Build the Moon Challenge

ACTIVITY GUIDE

CONTENTS

THE BTMC PROCESS

Embarking on the Build the Moon Challenge is the beginning of your adventure contributing to NASA's effort to create long-term sustainable habitats on the Moon! *This global citizen science and engineering challenge explores how in-situ (on-site) resources can be used to enhance construction opportunities for future lunar missions. You are tasked with helping to identify valuable regolith concrete mixtures to enhance future lunar construction capabilities. To conclude your project, you will use your new found knowledge on lunar resources to design your own lunar habitat incorporating on-site, lunar regolith into the design.*

The first question for all BTMC participants is "How do I get started?" It can be daunting starting any big project without some ideas for a starting point. The preliminary activities and fundamental three-step process defined in this guide will give you easy, step-by-step activities your team can complete to have a successful Build the Moon Challenge submission and earn your Certificates of Completion, and potentially one of our Best in Show recognition awards!

IN-SITU RESOURCE UTILIZATION

Using the materials found on the Moon has the potential to drastically reduce the costs of future Lunar missions. For this reason, there is much research and investment in lunar ISRU technologies. For one, on-site, in-situ resources can have great benefits for lunar construction capabilities. This is central to the Build the Moon Challenge.

THE BUILD THE MOON CHALLENGE PROCESS

Preliminary Activities

- Making Regolith
- Regolith Cement
- Making Adobe Bricks
- Nasa's *You Can't Take It With You* Activity Series

Step 1: Fundamental Process

- Creating a Regolith Recipe
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- Demo 1: a Landing Pad
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- Demo 3: a 3D Printed Wall

Step 3: Design a Lunar Habitat

- Submit Your Habitat Design

BTMC BACKGROUND

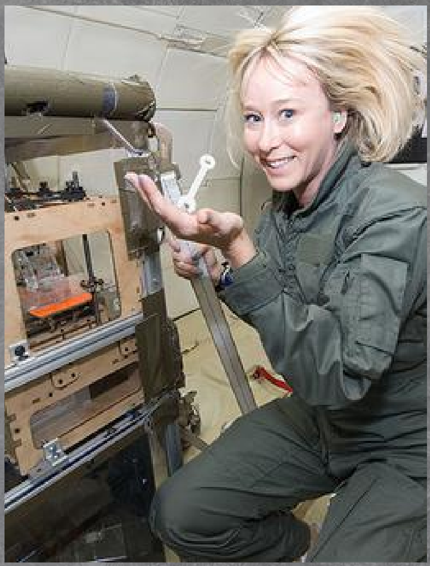


Image: NASA

Building on the Moon is at the same time, surprisingly similar and horribly different from construction on the Earth. While we have advanced industries here on the Earth that produce common materials like steel, lumber, and concrete, on the Moon we aren't so lucky. The established construction industry on the Earth relies on complex logistics, advanced materials, and robust transport networks. On the Moon, however, we don't have any of these resources. Lunar habitats - at least initially - will rely on one of two things, either bringing prefabricated structures to the Moon with us, or constructing them from the raw materials on the lunar surface (in situ resource utilization). While construction on the Moon will be difficult, the promise of ISRU technologies and innovative techniques such as 3D printing (additive manufacturing) with regolith are helping us bring a robust lunar future into reality.

Making concrete from in-situ lunar materials is vital to NASA’s plan to have long-term sustainable habitats on the Moon. Transporting large quantities of construction materials or heavy prefabricated habitats from Earth is prohibitively expensive. Launch costs to the Moon are estimated at between $10,000 to $20,000 per kilogram. NASA’s Artemis program, aiming to return astronauts to the Moon and establish a base, must strive to minimize the need for transporting materials from Earth. One of the most fundamental construction materials on the Earth is concrete. These same may be true for future lunar habitats. Researchers are working on the engineering principles, technologies, and fundamental science behind a number of ways to use the lunar regolith to create viable concrete mixtures for lunar habitats. Through the Build the Moon Challenge, your team will be contributing to the exciting body of knowledge in these areas.

