Proposal Number: ISU 4	**Total Amount Requested:** $547,011
Proposal Track: Commercialization	

Title of Proposed Project: A Sustainable AI-Powered Low-Carbon Emission Concrete (SCALE Concrete): Leveraging Agricultural Byproducts and Wastewater for Circular Economy Solutions
Specific Project Focus: This project aims to advance Sustainable AI-Powered Low-Carbon Emission Concrete (SCALE Concrete) from Technology Readiness Level (TRL) 4-5 (lab validation) to TRL 6-7 (field-scale demonstration). The transition will be achieved through mid-scale trials, AI-driven mix optimization, and pilot field demonstrations with key industry partners, such as the Idaho Transportation Department and the Pocatello Development Authority/Colliers Portneuf Valley.

Project Start Date: July 1, 2025	**Project End Date:** June 30, 2028

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Co-Investigator	Jared Cantrell	Research Eng./Lab Mgr.	
Co-Investigator	Kunal Mondal, Ph.D.	Senior Scientist	Kunal Mondal
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Name of Partnering Company	**Company Representative Name**	**Signature**
Idaho Transportation Department (ITD)	Zakary Johnson	
Amalgamated Sugar Company	Brian Roberson	
Oldcastle Infrastructure	Troy Banks	
Colliers Portneuf Valley	Donald Zebe	Don Zebe

Authorized Organizational Representative	**Name:** Dave Harris	**Signature:**

1. Background of the Problem

1.1. Sustainable Concrete with Agricultural Byproducts in Idaho

The construction industry is a significant driver of global carbon emissions, with concrete playing a central role in both infrastructure development and environmental impact. As the most widely used construction material, concrete ranks second only to water in global consumption [1]. Annual global concrete usage surpasses **22.5 billion cubic yards**, highlighting its critical importance to modern infrastructure while also making it one of the largest contributors to carbon emissions. A major factor in this environmental burden is **cement production**, which alone accounts for approximately **8% of total CO_2 emissions**. Additionally, the production of concrete places immense pressure on freshwater resources. Approximately **1 billion tons of freshwater** are consumed annually for concrete production activities, including mixing, curing, and equipment cleaning [2]. Concrete production accounts for **10% of industrial water withdrawals globally**, corresponding to around **1.7% of total global water withdrawal**. By 2050, it is projected that **75% of the water required for concrete production** will be concentrated in regions anticipated to face water scarcity or high-water stress [3]. These challenges underscore the urgent need for sustainable alternatives in concrete manufacturing.

Figure 1: Stockpile of PCC.

Idaho is uniquely positioned to address the challenge of sustainable construction through its **thriving sugar beet industry**. In 2023, the state produced **6.9 million tons of sugar beets**, making it a key player in the agricultural sector and a significant contributor to Idaho's overall economy, according to the U.S. Department of Agriculture (USDA) [4]. Idaho's leading sugar producer, **Amalgamated Sugar Company**, is the **second-largest sugar beet processor in the United States**, supplying **10% of the nation's sugar** and handling **20% of all sugar beets** grown nationwide. A key byproduct of sugar production is **precipitated calcium carbonate (PCC)**, with approximately **140,000 tons** generated annually. Over the past century, this has led to an accumulation of **10 million tons of PCC in Idaho** (Fig. 1), presenting both a challenge and an opportunity for sustainable reuse.

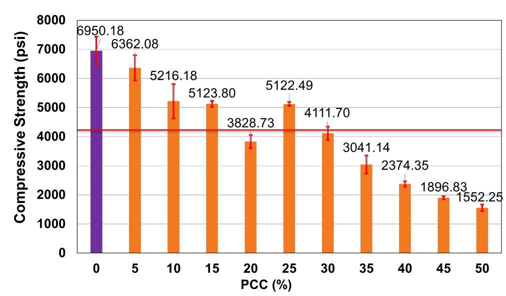

Figure 2: Preliminary experimental results.

Recognizing the potential of this byproduct for concrete production, our team at Idaho State University (ISU) developed an innovative dual-impact solution that replaces traditional carbon-intensive cement with PCC. This application diverts substantial waste from landfills and significantly **lowers greenhouse gas emissions** and **cost** associated with cement production. The results of our preliminary investigations (Fig. 2) confirmed the potential application of PCC in producing sustainable concrete [5]. Moreover, this innovative approach resulted in up to a **30% reduction in carbon emissions** and **cost** while maintaining the necessary performance requirements [5]. As a result, a provisional patent for this product has been filed by ISU's Office for Research[6].

Incorporating PCC in concrete prevents the material from being discarded into landfills, addressing both an **environmental liability** (landfill overcapacity) and a **market demand** for sustainable construction materials. Moreover, this project proposes the use of wastewater in concrete production to minimize the consumption of drinking water and contribute to water conservation efforts without compromising its performance.

2. Significance of Project and Project Objectives

This project offers a holistic solution to key challenges in the construction industry, including high carbon emissions, excessive freshwater use, and growing waste streams by integrating PCC and wastewater into concrete called SCALE Concrete. Another key factor that sets this project apart is its **integration of advanced artificial intelligence (AI), machine learning (ML), and multiobjective optimization (MOO) algorithms** to allow accurate optimization of concrete mixtures that achieve sustainability, cost efficiency and performance goals. Ultimately, this project aims to position Idaho as a leader in low-carbon, resource-efficient construction by leveraging emerging technologies such as AI, incorporating wastewater and agricultural byproduct into concrete production, diverting significant waste from landfills, and strengthening the state's economic resilience.

The proposed project is positioned to directly support state infrastructure projects while aligning with Idaho's economic development initiatives. With a strong existing partnership with the **Idaho Transportation Department (ITD)**, which oversees extensive highway infrastructure, SCALE Concrete can be applied in various projects, including the construction of **concrete barriers from Pocatello to Idaho Falls, as a first pilot project**. By utilizing this **cost-effective, locally sourced concrete**, ITD can significantly reduce material costs while enhancing infrastructure sustainability. Additionally, collaboration with **precast concrete producers** in the region will facilitate the production and deployment of SCALE Concrete in large-scale infrastructure projects. Beyond transportation infrastructure, this project will further bolster Idaho's economy by repurposing the state's **10-million-ton stockpile of PCC** and **wastewater** into a commercially viable product.

Moreover, the proposed project closely aligns with the recently established ISU and Idaho National Laboratory (INL) **SUPER (Strategic Understanding for Premier Education and Research) agreement**, which fosters collaboration between ISU and INL. Signed in December 2024, this agreement positions ISU as a leader in research supporting INL's mission, particularly in **reducing the waste burden by utilizing byproducts in concrete**. The SCALE Concrete initiative directly supports this goal by repurposing industrial waste such as PCC and wastewater into sustainable concrete solutions that could be used in **infrastructure applications for existing or new advanced nuclear reactors**, including **sidewalks, foundations, retaining structures**, and **radiation shielding**. Additionally, the integration of **AI** and **machine learning** in optimizing concrete formulations further strengthens this project's alignment with INL's research priorities. Given that AI and machine learning are trending focus areas at INL and the nation in general, this research enhances Idaho's leadership in **AI-driven solutions** to bridge state infrastructure advancements with national research objectives. The main objectives of this project are discussed as follows:

Objective 1: Preliminary Optimization of SALCE Concrete. This objective focuses on determining the ideal proportions of PCC, wastewater, and other constituent materials in SALCE Concrete to achieve optimal performance. Through rigorous analysis, this objective will ensure that the concrete achieves high compressive and flexural strength, reduced water absorption, and enhanced durability.

Objective 2: Deploy AI-Driven Multi-Objective Optimization. Advanced **explainable AI** and **MOO** algorithms will be employed to optimize concrete formulations considering multiple objectives, including cost, mechanical performance (e.g., compressive strength and flexural strength), and sustainability metrics. This builds on the PI's prior success in developing a sustainable, economical, and high-performance ultra-high-performance concrete (UHPC), where a comprehensive evaluation framework incorporating **19 objective functions**, including strength, cost, and 17 environmental metrics to assess the sustainability of concrete comprehensively was used [7]. The explainable nature of the AI algorithms will enhance transparency, trustworthiness, and usability.

Objective 3: Demonstrate Field-Scale Feasibility. The project will scale the technology from **lab validation (TRL 4-5)** to **pilot- and field-scale applications (TRL 6-7)** in collaboration with ITD and industry stakeholders. Field trials will focus on real-world infrastructure projects to validate the performance of SCALE Concrete. As a first pilot project, SCALE Concrete will be used for construction of **concrete barriers from Pocatello to Idaho Falls** in collaboration with ITD.

Objective 4: Develop a User-Friendly Software Tool. To facilitate widespread adoption, the AI-driven optimization framework will be translated into a **user-friendly software tool**. This tool will enable engineers, contractors, and decision-makers to obtain **project-specific** SCALE concrete that **meets specific project requirements**. The development of this software tool will enhance the accessibility of advanced technology and accelerate the practical implementation of SCALE Concrete to ensure industry-wide adoption and scalability.

Objective 5: Enable Commercial Adoption and Economic Growth. This objective focuses on the commercialization of SCALE concrete. It involves licensing the technology and enabling its wider adoption to create new market opportunities, jobs, and sustainable business practices within Idaho and beyond.

3. Specific Project Plan and Timeline

3.1. Detailed Project Plan

This project focuses on the development, optimization, and validation of a low-carbon sustainable concrete incorporating PCC and wastewater. The project is structured to systematically advance from Technology Readiness Level (TRL) 4 to TRL 7 over a three-year period, progressing through laboratory testing, development of an AI-driven optimization tool, and pilot projects on real-world applications.

3.1.1. Task 1: Material Characterization and Preliminary Testing

Objective: Characterize PCC and wastewater to ensure consistency and quality in production.

Completed Work for PCC: Previous research at ISU has performed a preliminary investigation of the physical and chemical properties of PCC [5]. An X-ray diffraction confirmed a high concentration of calcite ($CaCO_3$) and the presence of quartz (SiO_2), indicating its suitability as a supplementary cementitious material [5]. Energy-dispersive X-ray spectrometry analysis determined that PCC is composed of 45.9% calcium, 39.4% oxygen, and 9.2% carbon, reinforcing its chemical compatibility with cement-based systems [5]. Scanning electron microscopy revealed the fine, granular structure of PCC, which supports its potential for enhanced particle packing and reactivity in concrete mixtures [5]. Furthermore, preliminary results on the mechanical performance assessments, including compressive strength and flexural strength tests, demonstrated the potential application of PCC as a partial replacement for Portland cement [5].

Planned Work for Wastewater: To evaluate its suitability for concrete applications, the wastewater (e.g., dairy wastewater) will undergo a detailed physicochemical analysis. The assessment will include measurements of pH according to *ASTM D1293* [8] and chloride content following *ASTM D512* [9] to determine its compatibility with concrete mix designs. The analysis will also quantify total dissolved solids and suspended solids as per *ASTM D5907* [10] to ensure compliance with water quality requirements for concrete production. Organic material concentration and nutrient levels, such as nitrogen and phosphorus, will be evaluated using standard water quality assessment methods. Additionally, heavy metal content will be assessed in accordance with *ASTM C1602* [11], supplemented by *ASTM D1976* [12] or *EPA Method 200.7* [13] for a comprehensive evaluation of trace elements. These analyses will ensure that the wastewater does not introduce contaminants that could compromise concrete performance while maintaining adherence to industry standards.

