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## B07-低碳材料与可再生资源

## B07-Low Carbon Materials and Recyclable Resources

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# B07. 低碳材料与可再生资源（国际）

**分会主席：王清远、Veena Sahajwalla、Guomin Zhang**

**B07-01**

## AI and Robotic Innovations in Construction & Demolition Waste Sorting: Evolution, Industry Success Stories, and Future Research Directions

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Management of construction and demolition waste (CDW) is becoming increasingly challenging due to the rising amounts of CDWs generated. Environmental impacts and resource shortages have forced to limit landfilling and encouraged the reuse and recycling of CDWs. In this context, CDW sorting plays a crucial role, and this paper provides a comprehensive overview of the evolution of waste management practices, from manual sorting methods to advanced artificial intelligence (AI) based robotic systems. It discusses the architecture of robotic sorting systems, highlighting key components such as sensors, processing unit, actuators, conveyors, and control systems. Additionally, the paper provides insights into the advantages of AI-based robotic sorting including improved sorting accuracy and efficiency, increased throughput, enhanced workplace safety, and potential cost savings. Despite these advantages, the paper also addresses the challenges and limitations of AI-based robotic sorting systems, including technical complexities, high initial investment costs, and issues related to the diverse and contaminated nature of CDWs. Furthermore, it includes a case study of the successful implementation of AI-based robotic sorting systems in the industry by ZenRobotics, examining its features, performance, and limitations. Finally, the paper outlines potential future research directions in the domains of AI, robotics, and the internet of things (IoT), highlighting emerging technologies, integration with sustainable practices, and the impact of policies and industry collaborations. This comprehensive review underscore the importance of continued innovation and research in improving the efficiency and effectiveness of CDW sorting systems.

**B07-02**

## Integrated Wastes with CO2 for Carbon-negative Construction Materials

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Accelerated carbonation to mineralize industrial flue gas CO2 is gaining increasing momentum for combating climate change. Industrial waste residues present in a large amount are an attractive avenue for the affective capture of CO2. This technology creates dual environmental benefits: simultaneously utilizing solid wastes and permanently storing CO2. More importantly, the industrial waste residues are usually located in the vicinity of the CO2 source. In this presentation, different types of industrial wastes suitable for mineral carbon sequestration and the corresponding process routes will be introduced. As the main resulting product of the carbonation process, CaCO3 has been proven to be particularly useful in the production of construction materials. The practical applications of upcycling the generated CaCO3 in various types of construction products will also be discussed. Considering that the amount of CO2 that can be consumed by mineralizing steel slag produced in China alone is estimated to be equal to the total amount of current global CCUS capacity (63Mtpa), a wider application of accelerated mineral carbonation in developing sustainable construction products within the next decade is expected to substantially cut the greenhouse gas emissions from cement and concrete industry, which echoes a long-standing call for achieving the Net Zero Carbon Emission in the construction industry.

**B07-03**

## 光伏系统火灾特性及其火灾风险研究

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国务院出台了《2030 年前碳达峰行动方案》，提出“深化可再生能源建筑应用，推广光伏发电与建筑一体化应用”，党的二十大报告和国家十四五规划中也强调“推进工业、建筑、交通等领域清洁低碳转型”。光伏系统的推广是我国国家战略重点任务之一，但在应用过程中遇到一些挑战，其中比较重要的就是其消防安全。目前，光伏系统火灾安全研究较少、缺乏相应的测试以及应用标准，存在应用盲区。本报告介绍了分布式和集中式光伏系统的潜在火灾风险，分析了不同类型光伏板在各种条件下的火灾特性，确定了典型光伏板的风险等级与适用范围，建立了环境因素影响下光伏火灾风险评估方法，通过典型光伏电站案例分析了其火灾风险，为典型环境条件下光伏系统动态火灾风险评估提供了新思路和方法。

**B07-04**

## Upcycling of concrete waste via CO2 curing method

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Recycling concrete waste as recycled aggregate for concrete production can help mitigate environmental pollution and reduce the extraction of natural resources. However, the inherent porous nature of recycled aggregate results in poor quality, severely limiting its application in concrete. Developing enhancement methods for recycled aggregate to improve its quality and optimize the overall performance of recycled aggregate concrete is an urgent need. Current methods to enhance the quality of RCA typically involve either removal (grinding, thermal treatment, or acid dissolution) or enhancement (impregnation with nano-SiO2 or Na2SiO4 solution) of the mortar. The former is energy-intensive and generates a large amount of fine powder, potentially causing secondary pollution, while the latter is too costly to be sustainable. To address the poor performance of RCA, it is essential to establish a low-energy, pollution-free, and economically feasible quality enhancement method to achieve efficient utilization of recycled aggregates. And thus, a CO2 curing method was proposed to enhance the RCA by leveraging the carbonation reactivity of cement hydration products in the old mortar.

