



### Earth & Space Science Curriculum Link:

Describe the key processes of the rock cycle and examine how properties of rocks reflect their formation and influence their use.

### Geomechanics Focus:

Applying knowledge of the rock cycle and rock properties to understand how humans interact with Earth materials in construction, including how engineering reinforcement methods improve soil and rock stability.

### Background Information

Granular soils (such as sand and gravel) consist of individual particles that can shift, spread, or fail under load or when placed on a slope. Because these materials have little natural cohesion, engineers often use reinforcement techniques to increase stability and control movement.

Modern reinforcement methods include geogrids, woven geotextile fabrics, and piles:

- Geogrids and geotextiles are sheet-like reinforcement materials placed within soil layers to improve confinement and distribute loads.
- Piles are long, slender structural elements (often made from concrete, steel, or timber) that are driven or drilled deep into the ground. They transfer loads from a structure through weak or loose surface soils down to stronger, more stable layers beneath. Piles can also act as physical barriers that limit soil movement, improve slope stability, and increase the overall stiffness of the ground.

These reinforcement techniques are critical in the construction of roads, retaining walls, embankments, bridges, building foundations, and steepened slopes.

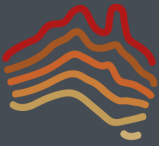
Although geosynthetic reinforcement materials are modern, the concept of soil reinforcement is ancient. One of the earliest recorded examples dates back approximately 3500 years to Mesopotamia. Under King Kurigalzu I, the Sumerians constructed the temple of Aqar Quf (near modern-day Baghdad). They stabilised foundations and brick walls using reed mats embedded within soil, an early form of reinforced earth.

Similarly, during the construction of the Great Wall of China, builders mixed reeds and other fibrous materials into compacted earth. These inclusions provided tensile resistance within the soil mass, allowing steeper wall angles and improved structural integrity. While the materials have changed over time, the engineering principle remains fundamentally the same: combining soil with tensile elements to improve strength and stability.

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Today, geogrids and woven geotextiles are polymeric reinforcement materials widely used in soil mechanics to enhance strength, stability, and load-bearing capacity. Through mechanical interlock and frictional interaction with surrounding particles, along with their inherent tensile resistance, these geosynthetics improve soil confinement, reduce lateral deformation, and promote more efficient load distribution. They are commonly applied in reinforced retaining walls, steepened slopes, embankments over soft soils, and pavement stabilisation.

By improving structural efficiency and long-term performance, reinforced soil systems provide durable and cost-effective solutions in modern geotechnical engineering — continuing a practice that began thousands of years ago.

You can watch the demonstration video [here](#).

A presentation for the following activity is provided in this teaching package.

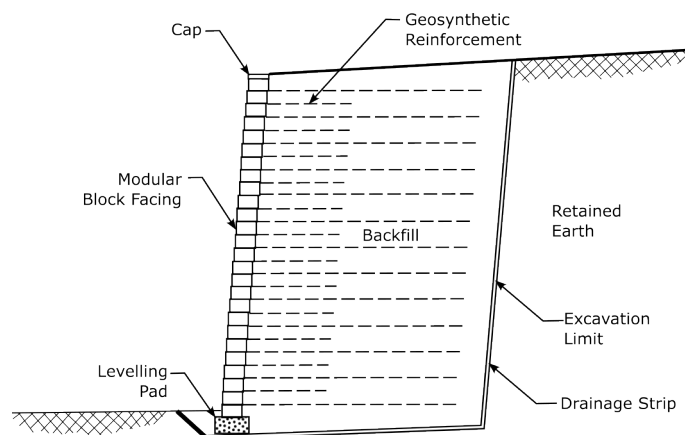


Figure 1: Typical Geogrid Reinforced Soil (GRS) wall with modular block facing



Figure 2: A geogrid or mesh laid over the dirt to reinforce the soil and stabilise the ground.

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## Aim

Investigate how reinforcement methods (geogrids, fabric strips, simulated piles) affect ground stability compared to unreinforced ground.