3.1.2. Task 2: Development of Test Matrix and Mix Design Optimization

Objective: This task aims to assess the effects of PCC and wastewater replacement levels on concrete properties and develop a robust experimental database for AI-based multi-objective optimization.

Test Matrix Design: The experimental program will evaluate five PCC replacement levels (0%, 20%, 25%, 30%, and 50%) and five wastewater replacement levels (0%, 10%, 20%, 30%, and 100%), creating 25 unique mix designs.

Performance Evaluation: The mechanical and durability properties of the developed concrete mixtures will be used as Key Performance Indicators (KPIs). The primary mechanical properties include **compressive strength**, which will be measured following ASTM C39 [14] and **flexural strength**, evaluated in accordance with ASTM C78 [15]. The durability of SCALE Concrete will be assessed through freeze-thaw resistance tests in accordance with ASTM C666 [16]. This test is crucial in evaluating the long-term durability of concrete, particularly in cold climates where freeze-thaw cycles can significantly impact structural integrity. Additionally, **shrinkage test**, which measures the dimensional stability of concrete over time and provides insights into its potential for cracking and long-term durability will be conducted according to ASTM C157/C157M [17]. Another important KPI is the workability of concrete, which is a key factor influencing construction efficiency, as it determines the ease with which concrete can be mixed, placed, and finished. To ensure practical applicability and ease of placement, the workability of each mixture will be evaluated using ASTM C143 [18].

Specimen Preparation and Testing Plan: Three replicates will be prepared for each mixture proportion, thus, a total of 75 tests will be conducted for each KPI, as listed in the following table.

Table 1: Test Matrix

Test Type, KPI	ASTM Standard	Specimen Type	Total Specimens
Compressive Strength	ASTM C39 [14]	100 mm × 200 mm cylinders	75
Flexural Strength	ASTM C78 [15]	150 mm × 150 mm × 500 mm beams	75
Workability (Slump)	ASTM C143 [18]	Fresh Concrete	75
Durability (Freeze-Thaw)	ASTM C666 [16]	100 mm × 100 mm × 400 mm prisms	75
Shrinkage Test	ASTM C157/C157M [17]	285 mm × 75 mm × 75 mm prisms	75

3.1.3. Task 3: AI-Driven Optimization and User-Friendly Software Tool

Explainable AI and MOO algorithms will be applied to optimize the SCALE Concrete mixture based on performance, cost, and sustainability. The AI models will be trained using data obtained from the previous task. A user-friendly software tool will then be developed to allow industry stakeholders to apply the

AI-driven optimization model.

3.1.4. Task 5: Field-Scale Validation

The project will culminate in field-scale trials and pilot projects to validate SCALE concrete's performance under real-world conditions (TRL 6-7).

3.2. Timeline and Milestones

The following table summarizes the project timeline and milestones.

Table 2: Project Timeline and Milestones

Year	**Key Activities and Milestones**
Year 1	Material characterization, test matrix development, laboratory testing
Year 2	AI-driven optimization, software tool development, mid-scale trials
Year 3	Field-scale validation, final software deployment, industry adoption

Technology Readiness Level (TRL) Progression: This project will advance from TRL 4-5 (lab validation) to TRL 6-7 (field-scale demonstration).

4. Potential Economic Impact

The commercialization potential of our low-carbon concrete technology, *SCALE Concrete* is immense, given its combined **economic, environmental**, and **social benefits** to Idaho in particular and the nation in general. This innovation addresses critical challenges in the construction industry, such as carbon emissions, waste management, and the overuse of freshwater resources by offering a cost-effective alternative to **conventional concrete**, while leveraging locally sourced **PCC** from Idaho's sugar beet industry and **wastewater**, including nutrient-rich dairy wastewater. It also reduces reliance on limited drinking water supplies while repurposing waste into valuable resources. In addition, this project generates new revenue opportunities by capitalizing on the sale and licensing of low-carbon formulations. At the same time, it spurs local job creation in engineering, construction, and ancillary service sectors, while fueling growth in both rural and urban areas through the provision of affordable, environmentally responsible construction materials.

Established relations throughout southern Idaho of state entities, contractors, concrete producers, and consultants provide the groundwork for the advancement of technology from the laboratory into various pilot projects. There has been explicit interest among both the state transportation department and the private industry in incorporating the technology into upcoming projects. The plan from both public and private partners for bringing SCALE Concrete into the market would be identifying and selecting low-risk pilot projects utilizing predominately non-structural components to exhibit SCALE Concrete as a viable market-ready product. The idealized market entry point has been largely theorized as retaining walls and dividing barriers, such as the one to be constructed between Pocatello and Idaho Falls as well as future developing transportation corridors throughout Idaho. These projects would be highly visible throughout the state and serve as low-risk conduits for which to exhibit Scale concrete. Additionally, there is interest from the private sector for using the product in retaining walls, both cast-in-place, precast, and masonry blocks. This would further expand the viability of Scale concrete's market thus exhibiting its performance through varying casting conditions. Interested parties includes partnering companies among others who service predominately Northern Idaho and the northwest region as whole.

4.1. Intellectual Property and Competitive Edge: We have a **provisional patent** [6] for the formulation of the concrete, which gives us a competitive advantage. This intellectual property ensures the scalability and attractiveness of our solution for industry adoption at both local and national levels.

4.2. Strong Industry and Government Partnerships: Our strong partnership with Amalgamated Sugar Company, Idaho Transportation Department, Pocatello Development Authority/Colliers Portneuf Valley, Oldcastle Infrastructure, and Idaho National Laboratory will ensure a direct pathway to market through **real-world pilot testing** of the technology, a **steady supply chain** of PCC and wastewater, and scaling capabilities for commercial production. These partners offer the infrastructure necessary to rapidly scale production, while the involvement of ITD guarantees that our concrete will be rigorously tested and implemented in **actual infrastructure projects** across Idaho and statewide. The research team has a rich experience of conducting research and development activities related to concrete materials and structures in Idaho. For instance, the new bridge for the **Fort Hall Interchange over I-15** in Southeast Idaho **employs the precast concrete technology that was developed and fully tested at ISU** in partnership with ITD and other industry champions. This project was also a national **winner for High Value Research from across all transportation systems by the American Association of State Highway and Transportation Officials (AASHTO)** in 2024. Building on the strong foundation of collaboration with ITD and others, the research team has identified a specific infrastructure project in Southeast Idaho where the SCALE Concrete will be potentially implemented. In 2024, ITD was one of the Departments of Transportation in the country to receive $31.9M from the Federal Highway Administration under the Low Carbon Transportation Materials Discretionary Grant Program. The program provides funds to purchase American-made low carbon construction materials such as concrete in transportation projects. ISU is planning to partner with ITD District 5 and other partners to use the SCALE Concrete in construction of the median concrete barrier that will run continuously between Pocatello and Idaho Falls (a distance of 52 Miles) with the addition of new planned lane(s) on I-15. Other pilot projects (e.g., foundations for modular housing) are also planned with the Pocatello Development Authority/Colliers Portneuf Valley. The partnership with Amalgamated Sugar allows for the consistent use of agricultural waste and creates a win-win scenario where waste disposal issues are mitigated while reducing carbon emissions from the construction sector. This positions Idaho as a leader in circular economy practices, where local resources are reused in innovative ways to address global challenges.

4.3. Market Demand and Revenue Generation: The construction industry is under **immense pressure to reduce its carbon footprint**, driven by the global push toward sustainability. The global green building materials market is projected to grow at an **8% compounded annual growth rate (CAGR)** over the next decade, surpassing **$500 billion by 2030**. This demand, driven by federal sustainability mandates and corporate Environmental, Social and Governance (ESG) goals, creates significant opportunities for SCALE Concrete. The ready-mix concrete manufacturing industry in the US over the past five years has grown at a CAGR of 0.9% to $41.5 billion, and it is expected to increase by 2.1% in the next 5 years due to the Infrastructure Investment and Jobs Act. The industry yields a profit of $2.4 billion annually. With more attention being given to environmental laws aimed at reducing emissions and the use of hazardous materials, eco-cements such as those that will come to the market through our low-carbon cement technology are expected to gain a fair share of the market. The state of Idaho alone has 37 companies that produce and sell ready-mix concrete. The ready-mix concrete manufacturing industry in Idaho is currently worth $143.9 million. Assuming we can achieve a conservative 5% market penetration in our first year, we can estimate a potential sales revenue of $7.2 million [19].

Our revenue generation strategy encompasses multiple streams. One will be direct licensing of our patent, where we will target the 37 ready-mix concrete manufacturing locations in Idaho providing a significant local market opportunity [20]. Secondly, partnerships and collaboration with major cement producers like Holcim, Inc. and Ash Grove Cement Company, which have a combined annual capacity of over 1.4 million metric tons in Utah, will expand our reach and accelerate adoption [21]. Finally, we plan to secure government contracts to partner on infrastructure projects, leveraging the eco-friendly aspect of our product to align with government sustainability goals [22].

4.4. Economic Impact Analysis: This project will have a direct and measurable impact on Idaho's economy. Idaho has experienced rapid growth over the past decade with continuous population growth expected through 2032, and it is highly likely that specific sectors will see ever increasing demands. Construction is anticipated to create **more than 16,000 new jobs** in direct correlation to an anticipated population growth of 300,000 by 2032. Additionally, transportation and trades are projected to supply **19,000 additional jobs within Idaho** within that time. Many of these positions will be delivery-based positions heavily taxing the state's existing and developing infrastructure as digital shopping steadily increases the demand for product transportation throughout the state. Concrete roads and barriers have increased in use over the past decades as proven solutions for increasing the life spans and safety of roadways. SCALE Concrete stands to be a viable solution for substituting the large cement consumption of an ever growing market in a rapidly expanding state.

4.5. Idaho's Competitive Advantage and Long-term Benefits: Idaho's economy will experience a lasting transformation into a hub for sustainable construction materials as a direct outcome of commercializing this solution, which will draw new businesses seeking eco-friendly innovations. The synergy of local resource utilization and robust industry partnerships places the state at the forefront of low-carbon development, fueling investment in manufacturing, research, and supportive service sectors. By replacing potable water in concrete production, this technology addresses Idaho's rising water demand and mitigates the environmental risks associated with wastewater disposal, such as nitrate contamination and eutrophication. In the long term, these advancements will elevate Idaho's competitive standing in both national and international markets and enhance its resilience in an evolving regulatory and environmental landscape. Furthermore, the **environmental benefits** are significant as they directly contribute to **Idaho's climate goals** and help the state transition toward a **low-carbon economy**. It will also position Idaho as a leader in the **meaningful and socially impactful application of AI**, demonstrating how **emerging technologies** can drive sustainable innovations that benefit both industry and society. This project represents the use of **AI** for **practical, high-impact solutions** that **address environmental challenges, enhance resource efficiency, and support economic growth**. In addition, it strengthens Idaho's water management practices, creates more jobs, and drives innovation.

4.6. Path to Profitability: A conservative three-year timeline for profitability is outlined below, aligning with the project's key milestones. Year 1 focuses on **material characterization, test matrix development, and laboratory testing**, which serve as the foundation for validating SCALE-Concrete's feasibility. At this stage, the project is focused on research and development without generating immediate revenue. In Year

2, the project transitions to **AI-driven optimization, software tool development, and mid-scale trials**. This phase enables early adopters, including ITD, to begin limited deployment of the technology. Initial revenue is expected as industry stakeholders test and validate the technology in controlled settings. By Year 3, the project will reach **field-scale validation, final software deployment, and industry adoption**. SCALE-Concrete will be integrated into large-scale infrastructure projects, leading to **sustained revenue streams** and positioning the project for long-term profitability.