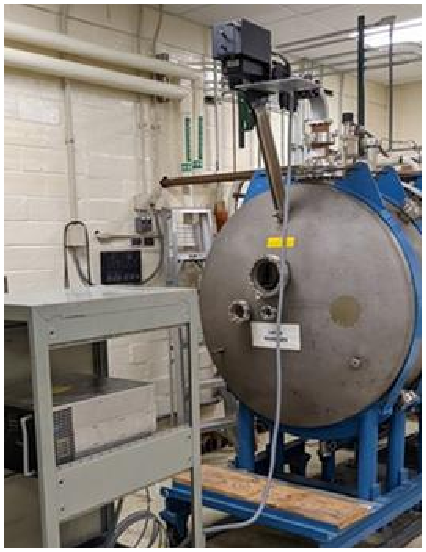


Image: NASA

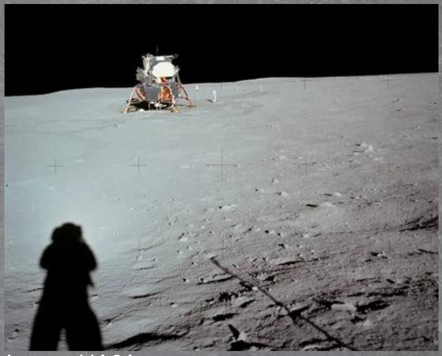


Image: NASA

By advancing technologies like space-made concrete, NASA and its collaborators are laying the foundation for a self-sustaining lunar base. Future astronauts could build habitats with lunar minerals contained in the regolith covering, significantly lowering construction costs—a cornerstone of the BTMC. The Preliminary Activities included below will help your team learn more about some of the basic differences between concrete and cement, and the history of organic building materials on Earth before you dive into the full BTMC process.

Step 1

FUNDAMENTAL PROCESS

The Fundamental Process activity in the Build the Moon Challenge is designed to offer participants hands-on experience in applying scientific and engineering principles to lunar construction. This activity helps learners grasp vital concepts related to lunar materials and construction techniques, particularly the properties of lunar regolith and their influence on building methods. It also provides practical skills in model construction and testing, enhancing critical thinking as participants tackle challenges in lunar building.

Furthermore, the activity promotes experimentation with various techniques for utilizing lunar resources effectively, encouraging innovation in construction methods, and fostering teamwork, as participants collaborate on projects and share insights. Overall, the Fundamental Process activity effectively connects theoretical knowledge with practical application, equipping participants to face more advanced challenges in lunar construction.

STEP 1: FUNDAMENTAL PROCESS

Regolith Concrete & Mortar Samples

Submission Item located on ICS Dashboard

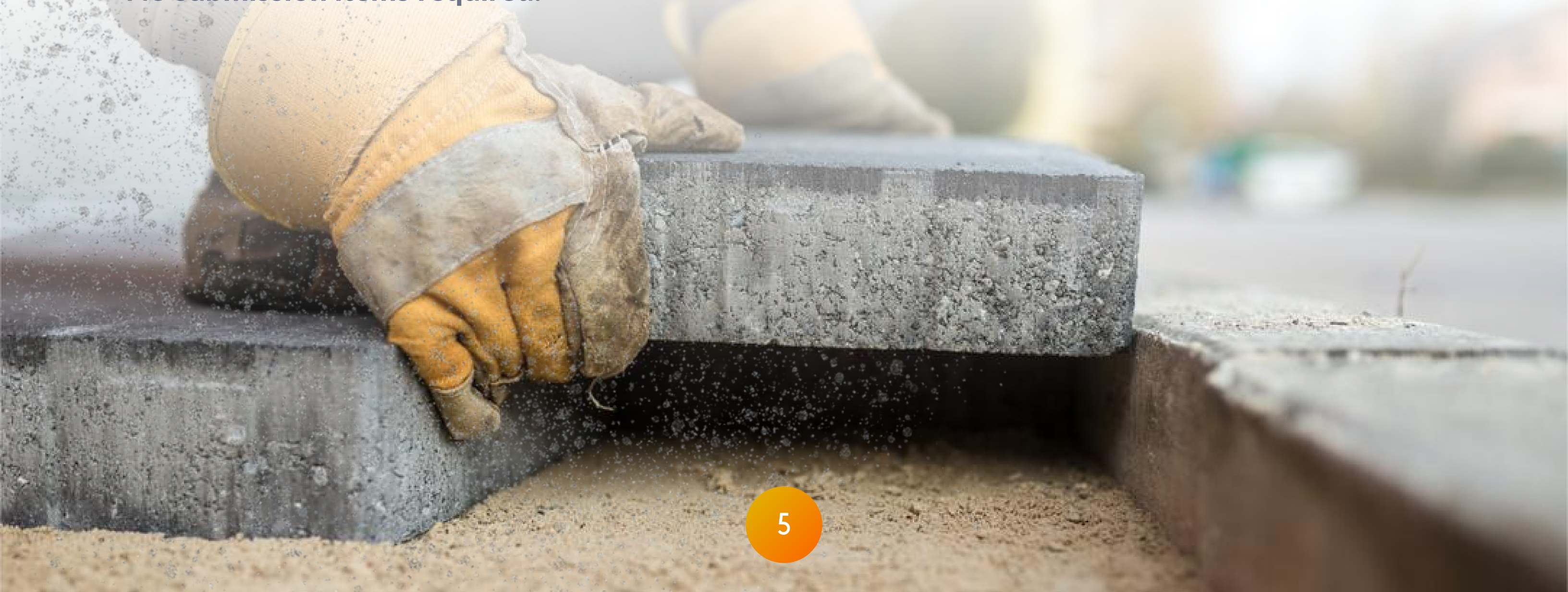
Document:

- **Recipe** - one page document with detailed lunar concrete recipe.
- **Design Process** - 1-2 page document outlining the process that makes the strongest brick.
- **Photo Documentation** - photo of each step of the process.

OPTIONAL EXTENSION ACTIVITY

Extension Testing for Concrete Samples

No submission items required.



Step 1

FUNDAMENTAL PROCESS

Regolith Concrete & Mortar Samples

The Fundamental Process activity in the Build the Moon Challenge gives participants hands-on experience with lunar construction, focusing on lunar materials and regolith properties. It builds practical skills, enhances critical thinking, and encourages innovative experimentation, promoting collaboration and problem-solving among teams. This activity bridges theory and practice, preparing participants for advanced challenges in lunar construction.

STEAM CONNECTION

Understanding how to assess and produce construction materials equips participants with skills relevant to engineering and construction. These skills are invaluable for future endeavors in architecture, environmental science, or sustainable development. Completing this activity not only develops participants' understanding of soil science and building materials but also emphasizes the broader importance of sustainable practices in construction. Through hands-on experience and critical analysis, students gain valuable insights that can be applied to both current and future building projects.

LEARNING OBJECTIVES

Understanding Lunar Materials: Participants will gain knowledge about lunar regolith and its properties. Participants will learn how the unique characteristics of lunar materials influence construction methods.

Engineering Practices and Problem-Solving: Participants will develop critical thinking and problem-solving skills in the context of lunar architecture. Participants will learn to analyze challenges and devise effective solutions during the construction process.

Bridging Theory to Practice: Integrate theoretical knowledge with practical application in a lunar construction setting. Equip participants with the insights and experience necessary to tackle more advanced challenges in lunar construction.

Communication of Ideas: Prepare participants to present their findings and proposals clearly and convincingly to a team or audience.

Students who demonstrate understanding can:

MS-PS3-3. **Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.*** [Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.] *[Assessment boundary: Assessment does not include calculating the total amount of thermal energy transferred.]*

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

- Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system.

Disciplinary Core Ideas

PS3.A: Definitions of Energy

- Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.

PS3.B: Conservation of Energy and Energy Transfer

- Energy is spontaneously transferred out of hotter regions or objects and into colder ones.

ETS1.A: Defining and Delimiting an Engineering Problem

- The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions. *(secondary)*

ETS1.B: Developing Possible Solutions

- A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. *(secondary)*

Crosscutting Concepts

Energy and Matter

- The transfer of energy can be tracked as energy flows through a designed or natural system.

Students who demonstrate understanding can:

MS-ESS3-3. **Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.** [Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce the impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

Science and Engineering Practices

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

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Disciplinary Core Ideas

ESS3.C: Human Impacts on Earth Systems

- Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.
- Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

Crosscutting Concepts

Cause and Effect

- Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World.

- The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.

Procedures for

STEP 1 FUNDAMENTAL PROCESS

Note: Maximum ratio of regolith to bricks and/or mortar additives is 50/50. Refer to Simulate Handling Instructions in the Project Guide.

Materials List

Kitchen scale
1 kg regolith
1/2 lb flour
Water
Mixing bowl
Piping bag
Silicone brick mold
2 Landscape bricks
Dish soap
Rubbing alcohol
Elmer's school glue

This step-by-step procedure guides participants through the development and testing various regolith concrete mixtures by creating individual bricks using each mixture and testing their compressive strength.

