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Development and Application of Modern Building Ceramic Materials

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Abstract

With the increasing demand for sustainable building design, modern building ceramic materials are one of the key factors driving innovation and development in the field of architecture, thanks to their excellent performance and environmentally friendly properties. The aim of this study is to provide an insight into the development and application of building ceramic materials in modern architecture, and to assess the contribution of material innovation to architectural design and sustainability goals by synthesising and analysing recent technological advances and case studies in this field. This study adopts a systematic literature review approach to screen and analyse a large number of academic articles and practical project reports on material innovation in building ceramics. Comparative analyses of different material properties, advances in production processes and the effects of their application in real building projects reveal the potential of building ceramic materials to improve the energy efficiency, extend the service life and enhance the aesthetic design of buildings. The findings show that the environmental and energy issues facing traditional building materials, such as improved thermal efficiency and a reduction in the overall carbon footprint of buildings, can be effectively addressed through the use of new building ceramic materials and technologies. In addition, the innovative use of architectural ceramics provides architects with more design flexibility, enabling them to create architectural works that are both aesthetically pleasing and functional. In the concluding section, the paper highlights the importance of continuing to explore technological innovations in building ceramic materials and how these innovations can contribute to a more sustainable and environmentally friendly building industry. Future research should further explore new areas of application for ceramic materials and how interdisciplinary collaboration can accelerate the practical application of these material technologies.

Keywords: *ceramic materials; sustainability; modern architecture; development and applications*

1 Introduction

In the long history, the development of building materials has always been an important force to promote the progress of architectural art and science. From mud bricks and wood in ancient times to steel and concrete in modern times, each material innovation has brought about changes in the way buildings are designed and constructed [1]. In the 21st century, this process has reached new milestones, especially in the field of architectural ceramic materials. In the last decades, modern building ceramic materials have undergone remarkable technological innovations and application expansions [2]. The building ceramic materials of recent years have not only achieved significant advances in performance and functionality, but have also demonstrated great potential for environmental protection and digitalisation.

In recent years, with the advancement of materials science, especially nanotechnology [3] and intelligent manufacturing technology [4-5], architectural ceramic materials are no longer limited to traditional decorative and structural uses only. The convergence of these technologies has resulted in modern ceramic materials with additional functionalities such as self-cleaning capabilities [6], improved thermal [7-8] and acoustic isolation properties [9], and even enhanced flexibility and transparency. The enhancement of these attributes has greatly enriched architects' design toolbox [10], providing them with unprecedented creative freedom and room for expression [11].Furthermore, environmental sustainability

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has taken centre stage in the development of building materials in recent years [12]. The production and application of modern building ceramic materials increasingly takes into account the need to save energy and reduce environmental impact. This not only includes optimising production processes to reduce waste and emissions, but also involves the development of recyclable or biodegradable [13] ceramic materials. These endeavours open up new possibilities for material innovation and diversity while pushing the construction industry towards green sustainability. The application of digital technologies, especially 3D printing [14-15], has played an important role in the innovation of modern building ceramic materials. These technologies have not only allowed ceramic materials to be made in more diverse shapes and sizes, but have also improved the precision and efficiency of manufacturing. Through these technologies, designers are able to realise more complex and fine architectural details, further pushing the boundaries of architectural design.

In this paper, we will explore in depth how the latest scientific research and technological breakthroughs have enabled a quantum leap in the use of modern ceramic materials in architecture. We will focus on how these advances have influenced the way architectural design is thought of, and how they are helping to realise a more efficient, environmentally friendly and aesthetically pleasing built environment. We will also explore new directions for the future development of building materials technology.

2 Literature Review

2.1 History of the development of ceramic materials

In the traditional sense, a ceramic is any of a variety of hard, brittle, heat- and corrosion-resistant materials made by moulding and firing inorganic non-metallic materials, such as clay, at high temperatures [16-17].Common examples are pottery, porcelain and brick. Traces of ceramics can be found as far back as the beginning of human history. The first ceramics made by humans were brick walls used to build houses and other structures, while pottery (jars, vessels, or vases) or figurines made of clay, either alone or mixed with other materials (such as silica), hardened and sintered in a fire was a common practice in the production of ceramics. Later, ceramics were glazed as well as fired to produce smooth, coloured surfaces, and porosity was reduced by using glassy, amorphous ceramic coatings on top of crystalline ceramic substrates [18]. Ceramics now include household, industrial and architectural products, as well as a variety of materials developed for advanced ceramic engineering, such as semiconductors. In the process of this change, the concept of ceramics has gradually changed from the traditional pottery, stoneware, porcelain and bone china made from clay-based materials to the more generalised ceramic matrix composites.

