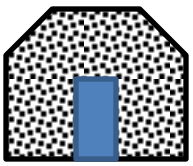
Student Pages



Engineering with Reinforced Concrete

Concrete is the most commonly used building material (steel is #2). Concrete is composed of sand and gravel, glued together by Portland cement and water. Concrete is usually reinforced by being poured around a mesh of steel bars, called *rebar* in the construction industry.

You are going to make two slabs of reinforced concrete. Imagine your slabs are the roof or wall of a storm shelter. You will be allowed to make certain choices about the materials which go into your concrete. Consider your choices carefully.

Problem Statement: Recent events have convinced you that your school is in danger from some external threat. A strong shelter should be constructed in, or adjacent to the main building, in which students would be safe from danger. You must design a shelter using reinforced concrete and present data to suggest that your design would have the strength to withstand the threat.

Materials: You and your partners will need:

- 1 cardstock sheet with forms and spreading tool
- 1 Design Comparison Sheet
- 4 Styrofoam cups
- 1 Styrofoam plate
- 1 craft stick for stirring
- 1 pair scissors
- 1 ruler
- 1 roll of tape

Choose Your Disaster

What type of threat must your shelter withstand? Is it an earthquake, hurricane, tornado, sharknado, zombie apocalypse, or something else? Select a disaster (natural or otherwise) from which your shelter must protect you and your fellow students. Obtain approval from your teacher.

The disaster which threatens our school is:

To be sure your reinforced concrete shelter is strong enough, you must think about the types of forces which the disaster might apply to the walls and roof of your shelter.

How the disaster might apply force against the shelter:

You will build small, rectangular slabs of reinforced concrete to test for strength. You will test competing designs to see which type of slab has the greatest strength for resisting your particular disaster.

Using the available materials, how can you model the forces applied against your shelter? How will you quantify the strength of your slabs?

How we will model the forces and test our slabs of reinforced concrete:

Procedure for Making the Slabs:

1. Using scissors, carefully cut-out one of your forms and the spreading tool from the white card stock.
2. The form is then folded into an open-topped box into which you will pour your wet concrete. Use a straight edge to help you make the long folds along the sides of the form.
3. Use a piece of tape at each of the four corners to join together the walls of your form. Try to make them watertight so no wet concrete can leak out.
4. Place your form on a Styrofoam plate. Label the plate with your names.
5. Take four small paperclips to use as rebar. There are two types of rebar to select from. Use either the smooth or the textured. Bend your rebar into whatever shapes you think will allow them to add the most strength to your concrete.
6. Find the separate paper labelled "Design Comparison Sheet". On the left-hand side of the Design Sheet you will see a large empty rectangle. The rectangle represents your form. Sketch how you will lay your rebar into the form once the wet concrete has been added.
7. Above the rectangle, indicate which type of rebar you have selected, smooth or textured.
8. Your concrete will be composed of 100 grams of solid material. You may use between 30 and 60 grams of sand. The balance will be Portland cement, which holds the sand together. Decide how much of each solid you will use and fill-in the blanks below:

   _____ grams of sand + _____ grams of Portland cement = 100 grams

9. The other required ingredient is water. The minimum amount of water needed is 1 gram for every 2 grams of Portland cement. Calculate the minimum amount of water for your concrete:

   _____ grams of Portland cement / 2 = _____ grams of water (minimum)

10. The maximum amount you can use is 35 grams. You must select an amount between the minimum and maximum. Record your choice below:

    _____ grams of water

Note that one gram of water has a volume of one milliliter so it may be easier to measure your water in a graduated cylinder.

11. On your Design Comparison Sheet, record the percentages of sand and water. Calculate and record the ratio of water to cement.

Safety note: Be sure you are wearing goggles and gloves before you begin to make your concrete! Keep concrete (wet or dry) away from the sink.

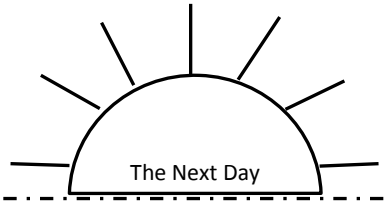
12. Obtain three Styrofoam cups. Measure the appropriate amount of each ingredient into a separate Styrofoam cup.
13. Slowly begin adding the Portland cement to the water. Stir the mixture as you add the cement. You have a craft stick for stirring.
14. Once the water and cement are thoroughly mixed, slowly add the sand, stirring as you go.
15. Pour about half of your concrete into the form and use your paper spreading tool to ensure that the bottom of the form is completely covered.
16. Lay your rebar on the wet concrete, just as you planned in your sketch.
17. Add the rest of your wet concrete to the form (if it will fit). Use the spreading tool to fill the form completely. It is possible that you might not have enough concrete to fill the form completely. That is ok. If you have extra concrete, leave it in the cup. Don't overflow the form.
18. Now you will make a second slab of concrete for testing. Think about the various choices you made in designing your first slab. Select one variable from the design which you will change for the second slab. By testing both slabs you may learn something about what makes the strongest reinforced concrete.

The variable we will change for the second slab is:

Follow the same steps for making your second slab, but record your design decisions on the right-hand side of the "Design Comparison Sheet".

It will take 24 hours for your concrete to dry, and even longer for it to reach maximum strength.

Put all of your waste into a plastic bag or trashcan (if it has a liner). Don't pour anything into the sink!



Examine your dried concrete slabs. Now look at those made by some other groups. Make note of any differences you see. Ask those students about how they made their slabs to see what might explain the differences. Record your observations and ideas below:

Perform the tests you designed to measure the strength of your two slabs. Record your data and observations below:

Which sample of reinforced concrete, slab **a** or slab **b** would be best for your shelter?

It is likely that another group did some testing that might be of use to you in making your decision. It's time to share your results.

On your Design Comparison Sheet is a circle located between your data about slab **a** and slab **b**. To indicate which design had the greater strength, put a > or < sign in the circle.

Place your Design Comparison Sheet where others can see it easily. Now go around and look at all the other groups' sheets. Who else tested the same variable you did? Did they get the same results? If not, why might that be?

After discussing the results of everyone's testing, explain what you think might make the strongest reinforced concrete in the box below. Justify your ideas by referencing test data.