

# Breath of Rio Tinto

##### Grant Type

Annual Grant

##### Application Type

Final Application

##### Project Manager 1 Name

cynthia navarro

##### Project Manager 1 Status

Student

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##### Project Manager 1 Department

Civil and Architectural Engineering

##### Project Manager 2 Name

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##### Project Manager 2 Status

Student

##### Project Manager 2 Department

Civil and Architectural Engineering

##### Project Manager 2 Role

Co-lead

##### Project Advisor Name

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##### Project Advisor Email

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##### Project Advisor Department

Civil and Architectural Engineering

##### Fiscal Officer

Kandie Stanton

##### Fiscal Officer Email

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##### Fiscal Officer Department Name

College of Engineering

##### Requested Funding Amount

Only enter this number after completing the budget sheet (the budget template will round up your request).
Mini Grants may request $250 up to $5,000.
Annual Grants may request $5,001 up to $100,000, and up to three years of funding.

#### Year 1:

$9700

#### Year 2:

#### Year 3:

##### Project Name

Breath of Rio Tinto

##### Primary Project Category

Waste

##### Secondary Project Category

Research and Academics

##### Background and Context

Please provide relevant background about your organization/team including your mission and/or expertise. Lay out the rationale for the proposed project, focusing on the issue that your project would address. You may also share how the project is new or how it complements, builds upon, or scales existing initiatives. This section is meant to give us more information about you and the context for the project, while the questions below provide space to go into detail about your proposal's plan and specifics.

###### Response:

The Rio Tinto Mine in Arizona is one of the most significant contributors to the global copper supply and plays a pivotal role in the region’s mining industry. However, the mining and smelting processes produce significant industrial byproducts, such as copper smelter slag—a glass-like material generated during metal extraction. While traditionally considered waste, copper slag and mine tailings present an opportunity for sustainable reuse in construction materials, particularly in the development of concrete.

Our project aims to leverage this industrial byproduct to create sustainable concrete furniture, enhanced with Sporosarcina pasteurii—a bacteria capable of absorbing CO₂ and improving material durability through microbial-induced calcium carbonate precipitation (MICP). This innovative approach aligns with growing research efforts in low-carbon construction materials and biologically enhanced concrete, providing a practical and scalable solution for sustainable furniture manufacturing.

WHO WE ARE
We are women-led project of two students from Architectural Engineering, dedicated to developing innovative, sustainable materials. Our project is supported by leading faculty and research laboratories focused on material innovation and microbial applications in construction.

-Cynthia Navarro is a senior in architectural engineering and sustainable built environment minor, has 2 years of research experience in material science and construction applications. She has spent more than a year at the M2D Lab and one semester at the SMART Lab, where she has worked on concrete innovation and microbial applications for soil stabilization.

-Alexa Armstrong is a junior in Architectural Engineering with two years of experience at EDC (Engineering Design Center). She has strong expertise in carpentry, machine use, and mold fabrication, making her instrumental in the manufacturing and fabrication processes for this project.

M2D Lab (Materials & Manufacturing Design Laboratory) – Primary Research Partner
The M2D Lab, led by Dr. Kim Hee-Jeong, is dedicated to developing advanced and sustainable construction materials. The lab focuses on low-carbon concrete, alternative cementitious materials, and the integration of industrial byproducts into innovative material systems. Their expertise in reusing mine tailings and industrial waste provides essential guidance for this project.

Dr. Kim Hee-Jeong, a professor in the Civil and Architectural Engineering Department, specializes in material sustainability, alternative cement systems, and industrial byproduct utilization.
The lab has extensive research on using mine tailings in concrete to enhance strength and durability while reducing carbon footprints.
\*\*\*M2D Lab's material research and innovation efforts can be found at M2D Lab Website\*\*\*

##### Project Description

Please provide a thorough description and explanation of your project. Be explicit in what your team is proposing. What will your project’s outcomes be and how will you achieve them? Outcomes should be specific, measurable, achievable, realistic, and timely.

###### Response:

This project was inspired by the film Women of Carbon and the urgency to innovate in sustainable materials. “Breath of Rio Tinto” is a women-led initiative aimed at transforming smelter slag and mine tailings into sustainable concrete furniture for campus beautification. By integrating Sporosarcina pasteurii bacteria into the concrete mix, this project explores biogenic mineralization as a method for reducing CO₂ emissions and enhancing material durability.

In collaboration with M2D Lab, we plan to invite 3-5 students to participate in this research-driven initiative. Under the guidance of Dr. Kim Hee-Jeong, students will develop and manufacture concrete landscape furniture using plywood molds and traditional formwork techniques, refining both the material composition and fabrication process to advance sustainable construction methods.