1 Prepare Work Area

Pre-Activity Setup

Work in a well-ventilated area.

Gather all materials.

2 Regolith Batching

Regolith Concrete Batching

Using the kitchen scale, weigh out 0.5 kg (500g) of regolith and 0.25 lb (113g) of all-purpose flour for each batch (two total: one control and one with additives).

Mix Dry Ingredients & Add Water

In a large mixing bowl, combine the dry regolith and flour thoroughly with a spoon. Measure out 50 mL of water and gradually incorporate it into the dry mixture using pipet. Mix the ingredients thoroughly, and if necessary, knead them by hand to achieve a putty like consistency. Adjust the water content to create a stiff but workable consistency.

Fill Molds

Carefully fill the prepared silicone molds with the regolith concrete mixture (24 possible chambers to test composition each batch). As for for varying brick composition make at least 9-10 water/flour/regolith control bricks; For additives utilize some common household binding agents ; compose some with non-toxic Industrial binding agents; also experiment with other non toxic local materials ie school glue, soil, etc.

Drying the Concrete

Place the filled silicone molds in a warm, dry area for 24-48 hours to allow the concrete to set. Leave in sun or near a window. Air dry only, do not bake in oven or apply external heat. After 24-48 hours, remove the bricks from the silicone mold to allow them to dry completely.

3 Strength & Extension Test

Chemical & Physical Properties Testing

See Step-by-Step Extension Testing for Concrete Samples Guide for optional activities to determine best composition mixture.

Test Strength

Use your best available mechanism to test the strength of your bricks. This could entail snapping the brick between your fingers, setting weight on top of your brick, or observing how much force it takes to break the brick with your available supplies

4 Making Mortar

Making Mortar

Repeat the mixing process (weigh 0.5 kg regolith and 0.25 lb flour, mix with water) add 2 oz. of Elmer's school glue for mortar. Ensure the mix reaches a workable consistency.

Prepare Piping Bag

Transfer the mortar into a resealable plastic bag and seal it tightly. Cut a small tip from one corner of the bag, or alternatively, attach a piping nozzle.

Testing Your Mortar

Optimize the mortar mixture to find the composition that will best adhere to your bricks. Evaluate drying times and consistency.

5 Next Steps

Document Mixtures

For each iteration of this activity, compare the properties of your bricks. Document observations regarding strength and flexural behavior of different mixtures of your mortar and regolith concrete bricks. Follow submission instructions in project guide.

Submission Items

Submit document on ICS dashboard which includes:

- **1 page document** with detailed lunar concrete recipe
- **1-2 page document** outlining the design process that makes the strongest brick
- **Photo Documentation** of each step of the process

Move on to Step 2: Demos

Once your regolith concrete recipes are perfected, you are ready to choose 1 or more of the Demos to complete.

Optional Extension Testing for CONCRETE SAMPLES

This step-by-step procedure guides participants through the extension testing phase of the concrete samples, enabling them to investigate and document physical and chemical properties while promoting hands-on scientific inquiry and critical analysis.

Physical Properties Testing

Density Calculation

Using the scale, weigh each concrete sample and record the mass (M) in grams.

Calculate Volume- For rectangular samples, use the formula:

Volume (V) = Length × Width × Height (in cubic centimeters)

Calculate Density- Use the density formula:

Density (p) = M / V

Test For Solubility

1. Break off a small piece of your concrete sample.
2. Place the piece into an empty cup.
3. Add enough water to cover the sample.
4. Stir the sample gently with a spoon or stick, observing for any dissolution.
5. Record your observations in the **Physical Property Table**, indicating whether the sample dissolves.

Wettability Testing

Place your camera or mobile device to clearly capture the samples being tested. For each sample:

1. Place a single drop of water on the sample.
2. Wait for 3 minutes.
3. Observe and record how quickly the water absorbs into the sample (in seconds).

Chemical Properties Testing

Soap and Alcohol Reactivity

After the water test, do the same for a drop of dish soap and a drop of rubbing alcohol.

Observe any changes, discolorations, or reactions that occur over the same 3-minute period for each.

Record your observations in the **Chemical Property Table.**

Complete Physical and Chemical Properties Tables

Complete the Physical & Chemical Property Tables (next page) with all recorded data, including mass, volume, density, solubility results, and wettability observations.