## Materials

Per small group (figure 3):

- Dry sand or fine gravel
- Plastic container or tray
- Fabric strips (simulate geotextile)
- Cardboard strips or mesh (simulate geogrid)
- Wooden skewers or matchsticks (simulate piles)
- Cardboard strip (simulate pile cap)
- Small weight (or full water bottle)

## Safety Notes

- Ensure containers are stable to prevent spills.
- Supervise use of skewers (sharp ends).
- Clean up sand promptly to avoid slipping hazards.



Figure 3: Materials

## Method

Run through the PowerPoint presentation provided in the teaching package.

### 1. Unreinforced Test

- Fill container with sand and create a slope at one end (figure 4).
- Apply load (small weight) on top (figure 5).
- Observe settlement and spreading/collapse of the slope.

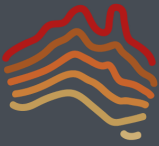


Figure 4: container with sand arranged into a slope



Figure 5: load applied to the slope. Slope has collapsed

Resource



## 2. Reinforced Test

- Repeat with fabric strips layered in the sand (figure 6).



Figure 6: Fabric strips layered in the sand with load applied. Slope has not collapsed

- Repeat with cardboard grid or mesh placed in the sand (Figure 7).



Figure 7: mesh placed in sand with load applied. Slope has not collapsed

- Insert skewers or matchsticks vertically (simulate piles; figure 8).



Figure 8: Inserting 'piles' vertically



- Apply a cap to the piles.
- Apply same load and observe differences (Figure 9).



Figure 9: cap applied to piles and load applied.  
Slope has not collapsed

## Results

- Unreinforced sand spreads and settles significantly.
- Fabric strips reduce spreading slightly.
- Cardboard grid or mesh locks particles, reducing movement.
- Skewers provide vertical resistance, improving stability.
- Reinforced slope holds shape better under load.

## Discussion

1. Why does reinforcement reduce soil movement?  
*Soil is very weak in tension - it just pulls apart, but when we reinforce it, e.g., with geogrid, we allow it to carry tension, preventing displacement.*
2. Which reinforcement method was most effective? Why?  
*Geogrid (cardboard grid) because it can carry tension forces when soil cannot, strengthening the combined system.*
3. Where might engineers use these techniques in real life?  
*Roads, retaining walls, embankments, and slopes, or generally where the soil is too weak for what we need it for and it needs to be strengthened.*

## Extension

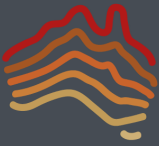
Activity 1: Design and outline your own experiment to investigate how different factors affect a slope's stability.

Your experiment design must include:

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1. A specific question you want to test

Examples:

- *How does grain size (sand vs gravel) affect the stability of a slope?*
- *How does moisture content change the slope's resistance to collapse?*
- *How does slope angle influence the likelihood of failure?*
- *How does adding vegetation (simulated with toothpicks or straws) affect slope stability?*

2. A hypothesis

A simple prediction of what you expect to happen and why (based on rock/soil properties and the rock cycle).

Example:

*I predict that wetter sand will be stronger, unless it is fully saturated.*

3. Independent variable (the thing you will change)

Some possibilities:

- Slope angle
- Grain size (fine vs coarse)
- Moisture content
- Type of reinforcement
- Amount of compaction

4. Dependent variable (what you will measure)

Some possibilities:

- Amount of slope movement
- Distance of material spread
- Height loss
- Visual observation of collapse pattern

5. Materials list

These must be items that are safe and accessible in class, e.g., sand, gravel, water, trays, rulers, protractors, straws, fabric strips, measuring cups.

6. Method

Students must outline the steps clearly enough that another group could repeat their experiment.

This should include:

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- How they will build the slope
  - How they will apply load or trigger movement
  - How they will keep tests fair and consistent
  - How they will measure changes
7. Safety considerations  
Students must identify and address any risks (e.g., slippery sand, careful handling of tools, spill management).
8. Expected results or data table format  
Students should sketch the type of data they will collect (e.g., table comparing slope movement under different moisture levels).

