

Choose the Stone: Which Rock Will Last on the Riverside Steps?

Learning target: I can use what I know about how rocks form and weather to evaluate candidate building stones against criteria and constraints, choose one, and justify the choice with evidence and rock-cycle reasoning.

Transfer and design

About 50 min

Pairs

MS-ESS2-1 · practice

MS-ETS1-2 · practice

engineering design

data analysis

writing

Name _____

Date _____

Period _____

Directions

The town of Millbrook is replacing the stone steps that lead from Main Street down to the river. The old sandstone steps crumbled after 60 winters. The town council has asked a student engineering team to recommend a stone. Read the design brief, study the quarry test results (a teaching dataset with realistic, invented numbers), and work through the parts in order. Your final recommendation must be justified with the test data, the cost calculation and what you know about how each rock formed and weathers.

You will need: This worksheet, Pencil, Calculator, Scrap paper for the comparison grid

The design brief

What the council needs — The steps need about **40 cubic meters** of cut stone. Millbrook has cold winters with about 90 nights a year when wet stone freezes, and its rain is slightly acidic, like rain in most towns. The council's requirements: (1) the steps must stay safe and solid for at least 100 years without replacement; (2) the stone must cost no more than **\$60,000** in total; (3) the stone must come from a quarry within **300 km**, to keep delivery practical; (4) the surface should not become dangerously smooth or crumbly when wet. The council would prefer a light color but says that is a wish, not a rule.

Quarry test results for four candidate stones (teaching dataset)

Simulated teaching dataset: the numbers are invented to be realistic, not measured.

Stone	Description under a lens	Water soaked up (% of block mass)	Weak acid test	Freeze-thaw cycles before damage	Cost per cubic meter	Quarry distance
A	Pink-gray; interlocking crystals 3 to 6 mm, no layers	0.3	No fizz	More than 300, no damage	\$1,400	120 km
B	White; interlocking crystals 1 to 3 mm, faint swirls	0.4	Fizzes; surface dulls	More than 300, no damage	\$1,900	250 km
C	Tan; rounded sand grains glued together, visible gaps, layers	6.0	No fizz	Cracked along layers at 45	\$600	40 km
D	Dark gray; crystals too small to see, scattered tiny holes	1.5	No fizz	Minor flaking at 220	\$900	500 km

Simulated data for teaching. The acid test drips a weak acid on the stone and watches for fizzing. The freeze-thaw test soaks a block and freezes and thaws it repeatedly until damage appears.

Part A: Define the problem

1. Complete the table from the design brief.

Criterion or constraint (write the requirement)	Is it a criterion (how good) or a constraint (a limit that cannot be broken)?	How will you test a stone against it?
Durability		
Budget		
Distance		
Wet surface		
Color		

2. Calculate the total stone cost for each candidate ($40\text{ m}^3 \times \text{cost per m}^3$). Which candidates stay within the \$60,000 budget? Show all four calculations.

3. Which candidates are eliminated by a constraint before you even think about durability? Name each and the constraint it breaks.

Part B: Explain the test results with the rock cycle

4. Stone C soaked up 6 percent of its mass in water and cracked after 45 freeze-thaw cycles. Use how a rock like C forms (grains, gaps, glue, layers) to explain why it failed, and name the type of weathering that destroyed it. Then estimate how many Millbrook winters 45 cycles represents, using 90 freezing nights a year, and say whether C could meet the 100-year criterion.

5. Stone B passed the freeze-thaw test but fizzed in weak acid and its surface dulled. Explain what the fizzing tells you about B's minerals, which type of weathering slightly acidic rain would cause, and why a stone that passes the frost test can still fail the 100-year criterion. What safety problem could a dulling, dissolving surface cause on steps?

6. Stone A and Stone D both have interlocking crystals and no fizz, but D flaked after 220 cycles and A showed no damage after 300. Using the descriptions, suggest what feature of D let water in, and explain how each stone's cooling history produced that difference.

Part C: Decide and justify

7. Write your recommendation to the council. State the stone you chose, show that it meets every constraint, use at least three pieces of test data as evidence, and explain in rock-cycle terms why it will resist Millbrook's frost and rain for 100 years. End with one honest limitation of your choice.

8. Trade-off: suppose the council's budget is cut to \$30,000. Which stone would you recommend now, what would the town have to accept, and what maintenance plan would you suggest so the steps still last as long as possible?

9. Even the best stone will not last forever. Describe what will eventually happen to the steps over thousands of years, and which part of the rock cycle, driven by which energy source, is responsible.

Eliminate, then compare

Engineers rarely compare everything at once. First use the constraints to cross out any stone that breaks a hard limit (over budget, too far away). Then compare only the survivors on the criteria, one criterion at a time, in a quick grid with stones across the top and criteria down the side: write a check, a cross or a question mark in each box. The stone with the most checks and no crosses is your recommendation. For q4 and q5, go back to how each rock formed: cemented grains have gaps that water can enter; interlocking crystals do not; minerals that fizz with acid dissolve slowly in acid rain.

Design the fifth test

The quarry's tests did not measure how slippery each stone becomes when wet, which the council listed as requirement 4. Design a fair test for wet slipperiness: name the variable you would change, the variable you would measure, three things you would keep the same, and how many trials you would run. Predict which of the four stones would do best and worst, using their textures as your reason. Then explain how a stone that scored best on durability could still be rejected after your test, and what that says about why engineers use several criteria instead of one.