Beyond Year 3, achieving even a **5% penetration** in Idaho's **$143.9 million** ready-mix market could yield approximately **$7.2 million in annual revenue**. This potential is expected to grow further as **regional and national demand** for **low-carbon, resource-efficient construction materials** increases. Additionally, the **AI-driven optimization tool** will provide a competitive edge, attracting both **local and out-of-state producers** seeking to rapidly adapt mix designs for different environmental and structural requirements, thereby expanding the market reach beyond Idaho. This commercial trajectory highlights the project's economic viability, positioning it as a transformative solution for both **Idaho's construction industry and broader national markets**.

5. Criteria for Measuring Success

The success of this project will be assessed using specific, objective, measurable, and realistic metrics to ensure that progress is effectively tracked on an annual basis. These metrics are categorized into three primary areas: **(a) technical performance, (b) economic impact,** and **(c) technology adoption**.

(a) **Technical Performance**: The project's technical success will be evaluated based on the performance of the SCALE Concrete mixes in terms of all KPIs in Table 1 for both structural and non-structural applications in addition to carbon footprint reduction. The compressive strength must reach at least **80% of the reference mix's strength at 28 days** to ensure structural reliability. The same is true for flexural strength. Workability will be monitored to ensure practical handling and placement of the concrete mix. Durability under freeze-thaw cycles will be assessed by ensuring that the developed material maintains resilience with **less than a 20% reduction in dynamic modulus** after testing. Additionally, the project aims to achieve a **minimum 25–30% reduction in CO_2 emissions** compared to conventional cement-based concrete.

(b) **Economic Impact**: The economic viability of the project will be determined through commercialization and market integration metrics. This includes securing at least **two commercial-scale partnerships** by the end of Year 3 to ensure industry adoption. Workforce development will be tracked by quantifying the **number of engineering professionals trained**, focusing on upskilling local talent in sustainable construction.

(c) **Technology Adoption**: The success of the AI-driven optimization tool will be measured by its academic and industry adoption. The number of research groups utilizing the AI-driven optimization tool for material innovation will be tracked, alongside scientific recognition in the form of **citations and references in peer-reviewed journals, industry reports, and conference proceedings**.

6. Development Challenges and Mitigation Strategies

Anticipated development challenges primarily revolve around variability in PCC composition and wastewater quality, scale-up logistics, and regulatory acceptance. Due to the heterogeneous nature of wastewater-derived materials, fluctuations in **chemical composition, particulate content, and impurity levels** may impact the consistency of the final mix. To mitigate these variations, the project team will implement a **rigorous**

characterization protocol for raw inputs and continuously refine the AI-driven mix design algorithm to dynamically adjust for fluctuations in both chemical and physical properties.

Scaling from laboratory to pilot and commercial applications presents another challenge, particularly in ensuring **process efficiency and structural reliability**. To address these issues, the project team will collaborate with industry partners to conduct **controlled field trials**. These trials will generate real-world performance data that inform necessary modifications in the mix design and curing protocols or any other required modifications.

Regulatory approval is another potential barrier, particularly regarding the **acceptance of SCALE Concrete in construction applications**. Early and ongoing engagement with ITD will ensure compliance with industry standards and facilitate smooth integration into infrastructure projects. This proactive approach will also provide necessary documentation to support policy adjustments that encourage sustainable material adoption.

Should **unanticipated research and development hurdles** arise—such as performance discrepancies in large-scale applications or unforeseen interactions between wastewater constituents and PCC, the project team will deploy a structured problem-solving framework. This will involve **accelerated testing cycles and iterative performance optimization**. Data-driven contingency planning will be utilized to ensure that the project remains on track toward achieving both technical and commercialization milestones.

7. Budget Justification

i. ISU Personnel – Total Request: $160,672 (Y1 - $, Y2 - $, Y3 - $)
PI: Dr. Tadesse Wakjira (3 months – Non-classified Salary: $16,993). Co-Investigators: Dr. Mustafa Mashal (1.5 months – Summer Salary: $17,625), Dr. Kavita Sharma (1.5 months – Summer Salary: $15,462), Dr. James Mahar (0.75 months – Summer Salary: $11,208), and Jared Cantrell (1.5 months – Non-classified Salary: $22,110). Technician and Industry Liaison: 18 months – Non-classified Salary: $77,273).

ii. Students Funding – Total Salary Request: $196,500 (Y1 - $58,500, Y2 - $69,000, Y3 - $69,000).

iii. Fringe Benefits ISU – Total Request: $48,389 (Y1 - $15,579, Y2 - $16,178, Y3 - $16,632). Fringe Rates: Summer Salary – 15.1%, Non-Classified – 33.3%, Student – 1.5%.

iv. Travel Funding – Total Request: $9,000 (Y1 - $3,000, Y2 - $3,000, Y3 - $3,000). Covers in-state and surrounding state overnight or two-night travel for 2–4 attendees for industry and workforce training.

v. Materials & Supplies – Total Request: $52,500 (Y1 - $12,500, Y2 - $22,500, Y3 - $17,500). Includes sample preparation consumables, sample analysis, mix materials, forms, tools, and sample testing.

vi. Computer Services – Total Request: $5,000 (Y1 - $4,000, Y2 - $500, Y3 - $500). Funds computing laptops for modeling and program subscriptions.

vii. Laboratory Fees – Total Request: $12,000 (Y1 - $4,000, Y2 - $4,000, Y3 - $4,000). Covers laboratory testing space allocation, equipment use, and maintenance.

viii. Total Direct Costs: $547,011 (Y1 - $173,761, Y2 – $194,129, Y3 - $179,120).

8. Project Management

Table 3 presents a Gantt chart outlining key research phases, development milestones, and implementation stages for the project. This structured timeline ensures that all tasks are scheduled efficiently over the three-year duration, covering material characterization and laboratory validation in Year 1, AI-driven optimization and mid-scale trials in Year 2, and field-scale validation and industry adoption in Year 3.

The project will be led by the PI, who will be responsible for overall project leadership, administrative coordination, and ensuring milestone completion. Co-Investigators will lead specific research components, supervise graduate researchers, and contribute domain expertise in structural engineering, materials science, environmental impact, and computational modeling. The Laboratory Manager will oversee laboratory operations, ensure proper testing conditions, and manage large-scale experimental setups. Graduate researchers will assist with data collection, conduct experimental and computational research, and support implementation efforts. Moreover, regular project meetings will be conducted to monitor progress, address challenges, and ensure alignment with project objectives. These meetings will also serve as checkpoints for evaluating milestone achievements and ensuring that the research activities stay on schedule, as depicted in Table 3.

Table 3: Proposed Project Schedule

Research Activities	**Year 1**				**Year 2**				**Year 3**			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Material Characterization & Lab Testing												
AI-driven Optimization & Software Development												
Mid-Scale Trials												
Field-Scale Validation & Industry Adoption												

9. Additional Institutional and Other Sector Support

Idaho State University's Office for Research is committed to supporting this project by facilitating technology transfer, strengthening industry collaboration, and assisting with commercialization efforts. The ISU Technology Commercialization Office will provide guidance in promoting research advancements and engaging with industry stakeholders. Additionally, the project will benefit from ISU's involvement in the NSF-funded EMERGE initiative, which enhances collaboration between university researchers and industry partners, as well as ISU's affiliation with the Oak Ridge Association of Universities, which provides access to government and industry resources. The Office for Research will further support the project by connecting researchers with industry leaders and providing resources to ensure the commercialization of research outcomes. These institutional commitments will help drive the successful development and implementation of this project, contributing to Idaho's innovation ecosystem and economic growth.

10. Future Funding

To ensure the continued advancement of this project along the TRL continuum, multiple funding avenues will be pursued. A primary target for funding is the U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy (EERE), which continues to support the advancement of energy technologies and processes. Additionally, the National Science Foundation (NSF) Partnerships for Innovation (PFI) program will be explored to facilitate technology commercialization and industry collaboration. Industry partnerships will be actively developed to secure co-funding from major construction firms, precast concrete manufacturers, and sustainability-driven investment groups. Furthermore, applications will be submitted to the Federal Highway Administration (FHWA) and the U.S. Environmental Protection Agency (EPA) for programs that support sustainable infrastructure and circular economy initiatives.

References

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[7] T. G. Wakjira, A. A. Kutty, M. S. Alam, A novel framework for developing environmentally sustainable and cost-effective ultra-high-performance concrete (UHPC) using advanced machine learning and multi-objective optimization techniques, Construction and Building Materials 416 (2024). doi:10.1016/j.conbuildmat.2024.135114.

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Table A1. Facilities in the Department of Civil and Environmental Engineering

Facility	Description / Equipment
Concrete Lab	• Gilson Concrete Compression Machine (Hveem-N-Beam Tester) with Pro Controller, 300 kips capacity, and 2.5” stroke • Three concrete mixers • ASTM Test Fixture for 4-point bending test • Emodumeter (E-meter) for Modulus of Elasticity • ASTM Shrinkage Testing Apparatus • Compressometer/Extensometer for Poisson ratio for concrete • Multiple complete sets of sieves • Concrete Cylinder Capping Components • Fog Room includes Concrete Curing Tank and Curing Tank Heater • Caron Freeze-Thaw Chamber • Aggregate drying oven • Specific Gravity & Absorption of Fine Aggregate Set • Fine Aggregate Angularity Apparatus • Four-Station Proportional Caliper • Quick Release Powder Kit for Unbonded Capping Sets • 4in Steel Retainer Set and Neoprene Pad, 60 Durometer • Plenty of metal cylindrical/cubic molds (different sizes) • Three steel concrete beam mold
Structural Lab	• Capable of testing specimens up to 38 ft. in length and 14 ft. height • Total Lab Area = 1520 sqft • Strong floor is 2 ft. deep and 875 sqft of structural floor • 374 anchor sleeves (each rated 100 kips) in grids of 18in • The hydraulic actuators can collectively produce force of 1.3 million lbs. • Heavy duty steel reaction frames designed for 400 kips loading • Dual servo-valve hydraulic actuators (static and dynamic), each with 160 kips capacity and ±12”stroke • Tinius Olsen Universal Testing Machine, 120 kips capacity and ±12” stroke • Enerpac jack, 440 kips capacity, and 6” stroke • Hydraforce hollow jack, 220 kips capacity, and 3” stroke • Six servo-valve hydraulic actuators (static) with 10 kips capacity and ±4” stroke