Objectives of "Breath of Rio Tinto"
Highlight the urgency of sustainable solutions

Raise awareness about the pressing need to address mine tailing waste through innovative, environmentally conscious construction practices.
Demonstrate how waste materials can be repurposed into functional, low-carbon infrastructure.
Develop and test CO₂-reducing concrete

Investigate the potential of Sporosarcina pasteurii to reduce CO₂ emissions through microbial mineralization.
Optimize a cementitious mix using mine tailings, balancing strength, durability, and sustainability.
Provide educational and research opportunities

Offer students hands-on experience in material science, microbial applications in construction, and sustainable fabrication.
Introduce participants to mine tailing processing, microbial-induced carbonate precipitation (MICP), and innovative concrete formulations.
Foster leadership and strengthen community impact

Empower students to take active leadership roles in the research, design, and manufacturing processes.
Promote collaborative learning and sustainable campus development through an interdisciplinary effort.
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This project aims to engage students from the College of Engineering, School of Architecture, and student clubs. The M2D Lab will provide space and equipment for concrete formulation and fabrication, while Dr. Kim Hee-Jeong will oversee the material development to ensure scientific rigor in the processing of mine tailings into durable concrete structures.

The initial goal is to create four medium-sized planters for native plants and two inclined lounge chairs. These structures will be cast using plywood molds and traditional concrete forming methods.

Vincent Natale from Facilities Management has reviewed the tentative location and preliminary designs, planned for installation between the Civil and Electrical Engineering buildings. This high-traffic pedestrian area near N Palm Drive, with ample tree shade and level ground, makes it an ideal site for sustainable seating and greenery. He expressed strong support for the project’s feasibility and approval.

##### Timeline

Please provide a timeline breakdown for the key steps in your project. The timeline can be basic, but please include anticipated timeframes for each major step, including any key dates for when certain elements must start or be completed. The timeline can be in list format.

###### Response:

Month 1: OUTREACH AND RECRUITMENT-----

Weeks 1-3: Conduct outreach to departments and student clubs. Share the project application to identify students with a strong interest in sustainable materials, fabrication, and campus infrastructure improvement. Emphasize the need for availability (5-7 weekly hours) and willingness to participate in concrete preparation, mold fabrication, and testing.

Week 4: Review applications and select students for collaboration. Provide an overview of lab safety, woodworking tools, concrete mixing, and project objectives.

Month 2: RESEARCH AND MATERIAL TESTING----
We are going to get students involved in research, we want them to learned the science behind this not only the physical job so that is why we include more weekly hours so they can have time to read the papers and literature reviews

Week 1:Finalize the final concrete formulation, there are existent formulas for concrete and Sporosarcina pasteurii, this week we will determine the water-cement ratio now that we are going to incroporate mine tailing
Weeks 2-4: Conduct small-scale test pours, evaluate strength,

---Month 3: PLANTER DESIGN & FABRICATION----
Week 1: Create detailed construction plans for mold-making and workshop preparation
Weeks 2-3: Begin plywood mold fabrication for planters.
Week 4: Pour and cure concrete planters.
(This phase might be faster than expected since the planters are easier, Cynthia Navarro has donde before and the curing is faster)

Month 4: LOUNGE CHAIR FABRICATION---

Weeks 1-3: Fabricate plywood molds for lounge chairs. Ensure precision in cutting, assembly, and reinforcement for smooth and accurate concrete casting.
Week 4: Pour and cure lounge chair components. Conduct structural testing, surface finishing, and evaluate final quality.

\*\*\*\*(This phase may extend by 1 month depending on students availability, It will be probaby finals so might extend it the final detailing after finals )\*\*\*

##### Budget Narrative

Use this section to provide supplemental justification for the items you are requesting on your budget sheet. Please break down your justifications into the budget categories: Personnel or operating budget. Do not list out each expense or repeat notes made in the budget template, but instead address why the line items are being requested and the purpose they will serve, providing elaboration when necessary.
If you are requesting funding for personnel, use this section to elaborate on the position you are creating and how the budget and timeline was established for it. If you plan to hire students, describe in what capacity. Describe relevant details thoroughly (wages, responsibilities, duration of job, extent of involvement, how you will solicit/ market these opportunities etc.).
Ensure the descriptions match the line items in the budget sheet.
If matching or supporting funds are secured for the project, identify the source and amount in this section, and detail the impact of the matching funds on your overall budget.

###### Response:

The majority of the requested funding is allocated for student stipends, materials, safety equipment, and shipping costs, as the project requires significant physical effort in concrete preparation, plywood mold fabrication, and manufacturing.

