

Nonmetallic Excellence and Innovation Center for Building Materials (NEXCEL)

2023 Program Guideline

Nonmetallic Excellence and Innovation Center for Building Materials (NEXCEL, hereinafter referred to as the Center) is a technology innovation institution co-founded by Saudi Aramco, the world's largest energy and chemical producer, and China Building Materials Academy (CBMA). The Center will be committed to promoting the application of nonmetallic materials in the building and construction sector, and providing more sustainable building and construction solutions. Compared with traditional construction materials, nonmetallic materials such as petroleum-based advanced composite materials are stronger and more durable, and less expensive to maintain, which will play an important role in boosting the development of low-carbon building and infrastructure construction in China.

NEXCEL is the first Nonmetallic Innovation Center established by Saudi Aramco in Asia. The Center aims to expand and accelerate nonmetallic technology deployment in the building and construction sector by carrying out research and development and publicity of nonmetallic material technology, developing and promoting nonmetallic material standards and regulations, training technical talents for the development and application of nonmetallic materials technology in the field of building and construction.

According to its vision and mission, the Center will carry out scientific and technological innovation tasks in seven fields, including Waterproofing and Repair Materials, Insulation and Composite Cladding, Special Mortars and Concrete, Flooring and Pavement for Road and Bridges, Fibers, Rebars and Fiber Composites, Admixtures and Construction chemicals, Paintings and Others. The Center releases annual Program Guideline and calls for project proposals supported by its Program Fund. The project proposals are selected through expert review and oral defense, and will be implemented based on signed contracts.

Below is the priority areas of 2023 Program Guideline.

1. TDA Project

TDA-1 Develop hydrocarbon-based graphene for improving properties of concrete

Research Content: Guided by China's policies on green and low carbon development, waste resource utilization, and new material development, the project focuses on the preparation of hydrocarbon-based graphene and develop key technologies for low-cost and mass production of hydrocarbon-based graphene; Study graphene's influence on concrete properties, and propose key technology and mechanism of improving graphene concrete properties; Explore low-cost preparation technology of graphene concrete.

Assessment Indicators: The graphene's carbon source is hydrocarbon-based, which does not require additional acid, alkali and oxidants in the preparation process. The cost of graphene less than 200 RMB/kg, the number of layers no more than 10 layers; the compressive and bending strength as well as comprehensive durability of graphene concrete all improve by more than 20%; Compared with regular concrete, the cost of graphene concrete per cubic meter increases by no more than 5%; Complete no less than 1 demonstration project of graphene concrete; Formulate at least 1 standard (group standard level or above, draft for review), apply for no less than 1 patent, publish no less than 2 relevant papers (including 1 SCI English paper); The project outcome reaches international advanced level.

Project Type and Quantity: TDA, 1

Funding: within 800,000 RMB

Project Duration: 2 years

TDA-2 Development and engineering demonstration for thermoplastic polyolefin waterproofing sheets with high flame retardancy and long service life

Research Content: In order to realize ultra-long service life of roof waterproofing, the project develops thermoplastic polyolefin waterproofing sheets and studies the influence of raw materials, preparation parameters and production process on the sheet properties including waterproofing, fireproofing, wind uplift resistance and hail resistance; Study material mechanism of high durability of thermoplastic polyolefin waterproofing sheets to achieve ultra-long service life; Propose key

application technologies in project design, material selection, construction, operation and maintenance for single-layer-sheet waterproofing roofing and metal roofing engineering; Complete project demonstration of thermoplastic polyolefin waterproofing sheets.

Assessment Indicators: The combustibility of thermoplastic polyolefin waterproofing sheets no lower than B2 grade; Time for artificial weathering accelerated aging test no less than 10, 000 h, thermal aging (115℃) time no less than 224d , and product performance index meets or exceeds the requirements of ASTM D 6878; The service life of thermoplastic polyolefin waterproofing sheets no less than 25 years; Complete project demonstration with area of no less than 10,000 m². Formulate no less than 1 standard (group standard level or above, draft for review), apply for no less than 2 patents, publish no less than 2 relevant papers; The project outcome reaches international advanced level.