2.2 Types and properties of building ceramics

2.2.1 Oxide ceramics

Typically, the raw materials for modern ceramics no longer include clay [19].Modern ceramics are mainly classified in three different materials: firstly, oxides, common examples of which are aluminium oxide, beryllium, cerium oxide and zirconium oxide, are made by a series of methods such as sintering and pressing; such ceramics usually have a high melting temperature as structural materials, and are very stable in oxidising atmospheres. With the exception of beryllium oxide ceramics, their thermal conductivity is low. They are usually dosed with ultrafine powders and small amounts of sintering accelerators and modifying additives. The atomic bonding of oxide ceramic materials is dominated by ionic bonding, with some covalent bonding present, so they have many excellent properties. Most of the oxides have high melting points, good electrical insulation properties, especially excellent chemical stability and oxidation resistance, and have been more widely used in the engineering field [20].Such ceramics can continue to be subdivided by component for single oxide ceramics, as well as composite oxide ceramics are different from traditional ceramic materials for daily use, high-tech oxide ceramic materials special electric, magnetic, optical, thermal, acoustic, chemical, biological, piezoelectric, thermoelectric, electro-optical, acousto-optic and magnetic properties, are classified as high-performance structural and functional ceramics. In the construction industry, these materials are mainly used in applications that require high wear and corrosion resistance or are subjected to high-temperature environments. For example, aluminium oxide (Al_2O_3) ceramics with high weather resistance and colour stability are used as building facade materials to provide long-term appearance retention and protection [21].

2.2.2 Non-oxide ceramics

The second type of ceramics is the non-oxide ceramics represented by carbides, borides, nitrides, silicides and so on. It as a non-oxide system of high temperature resistant structural materials, carbon silicon carbide, silicon nitride, aluminium nitride and other materials and the plug complex silicon nitride solid solution as raw materials. Therefore, non-oxide high temperature ceramics have excellent high temperature strength, low coefficient of thermal expansion, close to the thermal conductivity of the metal, resistance to oxidation, resistance to corrosion of high sulphur fuels, resistance to external stress and thermal shock and other characteristics. Non-oxide ceramics differ from oxide ceramics in a number of ways. Firstly, due to the scarcity of non-oxide in nature, usually less than 1% in the earth's crust, most of the raw materials need to be artificially refined and synthesised. Secondly, from the Gibbs thermodynamic function, we can learn that the standard free enthalpy of generation of non-oxide ΔG is generally greater than the corresponding standard free enthalpy of generation of oxide ΔG. This phenomenon is closely related to the high electronegativity of oxygen and the ability to form stable chemical bonds. The chemical bonding between oxide atoms is mainly ionic bonding, while non-oxides are generally covalent bonds with strong bonding. The above differences result in non-oxide ceramics being more difficult to sinter than oxide ceramics. Because the standard free enthalpy of generation of non-oxide ΔG is greater, non-oxide ceramics in the synthesis of raw materials and ceramic sintering, easy to generate oxides, and therefore must be carried out in a protective gas (such as N2, Ar, etc.). The raw materials of oxide ceramics are themselves oxides, so there is no fear of oxidation, so the production process is relatively simple.

Although non-oxide ceramics are difficult to sinter, it is also one of their major advantages. Non-oxide ceramic materials, due to the predominantly covalent bonding in their atomic structure, exhibit excellent physical and chemical properties. The high hardness, modulus of elasticity and creep resistance of these materials, and the stability of their properties especially at elevated temperatures, provide ideal conditions for their use in extreme environments. These attributes, a significant advantage over traditional oxide ceramic materials, make non-oxide ceramics ideal for use in fields such as aerospace, automotive manufacturing, and electronics. However, the widespread use of non-oxide ceramics does suffer from a number of constraints, one of which is their own brittleness and the challenges they face when joining with other materials such as metals. Nonetheless, the applications of these high-temperature structural materials remain promising, and researchers are addressing these issues through various approaches, such as interface engineering, design of functional gradient materials, and the use of advanced ceramic matrix composite technologies to enhance connection strength and durability. In building materials, high-strength and high-hardness non-oxide ceramics, such as silicon carbide, can be used as decorative or protective building materials for special structural applications. For example, as a protective layer for the outer shell of a building to enhance durability and corrosion resistance. Their excellent resistance to high temperatures also allows non-oxide ceramics to be used in parts of the interior of buildings that require refractory materials, such as chimney linings, fireplaces, boiler rooms and high-temperature furnace linings. And in areas that need to be very hard-wearing, such as commercial spaces, industrial plants or car parks, non-oxide ceramic materials can be used as floor cladding materials to provide a durable surface. In addition, there are many other potential or actual applications for non-oxide ceramics in the construction sector, which are not as commonly used as other building materials, but still have a promising future.

