUSION

Currently, the application of advanced materials in the construction industry in Vietnam is progressing, but some challenges and limitations are still being faced. Some strengths of the advanced materials application situation are the attention and investment from the government and the diversity and increase of advanced materials products on the market. However, there are still limitations, such as high costs, a lack of information and understanding among businesses and investors about the benefits of advanced materials, and a lack of highly qualified techniques and human resources to apply and use materials.

To effectively apply advanced materials in construction in Vietnam, there needs to be support and companionship from the government, efforts and investments from businesses, positive contributions from scientific research, and positive feedback from the construction market. The determination and close cooperation between these groups will play an important role in promoting the development and application of advanced materials in the construction industry in Vietnam while promoting sustainable development and improving the quality of materials. High efficiency of construction projects in the country.

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