	• Several hydraulic pumps, jacks, and accessories • Controller system for hydraulic actuators with data acquisition for 20 channels • Brand new Campbell Scientific data acquisition system with 96 channels, and up to 800 Hz sampling rate • Vishay data acquisition system (20 channels) • Forklift, 5 kips capacity, and 83” clearance • Gantry crane, 8 kips capacity, and 144” clearance • High Resolution Camera • Several load cells, up to 300 kips capacity • Accelerometers, Load Cells, LVDTs, Potentiometers, and Strain Gauges
Structural Dynamics Lab	This facility is used for shake table testing of structural and non-structural models. • Uni-directional horizontal shake table with MTS servo-valve actuator, 10 kips capacity, ±3” stroke, 31 in/sec velocity, 50 Hz 4.5 ft. x 4.5 ft. • Uni-directional vertical shake table with MTS servo-valve actuator, 3 kips capacity, ±3” stroke, 31 in/sec velocity, 50 Hz, 2 ft. x 2 ft. • Clearance height of 12 ft. • Two Spectral Dynamics PUMA Controller software integrated with data acquisition system (10 channels), antialiasing filters, and sampling rate in excess of 2,000 Hz • Two 50HP powerful hydraulic pumps with 22 GPM capacity and manifolds for the hydraulic actuators • One extra servo-valve MTS dynamic actuator, 10 kips capacity and ±3” stroke, 31 in/sec velocity • Accelerometers, Load Cells, LVDTs, Potentiometers, and Strain Gauges • State-of-the-art Laser Vibrometer Test Setup, data acquisition, controller, and all others accessories
Drop and Impact Platform	An outdoor reinforced concrete and steel armored pad for drop/impact testing. • The reinforced concrete pad is 13 ft. x 13 ft. and 6 ft. thick • The pad is armored with 2 in thick steel plate on top which is 8 ft. x 8 ft. • Road access for crane and other heavy equipment is available
Civil Materials Lab	This lab is used for general testing, material characterization, and teaching. • Tinius Olsen Universal Testing Machine, 60 kips capacity, ±6” stroke, recently retrofitted with new software and controller • United Universal Testing Machine, 30 kips capacity, ±12” stroke • Charpy V-Notch Testing Machine • Vishay data acquisition system (20 channels)

	• Vishay strain gauge data acquisition system and boxes (20 channels) • Electric uni-directional horizontal shake table, ±0.5” stroke, 11 Hz, 2 ft x 2 ft • Two Rockwell Hardness Testers • Seating for up to 33 students, projector, boards and other instruction equipment • Five high performance laptops • Instruments, electronic metal detector, digital calipers, digital pocket thermometers, and other equipment
Asphalt Lab	This lab is capable of preparing asphalt samples and testing. • California Kneading Compactor: Cox & Sons Kneading Compactor • Caron Freeze-Thaw Chamber • Hveem Stabilometer • Oven (Capable of Maintaining a Temperature Of 140 Degrees Fahrenheit) • 12qt. Digital Melting Pot • Spoons, pots, and other accessories
Geotechnical Lab	Comprehensive lab for soil testing and geotechnical research. • Over 950 sqft of floor space for physical modeling and component testing • California Bearing Ratio machine with the capacity of 10,000 lbs • Unconfined Compressive Strength machine with the capacity of 2,500 lbs • Six Casagrande devices and two microwaves for running Atterberg limits tests • Direct Shear test device • Different size of molds and hammers for running compaction test (four 4-inch and four 6-inch molds, four 5.5-lb hammers and two 10-lb hammers) • Consolidation test device • Three different sizes of sand cone • Four scales with capacity of 6,000 g with accuracy of 0.01g, one scale with capacity of 30 kg with accuracy of 0.002 kg • Three sets of different size of sieves and two shaking machines for Grain Size Distribution test • Different size of shovels, spatulas and tape measures for site surveying • Permeameter device for Permeability test • 5,000 lbs ATS Universal Testing Machine

Table A2. Facilities in the Department of Chemistry

Facilities/ Equipment	Description
Agilent 6890 Gas Chromatography (GC/MS)	• Electronic pneumatic control of gas flows and pressures, with pressure resolution of 0.01 psi • Capable with He, H2, N2, Ar/MeOH carrier gases • 28x13x16 column oven, capable of upper temperature of 450 ºC, with set point resolution of 1ºC • Programmable oven ramping, with a maximum input of 6 ramps and 7 plateaus • Split/Splitless capillary inlet, equipped with programmable temperature control and maximum pressure set point of 100psi
Agilent 5973N Mass Selective Detector	• Temperature control hyperbolic quadruple filter, with selective mass range of 10-800 amu • High performance turbo molecular pump • High energy dynode electron multiplier detector
Varian 720 Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES)	• Argon plasma, with radially oriented CCD detector • Capable of detecting 50 elements per sample
Differential Scanning Calorimeter-Thermal Gravimetric Analyzer (DSC-TGA)	• Inert gas heating capacities for microscale environment. • Temperature range RT up to 1400 °C • Heating and cooling rates 0,1 up to 50 °C/min • Temperature accuracy +/-0,5 °C • Vacuum 10-2 Pa • Crucibles Al2O3 0,12 ml, Platinum 0,12 ml
Agilent 6545 Liquid Chromatography-Mass Spectroscopy Quadrupole-Time of Flight (LC-MS QTOF)	• LC pumps can handle up to 600 psi • MS and MS/MS on the fly • Mass Range of up to 3200m/z • Sensitivity up to 1pg • Rapid switching between positive and negative ion mode

Biographical Sketch – Tadesse Gemeda Wakjira

Identifying Information

NAME: Wakjira, Tadesse Gemeda

ORCID ID: https://orcid.org/0000-0003-2572-6329

POSITION TITLE: Postdoctoral Researcher

PRIMARY ORGANIZATION: Idaho State University, Pocatello, Idaho, USA

Professional Preparation

ORGANIZATION AND LOCATION	DEGREE (IF APPLICABLE)	RECEIPT DATE	FIELD OF STUDY
The University of British Columbia, Kelowna, BC, Canada	Ph.D.	2024	Civil Engineering
Qatar University, Doha, Qatar	Ph.D.	2022	Civil Engineering
Qatar University, Doha, Qatar	M.S.	2018	Civil Engineering
Adama Science and Technology University, Adama, Ethiopia	B.S.	2013	Civil Engineering

Appointments and Positions

2024 – present: Postdoctoral Researcher, Idaho State University, Pocatello, Idaho, USA

08/2022 - 12/2023: Graduate Research Assistant, The University of British Columbia, Okanagan, BC, Canada

09/2019 - 07/2022: Graduate Research and Teaching Assistant, Qatar University, Doha, Qatar

Products

Products most closely related to the proposed project

1. Dey A., Rumman R., Wakjira T., et al. (2024). Towards net-zero emission: A case study investigating the sustainability potential of geopolymer concrete with recycled glass powder and gold mine tailings. Journal of Building Engineering, Elsevier, https://doi.org/10.1016/j.jobe.2024.108683.
2. Wakjira T., Kutty A., Alam MS. (2024). A novel framework for developing environmentally sustainable and cost-effective ultra-high-performance concrete (UHPC) using advanced machine learning and multi-objective optimization techniques. Construction and Building Materials, Elsevier, Vol. 416, 135114, https://doi.org/10.1016/j.conbuildmat.2024.135114.

3. Al Martini S., Sabouni R., Khartabil A., Wakjira T., Alam MS. (2023). Development and strength prediction of sustainable concrete having binary and ternary cementitious blends and incorporating recycled aggregates from demolished UAE buildings: Experimental and machine learning-based studies. Construction and Building Materials, Elsevier, Vol. 380, 131278. https://doi.org/10.1016/j.conbuildmat.2023.131278.
4. Al Sholi H., Wakjira T., Habib S., Alfadhli M., Aejas B., Onat N., Kucukvar M., Kim D., (2023). How circular economy can reduce scope 3 carbon footprints: Lessons learned from FIFA world cup Qatar 2022. Circular Economy, Elsevier, Vol. 2(1), 100026. https://doi.org/10.1016/j.cec.2023.100026.
5. Wakjira T., Abushanab A., Alam MS. (2024). Hybrid machine learning model and predictive equations for compressive stress-strain constitutive modelling of confined ultra-high-performance concrete (UHPC) with normal-strength steel and high-strength steel spirals. Engineering Structures, Elsevier, Vol. 304, 117633, https://doi.org/10.1016/j.engstruct.2024.117633.
6. Wakjira T., Alam MS. (2024). Peak and ultimate stress-strain model of confined ultra-high-performance concrete (UHPC) using hybrid machine learning model with conditional tabular generative adversarial network. Applied Soft Computing, Elsevier, Vol. 154, 111353, https://doi.org/10.1016/j.asoc.2024.111353.

Other significant products

1. Wakjira T., Abushanab A., Alam MS., Alnahhal W., Plevris V. (2024). Explainable machine learning-aided efficient prediction model and software tool for bond strength of concrete with corroded reinforcement. Structures, Elsevier, Vol. 59, 105693.
2. Al-Hamrani A., Wakjira T., Alnahhal W., Ebead U. (2023). Sensitivity Analysis and Genetic Algorithm-based Shear Capacity Model for Basalt FRC One-way Slabs Reinforced with BFRP bars. Composite Structures, Elsevier, Vol. 305, 116473.
3. Kutty A., Wakjira T., Kucukvar M., Abdella G., Onat N. (2022). Urban resilience and livability performance of European smart cities: A machine learning approach. Journal of Cleaner Production, Elsevier, Vol. 378, 134203.
4. Wakjira T., Abushanab A., Ebead U., Alnahhal W. (2022). FAI: Fast, accurate, and intelligent approach and prediction tool for flexural capacity of FRP-RC beams based on super-learner machine learning model. Materials Today Communications Journal, Elsevier, Vol. 33, 104461.
5. Wakjira T., Rahmzadeh A., Alam MS., Tremblay R. (2022). Explainable Machine Learning Based Efficient Prediction Tool for Lateral Cyclic Response of Post-Tensioned Base Rocking Steel Bridge Piers Structures. Structures Journal, Elsevier, Vol 44, 947-964.
6. Kennedy-Kuiper R., Wakjira T., Alam MS. (2022). Repair and retrofit of RC bridge piers with steel reinforced grout jackets: An experimental investigation. Journal of Bridge Engineering, ASCE, Vol. 27(8), 04022067.

7. Wakjira T., Alam MS., Ebead U. (2021). Plastic hinge length of rectangular RC columns using ensemble machine learning model. Engineering Structures, Elsevier, Vol. 244, 112808.
8. Wakjira T., Nehdi ML., Ebead U. (2020). Fractional factorial design model for seismic performance of RC bridge piers retrofitted with steel-reinforced polymer composites. Engineering Structures, Elsevier, Vol. 221, 111100.
9. Wakjira T., Ebead U. (2020). Shear span-to-depth ratio effect on steel reinforced grout strengthened reinforced concrete beams." Engineering Structures, Elsevier, Vol. 216, 110737.
10. Wakjira T., Ebead U. (2020). "Simplified Compression Field Theory-Based Model for Shear Strength of Fabric-Reinforced Cementitious Matrix-Strengthened Reinforced Concrete Beams." ACI Structural Journal, ACI, Vol. 117, 91–104.

Synergistic Activities

- ACI 341-0C Earthquake Resistant Bridges-Retrofit, Voting Committee Member (2023 - Present)
- American Society of Civil Engineers (ASCE), Associate Member
- Associate Editor, Innovative Infrastructure Solutions journal, by Springer (ISSN 2364-4184)
- Associate Editor, Computational Methods in Structural Engineering, specialty section of the journal Frontiers in Built Environment, by Frontiers (ISSN 2297-3362)
- Editorial Board Member, Buildings, by MDPI (ISSN 2075-5309)
- Academic Editor, The Scientific World Journal, by Hindawi (ISSN 2356-6140)
- Academic Editor, Research on Engineering Structures and Materials, by MIM Research Group (ISSN: 2148-9807)
- Editorial Board Member, International Journal of Computer Aided Engineering and Technology, by Inderscience (ISSN 1757-2665)
- Editorial Board Member, Smart and Sustainable Built Environment, by Emerald Publishing (ISSN: 2046-6099)

Certification

By submitting this biosketch, I certify that the information is current, accurate, and complete. This includes, but is not limited to, information related to domestic and foreign appointments and positions. Misrepresentations and/or omissions may be subject to prosecution and liability pursuant to, but not limited to, 18 U.S.C. §§ 287, 1001, 1031, and 31 U.S.C. §§ 3729-3733 and 3802.