Project Type and Quantity: TDA, 1

Funding: within 800,000 RMB

Project Duration: 2 years

TDA-3 Research and demonstration on thermal insulation and structure integration technology for ultra-low energy buildings

Research Content: To address the challenges of thermal insulation falling off the building and fire resistance of thermal insulation projects, the project conducts study and demonstration of thermal insulation and structural integration technology for ultra-low energy buildings. Focus on optimal selection and performance improvement of organic thermal insulation materials for exterior walls with integrated thermal insulation and structural cladding; Explore the method of using fiber reinforced composite (FRP) connectors to replace traditional connectors and their impact on thermal insulation and safety performance of exterior walls; Study key parameters of wall structure with integrated thermal insulation and structural cladding, and its thermal insulation and fire resistance performance; Develop key technologies with project demonstration for exterior walls with thermal insulation and structural cladding of ultra-low energy buildings.

Assessment Indicators: The fire resistance limit of exterior walls is no less than 4 hours, the heat transfer coefficient is no more than 0.14 W/m² · K; The combustion

performance of organic thermal insulation material reaches B1 grade; Tensile strength of FRP connectors is no less than 850 MPa, tensile elastic modulus is no less than 45 GPa, and interlaminar shear strength no less than 40 MPa; The retention of tensile strength and interlaminar shear strength of FRPs after 50 years of service is no lower than 50% of the initial value; Formulate a set of construction technologies for integrated thermal insulation and structural cladding; Formulate 1 technical standard (group standard level or above, draft for review); Apply for no less than 1 patent; Publish no less than 3 papers; Complete no less than 5 project demonstrations for exterior walls with thermal insulation and structural cladding of ultra-low energy buildings; The project outcome reaches international advanced level.

Project Type and Quantity: TDA, 1

Funding: within 800,000 RMB

Project Duration: 2 years

TDA-4 Preparation and application of FRP bent bar under corrosive environment

Research Content: Aiming at corrosion problem of steel bars in concrete structures under severe environments such as exposure and erosion, the project focuses on preparation of fiber-reinforced composite stirrups (including combined type closed stirrups, closed stirrups and spiral stirrups); Study technical process of improving tensile strength of FRP stirrups, with proposal for calculation of tensile strength for FRP stirrups; Explore design method of torsion and shear of concrete members prepared with FRP straight bars and FRP stirrups; Study on creep fracture performance of FRP stirrups and define the reduction factor for creep fracture of FRP stirrups; Formulate standards for FRP bent bar's engineering demonstrations.

Assessment Indicators: Develop 3 new-type FRP stirrup products (combined type closed stirrups, closed stirrups and spiral stirrups), and form 1 production line; Nominal diameter 8-20 mm for FRP stirrups, fiber content no less than 60%, and tensile strength no less than 40% of straight bar strength; Propose design method for concrete composite torsion and shear members of FRP straight bars and FRP stirrups; Formulate 1 standard for FRP hooped reinforcement products (group standard level or above, draft for review); Apply for no less than 1 patent; Publish no less than 3

relevant papers (including 2 SCI English papers); Complete no less than 2 project demonstrations, and the project outcome reaches international advanced level.

Project Type and Quantity: TDA, 1

Funding: within 800,000 RMB

Project Duration: 2 years

TDA-5 Fire endurance and creep resistance improvement for application of GFRP rebars

Research Content: Conduct research on tensile strength degradation of GFRP rebars at high temperature, and propose technology to improve fire endurance from GFRP composition design; Study fire endurance of GFRP reinforced concrete members, and propose fire-protection design method and protective measures; Study the effect of different raw materials on creep rupture of GFRP rebars under different stress levels, and propose technologies to improve creep resistance; Study long-term properties of GFRP reinforced concrete members, and propose calculation method for long-term deformation.

Assessment Indicators: Propose technologies to improve fire endurance and creep resistance of GFRP rebars; Tensile strength retention of GFRP rebars at 400 °C is no less than 45%; Creep rupture strength of GFRP rebars is no less than 45% of straight bar strength; Propose design method for fire endurance and long-term performance of GFRP concrete members; Apply for no less than 1 patent; Publish no less than 3 relevant papers (including 2 SCI English papers); Complete no less than 1 project demonstration; The project outcome reaches international advanced level.

Project Type and Quantity: TDA, 1

Funding: within 1,000,000 RMB

Project Duration: 2 years

TDA-6 Research on gradient enhanced polymer modified concrete for structural use and comparison with conventional concrete

Research Content: To address the challenges of early damage to concrete surface in highways, bridges and other concrete structures, the project designs a gradient composite concrete structure, proposes design method, preparation process and testing method of polymer modified concrete surface layer; Study interface bonding performance and compatibility improvement measures of surface layer and

base layer of the gradient concrete, reveal the gradient performance change of polymer modified concrete and non-modified concrete; Study special construction technology of gradient enhanced concrete composite structures; Compare polymer modified concrete with OPC concrete and concrete made with supplementary cementitious materials such as fly ash, blast furnace slag and silica fume in term of mechanical properties, durability and fire endurance; Develop a state-of-the-art report on polymer concrete and polymer modified concrete in China and internationally.