Through X-ray diffraction and morphology analysis, the mineral phases and microstructure evolution were characterized. It was found that cement hydrates such as CH and C-S-H reacted with CO2 to form calcium carbonate crystals, which deposited in capillary pores and microcracks. This process reduces the water absorption and crush value of the RCA while simultaneously achieving CO2 sequestration. By utilizing nanoindentation, microhardness, and compressive strength testing, the multiscale mechanical properties of carbonated RCA were quantitatively characterized. The relationship between mineral phase, microstructure evolution, and multiscale mechanical properties was established, revealing the mechanism behind the enhanced mechanical performance of carbonated RCA.

**B07-05**

## Recent development in algal biotechnology to achieve the sustainable development goals

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Amid unprecedented global sustainability challenges, algae (both micro- and macroalgae) have emerged as versatile and potent resources in the pursuit of sustainable and eco-friendly solutions. Their adaptability and diverse applications across various sectors confirm their pivotal role in innovation. Algae are now leading the way in biofuel production, wastewater treatment, emission reduction, nutrition, and sustainable agriculture. Biotechnology-driven strategies, including bioprocess engineering, innovative photobioreactor designs, molecular engineering, and integrated approaches, are maximizing the algae potential for sustainability. Their unique characteristics, such as high photosynthetic efficiency, rapid growth, carbon sequestration capabilities, and efficiency in nutrient cycling, have spurred recent research and developments across biotechnology, biochemistry, environmental science, and ecology. The distinct metabolic pathways of algae yield a plethora of bioactive compounds with potential biotechnological applications, promising new avenues for sustainable development. Their renewable nature makes them vital for climate change mitigation and ecological balance, while also offering opportunities in nutrition and biomaterials, thereby enhancing food security, human health, and reducing reliance on petroleum-based products. This speech aims to highlight recent advancements and explore new applications of algae, emphasizing their importance as a promising source of phytochemicals, emission reduction, and clean energy production.

**B07-06**

**Upgrading carbonaceous materials (Coal, tar, pitch, and beyond) for sensing, energy, and environmental applications**

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The policy-driven and strategic reduction in the use of fossil fuels for electric power generation is renewing the interest in the potential for coal and other heavy hydrocarbon materials (HCMs) to be used as feedstocks for carbon-based products. The complexity and tunability of heavy carbonaceous materials (HCMs, coal, tar, pitch, etc.) play in their thermal upgrading processes. In addition to processing temperatures and ramping/cooling rates, the native chemistries of HCMs play a crucial role in the carbon product crystallinities, morphologies, and conductivities, among other properties. Laser annealing and molecular dynamics simulations can provide general guidelines to select the candidate of HCMs for target properties, together with continuous manufacturing for high-throughput HCM screening, toward a consistent and flexible manufacturing process. We will showcase a few examples of extreme manufacturing of HCMs-based devices including ultrafast sintering low-rank coals for conductive membranes; laser direct-writing wireless sensors for harsh environment monitoring; and laser-induced high-pressure driven coal-to-diamond conversion.

**B07-07**

**Biowaste recycling by insect farming: Current Technologies and research directions**

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Liquid biofuels like biodiesel and bioethanol are crucial in the transition to low-carbon and high-energy alternatives to fossil fuels. One significant by-product of biodiesel production is glycerol, which accounts for about 10% of the total conversion output. While waste glycerol poses challenges due to its impurities and contaminants, it also holds potential as a metabolic resource for essential cellular components in microorganisms. The black soldier fly larvae have demonstrated higher competitiveness for lipid contents (35–43%), making them a promising organism for recycling waste glycerol into biodiesel production, alongside microalgae and oleaginous yeast. The microbial biodiesel productivity from oleaginous yeast is notably higher (3546 kg

ha−1y−1) than soybean biodiesel (562 kg ha−1y−1), while microalgal biodiesel productivity surpasses palm biodiesel by more than 25 times. Remarkably, black soldier fly larvae biodiesel productivity was reported to be ~ 1.7 times higher than microalgae and an impressive ~ 43 times higher than palm biodiesel. Despite their potential for biodiesel production, waste glycerol from biodiesel industry still represents a challenge because of high impurities, high viscosity, and limited direct applications in existing processes. To further enhance energy sustainability and address the challenge of waste glycerol, biocircular platforms are discussed for waste glycerol utilization with domestic wastewater sludge, lignocellulosic biomass, and protein-rich wastes. These platforms offer opportunities to create other sustainable agricultural products while minimizing their environmental footprint.