Reflect and Discuss

Review the results with peers or supervisors. Discuss how different additives or mixtures may have influenced the samples' performance. Reflect on how to improve your mixture.

Physical Properties Table

Sample	Mass	Volume	Density	How well does the sample hold form?
A (small)				
B (small)				
A (large)				
B (large)				
Average				

Chemical Properties Table

Sample	Soap Observation	Water Observation	Alcohol Observation
A			
B			

Solubility Table

Sample	Solubility Observation
A (control)	
B	

Step 2

REGOLITH CONSTRUCTS

In Step 2 of the Build the Moon Challenge, teams can demonstrate their lunar concrete's capabilities by choosing from three fundamental construction activities, each taking 1 to 2 hours.

The first activity, Demo 1: Build a Landing Pad, involves pouring a scaled version of a lunar concrete landing pad using the best mixture from Step 1, allowing it to dry, and testing its strength to minimize the risk of dust plumes during landings.

Demo 2: Build a Brick Wall focuses on creating at least nine bricks from the lunar concrete mixture, letting them dry, and constructing a three-layer wall using mortar to attach the bricks, with strength tested through a compressive weight test.

Lastly, Demo 3: Build a 3D Printed Wall explores the use of 3D printing techniques for constructing a wall with lunar concrete, allowing teams to create a suitable mortar composition for extrusion and layering. Teams will submit their results for each activity on the ICS dashboard, completing the instructions provided here in the Activity Guide.

SUBMISSIONS FOR DEMO 1: BUILD A LANDING PAD

Submission Items located on ICS Dashboard

Document:

- **Design Process** - 1-2 page document outlining process to make the landing pad
- **Photo Documentation** - photo of each step of the process

Video Recording:

- **Strength Test -** video recording of team testing the maximum strength

SUBMISSIONS FOR DEMO 2: BUILD A BRICK WALL

Submission Items located on ICS Dashboard

Document:

- **Design Process** - 1-2 page document outlining process to make the brick wall
- **Photo Documentation** - photo of each step of the process

Video Recording:

- **Strength Test** - video recording of team testing the maximum strength

SUBMISSIONS FOR DEMO 3: BUILD A 3D PRINTED WALL

Submission Items located on ICS Dashboard

Document:

- **Design Process** - 1-2 page document outlining process to make the 3D printed wall
- **Photo Documentation** - photo of each step of the process

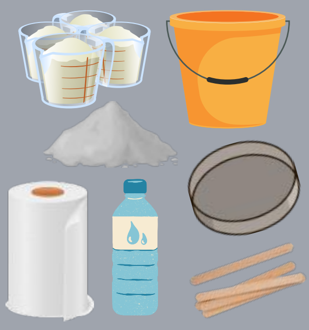
Video Recording:

- **Strength Test** - video recording of team testing the maximum strength

Procedures for DEMO 1 BUILD A LANDING PAD

Note: Maximum ratio of regolith to bricks and/or mortar additives is 50/50. Refer to Simulate Handling Instructions in the Project Guide.

Materials List



- **Buckets or bowls**
- **Measuring utensils**
- **Silicone pad mold (circle)**
- **2 cups regolith**
- **Paper towels**
- **Stir sticks**
- **Water**

One fundamental component of future lunar habitats is landing the needed materials and future missions close enough to not need to traverse the surface for very long distances. While the lunar regolith provides potentially usable construction materials, it also provides potential hazards from the dust that may be kicked up during landing. Constructing a concrete landing pad will be important to minimize the risk of these dust plumes.

1 Prepare Work Area

Pre-Activity Setup
Work in a well-ventilated area. Gather all materials.

Research & Background
Take your best lunar concrete mixture from Step 1.

2 Making Regolith Cement

Prepare Your Workspace
Select a clean, hard surface for your mixing in a large bucket. Set up your materials.

Mix "Best" Regolith Concrete Recipe
Create a well in the center of your dry mix ingredients. This will be where you add water and other compositional components following your chosen "best" recipe from Step 1.

Fill Pad Mold
Scoop and pat the mixture into the mold.

Drying the Concrete
Place the filled silicone molds in a warm, dry area for 24-48 hours to allow the concrete to set. Leave in sun or near a window. Air dry only, do not bake in oven or apply external heat. After 24-48 hours, remove the bricks from the silicone mold to allow them to dry completely.