Certified by Tadesse Gemeda Wakjira on 2024-05-29 01:05:29

Biographical Sketch – Mustafa Mashal

Identifying Information

NAME: Mashal, Mustafa

ORCID ID: https://orcid.org/0000-0003-4654-0531

POSITION TITLE: Professor

PRIMARY ORGANIZATION: Idaho State University, Pocatello, Idaho, USA

Professional Preparation

ORGANIZATION AND LOCATION	DEGREE (IF APPLICABLE)	RECEIPT DATE	FIELD OF STUDY
University of Canterbury	PhD	2015	Civil Engineering
The State University of New York at Buffalo	M.S.	2011	Civil Engineering
Kabul University	B.S.	2009	Civil Engineering

Appointments and Positions

01/2023 – Present: Associate Director, Center for Advanced Energy Studies, Idaho, United States

01/2023 – Present: Joint Appointee, Idaho National Laboratory, Idaho, United States

04/2024 – Present: Professor & Director, Idaho State University, Idaho, United States

05/2020 – Present: Associate Professor & Director, Idaho State University, Idaho, United States

08/2022 – 06/2023: Fulbright U.S. Scholar, Qatar University, Doha, Qatar

05/2022 – 08/2022: Visiting Erskine Fellow, University of Canterbury, Christchurch, New Zealand

06/2017 – 05/2020: Assistant Professor & Director, Idaho State University, Idaho, United States

07/2016 – 05/2017: Visiting Assistant Professor, Idaho State University, Idaho, United States

Awards and Honors

1. 2023: Fellow of the Structural Engineering Institute (F.SEI) of the American Society of Civil Engineers
2. 2022: Fulbright U.S. Scholar Award (Qatar)
3. 2023: Fulbright Regional Travel Program (Jordan)
4. 2023: Accomplished Under 40

5. 2022: University of Canterbury Visiting Erskine Fellowship
6. 2022: Al Fikra National Entrepreneurship Competition (Shortlisted)
7. 2021: CAES Annual Pitch Event 2021 (Pathways to INL Net Zero) - Winner of Track C “Open Submission”
8. 2020: Alfred Noble Prize
9. 2020: CAES Fellow
10. 2020: Distinguished Teacher Award (Shortlisted)
11. 2019: Winner of the “Be a Bengal” (Stability)
12. 2019: ASCE Southern Idaho Section Outstanding Civil Engineer of the Year Award
13. 2019: Career Path Internship (CPI) Supervisor of the Semester – Runner Up
14. 2019: Laboratory Operations Supervisor Academy (LOSA)
15. 2019: ASCE/SEI Tier 1 Young Professional Scholarship
16. 2018: ASCE ExCEEd Faculty Fellowship
17. 2017: Idaho State University’s Teaching Innovation Grant
18. 2014: New Zealand Concrete Society Travel Bursary
19. 2014: ASEC Conference Registration Prize
20. 2013: New Zealand Society for Earthquake Engineering (NZSEE) Research Scholarship
21. 2013: New Zealand Concrete Society (NZCS) “Concrete Prize”
22. 2013: University of Canterbury Research and Innovation Grant “The Stimulator”
23. 2011: University of Canterbury Doctoral Scholarship
24. 2009: Fulbright Foreign Student Program
25. 2009: Excellent Lead Instructor
26. 2008: SAARC - Japan Leadership Development Study Tour
27. 2006: Certificate of Achievement

Products

Products most closely related to the proposed project

1. K. Phuyal, U. Sharma, J. Mahar, K. Mondal, and M. Mashal (2023). Reducing the Carbon Footprint through the Utilization of Precipitated Calcium Carbonate (PCC) in Soil-Cement Applications. Civil Eng. MDPI.
2. K. Phuyal, U. Sharma, J. Mahar, K. Mondal, and M. Mashal (2024). Reducing the Carbon Footprint through the Utilization of Precipitated Calcium Carbonate (PCC) in Soil-Cement Applications. Civil Eng. Sustainability MDPI, 16(5):1909.
3. M. Mahat, M. Acharya, and M. Mashal (2023). The Use of Waste Tires as Transverse Reinforcement and External Confinement in Concrete Columns Subjected to Axial Loads. MDPI Applied Sciences, special issue on Materials for Civil Construction and Sustainability, Vol. 15(15), 11620.
4. A. Ebrahimpour, A. Shokrgozar, and M. Mashal (2023). Field Performance of High-Early Strength Concrete with Polypropylene Fibers as a Cost-Effective Alternative for Longitudinal Connection Between Bridge Deck Bulb-T Girders. ASCE Journal of Performance of Constructed Facilities, 37(3): 04023015.

5. A. Ebrahimpour, A. Shokrgozar, and M. Mashal (2023). Field Performance of High-Early Strength Concrete with Polypropylene Fibers as a Cost-Effective Alternative for Longitudinal Connection Between Bridge Deck Bulb-T Girders. ASCE Journal of Performance of Constructed Facilities, 37(3): 04023015.

Other significant products

1. M. Mashal, J. Mahar, K. Mondal, K. Phuyal (2024). “Eco-Friendly Concrete and Soil Cement Utilizing Waste Products”, United States Patent and Trademark Office, 63/638,006.
2. M. Mashal (2023). “Ductile Connections for Pre-Formed Construction Element”, United States Patent and Trademark Office, US11788314B2.
3. K. Hogarth, A. Ebrahimpour and M. Mashal (2023) . Experimental Validation of Repair Methods for Earthquake-Damaged Bridges Incorporating Pipe-Socket Precast Pier System. International Conference on Civil Infrastructure and Construction (CIC 2023), Qatar University, Doha, Qatar. - Winner of the Best Paper in Theme 2 “Advances in Infrastructure Sustainability, Renovation, and Monitoring” at CIC 2023 in Doha, Qatar.
4. M. Mashal and A. Palermo (2019) . Low-Damage Seismic Design for Accelerated Bridge Construction, Special Issue on Accelerated Bridge Construction, ASCE Journal of Bridge Engineering, Vol 24(7). - Winner of 2020 Alfred Noble Prize from the American Society of Civil Engineers.
5. M. Casanova, C. Clauson, A. Ebrahimpour, and M. Mashal (2019) . High-Early Strength Concrete with Polypropylene Fibers as a Cost-Effective Alternative for Field-Cast Connections of Precast Elements in Accelerated Bridge Construction, ASCE Journal of Materials in Civil Engineering, Vol 31(11). - One of the 2019 Sweet Sixteen (High Value Research Projects) by the American Association of State Highway and Transportation Officials (AASHTO) Research Advisory Committee (RAC)/Transportation Research Board (TRB).

Synergistic Activities

1. Fulbright U.S. Scholar, Qatar (2022-23)
2. University of Canterbury Visiting Erskine Fellowship, New Zealand (2022)
3. Fellow of the American Society of Civil Engineers - Structural Engineering Institute (2023)
4. Fellow of the Center for Advanced Energy Studies (2020)
5. ASCE Alfred Noble Prize Winner (2020)

Certification

By submitting this biosketch, I certify that the information is current, accurate, and complete. This includes, but is not limited to, information related to domestic and foreign appointments and positions. Misrepresentations and/or omissions may be subject to prosecution and liability pursuant to, but not limited to, 18 U.S.C. §§ 287, 1001, 1031, and 31 U.S.C. §§ 3729-3733 and 3802.

Certified by Mustafa Mashal on 2024-06-13 11:21:45

IDENTIFYING INFORMATION:

NAME: Sharma, Kavita

POSITION TITLE: Assistant Professor

PRIMARY ORGANIZATION AND LOCATION: Department of Biomedical and Pharmaceutical Sciences, Idaho State University, Pocatello, Idaho, United States

Professional Preparation:

ORGANIZATION AND LOCATION	DEGREE (if applicable)	RECEIPT DATE	FIELD OF STUDY
Konkuk University, Seoul, Gyeonggi , South Korea	PHD	02/2015	Molecular Biotechnology
University of Pune, Pune, Maharashtra, India	MS	06/2007	Analytical Chemistry
University of Pune, Pune, Maharashtra, India	BS	06/2005	Chemistry

Appointments and Positions

2024 - present Assistant Professor, Department of Biomedical and Pharmaceutical Sciences, Idaho State University, Pocatello, Idaho, United States

2022 - 2024 Research Assistant Professor, Department of Biomedical and Pharmaceutical Sciences, Idaho State University, Pocatello, Idaho, United States

2021 - 2022 Postdoc Researcher, Dept. of Biomedical and Pharmaceutical Sciences, Idaho State University, Pocatello, Idaho, United States

2017 - 2020 Research Assistant Professor, Department of Chemistry, Idaho State University/Idaho National Laboratory, Pocatello, Idaho, United States

2015 - 2017 Assistant Professor, Yeungnam University, Gyeongsan, Gyeongsang, South Korea

2007 - 2010 Research Chemist, CHEMBIOTEK Research International Pvt. Ltd., Pune, Maharashtra, India

Products

Products Most Closely Related to the Proposed Project

1. De Jesus K, Rodriguez R, Baek D, Fox R, Sharma K. Extraction of lanthanides and actinides present in spent nuclear fuel partitioning and in electronic waste. Journal of Molecular Liquids. 2022; 336(13):116006.
2. Paucar N, Kiggins K, Blad B, De Jesus K, Pashikanti S. Ionic liquids for the removal of sulfur and nitrogen compounds in fuels: a review. Environmental Chemistry Letters. 2020.
3. Saini RK, Ranjit A, Sharma K, Prasad P, Shang X, Gowda KGM, Keum YS. Bioactive Compounds of Citrus Fruits: A Review of Composition and Health Benefits of Carotenoids, Flavonoids, Limonoids, and Terpenes. Antioxidants (Basel). 2022 Jan 26;11(2) PubMed Central PMCID: PMC8868476.
4. Anibogwu R, Jesus K, Pradhan S, Leuven SV, Sharma K. Sesquiterpene Lactones and Flavonoid from the Leaves of Basin Big Sagebrush (Artemisia tridentata subsp. tridentata): Isolation, Characterization and Biological Activities. Molecules. 2024 Feb 9;29(4) PubMed

Central PMCID: PMC10892904.

5. Struhs E, Hansen S, Mirkouei A, Ramirez-Corredores MM, Sharma K, Spiers R, Kalivas JH. Ultrasonic-assisted catalytic transfer hydrogenation for upgrading pyrolysis-oil. Ultrason Sonochem. 2021 May;73:105502. PubMed Central PMCID: PMC7921008.

Other Significant Products, Whether or Not Related to the Proposed Project

1. Mahato N, Sharma K, Sinha M, Baral ER, Koteswararao R, Dhyani A, Hwan Cho M, Cho S. Bio-sorbents, industrially important chemicals and novel materials from citrus processing waste as a sustainable and renewable bioresource: A review. J Adv Res. 2020 May;23:61-82. PubMed Central PMCID: PMC7021529.
2. Sharma K, Mahato N, Lee YR. Systematic study on active compounds as antibacterial and antibiofilm agent in aging onions. J Food Drug Anal. 2018 Apr;26(2):518-528. PubMed Central PMCID: PMC9322202.
3. Nile SH, Nile AS, Keum YS, Sharma K. Utilization of quercetin and quercetin glycosides from onion (Allium cepa L.) solid waste as an antioxidant, urease and xanthine oxidase inhibitors. Food Chem. 2017 Nov 15;235:119-126. PubMed PMID: 28554615.
4. Mahato N, Sinha M, Sharma K, Koteswararao R, Cho MH. Modern Extraction and Purification Techniques for Obtaining High Purity Food-Grade Bioactive Compounds and Value-Added Co-Products from Citrus Wastes. Foods. 2019 Oct 23;8(11) PubMed Central PMCID: PMC6915388.
5. Anibogwu R, Jesus K, Pradhan S, Pashikanti S, Mateen S, Sharma K. Extraction, Isolation and Characterization of Bioactive Compounds from Artemisia and Their Biological Significance: A Review. Molecules. 2021 Nov 19;26(22) PubMed Central PMCID: PMC8618776.