2.2.3 Composite ceramics

The third category of ceramics is ceramics made from composite materials, and ceramic matrix composites. Ceramic composites are a class of materials made from a combination of at least two different materials, at least one of which is a ceramic. Ceramics are often chosen for their good thermal stability, chemical resistance and high hardness, but they are also prone to brittle fracture. By combining them with other materials, their mechanical properties, such as increased toughness and fracture resistance, can be significantly improved, making them more suitable for a variety of engineering applications. There are a wide range of types and uses for ceramic composites, and several common ceramic composites and their properties are described in detail below: Particle-reinforced ceramic composites, which enhance the mechanical properties of the composite by adding hard particles (such as silicon carbide (SiC) particles) to the base ceramic (such as aluminium oxide (Al_2O_3)). The addition of particles can improve the hardness and wear resistance of the composites. However, the distribution, size and volume fraction of the particles must be carefully controlled to avoid excessive weakening of the material's toughness: fibre-reinforced ceramic composites, which improve the toughness and fracture resistance of the material by embedding continuous or short fibres in the ceramic matrix. Commonly used reinforcing fibres include carbon fibres and ceramic fibres (e.g. silicon carbide fibres). These fibres effectively transfer stresses and bridge cracks when force is applied, thus improving the overall performance of the material. As well as layered ceramic composites, they usually consist of alternating layers of different materials, each with a specific function. For example, one layer may have a high hardness to provide wear resistance, while another layer may have a higher toughness to absorb energy and stop crack propagation. Composites with this structure are particularly useful in wear-resistant and protective applications: there are also self-healing ceramic composites, which contain specific components that respond to damage within the material. When a crack occurs, these components react chemically, filling the crack and restoring some degree of material integrity. This type of composite is particularly valuable for increasing long-term reliability and reducing maintenance costs.

In the construction sector, ceramic composites are used in many high-performance application scenarios due to their unique properties. For example, they are used in facade and curtain wall systems. Ceramic composites can be used as curtain wall systems on the exterior of buildings due to their abrasion and corrosion resistance. These materials not only provide an aesthetically pleasing and modern look to a building's exterior, but can also withstand harsh environmental conditions, including temperature changes, UV exposure and the effects of chemicals. Traditional roof tiles can also be made from ceramic composites to improve their durability and functionality. For example, solar cells can be embedded in roof tiles for energy harvesting and use.As well as floor and wall tiles by adding specific composite materials to improve hardness and wear resistance. Ceramic composite floor tiles with the addition of, for example, silicon carbide, alumina or diamond particles can withstand higher friction and pressure. There are also a range of areas of construction engineering where ceramic composites can be used, such as bridges and infrastructure, earthquake-resistant components, decorative panels and acoustic materials.

In summary, the use of ceramic composites can improve the durability of buildings, reduce maintenance costs, enhance functional performance, and enhance the aesthetic and environmental performance of buildings. With technological advances and material innovation, it is expected that ceramic composites will play a more important role in the construction industry in the future.

3 The Development of Modern Building Ceramics Technology

Modern building ceramics technology has undergone significant development and innovation. Today, building ceramics is not just a decorative material in the traditional sense, but an advanced building material that integrates aesthetics, functionality and durability. From the basic materials, traditional ceramic materials such as porcelain clay, glaze after reformulation and modification, its physical strength and durability has been significantly improved. At the same time, the development of new materials such as lightweight ceramics, high-performance oxide ceramics and ceramic composites has greatly improved the functionality of building ceramics, such as enhanced thermal and acoustic insulation, weathering and self-cleaning functions. And from the technical side, intelligent manufacturing technology, green sustainable technology, intelligent ceramic technology and surface treatment technology have all made great progress in recent years.