**B07-08**

**Functional mesoporous carbon materials and their applications**

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Functional mesoporous materials are popular multifunctional materials, which have great application potentials in various fields. This is mainly because mesoporous nanomaterials not only have the properties of general porous nanomaterials, such as adjustable pore size, large pore volume, high specific surface area, etc, but also possess many advantages of unique morphologies or structures. It has a broad prospect in catalysis, hydrogen storage, separation and electrochemistry. So far, many methods have been developed to regulate the morphology and structure of mesoporous materials, including spraying, drip, Stober method, colloid assisted assembly, confined assembly and solid state reaction. However, the morphology and mesoscopic structure synthesized by the above methods still cannot meet the needs of the development of the times. At the same time, the research on the synthesis mechanism is not profound enough, and the application research is also very limited. Therefore, it is of great significance to further develop a simple and powerful method to construct bio-inspired porous nanomaterials, to conduct in-depth research on its synthesis mechanism, and to give full play to its application potential.

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**B07-09**

**Approches to enhance energy recovery from agriculture wastes (AGWs) and fats, oils, and grease (FOG) by low carbon additives**

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Anaerobic digestion (AD) of fats, oils, and grease (FOG) and agriculture wastes (AGWs) is mainly limited by a lack of nutrient availability and a substantial, viable, and enormous microbial population. AD offers a range of beneficial environmental benefits, including reducing emission of greenhouse gases, removing mineral fertilizers, generating renewable energy, and waste disposal. The two significant ways to enhance anaerobic digesters are:

1). the application nanomaterials and 2). Addition of a single additive (such as biochar or calcium).

Supplementing high-density microorganisms to improve the production of biogas and biomethane along with preventing beneficial microbes from being washed away from the effluent plays a significant role. Biological syntrophic interaction can be defined as the nutritional conditions in which different syntrophic microbes perform their metabolic activities to biodegrade complex organic matters that cannot be catabolized otherwise by individually.

Herein, a novel approach is suggested to enhance the energy recovery from AGWs and FOG through a two-step conversion using eggshell-based catalytic pyrolysis and animal waste bone pyrolysis followed by biochar-based anaerobic mono and co-digestion. Pyrolysis with eggshell significantly enhanced the crude bio-oil yield by 4.6 %. Anaerobic digestion of rice straw using various concentration of rice straw biochar (RB) recorded high biogas of 503.7 L kg−1 VS, with 268.6 L kg−1 VS biomethane yield. whereas, the calcium-enriched eggshell rice straw biochar enhanced the biomethane yield to 281.8 L kg−1 VS, which represented 95.6 % higher than the control. The suggested route enhanced the energy recovery in the form of bio-oil and biomethane by 41.6 %.

**B07-10**

**Study on mechanical properties and modification mechanism of rice husk ash based geopolymer concrete reinforced by fiber and nanomaterial**

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Rice husk ash and blast furnace slag were used as raw materials, and an orthogonal experiment was designed to optimize the material proportions. To further improve the mechanical properties of geopolymer concrete, hooked-end steel fibers (0-0.9 vol%) and nano-CaCO3 (0-2.5 wt%) were used for composite modification. The compressive strength, splitting tensile strength and drop-weight impact resistance of the specimens before and after modification were evaluated. The Scanning Electron Microscopy (SEM) and X-Ray Diffraction (XRD) were used to analyzed the microstructure and phase composition of the matrix. Furthermore, the synergistic mechanism of composite modification and the reason led to the difference in optimal dosage ranges under different loads were elaborated. The results showed that the composite addition of hooked-end steel fibers and nano-CaCO3 significantly improved the static and dynamic mechanical properties of the specimens. The compressive and splitting tensile strengths increased by up to 32.1% and 91.7%, reaching 37.93 MPa and 3.95 MPa, respectively. Under drop-weight impact, the energy absorption capacity of the specimens at initial cracking and final failure increased by up to 300% and 333%, respectively. The results deepened the research on the static and dynamic mechanical properties of fiber-nanomaterial composite modified rice husk ash based geopolymer concrete, provided data support for its practical application and enriched the selection range of green material in the construction industry.