Certification:

I certify that the information provided is current, accurate, and complete. This includes but is not limited to current, pending, and other support (both foreign and domestic) as defined in 42 U.S.C. § 6605.

I also certify that, at the time of submission, I am not a party to a malign foreign talent recruitment program.

Misrepresentations and/or omissions may be subject to prosecution and liability pursuant to, but not limited to, 18 U.S.C. §§ 287, 1001, 1031 and 31 U.S.C. §§ 3729-3733 and 3802.

Certified by Sharma, Kavita in SciENcv on 2025-02-22 22:08:02

02/20/2025 NSF BIOGRAPHICAL SKETCH

IDENTIFYING INFORMATION:

NAME: Mahar, James

POSITION TITLE: Senior Lecturer

PRIMARY ORGANIZATION AND LOCATION: Idaho State University, Pocatello, Idaho, United States

Professional Preparation:

ORGANIZATION AND LOCATION	DEGREE	RECEIPT DATE	FIELD OF STUDY
Idaho State University, Pocatello, ID United States	BS	05/1967	Geology
Colorado State University, Ft Collins, CO United States	MS	05/1972	Hydrogeology
University if Illinois, Champaign-Urbana, IL United States	PhD	05/1977	Engineering Geology/ Soil/Rock Engineering

Appointments and Positions

2003 – Present Senior Lecturer, Idaho State University, Civil and Environmental Engineering/Geosciences, United States
1971 – Present Owner, Geotechnical Consultants Inc, Savoy, Illinois, United States.
1971-1974 Research Assistance, University of Illinois at Urbana-Champaign, United States
1975-1980 Visiting Assistant Professor, University of Illinois at Urbana-Champaign, United States
1980-1995 Research Engineer, University of Illinois at Urbana-Champaign, United States.

Professional Licenses:

State of Illinois: Geologist #196-000325
State of Washington: Geologist #1184
Engineering Geologist
Hydrogeologist
State of Texas: Geoscientist #6784

Professional Societies:

ASTM - Committee D-18: Soil and Rock for Engineering Purposes
Dispute Review Board Foundation

Products:

Products Most Closely Related to the Proposed Project

1. Fifty-three years of professional practice as a geotechnical consultant on building foundations and pavement subgrades in US and overseas.
2. Starting in 2009, research studies at Idaho State University on stabilization on collapsible soils beneath structures and roadways.
3. Extensive laboratory studies including published results on use of PCC in lieu of Portland Cement to stabilize wind-blown soils (loess) beneath southeast Idaho roads and UCA in structures for fine aggregate to reduce the carbon footprint.
4. Since 2003, Dr. Mahar has and is teaching courses in soil mechanics and foundation engineering during fall and spring semesters at Idaho State University.

5. Under separate cover, I can send a summary of past and present geotechnical experience on surface and subsurface dams.

Other Significant Products, Whether or Not Related to the Proposed Project

Zoghi M, J.W. Mahar, A. Ebrahimpour, M. Y. Araya and P. Katamaneni (2009): Geo-Sustainable Stabilization of Collapsible Loess Soil Deposits, Proceedings of the 42th Symposium on Engineering Geology and Geotechnical Engineering, Idaho State University, November, pp 93 to 102.

Mahar J.W. (2013): Case Histories in Geotechnical Engineering Education. Seventh International Conference on Case Histories in Geotechnical Engineering, #1.05b, Chicago, IL.

Phuyal, K., U. Sharma, J. Mahar, K. Mondal and M. Mashall: 2023 A Sustainable and Environmentally Friendly Concrete for Structural Applications, MDPI Sustainability 15, 14694 https://doi.org 10.3390/SU 152014694. (peer-reviewed)

Phuyal, K., U. Sharma, J. Mahar, K. Mondal and M. Mashall: 2024 Reducing Carbon Footprint with Precipitated Calcium Carbonate (PCC) in Geotechnical Applications, MDPI Sustainability, mdpi.com/journal/sustainability.

Phuyal, K., J. Mahar and M. Mashal: 2024 Utilization of Precipitated Calcium Carbonate (PCC) and Upcycled Concrete Aggregate (UCA) in Civil Engineering, ICE – IASE Symposium held on the Campus of Idaho State University, 6 April 2024.

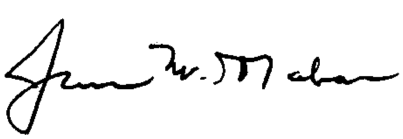
Murri, B., W. Lebrecht, B. Savage, J. Mahar: 2024 Soil-Cement Earth Structures/Subgrades, ICE – IASE Symposium held on the Campus of Idaho State University, 6 April 2024.

Certification:
I certify that the information provided is current, accurate, and complete. This includes but is not limited to current, pending, and other support (both foreign and domestic) as defined in 42 U.S.C. § 6605.

I also certify that, at the time of submission, I am not a party to a malign foreign talent recruitment program.

Misrepresentations and/or omissions may be subject to prosecution and liability pursuant to, but not limited to, 18 U.S.C. §§ 287, 1001, 1031 and 31 U.S.C. §§ 3729-3733 and 3802.

Certified by James W. Mahar on 2025-01-12 at 19:21.



IDENTIFYING INFORMATION:

NAME: Cantrell, Jared

ORCID iD: https://orcid.org/0000-0002-0689-6288

POSITION TITLE: Research Engineer

PRIMARY ORGANIZATION AND LOCATION: Idaho State University, Pocatello, Idaho, United States

Professional Preparation:

ORGANIZATION AND LOCATION	DEGREE (if applicable)	RECEIPT DATE	FIELD OF STUDY
Idaho State University, Pocatello, Idaho, United States	PHD	12/2025	Structural Engineering
Idaho State University, Pocatello, Idaho, United States	MS	05/2021	Structural Engineering
Idaho State University, Pocatello, Idaho, United States	BCE	05/2018	Civil Engineering

Appointments and Positions

2017 - present Research Engineer, Idaho State University, Pocatello, Idaho, United States
2022 - 2024 Structural Engineer, A&E Engineering, Inc., Pocatello, Idaho, United States

Products

Products Most Closely Related to the Proposed Project

1. Cantrell J, Duran J, Mashal M. Experimental Investigation on the Use of Mechanical Fasteners to Anchor FRP Composite Strips. 18th World Conference on Earthquake Engineering; 2024; Milan, Italy.
2. Acharya M, Bedrinana L, Cantrell J, Mashal M. Prediction of Ultimate Bond Strength Between UHPC and Titanium Alloy Bars Using a Machine Learning Approach. The Second International Conference on Maintenance and Rehabilitation of Infrastructure Facilities (MAIREINFRA2); 2023; Honolulu, HI, United States.
3. Cantrell J, Mashal M, Ebrahimpour A. Large-Scale Testing of a Precast Bent System for Accelerated Bridge Construction: Seismic Performance and Comparison with Cast-In-Place. PCI Convention; 2021; New Orleans, ID, United States.
4. Cantrell J, Mashal M, Ebrahimpour A. An Earthquake Resistant Precast Pier System for Accelerated Bridge Construction International. Association for Bridge and Structural Engineering (IABSE) Congress; 2021; Christchurch, New Zealand.
5. Cantrell J, Khadka R, Mashal M. Experimental Investigation on Mechanical Properties of Titanium Alloy Bars: Comparison with High-Strength Steel. ACI Symposium Publication. 2020; 341(8):160.

Other Significant Products, Whether or Not Related to the Proposed Project

1. Hogarth K, Cantrell J, Mashal M, Savage B, Khadka R. A Disaster Response Complex for Training Emergency Responders in the Northwest United States. Journal of Emergency

Management. 2024; 21.

2. Acharya M, Duran J, Cantrell J, Mashal M. A Seismic Resilient Concrete Pier System Incorporating Titanium Alloy Bars and Comparison with Conventional Reinforced Concrete. American Concrete Institute Special Publication. 2023; (358):206-229.
3. Acharya M, Cantrell J, Bedrinana L, Mashal M. Experimental Research on Durable and Seismic-Resilient Concrete Bridges with Use of Novel Materials. 18th World Conference on Earthquake Engineering, Milan, Italy. 2024.

Certification:

I certify that the information provided is current, accurate, and complete. This includes but is not limited to current, pending, and other support (both foreign and domestic) as defined in 42 U.S.C. § 6605.

I also certify that, at the time of submission, I am not a party to a malign foreign talent recruitment program.

Misrepresentations and/or omissions may be subject to prosecution and liability pursuant to, but not limited to, 18 U.S.C. §§ 287, 1001, 1031 and 31 U.S.C. §§ 3729-3733 and 3802.

Certified by Cantrell, Jared in SciENcv on 2025-01-07 18:38:01

NAME: Kunal Mondal

POSITION TITLE & INSTITUTION: Staff Scientist, Oak Ridge National Laboratory, TN, USA

A. PROFESSIONAL PREPARATION - (see PAPPG Chapter II.C.2.f.(i)(a))

INSTITUTION	LOCATION	MAJOR/AREA OF STUDY	DEGREE (if applicable)	YEAR (YYYY)
Indian Institute of Technology (IIT) Kanpur	Kanpur, U.P., India	Chemical Engineering	Ph.D.	2015
Indian Institute of Engineering Science and Technology, (IIEST) Shibpur	Shibpur, West Bengal, India	Materials Engineering	M.Tech.	2010
Indian Institute of Engineering Science and Technology, (IIEST) Shibpur	Shibpur, West Bengal, India	Applied Physics	M.Sc.	2008

B. APPOINTMENTS - (see PAPPG Chapter II.C.2.f.(i)(b))

From - To	Position Title, Organization and Location
2023-till date	Staff Scientist at the Oak Ridge National Laboratory, Oak Ridge, TN, USA, in the Integrdated Nuclaer Fuel Cycle Division
2019 - 2023	Staff Scientist at the Idaho National Laboratory, Idaho Falls, ID USA, in the Materials Science and Engineering Department
2020 - till date	Joint Faculty at the Idaho State University, Pocatello, ID in the Department of Civil and Environmental Engineering and Oak Ridge National Laboratory
2021- till date	Associate Editor (2021-present) at the Elsevier journal Sensor International
2021- till date	Associate Editor (2021-present) at the IEEE Sensor International Journal
2019-2020	Postdoc at the Idaho National Laboratory, Idaho Falls, ID USA, in the Materials Science and Engineering Department
2018-2019	Postdoctoral Fellow at Florida Atlantic University, Boca Raton, FL, USA in the Department of Ocean & Mechanical Engineering
2015-2018	Postdoctoral Research Associate at NC State University, Raleigh, NC, USA in the Department of Chemical and Biomolecular Engineering

C. PRODUCTS - (see PAPPG Chapter II.C.2.f.(i)(c)) Products Most Closely Related to the Proposed Project

1. Chorney, MP.; Hurley, BP.; Mondal, K, Khanolkar, AR; Downey, JP.; Tripathy, PK., "Transformation of a ceramic precursor to a biomedical (metallic) alloy: Part I - sinterability of Ta2O5 and TiO2 mixed oxides," Materials Science for Energy Technologies, 2022, 5, 22, 181–188.