3 Testing & Extension

Crumble Test
Place firm pressure on outer edges of the disk structure and observe if fragility of the structural cement.

Shatter Test
Lift your product approximately 4 feet from the ground (you make adjust surfaces) and drop product revealing shatter consistency).

Test for Solubility
Break off a small piece of your concrete sample.

- Place the piece into an empty cup.
- Add enough water to cover the sample.
- Stir the sample gently with a spoon or stick, observing for any dissolution.

4 Next Steps

Submission Items
Submission items required for completion of this Demo are as follows:

- **1-2 page document** outlining process to make the landing pad
- **Photo documentation** of each step of the process
- **Video recording** of team testing the maximum strength

Sample	Strength Observation
Crumble Test	
Shatter Test	

Move on to Step 3 or complete another demo.

Once you have completed at lest 1 of the demos you can move on to Step 3, or you can complete another (or all 3) of the demos before moving to Step 3.

Procedures for DEMO 2 BUILD A BRICK WALL

Note: Maximum ratio of regolith to bricks and/or mortar additives is 50/50. Refer to Simulate Handling Instructions in the Project Guide.

Materials List

- **1 kg regolith**
- **1/2 lb flour**
- **Water**
- **Bucket or bowl**
- **1 lb. weight(s)**
- **Piping bag**
- **Silicone brick mold**
- **2 Landscape bricks**
- **Baking Sheet**
- **Elmer's school glue**

This activity engages participants in applying Earth-based construction techniques to build a brick wall using a concrete mixture made from lunar regolith, As participants create bricks, adhere them with mortar, and assemble the wall, they gain valuable experience in the key principles of structural integrity and design.

1 Prepare Work Area

Pre-Activity Setup

Work in a well-ventilated area. Gather all materials.

2 Making Regolith Concrete Blocks

Prepare Your Workspace

Select a clean, hard surface for your mixing in a large bucket. Set up your materials.

Mix "Best" Regolith Concrete Recipe

Create a well in the center of your dry mix ingredients. This will be where you add water and other compositional components following your chosen "best" recipe from Step 1.

Fill Molds

Carefully fill the prepared silicone molds with the regolith concrete mixture.

Drying the Concrete

Place the filled silicone molds in a warm, dry area for 24-48 hours to allow the concrete to set. Leave in sun or near a window. Air dry only, do not bake in oven or apply external heat. After 24-48 hours, remove the bricks from the silicone mold to allow them to dry completely.

3 Constructing Your Wall

Prepare Mortar & Piping Bag

Using your "best" regolith mortar recipe from Step 1, mix dry and wet ingredients and transfer the mortar mixture into a resealable plastic bag and seal it tightly. Cut a small tip from one corner of the bag, or alternatively, attach a piping nozzle.

Assembling Your Brick Wall

Using nine of your regolith concrete bricks, build your three-layer lunar concrete wall, adhered by your mortar. 4 brick bottom layer, 3 brick 2nd layer. 2 brick top layer. These building materials should represent your best compositional recipes and your control bricks from Step 1.

4 Strength & Extension Test

Test Strength

Place two concrete blocks approximately 6-8 inches apart on the floor. Rest the ends of the regolith brick wall on the two blocks. Place the baking sheet on top of the brick wall so that you can stack the weights on the sheet. Gently place 1 lb. weight on the center of the baking sheet, continue to add weight until defect observed.

Sample	Strength Observation
Control	
Sample A	

5 Next Steps

Submission Items

Submission items required for completion of this Demo are as follows:

- **1-2 page document** outlining process to make the brick wall
- **Photo documentation** of each step of the process
- **Video recording** of team testing the maximum strength

Move on to Step 3 or complete another demo.

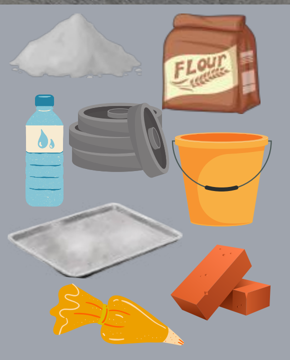
Once you have completed at lest 1 of the demos you can move on to Step 3, or you can complete another (or all 3) of the demos before moving to Step 3.

Procedures for

DEMO 3 BUILD A 3D PRINTED WALL

Note: Maximum ratio of regolith to bricks and/or mortar additives is 50/50. Refer to Simulate Handling Instructions in the Project Guide.