**B07-11**

**Influence of carbonated recycled aggregates on the compressive strength and ITZ of geopolymeric recycled concrete**

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In this study, carbonated recycled aggregates (CRA) were used in preparing geopolymeric recycled concrete

(GRC). The influence of CRA with different carbonation durations on the compressive strength of GRC was studied, and the physical properties of CRA were tested. Bi-material Brazilian disc (BBD) was explored to simulate interfacial transition zones (ITZ). According to the test results, CRA was found to introduce quantities of carbonate ions, causing a similar adverse effect of efflorescence in GRC. Therefore, the compressive strength decreased in the first 24 hours of carbonation. After 96 hours' carbonation, the reduction in compressive strength was insignificant. When using CRA to prepare GRC, it would be advisable to carbonate recycled aggregates for longer than 96 hours. The results of the splitting tensile tests and nanoindentation test of BBD revealed that the carbonation treatment of recycled aggregates could slightly weaken the bonding properties of ITZ in GRC.

**B07-12**

**Influence of nano-SiO2 and steel fiber on mechanical and microstructural properties of red mud-based geopolymer concrete**

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Red mud-based geopolymer concrete (RMGC) is a new type of green building material widely studied at this stage, which has many advantages such as acceptable early strength, durability, and comprehensive utilization of industrial waste residue. But because of the chemical properties of red mud itself, the performance of RMGC is generally not satisfactory. Therefore, the research on its modified materials and mechanisms has become a hot spot. In this study, RMGC was prepared using red mud, coal gangue, and slag as raw materials. The effects of nano-SiO2 (0–2.5 wt%) and steel fiber (0–1.25 vol%), as well as the effect of the compounding of both on the mechanical properties of RMGC, were investigated, respectively. The microscopic morphology of RMGC was investigated using scanning electron microscopy (SEM). The results showed that the appropriate amount of steel fibers and nano-SiO2 could significantly enhance the performance of the RMGC, either alone or in combination, where the best modification effect can be obtained by mixing the two. On this basis, the mechanism of single and synergistic modification of RMGC by nano-SiO2 and steel fiber was analyzed. The results of this study will enrich the knowledge system of the performance of steel fiber and nano-SiO2 modified geopolymer composites and guide the further promotion and application of red mud-based geopolymer concrete.

**B07-13**

**硅酸盐水泥对负温下碱矿渣砂浆性能及微结构的影响**

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研究了硅酸盐水泥（OPC）对负温成型及养护下碱矿渣砂浆流动度、水化放热行为、抗压强度、水化产物和微观机构的影响。结果表明：OPC 能够提高-10 ℃下碱矿渣砂浆的抗压强度，28 d 抗压强度可达到 35.4 MPa，但会降低其流动度；OPC 的掺入加速了碱矿渣砂浆的早期水化，导致水化放热总量增大，水化放热峰值提高，放热峰出现位置提前；掺入 OPC 后，水化产物种类不变，主要为 C-(N)-A-S-H 凝胶和 CaCO3，但水化产物含量增加，导致砂浆孔隙率降低，大孔数量明显降低，微观形貌更加致密，因此抗压强度提高。

**B07-14**

**Effects of alkali equivalent and polypropylene fibres on performance of alkali-activated municipal waste incineration bottom ash-slag mortar**

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Slag demonstrate significant potential as an important cementitious material for alkali-activated systems; however, the increase in alkali-activated materials has resulted in a short supply of slag. Therefore, other industrial wastes must be identified urgently to replace slag as an alkali-activated material while considering the alkali equivalent (AE) as an important factor affecting alkali-activated materials and the modification of polypropylene fibre (PPF). Effect. In this study, the effects of the AE and PPF length on the fluidity, consistency, compressive strength, and flex-ural strength of municipal waste incineration bottom ash-slag mortar are investigated by partially replacing slag with bottom ash (BA) derived from waste incineration as an alkali-activated mater-ial. The mechanism is elucidated via X-ray diffraction analysis and scanning electron microscopy. Finally, studies were conducted on the freeze-thaw resistance and dry shrinkage of alkali-activated bottom ash-slag mortar (AABA-SM). The results show that the performance of an AABA-SM can be modified and enhanced by controlling the AE size and the PPF length. Consistency of AABA-SM increased with the AE. The fluidity and mechanical strength of the AABA-SM enhanced significantly when the AE is 6.5%. PPF length of 12 mm were more significant in increasing the flexural strength of AABA-SM. This is attributed to the denser microstructure formed by the ap-propriate AE and the superior reinforcing effect of the well-coated 12 mm PPFs.In particular, at an AE of 6.5% and a PPF length of 12 mm, the AABA-SM shows a similar change in terms of dry shrinkage as natural mortar and is better resistant to freezing and thawing. This research provides theoretical support to improve the performance of AABA-SM, enhance the utilization of BA, and reduce environmental pollution.