2. Chen, J.; Saeidi-Javash, M.; Palei, M.; Zeng, M.; Du, Y.; Mondal, K.; McMurtrey, MD.; Hoffman, A J.; Zhang, Y., "Printing noble metal alloy films with compositional gradient", Applied Materials Today, 2022, 27, 101405.

3. Rozati, SA., Keesara, P., Mahajan, C., Mondal, K., Gupta, A., "Magnetically aligned metal-organic deposition (MOD) ink based nickel/copper heater surfaces for enhanced boiling heat transfer", Applied Thermal Engineering, 2022, 211, 118473.

4. Tripathy, Prabhat K., Mondal, K. "A Molten Salt Electrochemical Process for the Preparation of Cost-Effective p-Block (Coating) Materials," Crystals, 2022, 12 (3), 385.

5. Katiyar, S., *Mondal, K. & Sharma, A. One-step sol–gel synthesis of hierarchically porous, flow-through carbon/silica monoliths. RSC Adv 6, 12298–12310 (2016).

6. Sharma, A., Katiyar, S., Mondal, K., Hierarchical porous monoliths and methods for their preparation and use. Ref. No: US Patent Application Number: 20150290624, Year: 10/2015.

7. Sharma, A., Katiyar, S., Mondal, K., Hierarchically porous polymer, carbon, silica and composite carbon/silica monoliths with ultra-high BET surface area synthesized by combined templated sol-gel and micro-phase separation for applications in supported metal catalysis. Ref. No: IN-875004, Year: 06/2015.

Other Significant Products, Whether or Not Related to the Proposed Project

1. Poblete, FR., Mondal, K., Ma, Y., Dickey, MD., Genzer, J., Zhu, Y., "Direct measurement of rate-dependent mode I and mode II traction-separation laws for cohesive zone modeling of laminated glass", Composite Structures 279, 11475, 2021.

2. Tripathy, PK., Mondal, K., Khanolkar, AR, "One-step manufacturing process for neodymium-iron (magnet-grade) master alloy", Materials Science for Energy Technologies, 4, 2021, 249-255.

3. Mondal, K., Pawar, G., McMurtrey, M. D., Sharma, A., Finetuning hierarchical energy material microstructure via high temperature material synthesis route, Mater. Today Che., (2020), DOI: 10.1016/j.mtchem.2020.100269.

4. Mondal, K., Maitra, T., Srivastava, AK., Pawar, G., McMurtrey, MD., Sharma, A., 110th Anniversary: Particle Size Effect on Enhanced Graphitization and Electrical Conductivity of Suspended Gold/Carbon Composite Nanofibers, Ind. Eng. Chem. Res., (2020), DOI: 10.1021/acs.iecr.9b06592.

5. Mondal, K., Kumar, J. & Sharma, A. Self-organized macroporous thin carbon films for supported metal catalysis. Colloids Surf. Physicochem. Eng. Asp. 427, 83–94 (2013).

6. Singh, P., Mondal, K. & Sharma, A. Reusable electrospun mesoporous ZnO nanofiber mats for photocatalytic degradation of polycyclic aromatic hydrocarbon dyes in wastewater. J. Colloid Interface Sci. 394, 208–215 (2013).

7. Daw J, Unruh TC, Heidrich BJ, Hurley DH, Fujimoto KT, Estrada D, McMurtrey M, Mondal K, Hone L, Seifert RD, inventors; Boise State University, assignee. Sensors for passively measuring a maximum temperature of a nuclear reactor, and related methods. United States patent application US 17/303,633. 2021 Dec 23.

D. SYNERGISTIC ACTIVITIES - (see PAPPG Chapter II.C.2.f.(i)(d))

1.I am staff scientist in Oak Ridg National Laboratory and formerly at the Idaho National Laboratory. My research interests include additive manufacturing, micro/nano fabrication of functional materials, soft and stretchable electronics, microfluidics, liquid metal, colloids and interfaces of soft nanostructures, self and directed assembly, photovoltaics, polymer thin-films, carbon nanomaterials, energy and environmental and health sensors, nuclear sensors, soft electronics. I work in collaboration with several national laboratories, universities and industries. Through this role, I obtain an improved understanding of the sophistication between basic science and applied science and develop an in-depth knowledge of where the knowledge gaps are.

2. As a joint faculty member at Idaho State University, I have been working with several university and Center for Advanced Energy Studies (CAES) teams in a Multi-University and National Laboratory Research Initiative project funded by Department of Energy (US-DOE) to study Advanced Manufacturing for Hydrogen Storage Applications. It was an exceptional setting to interact with multiple institutions and research teams and undergraduate and graduate students in developing advanced manufacturing concepts and sharing multi-disciplinary knowledge to solve the storage and transportation issue of hydrogen.

IDENTIFYING INFORMATION:

NAME: Acharya, Mahesh

ORCID iD: https://orcid.org/0000-0002-3009-7099

POSITION TITLE: Joint Appointee

PRIMARY ORGANIZATION AND LOCATION: Idaho National Laboratory and Idaho State University, Idaho Falls, Idaho, United States

Professional Preparation:

ORGANIZATION AND LOCATION	DEGREE (if applicable)	RECEIPT DATE	FIELD OF STUDY
Idaho State University, Pocatello, Idaho, United States	PHD	12/2023	Engineering and Applied Science (Structural Engineering)
Idaho State University, Pocatello, Idaho, United States	MS	05/2021	Civil Engineering (Structural Emphasis)
Idaho State University, Pocatello, Idaho, United States	BS	05/2020	Civil Engineering

Appointments and Positions

2024 - present	Joint Appointee, Idaho National Laboratory and Idaho State University, Idaho Falls, Idaho, United States
2023 - 2023	Adjunct/Affiliate Faculty, Idaho State University, Pocatello, Idaho, United States
2022 - 2023	Graduate PhD Intern, Idaho National Laboratory, Idaho Falls, Idaho, United States
2021 - 2023	Graduate Teaching Assistant/Instructor, Idaho State University, Pocatello, Idaho, United States
2020 - 2023	Deputy Manager, Idaho State University, Pocatello, Idaho, United States

Products

Products Most Closely Related to the Proposed Project

1. Mashal M, Gurung K, Acharya M. Full-scale experimental testing of Structural Concrete Insulated Panels (SCIPs). IABSE Congress, Christchurch 2021: Resilient technologies for sustainable infrastructure; ; Christchurch, New Zealand. Available from: https://structurae.net/en/literature/id/10591458 DOI: 10.2749/christchurch.2021.0833
2. Acharya M, Gurung K, Mashal M. Full-scale flexural testing of slabs made of modular structural concrete insulated panels. PCI Journal. 2022; 67(2):-. Available from: https://www.pci.org/PCI/Publications/PCI_Journal/Issues/2022/March-April/Full-scale-flexural-testing-of-slabs-made-of-modular-structural-concrete-insulated-panels.aspx DOI: 10.15554/pcij67.2-03

Other Significant Products, Whether or Not Related to the Proposed Project

1. Acharya M, Duran J, Ebrahimpour A, Cantrell J, Mashal M. A Fully Precast Pier System for Accelerated Bridge Construction in Seismic Regions. Journal of Bridge Engineering. 2023 October; 28(10):-. Available from: https://ascelibrary.org/doi/10.1061/JBENF2.BEENG-

6154 DOI: 10.1061/JBENF2.BEENG-6154

2. A Seismic Resilient Concrete Pier System Incorporating Titanium Alloy Bars and Comparison with Conventional Reinforced Concrete. "SP-358: Advances in Repair/Retrofit/Strengthening, Design and Analysis of Structures". "SP-358: Advances in Repair/Retrofit/Strengthening, Design and Analysis of Structures"; ; American Concrete Institute; c2023. Available from: https://www.concrete.org/publications/internationalconcreteabstractsportal.aspx?m=details&id=51740237 DOI: 10.14359/51740237
3. Acharya M, Khadka R, Mashal M. Preliminary Bond Testing and Splicing of Titanium Alloy Bars. Transportation Research Record: Journal of the Transportation Research Board. 2022 January 18; 2676(5):410-427. Available from: https://journals.sagepub.com/doi/10.1177/03611981211067785 DOI: 10.1177/03611981211067785
4. Khadka R, Acharya M, LaBrier D, Mashal M. Visualization of Macroscopic Structure of Ultra-high Performance Concrete Based on X-ray Computed Tomography Using Immersive Environments. Lecture Notes in Computer Science [Internet] Cham: Springer International Publishing; 2022. Chapter Chapter 220-33p. Available from: https://link.springer.com/10.1007/978-3-031-05939-1_2 DOI: 10.1007/978-3-031-05939-1_2

Certification:

I certify that the information provided is current, accurate, and complete. This includes but is not limited to current, pending, and other support (both foreign and domestic) as defined in 42 U.S.C. § 6605.

I also certify that, at the time of submission, I am not a party to a malign foreign talent recruitment program.

Misrepresentations and/or omissions may be subject to prosecution and liability pursuant to, but not limited to, 18 U.S.C. §§ 287, 1001, 1031 and 31 U.S.C. §§ 3729-3733 and 3802.

Certified by Acharya, Mahesh in SciENcv on 2025-02-24 14:08:56

Appendix C: Senior Personnel

Senior Project Personnel and Expertise (Idaho State University)

1. **Lead Principal Investigator (Dr. Tadesse Wakjira)**: Dr. Wakjira is an expert in structural engineering, sustainable construction materials, concrete, circular economy, experimental research, precast concrete, and emerging technologies, including artificial intelligence, machine learning, and multi-objective optimization algorithms. He will lead the overall research and project coordination.

2. **Co-Investigator (Dr. Mustafa Mashal)**: Dr. Mashal is an expert in structural engineering with extensive experience in concrete materials, precast concrete, and infrastructure resilience. He will contribute to the experimental validation and field-scale demonstration of SCALE Concrete. Additionally, he will coordinate with the PI to oversee the overall progress of the project.

3. **Co-Investigator (Dr. Kavita Sharma)**: Dr. Sharma specializes in bioanalytical chemistry and sustainable material applications. She will oversee the utilization of wastewater and all tests related to wastewater physicochemical analysis and its integration into concrete.

4. **Co-Investigator (Dr. James Mahar)**: Dr. Mahar has expertise in geology, hydrogeology, and environmental science. He will lead the environmental impact assessment and sustainability evaluation of SCALE Concrete. Additionally, he will support experimental validation and field-scale demonstration.

5. **Co-Investigator (Jared Cantrell)**: Jared is the research engineer and laboratory manager at Idaho State University. He has successfully led large-scale experimental campaigns and will be responsible for all experimental work and pilot projects. He will also assist the PI in overseeing the overall progress of the project, coordinating team communications, and managing interactions with external collaborators.

National Laboratory Collaborator (Idaho National Laboratory)

1. **Dr. Mahesh Acharya**: Dr. Acharya is an expert in concrete materials, experimental research, and AI-based optimization. He will assist in AI-driven mix designs and performance evaluation.

National Laboratory Collaborator (Oak Ridge National Laboratory)

1. **Co-Investigator (Dr. Kunal Mondal)**: Dr. Mondal is a materials scientist with expertise in sustainable materials development and advanced material characterization. He will contribute to mix optimization, pilot projects, and scalability of the concrete formulation.