Assessment Indicators: The abrasion loss of polymer modified concrete surface layer is no more than 2 kg/m², 28 d flexural strength is no less than 12.0 MPa, 28 d compressive strength is no less than 60.0 MPa, 28 d shrinkage rate is no more than 300×10⁻⁶; 28 d interface bonding strength between the surface layer and base layer of gradient enhanced concrete is no less than 2.5 MPa; The frost resistance grade of the composite structure of gradient enhanced concrete is no less than F300; Apply for no less than 1 patent; Publish no less than 2 relevant papers; Formulate no less than 1 standard (group standard level or above, draft for review); Complete a state-of-the-art report on polymer concrete and polymer modified concrete in China and internationally; Complete 1 project demonstration.

Project Type and Quantity: TDA, 1

Funding: within 520,000 RMB

Project Duration: 2 years

2. Small Fund Project (SFP)

SFP-1 Effects of recycled plastics on the performance of asphalt mixture

Research Content: In order to reduce environmental impact of plastic waste, the research will be conducted on: 1. Study the potential of recycled thermoplastics to replace asphalt in asphalt mixtures, as well as the effect of recycled thermoplastics on the performance of asphalt mixtures. Clarify the influence of recycled plastics on the interface bonding performance and reveal its mechanism. 2. Study the potential of recycled thermosetting plastics to replace fillers in asphalt mixtures, as well as the influence of recycled thermosetting plastics on the performance of asphalt mixture, and realize overall performance improvement of recycled thermosetting plastics modified asphalt mixtures.

Assessment Indicators: The replacement rate of recycled thermoplastics is not less than 20% of asphalt quality, and the replacement rate of recycled thermosetting plastics is not less than 5% of mixture quality; The properties of recycled plastic modified asphalt and mixture meet corresponding technical requirements in "*Technical Specifications for Construction of Highway Asphalt Pavements*" (JTG F40), and the dynamic stability of the mixture is not lower than 5000; Formulate 1 standard (group standard level or above, draft for review); Apply for at least 1 patent; Publish at least 1 relevant paper; 1 project demonstration for recycled thermoplastic asphalt mixture pavements and recycled thermosetting plastic asphalt mixture pavements respectively, covering a total mileage of not less than 2 km.

Project Type and Quantity: Demonstration, 1

Funding: within 300,000 RMB

Project Duration: 1 year

SFP-2 Standardization of product properties for continuous fiber reinforced thermoplastic resin composite rebars

Research Content: For the application of concrete structures in corrosive environments, the research focuses on product form, physical, mechanical and hot bending properties to obtain basic performance indicators of thermoplastic composite rebars; Explore hot bending test methods of thermoplastic resin composite rebars, and obtain verification data of the test methods; Formulate product or testing standards for continuous fiber reinforced thermoplastic resin composite rebars.

Assessment Indicators: Test basic properties of no less than 3 thermoplastic composite rebars; Deliver 1 project report and formulate no less than 1 standard (group standard level or above, draft for review).

Project Type and Quantity: Standardization, 1

Funding: within 200,000 RMB

Project Duration: 1 year

SFP-3 Standardization and demonstration of preparing building formwork with waste plastics

Research Content: In order for comprehensive evaluation of reasonable and higher value application of waste plastics in terms of technology, economy, and carbon emission, the project studies physical and mechanical properties of building

formwork prepared by waste general plastics and waste engineering plastics respectively, and conducts cost comparison between building formwork prepared by waste plastics and primary plastics; Formulate technical standards of using waste plastics for building formwork with project demonstration.

Assessment Indicators: The content of waste plastics in building formwork is no less than 50%, and its performance is no lower than the requirements in *"Plastic Formwork" (JG/T 418)*; Establish no less than 1 production line of using waste plastics to prepare building formwork; Complete no less than 1 project demonstration of using waste plastics to prepare building formwork; Formulate no less than 1 standard of waste plastics for preparing building formwork (group standard level or above, draft for review).