**B07-15**

**Optimization of Alkali-Activated Mortar Utilizing Municipal Solid Waste Incinerator Bottom Ash and Slag: A Multi-Objective Response Surface Method Approach**

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Addressing the twin challenges of air pollution and the greenhouse effect, which are exacerbated by cement production and the handling of industrial waste, researchers have turned their attention to Alkali-Activated Materials (AAMs). AAMs offer a promising alternative to Ordinary Portland Cement (OPC) given their lower production costs and reduced environmental impact. This study's principal aim is to leverage Response Surface Methodology (RSM), underpinned by a Box-Behnken Design (BBD), to predict and optimize the various effects—both individual and interactive—of municipal solid waste incineration bottom ash (MSWIBA) admixture ratios, water-to-cement ratios, and sand-to-cement ratios on the rheological and mechanical properties of AAMs. Specifically, this research examines the flowability, consistency, solidification times, as well as the 28-day compressive and flexural strengths of alkali-activated MSWIBA-Slag mortar (AAMS).The analysis has yielded a robust predictive model, as evidenced by coefficient of determination (R2) values ranging from 0.9885 to 0.9969, indicating high reliability. The optimal formulation identified consists of 55.63% MSWIBA by weight, a water-to-binder ratio of 0.41, and a sand-to-binder ratio of 2.60. Experimental validations of the AAMS's flowability, consistency, setting times, and 28-day compressive and flexural strengths closely align with the predictive model's results, with discrepancies of less than 10%.The AAMS formulated in this investigation not only incorporates a substantial proportion of MSWIBA but also stands to address pressing concerns of resource depletion and waste management, thereby contributing to sustainable development goals. The findings of this study are poised to assist in optimizing the proportioning of mortars that incorporate waste materials, fostering more sustainable approaches in construction.

**B07-16**

**挤压态双相 Mg-Li 合金的疲劳裂纹扩展行为研究**

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采用超声疲劳试验和表面复型技术研究了挤压态双相镁锂合金的高周疲劳行为。对沿着挤压方向（ED 试样）和材料横向（TD 试样）加工的不同试件的裂纹行为进行了比较。研究发现 α-Mg 在 ED 和 TD 试样中表现出不同的变形织构和显微组织，并随之显著影响了不同取样方向试件的疲劳裂纹生长行为。此外，ED 试样中的 α-Mg 具有较强的柱面织构，阻碍了 α-Mg 晶粒基面内裂纹的萌生，因而疲劳强度高于 TD 试样。本研究强调了微观组织和变形织构对于双相 Mg-Li 合金疲劳行为中的重要性。

**B07-17**

**Impact of Recycled Aggregate Pretreatment on Mechanical and Drying Shrinkage Properties of Recycled Concrete**

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As the market for construction waste stockpiles grows, traditional treatment methods fall short of meeting the demand for efficient utilization. In contrast, the aggregate pre-treatment process emerges as an effective strategy to markedly improve the performance of recycled aggregates. To optimize the properties of recycled aggregates and improve the fundamental characteristics of recycled concrete, this study introduces a pretreatment method involving initial coating and pressurization of the aggregates, followed by curing. Building on the wrapping and pressing techniques, it specifically investigates the impact of aggregate curing on the mechanical properties, dry shrinkage, and microstructure of concrete. The study demonstrated that a water-to-cement ratio of 0.6 for the coated slurry and a pressurization value of 0.5 MPa yielded optimal results, notably reducing the aggregate's crushing index and increasing its apparent density. Aggregate curing under optimal conditions involved drying at 35℃ for 48 hours followed by exposure to ambient temperature for another 48 hours. As a result, the compressive and splitting strengths of the recycled concrete increased by 28.7% and 21.7%, respectively, while drying shrinkage decreased by 43.54%. Microscopic analysis revealed that aggregate pretreatment led to increased hydration products, including hydrated calcium silicate and calomel, within the internal crevices of the aggregate. Additionally, a denser structure was observed in the interfacial transition zone between the old and new mortar at the aggregate periphery. These enhancements in both the internal aggregate structure and the performance of the peripheral matrix collectively contributed to the strengthened recycled concrete and reduced dry shrinkage rate. This study aims to propose a streamlined and effective pre-treatment method for recycled aggregates, characterized by its ease of operation, and apply it to a wide range of recycled concrete products.