Activity 2: Research real-world applications of geogrids and piles in highway construction or slope stabilisation.

Activity 3: Research ancient use of geogrids (e.g., “Construction Secrets of the Original Great Wall” on Youtube)

Activity 4: Have a competition to see who can build the highest sandcastle using fixed amounts of sand and reinforcing materials

**Possible sources:**

Ace Geosynthetics. (2020, Jan 31). Geosynthetic Reinforced Structure for Bridge Abutment Construction [Video]. Youtube.

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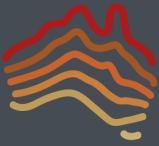
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## What Geomechanics Is and Why It Matters

Geomechanics is the study of how soil, rock, and Earth materials behave, forming a critical foundation for the design and performance of modern infrastructure. It enables engineers and planners to develop safe, efficient, and sustainable structures, such as buildings, tunnels, roads, and dams, by providing accurate ground models and an understanding of how the ground responds to natural and human induced changes. Geomechanics also contributes to public safety by helping identify and manage geohazards such as landslides, sinkholes, and ground instability, supporting climate resilience, sustainable development, and the global energy transition. Through proactive ground assessment and risk evaluation, geomechanics helps prevent infrastructure failures, reduce project delays, and lower financial and social costs. Careers in geomechanics span a wide range of roles, including field investigations, laboratory testing, data analysis, and engineering design, with entry pathways commonly through geology, civil engineering, and environmental science. Alternative routes, such as experience in construction, surveying, or environmental monitoring, also provide effective foundations for moving into the field. Professionals develop skills in technical analysis, communication, critical thinking, and multidisciplinary collaboration, supporting informed decision making across infrastructure and environmental projects.

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# Ground Reinforcement

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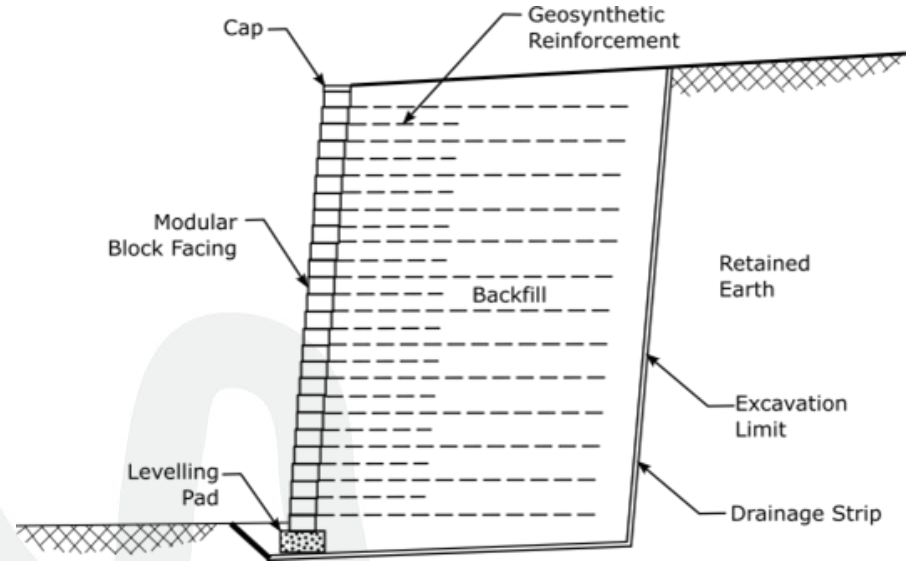


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- Cardboard strip (simulate pile cap)
- Small weight (or full water bottle)



## Unreinforced test



- Fill container with sand and create a slope at one end
- Apply load (small weight) on top and observe settlement and spreading/collapse of the slope.



## Reinforced test – fabric strips



- Repeat with fabric strips layered in the sand



## Reinforced test – mesh



- Repeat with cardboard grid or mesh placed in the sand



## Reinforced test – skewers (piles)



- Insert skewers or matchsticks vertically

- Apply a cap to the piles and apply the load



# Discussion





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