Materials List



1 kg regolith
1/2 lb flour
Water
Bucket or bowl
Piping bag
1 lb. weight(s)
2 Landscape bricks
Baking Sheet

Explore the potential for 3D printing with lunar concrete to build future habitats. Companies have now demonstrated construction of houses using 3D printing techniques with concrete on the Earth. NASA is interested in seeing how 3D printing with lunar concrete could be valuable in constructing future habitats. No fancy 3D printer needed! You will use a cake icing extruder and an icing piping bag to manually build your wall layers.

1 Prepare Work Area

Pre-Activity Setup
Work in a well-ventilated area. Gather all materials.

Mix "Best" Regolith Concrete Recipe
Create a well in the center of your dry mix ingredients. This will be where you add water and other compositional components following your chosen "best" recipe from Step 1.

2 Printing Your 3D Wall

Prepare Mortar & Piping Bag
Using your "best" regolith mortar recipe from Step 1, mix dry and wet ingredients and transfer the mortar mixture into a resealable plastic bag and seal it tightly. Cut a small tip from one corner of the bag, or alternatively, attach a piping nozzle.

Printing Your 3D Wall
Using your piping bag you will squeeze out 1 layer approximately 6 inches long (you may let each layer dry before adding an additional layer). You will continue the process adding 3 layers to complete the wall structure.

Printing Your 3D Wall
Using your piping bag you will squeeze out 1 layer approximately 6 inches long (you may let each layer dry before adding an additional layer). You will continue the process adding 3 layers to complete the wall structure.

3 Strength & Extension Test

Test Strength
Place two concrete blocks approximately 6-8 inches apart on the floor. Rest the ends of "printed" wall on the two blocks .Place the baking sheet on top of the structure so that you can stack the weights on the sheet. Gently place 1 lb. weight on the center of the baking sheet, continue to add weight until defect observed.

Optional Extension Reinforcement #1
You may choose to amend the trails by adding a mold to support external structure of your wall while it dries. The composition and development of your mold will be up to you, document and record your findings

Optional Extension Reinforcement #2
You may choose to amend the trails by creating an internal support structure (like a cage or rebar) the composition and development of your mold will be up to you, document and record your findings

Sample	Strength Observation
Unsupported Wall	
Optional Supported Wall	

4 Next Steps

Submission Items
Submission items required for completion of this Demo are as follows:

- **1-2 page document** outlining process to make the 3D printed wall
- **Photo documentation** of each step of the process
- **Video recording** of team testing the maximum strength

Move on to Step 3 or complete another demo.
Once you have completed at lest 1 of the demos you can move on to Step 3, or you can complete another (or all 3) of the demos before moving to Step 3.

Step 3

DESIGN A LUNAR HABITAT

The rationale for the "Design a Habitat" activity in the Build the Moon Challenge is to leverage participants' knowledge of in-situ regolith construction acquired from previous activities to create a practical and innovative lunar habitat design utilizing 3D printed construction techniques.

This exercise encourages participants to synthesize their understanding of lunar materials and apply them to address the unique challenges of living and working on the Moon. By focusing on mission parameters, teams will ensure that their habitat designs comply with essential criteria outlined in the challenge materials, enhancing the viability of their proposals.

Moreover, the prudent use of lunar resources is critical in this context, as it fosters sustainability and efficiency, minimizing reliance on Earth-supplied materials and optimizing local resources like lunar regolith.

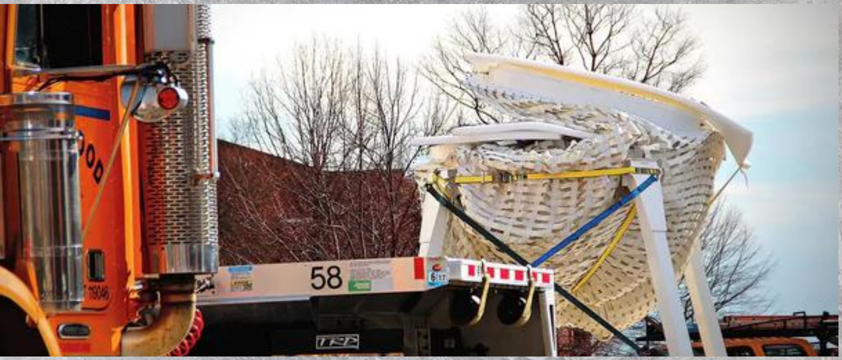
Finally, encouraging innovation in design will stimulate creative problem-solving and forward-thinking approaches to habitat construction, promoting the development of solutions that could potentially enhance human adaptability, safety, and comfort on the Moon. This strategic combination of practicality, sustainability, and creativity in habitat design prepares participants to contribute valuable insights to future lunar exploration and habitation efforts.