**B07-18**

**Effect of weathered granite coarse and fine aggregates on mechanical properties and microstructure of recycled concrete**

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The simultaneous use of recycled coarse aggregate (RCA) made from crushed waste concrete and weathered granite (WG) in concrete can substantially enhance the recycling rate of construction and demolition waste. However, the effects of WG on the mechanical properties and microstructure of recycled concrete remain unknown. In this paper, we investigated the effects of WG on the mechanical properties and microstructure of recycled concrete by substituting RCA and natural fine aggregate, respectively. The results show that: i) the mechanical properties of the recycled concrete are optimal when the replacement rate of weathered granite coarse aggregate (WGCA) is 60%, and the splitting tensile strength is better than that of natural concrete. This is mainly

attributed to the following two reasons: i) the synergistic effect produced by the difference in the nature of the two types of coarse aggregates, especially since part of the WGCAs will be crushed in the process of making concrete, thus filling in between the coarse aggregates with smaller particle sizes, which increases the concrete densification and presents a denser microstructure. Secondly, the presence of WG facilitates the generation of hydrated calcium silicate, which improves the strength of WGCA. The mechanical properties of recycled concrete peaked at 40% replacement of weathered granite fine aggregate (WGFA), attributable to the synergistic effect of both WGFA and natural fine aggregate, which reduces pore creation and promotes the production of hydrated calcium silicate and improves the interfacial transition zone of RCA. This indicates that solid waste blending offers better performance than utilizing single solid waste blending. In particular, NaAlSiO4 is observed as a new hydration product in the reaction of WG, which differs from that of Recycled concrete.

**B07-19**

**Improving recycled concrete aggregates using flue gas based on multicyclic accelerated carbonation: Performance and mechanism**

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Utilizing flue gas from cement plants to treat the recycled concrete aggregates (RCAs) through accelerated carbonation is a new strategy for reducing carbon emission and improving the quality of RCAs. However, due to the low CO2 concentration, carbonation efficacy is always unsatisfactory. In this study, multicyclic carbonation treatment was performed to enhance the carbonation efficacy using flue gas as CO2 source. The key operation parameters including carbonation duration, gas pressure and cycle numbers were optimized, and the carbonation performance and mechanisms were evaluated. Results showed that treating the RCAs for six cycles within 24 hours at gas pressure of 0.1 MPa could obtain satisfactory carbonation percentage. Microstructure analysis verified that, after multicyclic carbonation, large amount of calcium hydroxides were converted into calcium carbonates to reduce the porosity and promote the quality of RCAs. Furthermore, compared with non-carbonated recycled aggregate concrete, the compressive strength and flexural strength of concrete incorporating RCAs treated by flue gas increased by 25.2% and 26.5%, respectively. The present study proposes an innovative approach for improving the carbonation efficacy of flue gas as CO2 source.

**B07-20**

**Study on the Effect of Mineral Admixtures on the Mechanical, Microscopic and Freeze-thaw Resistance Properties of Tunnel Slag Recycled Concrete**

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To promote the recycling of tunnel slag concrete containing two types of solid waste and conserve natural sand and gravel resources, this study investigated the enhancement of tunnel slag concrete properties through the addition of various mineral admixtures (silica fume (SF), fly ash (FA), and ground granulated blast furnace slag (GGBS)). The effects of different mixing methods on the mechanical properties, microstructure, and freeze-thaw resistance of the concrete were examined. Macroscopically, the compressive, flexural, and splitting tensile strengths of the concrete were tested at different ages. Microscopically, XRD and SEM were utilized to analyze the concrete's composition and internal pore structure. Additionally, freeze-thaw resistance tests were conducted. The results revealed that the addition of SF significantly enhanced the compressive strength of the tunnel slag concrete, while the combination of mineral admixtures improved the flexural and splitting tensile strengths. The FA promoted the production of calcium hydroxide (C-H), and its combination with GGBS favored the formation

of calcium silicate hydrate (C-S-H). Furthermore, a single addition of GGBS, or a combination of FA with SF or GGBS, resulted in a denser concrete microstructure. The combination of FA and GGBS proved to be more effective for enhancing the freeze-thaw resistance of tunnel slag concrete. In conclusion, the mixture of FA and GGBS effectively improves multifaceted performance of tunnel slag concrete, enhancing its suitability for a wider range of applications.