Each student will dedicate approximately 77 hours over a 5-6 month period, divided into three phases:

Research Phase (17 hours): Literature review on concrete science, sustainability, and microbial applications.
First Manufacturing Phase (25 hours): Concrete preparation, pouring, and curing for the planters.
Second Manufacturing Phase (35 hours): Similar tasks, scaled to the larger lounge chair designs.
We aim to involve 3-5 students, ensuring equitable access to this learning opportunity through stipends. If fewer students are selected or the project progresses more efficiently, any unused funds will be returned to the Campus Sustainability Fund (CSF).

Material Costs and Waste Management
The materials budget is based on Arizona regional costs, accounting for the fabrication of 2 concrete lounge chairs and 4 medium planters. We have included a 30% waste margin to accommodate potential material losses during mixing, molding, and pouring. However, Cynthia Navarro and Dr. Kim Hee-Jeong will oversee material efficiency, aiming to reduce waste to below 10%, aligning with M2D Lab’s standard efficiency rates.

-IF WE HAVE LEFT OVER MATERIAL WE CAN DO MORE PLANTERS--

##### Project Feasibility and Logistics

The Campus Sustainability Fund will only fund projects that have completed the necessary work to ensure they can succeed, be completed in the grant’s timeline, or have an accurate budget.
Please provide a description of the work that has been completed so far to make this project feasible. Please provide a description of the work that has been completed so far to make this project feasible. If relevant partners have been contacted/coordinated with, please identify them in your response.
For example, have you received consent or authorization to complete your project (such as from Housing and Residence Life, Facilities Management, Parking and Transportation, etc.)? If you are making modifications to campus, do you have written authorization or official quotes from Facilities Management to accurately identify the cost of labor and supplies?

###### Response:

The "Breath of Rio Tinto" project has undergone significant preparatory work to ensure feasibility, alignment with campus policies, and smooth implementation. We have engaged with key partners, including Facilities Management (FM), to confirm the suitability of the proposed location for the installation of the concrete furniture.

Site Selection and Placement Considerations
Cynthia Navarro met with Vincent Natale from Facilities Management to discuss potential installation sites. The area identified for placement is between the Civil Engineering and Electrical and Computer Engineering (ECE) buildings, which was confirmed as a stable, safe site requiring no land preparation. This space consists of stabilized earth, eliminating concerns about uneven ground or site modifications.

While the department-managed project for a shade sail is in permitting, we are not relying on its completion for our project’s feasibility. Instead, we plan to place the furniture under the natural shade of nearby trees, ensuring usability and comfort regardless of external project timelines. FM has agreed that this placement is feasible and does not interfere with utilities, egress, or other campus infrastructure.

Fabrication Method and Impact on Design---
The project will directly proceed with plywood molds for concrete casting. This method:
-Ensures design flexibility and durability – The lounge chairs and planters are cast in three separate modular pieces, making them easier to handle, transport, and install.

The estimated weight per modular piece is approximately 80 lbs.

--Transport and Installation Plan--
The Department of Civil Engineering has industrial carts available for transporting the concrete pieces. Since the planters and lounge chairs are assembled from three separate parts, they can be moved and installed efficiently without requiring heavy machinery.

Expertise in Mine Tailings and Concrete Research---
The M2D Lab has extensive experience in utilizing industrial byproducts, such as mine tailings, in concrete formulations. Dr. Kim Hee-Jeong has led multiple studies on the use of alternative materials in construction, and Cynthia Navarro has shadow research on mine tailing applications during her time in the lab. This expertise ensures that the integration of Rio Tinto mine tailings into this project is backed by rigorous material testing and proven methods. Mine Tailing is not toxic (we work with this chemical already processed) neither the bacteria, I will atatch scientific articles, but we do need gloves and masks due the cement, it can dry skin if you mantain direct contact for many hours.

Watering and Maintenance
Since the planters will feature low-water native species, they will require only occasional watering, WACE Club members can be responsible for watering the plants if FM does not agree on the manteinance of 4 cactus.

##### Environmental Sustainability Outcomes

Please provide a description of how you expect your project to advance environmental sustainability on campus. A definition of environmental sustainability is provided on our Guides and Tips page.

###### Response:

The “Breath of Rio Tinto” project embodies a practical and innovative approach to sustainability by repurposing smelter slag, a mining byproduct, into durable and functional concrete furniture. This initiative directly addresses environmental concerns associated with both mining waste and cement production, two industries with significant environmental footprints.

Environmental Benefits of the Project
1. Reduction in Cement Use and Carbon Emissions
Portland cement production is a major contributor to global CO₂ emissions, responsible for approximately 8% of total anthropogenic CO₂ emissions. This is primarily due to:

Calcination: The process of heating limestone to produce cement releases CO₂ as a byproduct.
Energy-intensive Manufacturing: Cement kilns operate at extremely high temperatures, requiring large amounts of fossil fuels.
How This Project Reduces Environmental Impact:
✅ By substituting 10-15% of Portland cement with smelter slag, the CO₂ footprint of the concrete mix is significantly lowered.
✅ Reduces demand for raw materials, minimizing quarrying and land degradation.
✅ Encourages circular economy principles, extending the life cycle of industrial waste materials.