3.1 Intelligent manufacturing technology of ceramics

3.1.1 Ceramics intelligent manufacturing technology of the main research direction

Modern building ceramics intelligent manufacturing technology, mainly embodied in two aspects, one is to computer-aided design (CAD) as the representative of the digital design technology, on the other hand, is embodied in the inclusion of three-dimensional printing (3D Printing), computer numerical control (CNC) machining, as well as automation and robotics systems on the digital production technology. Take 3D Printing technology as an example, since the United States Hull in 1986 for the first time proposed [22] three-dimensional light-curing technology (SL), digital light processing technology (DLP), as well as two-photon polymerisation technology (TPP) also appeared one after another. The above methods usually use organics ceramic precursors (preceramic polymers, PCPs) photosensitively polymerisable liquid systems or slurry systems containing a mixture of photosensitive solutions and ceramic powders. Photosensitive polymerisation, i.e., light curing, refers to a certain volume of liquid materials such as polymer monomers that are irradiated by light at a certain wavelength to cause cross-linking polymerisation reactions to complete curing [23]. In terms of this 3D printing process, it is actually the resin polymerisation crosslinking into a mesh structure uniformly wrapping the ceramic particles dispersed in the system, thus macroscopically forming the curing of the mixed material. Afterwards, the printed parts are subjected to high-temperature degreasing and sintering processes and the organic matter in the samples is discharged, the ceramic samples are further densified, and at the same time the grains are enlarged to form the final samples, which is similar to the traditional ceramic fabrication methods in this heat treatment stage. PCPs can be photosensitive polymerisation of liquid systems is more through chemical changes, which is similar to the ordinary photosensitive resin light-curing 3D printing process, followed by high-temperature pyrolytic ceramisation to become the required precursor conversion ceramics (polymer derived ceramics, PDCs) samples.

Stereolithography (SL) is a popular 3D printing technology that is now widely used. During the printing process, a beam of specific wavelength (usually UV light) is usually used to scan and cure the surface of the material system in point-line-face scanning, followed by layer-by-layer stacking, and progressive construction from the longitudinal direction; when a layer is cured, the construction of the next layer is started by elevating or decreasing the thickness of one layer. Digital light processing (DLP) is a technology that can produce high surface quality parts with micron resolution because of the extremely fine spot size of its beam (60-140 μm).

Digital light processing, on the other hand, is actually a mask-based surface-exposure SL technology. This technology exposes a whole layer of printed shapes after layering to the photosensitive resin surface for layer-by-layer curing through a light source in a single pass through a mask. The concept was initially realised by Nakamoto and Yamaguchi in Japan in 1996 through the use of a solid mask [24].In 1997, it was further improved by Bertsch et al. using a liquid crystal display (LCD) as a dynamic mask generator [25]. Since 2001, Texas Instruments' digital mirror device (DMD) has dramatically improved the display resolution and contrast due to its competitive fill factor and reflectivity, subsequently replacing LCD as a new generation of mask technology for use in DLP printing [26].The DMD is made up of millions of display image pixels corresponding to the DMD is a chip composed of a rectangular array of micromirrors corresponding to the pixels of the displayed image. The micromirrors are driven by electrostatic force and can be individually rotated ±(10~12)°to serve to control the state of ultrafast light on or off. In this way, an incident light beam with a spatial resolution of 1.1 μm is reflected across or deflected away from the lens, causing the pixels to appear light or dark on the projection surface [27]. Ultra-fast light switching and overall projection allow DLP 3D printing processing times to be significantly shorter than conventional SL point-line-plane scanning processes, and micron-level feature resolution can be achieved, enabling parts to be fabricated more quickly and with higher accuracy [28].

3.1.2 Problems and challenges of ceramic sl and dlp processes

The ceramic SL and DLP process mainly uses ceramic light-curing slurry made by mixing ceramic powder and photosensitive solution. This approach is more or less faced with a number of problems and challenges, such as ceramic raw material powder particle size distribution and morphology is not ideal, slurry precipitation, viscosity is too large, 3D printers need to add a scraper for slurry scraping level, hindering the further development of ceramic 3D printing technology. The above problems can be effectively solved by the clever combination of organic precursor ceramic conversion (PDC) technology, which is different from ceramic powder-photosensitive solution, and 3D printing.PDC technology is a polymer that can be converted into ceramic material by heat treatment by chemical method, and pyrolysis can be converted into precursor ceramics within a certain range of temperatures [23]. Precursor polymers control the composition and microstructure of precursors through molecular design, and the presence of chemically reactive groups undergoes cross-linking, which results in higher yields of ceramics that are pyrolysed after cross-linking [23]. Preparation of ceramic materials by pyrolysis of organic ceramic precursors (PCP) is a new method developed in recent years for the preparation of ceramic materials and components, the technology has the characteristics of simple processing, precursors are easy to isolate and purify, inherited the excellent moulding properties of polymer materials and high-temperature stability of ceramic materials, so that the traditional ceramics process has undergone a revolutionary change [23].