**B07-21**

**碱激发保温一体化模板开发及性能研究**

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As a new type of non-dismantling formwork, the non-dismantling composite insulation formwork has received high attention from the engineering community due to its significant energy-saving and economic benefits. The study combined the current excellent design concept of non-dismantling composite insulation formworks and proposed a new system of non-dismantling composite insulation formworks that is more in line with the "dual carbon" strategic development concept by introducing alkali activation technology into non-dismantling composite insulation formworks. Developed the preparation technology of inorganic insulation materials and protective materials based on the principle of alkali activation, obtained inorganic insulation materials for building walls and protective materials for the inner and outer sides of insulation layers. Developed a composite wall with integrated insulation and formwork, revealed the bonding characteristics and failure mechanisms between the interface layers of the composite wall, and proposed a calculation method for interface splitting tensile strength and shear strength. Studied the collaborative stress mechanism between non-dismantling composite insulation formwork and walls. The results showed that the non-dismantling composite insulation formwork proposed based on alkaline activation technology can achieve the same lifespan or even exceed the lifespan as RC walls under earthquake action. The research results could provide a new idea and method for the future research direction of building exterior wall insulation systems and building formwork engineering.

**B07-22**

**Study on Mechanical Properties of High Strength Concrete Modified with Ultrafine Mineral Admixtures**

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To reduce carbon emissions in the construction industry, ultrafine fly ash and ultrafine slag with similar average particle sizes were selected to replace cement in the preparation of high-performance concrete (HPC). The study examined the effects of these ultrafine mineral admixtures on the workability and mechanical properties of ultrafine mineral admixture high-performance concrete (UMAHPC). X-ray diffraction (XRD) and scanning electron microscopy (SEM) were employed to investigate the effects of incorporating ultrafine mineral admixtures on the hydration products and microstructure of HPC. The results indicate that ultrafine fly ash can significantly enhance the workability of HPC, Ultrafine fly ash（UFA）0can significantly improve the workability of HPC, but negatively affects the mechanical properties of HPC. In contrast, the incorporation of ultrafine slag（US）notably improves both the workability and mechanical properties of high-performance concrete.

**B07-23**

**粉煤灰地聚物混凝土的二氧化碳减排成本**

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Using geopolymer concrete (GC) is a technically feasible decarbonization strategy in the cement and concrete industry shown by numerous papers. A key factor determining its commercial application is whether its cost is competitive. However, related study is scarce. In this paper, we present the analysis of GC's CO2 avoidance cost, the cost incurred to reduce one metric ton of CO2 emissions. The results show that among the 486 GC mixtures analyzed, only seven yield negative CO2 avoidance costs, while 379 are even more expensive than capturing CO2 from cement plants, which is another technically feasible decarbonization strategy and has been evaluated to have a CO2 avoidance cost of 55 USD/tCO2 in Chinese demonstration project. Only a few GC mixtures with lower CO2 avoidance costs will be considered by the industry, and they are associated with low activator dosage and high compressive strength. To quantify this relationship, we introduce the activator index (Ai), which refers to the activator dosage (kg·m−3) required to achieve 1 MPa of compressive strength. The result shows that Ai values below certain thresholds correspond to lower CO2 avoidance costs and significant emission reductions of GC. This Ai-based criterion helps identify the optimal GC mixture that effectively reduces CO2 emissions at the lowest possible cost, thereby promoting its commercial application.

**B07-24**

**Research on the modification effect and performance of basalt fiber on gangue concrete**

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Coal gangue, a by-product of coal mining and processing, poses a significant environmental threat due to its massive accumulation. Harnessing coal gangue for resource utilization presents substantial environmental advantages. This study investigates the conversion of gangue into coarse aggregate as a substitute for natural aggregate in the production of gangue concrete (CGC), a practice that potentially curtails the exploitation of natural sand and gravel and mitigates the environmental pollution from gangue piles. Utilizing gangue sourced from Liupanshui, Guizhou Province, the research establishes an optimal substitution rate for gangue aggregate through macro-mechanical experiments, including assessments of compressive strength, splitting tensile strength, and flexural resistance. Further, this study incorporates basalt fibers (BF) of varying volumes and lengths into CGC, examining their impact on the mechanical and durability characteristics of the concrete and elucidating the underlying mechanisms via scanning electron microscopy (SEM) imagery. Findings indicate that the strategic incorporation of BFs enhances the mechanical and durability properties of concrete by refining its internal pore structure and bolstering its microstructure, which in turn impedes the progression and widening of microcracks. Notably, BF within CGC exhibits four primary distribution patterns: a tight integration with the cement matrix, embedding within the matrix, overlapping among fibers to create a three-dimensional mesh, and formation of agglomerated structures.