Quantitative Impact:

Total Concrete Volume: ~2.7 cubic meters (1.5 m³ for lounge chairs, 1.2 m³ for planters).
Slag Integration: 10-15% substitution = 0.27-0.40 cubic meters of repurposed slag used instead of cement.
Estimated CO₂ Reduction: Based on industry standards, replacing each ton of cement with slag can reduce emissions by 0.8-1.0 tons of CO₂.
By utilizing this replacement strategy, our project contributes to reducing greenhouse gas emissions while maintaining material socation

trength and durability.

2. Responsible Waste Management and Circular Economy Approach
✅ Repurposing smelter slag prevents this industrial byproduct from being discarded as waste.
✅ Extends the usability of mining byproducts, reducing landfill accumulation and potential leaching risks.
✅ Supports research into sustainable material applications, encouraging future adoption of low-carbon alternatives in construction.

Safety and Handling of Mine Tailings
A key concern with mine tailings is the potential presence of heavy metals and other contaminants. However, the smelter slag used in this project differs from traditional mine tailings in several ways:

Processed and Vitrified

Smelter slag undergoes high-temperature processing, which immobilizes heavy metals within a glass-like matrix, making them chemically stable and reducing the risk of leaching. M2D Lab alredy works with this mine tailing and is safe to work with, cement might be a minor concent but that is why we are obligated to wear gloves. Sporosarcina pasteurii is a non-pathogenic, naturally occurring bacterium commonly found in soil and has been widely studied for its ability to precipitate calcium carbonate (CaCO₃) in construction applications. It poses no harm to humans or the environmen

##### Social Sustainability Outcomes

Please provide a description of how you expect your project to advance social sustainability on campus. A definition of social sustainability is provided on our Guides and Tips page.

###### Response:

Social Sustainability Outcomes
This corridor, located between the Civil Engineering and Electrical Engineering buildings, is a shaded area with significant foot traffic, making it an ideal location for seating and greenery. The two lounge chairs and four planters will enhance the aesthetic and usability of this space, transforming it into a communal hub where people can take a break, study outdoors, or engage in conversations. This thoughtful placement contributes to the overall campus experience, encouraging students and staff to spend more time in shared spaces that inspire collaboration and creativity.

By involving students in the design process, we ensure the furniture reflects the needs and preferences of the campus community. This participatory approach helps students develop leadership skills while fostering a sense of ownership and pride in their contributions. Knowing they’ve helped create a space that benefits others leaves a lasting impact on the participants and strengthens their connection to the university.

##### Student Leadership & Involvement

Please provide a description of how your project will benefit students on campus regarding the creation of leadership opportunities or student engagement. What leadership opportunities exist within your proposal? If you plan to seek student involvement, include relevant details thoroughly and how you will solicit/ market these opportunities.

###### Response:

Student Leadership and Involvement
By actively participating in each phase, from brainstorming designs to fabricating and installing the final furniture pieces, students will have a platform to take ownership of the project. They will provide their input on the designs to ensure the final products meet the needs of the campus community, fostering a sense of inclusivity and collaboration.
This is a women-led project, emphasizing the importance of representation and leadership in traditionally male-dominated fields like engineering and construction.
By the end of the project, students will not only have developed leadership skills but also the satisfaction of knowing they’ve contributed to something meaningful. When they graduate, they’ll be able to look at the campus and see their hard work and creativity reflected in its infrastructure, knowing they played a part in improving their community in a sustainable and impactful way.

##### Education, Outreach, and Behavior Change

What opportunities does this project provide for members of the campus/community to learn about sustainability? How will your project educate the campus community and/or incorporate outreach and behavior change, particularly those who are not currently engaged with sustainability or environmental work?
Please provide a description of how you expect your project will communicate its impacts to the campus community.

###### Response:

Education, Outreach, and Behavior Change
The educational value of this project comes from the research opportunities and hands-on experience it offers. Students will learn practical skills in sustainable materials, concrete science, and construction technologies, including 3D concrete printing. While this project is particularly relevant for engineering students, it’s also designed to engage students from CAPLA (College of Architecture, Planning, and Landscape Architecture) and Sustainable Built Environments (SBE), as it combines technical knowledge with creativity and design.

We’re open to working with students who are enthusiastic about learning and willing to contribute their ideas and creativity. This approach ensures that students from a variety of academic fields can add meaningful input, whether that’s through technical expertise or innovative design suggestions. By working together, participants will have the chance to collaborate across disciplines, build teamwork skills, and learn from one another throughout the process.