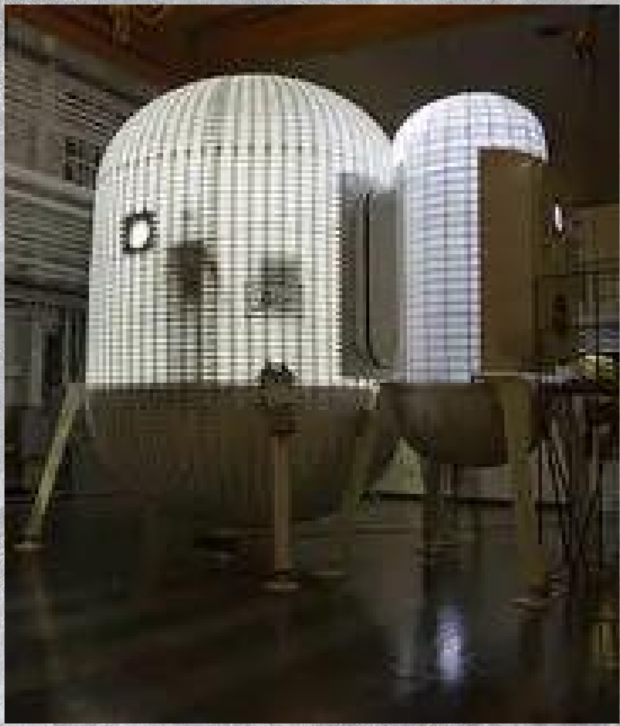
STEP 3: HABITAT DESIGN SLIDES

Submission Items located on ICS Dashboard

Slide Deck (5-10 slides) outlining:

- Description of design structure
- Graphic slide visualizing habitat
- Design features
- Description of incorporating simulant materials





Photos: Inflatable lunar habitat in a lab at NASA's Langley Research Center in Hampton, Virginia.

Procedures for

STEP 3 DESIGN A LUNAR HABITAT

This step-by-step procedure guides participants through the mission parameters, teams will ensure that their habitat designs comply with essential criteria outlined in the challenge materials, while incorporating the lunar regolith materials explored in Steps 1 & 2 to enhancing the viability of their proposals.

Mission Parameters

Mission Objective

Design a lunar habitat meeting the requirements below. Habitat submissions should pay specific attention to how in situ resources (lunar regolith) are incorporated into their designs. Teams should demonstrate how they are able to replace some Earth materials with resources created from lunar regolith while still meeting all mission requirements.

Habitat Design Requirements

1. Design must provide enough room for four astronauts to live continuously on the surface of the Moon for at least 6 months. Teams should consider the amount of space and how it is constructed.
2. Design must include a way for astronauts to safely enter/exit the habitat.
3. Design must include space/area for life support facilities/systems. Consider what a group of four astronauts would need to live in an isolated facility for 6 months.
4. Design must include space/area for a science/research laboratory.
5. Design must include a way for the habitat to protect astronauts from harmful solar radiation. Consider how humans are protected from radiation on the Earth. What can be used on the Moon for protective radiation shielding?

Submission Components

Submission on ICS Dashboard

Submission items require for completion of this step are as follows:

Slide Deck - 5-10 slides

Slide Deck Requirements

1. Slide deck must include 1 introduction slide (team name, members, ect.) and 1-2 slides providing a detailed description of your design structure.
2. Slide deck must include 1-2 slides providing a graphic (visual) representation of habitat.
3. Slide deck must include 1-2 slides providing a detailed description of design features that support the mission objective and fulfill habitat design requirements.
4. Slide deck must include 1-2 slides providing detailed description of incorporation of simulant building material compositions in the previous 2 steps.

Teams should focus on utilizing lunar regolith materials explored in Steps 1 & 2 in the structure, materials, size, and shape, of the habitat rather than what goes into it.

Teams should design habitat with payload cost and resource availability in mind!