**B07-25**

**Recycled glass concrete with cementitious materials: study of mechanical prediction model and dry shrinkage mechanism**

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Adding supplementary cementitious materials effectively improves the mechanical properties and durability of Recycled glass concrete (RGC). The study tested three mixes: single-doped limestone powder (RGC-L), single-doped metakaolin (RGC-M), and a limestone-metakaolin mix (RGC-LM). They were evaluated for mechanics, shrinkage, and microanalysis. Results showed RGC-L5M5 had the best performance, improving

compressive strength by 23.3%, tensile strength by 38.1%, and flexural strength by 7.3%.Additionally, based on these results, a series of predictive models for mechanical properties of RGC was developed, yielding relational equations for splitting tensile strength, flexural strength, and compressive strength. Dry shrinkage results showed that RGC-L10M20 performed optimally, achieving 32.5% dry shrinkage reduction. Microstructure analysis indicates that both the RGC-L and RGC-M can effectively enhance the interfacial transition zone, and within the microstructure of the RGC-LM, the formation of CO3-AFm from the reaction of Al2O3 and CaCO3 in MK is observed, resulting in a denser microstructure for RGC. Ultimately, the study summarizes the micro-mechanisms and dry shrinkage mechanisms of LP and MK in RGC, offering a promising avenue for improving construction waste utilization. This approach is beneficial for the clean production of recycled glass concrete, providing valuable insights into sustainable construction practices.

**墙报**

**B07-P01**

**二硫化钼与生物大分子之间的作用研究**

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二硫化钼，作为一种低碳材料，在生物医学和环境领域有着广泛的应用。以往的研究表明，二硫化钼纳米片可能诱导毒性。然而，对其潜在毒性机制的了解尚缺乏。在本研究中，我们发现，二硫化钼纳米片可以在有或没有外部能量输入的情况下直接诱导双链 DNA 断裂，这与其他二维纳米材料不同。在黑暗环境下，由于不同 pH 值下活性氧的生成，DNA 的裂解呈现出 pH 依赖的趋势。该研究证明了二硫化钼作为一种新型的低碳材料，能够有效处理生物污染物。

**仅发表论文**

**B07-PO01**

**热处理天然毛竹拉伸力学性能及断裂机理研究**

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Bamboo is a natural fiber composite material with a unique structure, consisting of thick-walled fibers as reinforcing material and parenchymal cells as the matrix phase. This study explores the tensile mechanical behavior of heat-treated bamboo, considering its multi-scale structure. The investigation focuses on stress-strain curves, crack propagation modes, chemical composition, microstructure, and fracture mechanisms. Heat treatment temperatures ranged from 160 ℃ to 220 ℃. Understanding the effects of heat treatment on bamboo is crucial for enhancing its dimensional stability and durability.

Tensile tests were conducted on bamboo specimens and fiber bundles. Various experimental techniques, including DIC, SEM, XRD, and FTIR, were employed to analyze crack extension, microstructure, and chemical changes. The mechanical properties and fracture mechanisms of both untreated and heat-treated specimens were examined.

Tensile strength decreased as heat treatment temperature increased. For example, at 220 ℃, the strength dropped by 62.68%. Elastic modulus initially increased and then decreased, peaking at 18.30 GPa for 180 ℃ treatment. The stress-strain curves exhibited different plastic deformation and fracture behavior based on heat treatment temperature.

Heat treatment affected the tensile behavior and fracture mode of bamboo fiber bundles. Tensile strength

decreased gradually with higher treatment temperatures. The outer regions exhibited ductile fracture, while the inner regions showed brittle fracture. Changes in cellulose and hemicellulose content influenced the mechanical properties.

Heat-treated bamboo displayed altered fracture characteristics and mechanisms. Degradation of cellulose and hemicellulose reduced tensile strength, while increased lignin content raised the elastic modulus. Crack propagation followed a "Z"-shaped pattern, with multiple steps in the stress-strain curve. Delamination, increased porosity, and tissue loss occurred due to heat treatment.