Dear Dr. Sharma and Dr. Wakjira,

The Office for Research at Idaho State University (ISU) is pleased to support your proposal for the IGEM-HERC award because this project is ideally positioned to advance Idaho's Higher Education Research Strategic Plan and the mission of the IGEM. This project–*Sustainable AI-Powered Low-Carbon Emission Concrete (SCALE Concrete): Leveraging Agricultural Byproducts and Wastewater for Circular Economy Solutions*–leverages by-products from Idaho's agricultural sector to develop a new and sustainable form of concrete. This work will further the economic vitality of Idaho by transforming the state's 10-million-ton stockpiles of precipitated calcium carbonate (PCC) and wastewater into a commercial product that will drive economic growth within the sugar beet sector while preserving Idaho's valuable natural resources.

According to the USDA, in 2023 Idaho produced 6.9 million tons of sugar beets, comprising a vital component of Idaho's agricultural output and thus Idaho's overall economic activity. By transforming a byproduct of sugar beet processing into a valuable commodity, this project will position researchers at ISU to directly add value to the agricultural industry. Low-carbon sustainable concrete is increasing in value as governments and private sector investors look for ways to reduce the carbon footprint of projects while maintaining their durability. By transforming PCC from Idaho's sugar beet industry and treated wastewater, the SCALE Concrete project will generate valuable intellectual property that will result in new revenue streams for both higher education and agriculture. This aspect of the project directly aligns SCALE Concrete with the second and third goals of Idaho's Higher Education Research Strategic Plan: SCALE Concrete will strengthen the research relationship between Idaho's institutions and the private sector, and will contribute to Idaho's economic development through research.

SCALE Concrete will advance Idaho's strong track-record of producing research that addresses the commercial needs of the agricultural sector while promoting conservation. With cement production accounting for a substantial component of carbon emissions and concrete manufacturing requiring significant freshwater resources, this research seeks to minimize environmental impact while preserving the structural integrity of concrete. By substituting wastewater for freshwater in concrete production, the SCALE Concrete project promotes water conservation and advances circular economy solutions, contributing to more sustainable construction practices in Idaho. In both cases, these advances in sustainability will add value to the local economy by reducing farmers' reliance on increasingly expensive natural resources and by creating an in-demand, commercially viable technology.

Office for Research
921 South 8th Ave., Stop 8130 | Pocatello, ID 83209-8130 | (208) 282-5907 | isu.edu/research | or@isu.edu

To ensure the economic viability of this project, SCALE Concrete is designed to enable efficient technology transfer from ISU’s researchers to farmers. This project will progress from lab-scale validation to field-scale demonstration over a three year period. As this project develops, researchers will create a comprehensive database for optimizing mix designs and develop a user-friendly software tool for industry adoption. In this way, SCALE Concrete will position Idaho as a leader in green construction innovation through technology transfer into the agricultural sector. This transfer will result in the development of new products and techniques that will lead to higher-paying jobs and will build a strong economic foundation for Idaho. The proposed research is very much in line with the ISU's broader research agenda and specifically supports initiatives such as the recently signed ISU-INL SUPER Agreement.

The Office for Research at ISU is committed to providing SCALE Concrete with the resources needed to ensure successful technology transfer and on-going industry connections. This support will include connections to industry partners and support for the commercialization of the intellectual property that will result from SCALE Concrete. Staff at ISU's Technology Commercialization Office in the Office for Research will support the SCALE Concrete researchers in promoting scientific developments and fostering partnerships with private-sector entities. In addition, ISU is a partner on the NSF-funded project, EMERGE, which is designed to facilitate and enhance collaboration between university researchers and industry partners; researchers associated with SCALE Concrete will be onboarded to this project to increase their industry connections and to attract investment beyond funding from the IGEM-HERC project. Lastly, as Idaho’s only member of the Oak Ridge Association of Universities, ISU also benefits from increased access to government and industry partnerships, including those associated with technology, advanced manufacturing, and the deployment of engineering technology. The Office for Research will utilize this tool to provide on-going support for the research and development needs of the SCALE Concrete project.

ISU is proud to support the SCALE Concrete project; this project will advance Idaho’s research ecosystem while also supporting Idaho’s economic growth. Thank you for your consideration and please do not hesitate to contact me with any questions.

Sincerely,

Martin “Marty” Blair, PhD
Vice President for Research and Economic Development
Idaho State University

IDAHO TRANSPORTATION DEPARTMENT
5151 South 5th Ave. • Pocatello, ID 83204-2202
(208) 239-3300 • itd.idaho.gov

Zak Johnson, P.E

Engineer Manager 2

Idaho Transportation Department, District 5

Zak.Johnson@itd.idaho.gov

12 February 2025

Subject: *A Sustainable AI-Powered Low-Carbon Emission concrete (SCALE Concrete): Leveraging Agricultural Byproducts and Wastewater for Circular Economy Solutions*

To: Idaho Education Research Council's Idaho Global Entrepreneurial Mission

I am writing to express my support for Idaho State University's innovative research in low-carbon concrete. Their dedicated efforts in this field are not only advancing academic understanding but are also poised to make significant contributions to sustainable practices within the construction industry. With traditional cement being harder to come by, the direction to find products that will replace/supplement cement is highly needed.

The production of traditional concrete is a major source of carbon emissions globally, largely due to the energy-intensive process of cement manufacturing. Idaho State University's research addresses this critical environmental challenge by exploring using Precipitated Calcium Carbonate (PCC) material and methods to reduce the carbon footprint of concrete. Their investigation into low-carbon concrete is a pivotal step toward more sustainable construction materials without compromising structural integrity or performance. This PCC material is a byproduct of the production of sugar and is stored in fields with no current use for the bi-product.

With rising infrastructure costs and the supply of cement becoming harder to come by, the Idaho Transportation Department (ITD) is looking for new products to use to provide taxpayers and the traveling public with the best infrastructure possible. ITD spends millions of dollars each year on cement and concrete which produces a high amount of carbon, and the costs are continuing to increase. If this product can help reduce the carbon footprint that ITD contributes to and helps reduce the cost of concrete, we would be doing our part to help create a more sustainable future.

IDAHO TRANSPORTATION DEPARTMENT
5151 South 5th Ave. • Pocatello, ID 83204-2202
(208) 239-3300 • itd.idaho.gov

The transition to using low-carbon concrete to supplement cement has the potential to significantly reduce environmental impact, promote sustainable development, and set new industry benchmarks along with helping reduce the costs of the concrete. Idaho State University's research is instrumental in making this transition feasible and economically viable. Their work lays the groundwork for the widespread acceptance of engineers, our contractors, and suppliers with the confidence needed to embrace this innovative material.

In conclusion, I strongly support Idaho State University's research in low-carbon concrete. Their progress is moving the technology closer to implementation in large-scale projects will help the acceptance industry-wide. The implications of their work extend beyond academia, offering tangible benefits for the environment and the future of projects for highways and infrastructure.

Please feel free to contact me at Zak.Johnson@itd.idaho.gov or 208-239-3363 if you require any further information or wish to discuss this matter in more detail.

Sincerely,

Zak Johnson, PE

Engineer Manager 2

2240 S. Yellowstone Hwy
Idaho Falls, ID, 83402

February 12, 2025

Subject: Letter of Support

Institution: Idaho State University (ISU)

Project: A sustainable AI-Powered Low-Carbon Emission Concrete (SCALE Concrete): Leveraging Agricultural Byproducts and Wastewater for Circular economy Solutions.

Oldcastle Infrastructure is a CRH company which is the leading provider of building material solutions in the world employing over 78,000 people with 3,390 operating locations in 28 countries. We have two precast plants with proximity to ISU with fully operational concrete batching and testing capacities. We have successfully partnered in the past with ISU on previous projects.

We are very excited to provide support to ISU in the development of a low-carbon sustainable concrete by incorporating precipitated calcium carbonate (PCC) from Idaho's sugar beet industry and treated wastewater. Oldcastle will offer support in the implementation of this concrete in real world infrastructure applications. This research with ISU is fully aligned with our long-term goals.

CRH has a business ambition of net-zero carbon emissions by 2050 and are working to ensure that our businesses and products are part of the solution. We are implementing our 2030 decarbonization roadmap and are decarbonizing our own business by reducing our CO_2 emissions, while achieving significant business growth.

Please let me know if there is any other way we may be of assistance.

Sincerely,

Troy Banks, P.E.
Regional Engineering Manager
Oldcastle Infrastructure
troy.banks@oldcastle.com
801-786-9292

Amalgamated Sugar

February 11, 2025

Dr. Mustafa Mashal, PhD, PE, CPEng, IntPE (NZ)
Professor, Civil and Environmental Engineering
Idaho State University
921 South 8th Ave, Stop 8060, Pocatello, ID 83239

Subject: *A Sustainable AI-Powered Low-Carbon Emission concrete (SCALE Concrete): Leveraging Agricultural Byproducts and Wastewater for Circular Economy Solutions*

Dear Dr. Mashal:

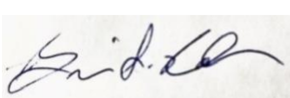
Amalgamated Sugar Company (Amalgamated) is pleased to participate with Idaho State University (ISU) and Idaho National Laboratory (INL) in the above referenced proposal in support of funding through the Idaho Education Research Council's Idaho Global Entrepreneurial Mission (IGEM) Grant Program.

Amalgamated is a grower-owned Cooperative consisting of approximately 500 activate sugar beet growers throughout Idaho, Oregon and Washington. The cooperative's primary operations and headquarters are based in Idaho. Annually, Amalgamated processes approximately 7,300,000 tons of sugar beets grown by its grower-owners. A byproduct of the Sugar extraction and purification process is a crude Precipitated Calcium Carbonate (PCC) by-product. The operations produce 500,000 tons per year and Amalgamated has accumulated 12,000,000 tons that are stored at three locations in Idaho and one location in Oregon.

Amalgamated actively seeks commercial uses for PCC in lieu of disposing it as waste. The subject project, led by Dr. Mustafa Mashal and his colleagues, could create an eco-friendly application that uses our agricultural byproduct, PCC, as a key raw material. Success of this project could transform an agricultural byproduct currently treated as a liability and create an opportunity to use it as raw material in a commercially sustainable concrete product.

Please contact me at your convenience if you have any questions regarding our interest in this project.

Best Regards,



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25 February 2025

Dr. Mustafa Mashal, PhD, PE, CPEng, IntPE (NZ)
Professor, Civil and Environmental Engineering
Idaho State University
921 South 8th Ave, Stop 8060, Pocatello, ID 83239

RE: *A Sustainable AI-Powered Low-Carbon Emission concrete (SCALE Concrete): Leveraging Agricultural Byproducts and Wastewater for Circular Economy Solutions*

Dear Mustafa,

Colliers is a leading commercial real estate company dedicated to providing services for developers of commercial property and infrastructure specific to the construction of roadways, parking lots, office building for medical and general use, coupled with retail, industrial, hospitality and the like.

We have come under a significant amount of outside pressure by the end users of these development to ensure that they facilities they are occupying will contribute to reducing the carbon footprint, coupling that with reduced construction costs to reduce rents.

It is ever so more important now. more than ever before to meet the demands of the end user. The demands are driving the need for low-emission concrete as much of these facilities are constructed with concrete.

We look forward to the time when this becomes available commercially not only for the environmental results but the reduced costs that can be passed on across the board where all will benefit.

I will be glad to have a conversation with anyone who is willing to listen.

Kindest regards,

Don Zebe, Partner
Colliers Portneuf Valley

Don Zebe