3.1.3 Development of ceramic light-curing 3D printing technology

In recent years, there are also more scholars in China who have carried out a lot of work in ceramic light-curing 3D printing. The main research units are Xi'an Jiaotong University, Shenzhen University, Guangdong University of Technology, Beijing Institute of Technology and so on. Xi'an Jiaotong University, such as Li Deduchen belongs to the earlier ceramic SL research team in China, using including oxide ceramic slurry as well as tricalcium phosphate bioceramic slurry, etc. for 3D printing research. A great deal of work has been carried out on the mechanism of ceramic light-curing moulding, the relationship law between ceramic slurry component formulation and light-curing moulding effect, and the application of the process [22,29-34]. Various types of porous or dense ceramic parts, such as porous bone scaffolds, three-dimensional photonic crystals, hollow turbine blades and impeller models, as well as complex structural castings to meet the needs of investment casting, have been manufactured. Due to the low wet strength of water-based ceramic slurry printed parts, most of the ceramic SLs use non-water-based ceramic slurries, which are dominated by acrylate monomer resins. Zhou Weizhao et al [30]investigated in detail the effects of ceramic particle size, solid content, monomer concentration, dispersant, diluent concentration and other factors on the viscosity of ceramic slurry, determined the optimal component content, and successfully developed a new silica-sol-based water-based ceramic slurry, which was prepared with a solids content of up to 50% of the silica-oxide ceramic slurry.Chen et al [37] used this improved water-based environmentally friendly slurry for the printing of SL Chen et al [22]used this improved water-based environmentally friendly paste to conduct an in-depth study on the forming mechanism, the size and precision control of the forming unit and the sintering process, etc., and printed various types of complex structural ceramic parts, and the blanks obtained from printing can maintain good strength and low surface viscosity, which can help in the post-processing process.Bian et al [34]used SL to print tricalcium phosphate cartilage scaffolds with a porous structure in order to obtain good regenerative repair results. In addition, Li Tetsuzumi's team [35]recently used sub-micron zirconia powder slurry to obtain 99.3% densified dental crown and bridge components after DLP light-curing 3D printing and sintering, and the optimised three-stage support design contributed to the smooth printing of the prototype. Some software and hardware optimisation work was also done for the surface exposure process of ceramic DLP to provide technical and theoretical support for improving the print quality [36].

3.2 Intelligent manufacturing technologies applicable to the architectural ceramics industry

Compared to another technology, ceramic SL and DLP process is more suitable for the construction industry. And with the developments of recent years, ceramic SL and DLP processes have proved their worth in the construction industry, offering a degree of design freedom and manufacturing flexibility that is different from traditional construction methods. Both technologies have made it possible to manufacture complex architectural elements and customised components, demonstrating a high degree of efficiency and precision from prototyping through to the production of functionally integrated building blocks. In addition, by breaking through the traditional constraints of design and manufacturing, ceramic SL and DLP technologies are driving the architectural industry in a more personalised and innovative direction. Professionals are now able to explore new design ideas without worrying about the additional costs associated with complexity. And for the restoration and preservation of historic buildings, these technologies offer an effective way to accurately replicate ancient architectural elements, preserving cultural heritage in a non-invasive and sustainable way.

In terms of other technologies, with the development and research of architectural ceramic materials in recent years, considerable achievements have been made, such as the photocatalytic ceramic tiles [37] studied with gC3N4/CuPc composites that can absorb sunlight and decompose hazardous substances (e.g., nitrogen oxides and volatile organic compounds) in the air by photocatalysis, which is a reflection of various technological advances such as green and sustainable technologies, smart ceramic technologies, and surface treatment technologies. The green sustainable technology, smart ceramics technology and surface treatment technology are the embodiment of various technological advances.