Project Type and Quantity: Standardization, 1

Funding: within 220,000 RMB

Project Duration: 1 year

SFP-4 Development of self-healing fire-retardant coatings highly compatible with nonmetallic surfaces

Research Content: As traditional intumescent fire-retardant coatings are challenged by short duration of fire resistance, micro-cracks during service life and vulnerability to external force, the project aims to develop self-healing fire-retardant coatings applied on the surface of organic composites; Develop key hydrocarbon-based fire-retardant additives and self-healing additives and study their effects on coatings; Study application process and performance evaluation of fire-retardant coatings; Compare the fire resistance and cost of new fireproof coating on the surface of FRP substrate, traditional intumescent fireproof coating on the surface of FRP substrate and FRP substrate containing fire retardant additives.

Assessment Indicators: Develop no less than 2 hydrocarbon-based key materials with either of fire retardant and self-healing property, or both; The water resistance of coatings is no less than 100 h; Compared with traditional coatings, the bonding of self-healing and fire-retardant coatings on the nonmetallic surface is improved by more than 20%, the strength of self-healing rate within 24 h is no less than 80%, and fire resistance grade reaches V0; Apply for no less than 1 patent, and

publish no less than 1 paper; Formulate no less than 1 standard (group standard level or above, draft for review).

Project Type and Quantity: Small R&D Project, 1

Funding: within 280,000 RMB

Project Duration: 1 year

SFP-5 Ph.D Training Program

Research content: The research content is consistent with the research topic of Ph.D students; The project should focus on the application of petroleum-based materials in the fields of architecture, building materials and construction; Each Ph.D student can only apply for 1 project, and the student is required to have enrolled since September 2021.

Assessment Indicators: Publish no less than 2 SCI papers (collected or published in journals). Deliver no less than 1 oral presentation (Ph.D student presents) at national or industry conferences; Deliver final project report.

Project Type and Quantity: Ph.D Training, 3

Funding: within 100,000 RMB / per project

Project Duration: 2 years

SFP-6 Advocacy or Training Projects

Advocacy or Training Content: Focus on the application of petroleum-based materials in building and construction; Priority funding areas include on-site conferences, trainings and international activities.

Assessment Indicators: Cover more than 1,000 professionals; Release no less than 2 news articles; Deliver advocacy or training acceptance materials.

Project Type: Advocacy Project

Funding: within 100,000 RMB / per project

Project Duration: 1 year

3. Application Requirements

3.1 All projects are accessible to the public for selection of the best applicants. The applicant should meet application requirements and the project leader should be a professional researcher with profound technical background.

3.2 The applicant must be the actual project leader, who is formally employed by main implementation organization of project proposal, and has sufficient time and energy to engage in the research of the applied project.

3.3 During project implementation period, each applicant can only undertake one NEXCEL project. Applicants who have previously undertaken NEXCEL funded project as the project leader and not yet completed the project will not be further funded in principle.

3.4 Each applicant can only apply for one project (except for Ph.D Training Program).

3.5 Proposals for TDA and Demonstration Projects should reflect innovative academic thoughts, clear scientific questions, feasible research routes or technical solutions, with clear research priorities, and explicit assessment objectives.

4. Application Procedures and Instructions

4.1 The applicant can download "NEXCEL Project Proposal Form" on www.non-metallic.net at Download Section, and fill in the form based on prescribed format. The implementation time of TDA projects is from January 1, 2023 to December 31, 2024; Small Fund projects from January 1 to December 31, 2023.

4.2 The project proposal should be reviewed, signed and stamped by the applicant's organization and leader before submission.

4.3 All application materials should include both electronic and physical versions. Electronic versions (Word for submission, PDF with stamps) should be sent via email, and physical materials should be sent by post (stamped in duplicate version). The content of both electronic and physical materials should be identical. All written documents should be double-sided printed on A4 papers, with ordinary paper as the cover without gluing.

4.4 The review and management of project proposals is in accordance with "NEXCEL Program Fund Management Regulations".

4.5 All application materials shall not be returned. The applicant should back up original project proposals.

4.6 Applications for all projects of 2023 Program Fund are accepted from September 13 to October 15, 2022 (Application by post is subject to postmark).

4.7 Any papers, books and software copyrights produced during the implementation of projects are jointly owned by NEXCEL and the author, and NEXCEL has the right of authorship. CBMA and Saudi Aramco have the right of authorship for intellectual property of standards and patents.

5. Contact Information

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