4 Existing Problems and Challenges

Since the research and analysis of the China Business Industry Research Institute, although China's building ceramics exports have been on a downward trend since 2015, 2020 by the global epidemic and the impact of the U.S.-China trade friction fall is particularly obvious, 2021, the export volume of the fall slowed down, the downward curve tends to flatten out.2021 China's building ceramics exports of 601 million square metres, a year-on-year decline of 3.40%, the export volume of 4.099 billion U.S. dollars, a year-on-year decline of 0.70%. But with internal and external development advantages and opportunities, China's building ceramics industry in the past decade has been rapid development, has become the world's production and consumption of building ceramics, the world's more than half of the building ceramics produced from China.

In the construction industry, the introduction of modern ceramic materials is seen as an innovation that can provide buildings with increased durability, aesthetics and functionality. Despite the many potential benefits of these materials, their widespread use still faces a number of challenges. Firstly, in practice, modern ceramic materials often require specialised construction techniques. This is not limited to precise installation procedures, but also includes a deep understanding of the material's properties to ensure its correct application. This requires specialised training for the building and construction teams, adding to the complexity and cost of project implementation. In addition, modern ceramic materials are typically higher in cost compared to traditional building materials such as concrete and steel. This adds to the budgetary pressures of construction projects, especially in projects with tighter budgetary constraints, where higher material costs can be an important consideration in material selection. Whilst modern ceramic materials excel in terms of strength, wear resistance and chemical resistance, their brittleness has not been fully addressed. When faced with impact loads or specific harsh environmental conditions, these materials may crack or otherwise suffer damage, which poses a potential risk to the long-term stability and safety of the building. Environmental impact and sustainability issues are also challenges that must be addressed in the development of modern ceramic materials. Although superior to most traditional materials in terms of performance, the high energy consumption and possible environmental pollution of steps such as high-temperature sintering during their production need to be effectively mitigated through technological innovation and process improvement. This is not only about environmental protection, but also the key to public acceptance and market promotion. Finally, modern ceramic materials also need to overcome low market acceptance and poor matching of regulations and standards when promoting their use. It often takes time for the many stakeholders in the construction industry, including designers, engineers, contractors and regulatory bodies, to accept and recognise new materials. In addition, existing building codes and standards may not be fully adapted to the properties of the new materials, requiring continuous communication, testing and adjustment to gradually expand their use in the construction industry.

5 Future Research Directions

According to the literature obtained above. Modern building ceramic materials have gradually become the favourite in the construction industry through their excellent performance, and are gradually entering a steady development trend, while more diversified ceramic matrix composites will become the key direction of development. However, its high cost is still the main factor hindering its wide application. Cost-benefit analyses show that, despite low long-term maintenance costs, high initial investment requirements deter many project owners and developers. This raises an urgent question: how to reduce the cost of these advanced materials through technological innovation and production scale-up so that more projects can benefit. During construction, modern building ceramic materials require a higher level of skill and precision relative to traditional materials, which adds to the complexity and cost of construction. To overcome this challenge, investments need to be focussed on worker training and the development of more efficient installation techniques and tools. For example, the use of digital mouldings and robotic construction techniques has already demonstrated the potential to reduce construction time and improve installation accuracy in some projects. As for environmental and sustainability issues, the production process of modern ceramic materials, despite being more energy efficient and reducing emissions than traditional building materials, still has a certain environmental impact. In the future, further reductions in their environmental footprint are expected through the adoption of circular economy principles, the use of waste materials as raw materials, and the development of lower-energy manufacturing processes. In addition, given the durability and long service life of ceramic materials, their environmental impact may be significantly reduced from a life cycle assessment (LCA) perspective.

6 Conclusion

In summary, in the society aiming at sustainable development, the new type and greening of building materials are the urgent need for sustainable development in the 21st century, and are the main direction for the future development of the construction industry. Ceramic matrix composites are the key direction for the development of modern building ceramic materials. The development and progress of new materials will produce many high-quality, practical, inexpensive building materials, and adhere to the path of sustainable development; maintain the environmental coordination of building materials will also enable the traditional construction industry to play a greater role and characteristics.

Although modern building ceramic materials bring new possibilities to the field of architecture in terms of technology and aesthetics, their wide application still faces challenges such as cost, construction technology, and sustainability. However, the green sustainability technologies and smart ceramics technologies embedded in architectural ceramics motivate us to promote the development and application of these advanced materials, which then require concerted efforts from the industry, academia, and government to address these issues and ultimately lead to more sustainable, cost-effective, and aesthetically pleasing modern building practices.

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