Can you make some concrete?

Project Steps

* Establish your design goals. What do you want to use the concrete for?
* Make some concrete!
* Evaluate the concrete – Is it fluid enough to place? Is it strong enough when hardened?





What you need

* About 4 lbs of cement (depends on number of students and size of form – this is approximate for 30 students and forms like in the pictures)
* About 15 lbs of sand
* Water
* Scale (for measuring weights) (Note: if a scale is not available you can measure by volume)
* Mixing bowl and spoon
* Form for concrete (what are you making?). May need cooing spray or other oil to help release from form
* Decorative pieces (if needed)..gloves



Establish your design goals

What do you want to use the concrete for? Do you want to make a decorative stone for your garden? Do you want to make a decorative gift? There are lots of uses of concrete. Decide (with your teacher) what you want to make and then find some forms for the concrete to fill. These could be molds (like used for gelatin) or a simple cup or bowl, or even just a flat surface. They just need to be able to hold water (because wet concrete is fluid). If you want to decorate your concrete (with shells, beads, pretty stones, etc.) have those ready too.

Get it ready!

The first step in any concrete job is being prepared. Make sure you have everything you need for mixing your concrete, forms prepared, and supplies to decorate,

Concrete Mix Design

For your concrete mix design first you have to determine how much concrete you need – how big is your form? Below is a simple mix design for concrete that can be scaled to fit your form – see step by step instructions in worksheet. We are only using sand in this mix because our forms are small. For normal concrete you would use both sand and gravel.

* 1 part cement
* 0.5 parts water (by weight, if using volume use 1.5 x cement volume)
* 4 parts sand

The ratio between the water and cement is the most important. It controls the strength and the durability of the concrete. These ratios are for weights, but you can use them for volumes as well.

Evaluate your concrete

Once you mix your concrete evaluate it.

* Is it too soupy or runny?

If the concrete is too soupy that means it may not be strong enough once it cures. Try adding some more cement and sand to the mix

* Is it too stiff?

If the concrete is too stiff you may not be able to get it to fill the form completely or be able to smooth it out. Try adding a little more water. But be careful – a little water goes a long way!

Decorate

Once you fill your form it is time to decorate the concrete (if you are doing this).

Let it cure

Concrete does not dry out. There is a chemical reaction between the water and cement that grows crystals that interlock and make the concrete hard. This takes time. Let the concrete sit overnight to harden. Make sure it is not drying out! You may need to cover it with a plastic bag or moist towel. Tomorrow, you can remove it from the form and see your finished product.

Redesign?

Your first design may not be the best one. Engineers usually go through many designs before determining which one best meets their design goals. Can you redesign your concrete and make it better?

Do you want to be an engineer?

Do you like to solve problems, figure out how things work, or make them better? Then engineering might be for you! There is a wide variety of engineers out there and they need lots of different skills. What engineering skills do you have?

* Likes to solve problems
* Good at math and science
* Good at creative thinking (coming up with new ideas)
* Great at communication (writing and talking)
* Ability to organize and make connections
* Can get along well with others
* Determined to get things done and do a good job
* Leadership

**Steps:**

(Your teacher may have completed some of these steps ahead of time)

Step 1 – Determine the volume of your form:

Measure the length width and depth of the form you are going to fill.

Length = in.

Width = in.

Depth = in.

Volume = length x width x depth = in3

Note: If your form is not rectangular this will give you some extra concrete – which is fine!

Step 2 – Determine how much concrete you need and weigh it out:

Total weight = Volume x 0.09 lb/in3 = lb

Weight of cement = Total weight /5 = lb

Weight of water = Cement weight / 2 = lb

Weight of sand = Cement weight x 4 = lb

Note: You may get some very small weights in lbs. You can multiply by 453 grams/lb to convert into grams for easier weighing.

Optional - if using volume to measure use these equations

Volume of cement = Total volume /5 = in3

Volume of water = Cement volume x 1.5 = in3

Weight of sand = Cement volume x 4 = in3

Note: you don’t have to measure the volumes exactly – just get the ratios close.

Step 3 – Get it all ready

Make sure you have everything you need to make your concrete

* Measured amount of cement
* Measured amount of water
* Measured amount of sand (Note: we are just using sand instead of sand + gravel in this mix because the forms are small. This would technically be considered a mortar)
* Mixing bowl and spoon
* Form (Note: make sure the form is waterproof. You may coat the form in a light coat of oil (any kind) to help the concrete release. Do not use cardboard or paper products that absorb water.)
* Decorations – if any



Step 4 – Make some concrete!

Add all the dry ingredients (cement and sand) and mix them first. Then slowly add water until you get a good consistency. If the concrete becomes too runny add more sand or cement. If it becomes too stiff add a little more water.

 

Step 5 – Fill your form and decorate

Now fill up the form. You may need to tap the sides of your form to help the concrete settle (or consolidate) to fill all the spaces. Make sure it is completely filled and smooth off the top. If you are decorating then you can add these now. Try to avoid touching the concrete. If you do wash your hands soon after.



Step 6 – Clean up and Cure the concrete:

Make sure everything is clean and you wash your hands if you touched the concrete. Concrete needs to cure to allow the chemical reaction between the cement and water to take place and make the concrete hard. You can cover it with a plastic sheet to help keep it moist. Wait at least 1 day for the concrete to cure.

Step 7 – Remove the form and enjoy!

You can remove the form after the concrete cures, but you don’t have to.

Comments for teachers:

* You can complete the first 2 steps ahead of class time. This may be required for younger students. Older students may need a calculator to do the equations.
* The form is completely up to you. You can use molds for baking, or make your own. You can just use a sheet of plastic wrap and let the students make their own shape. Just make sure it holds water. If you use something that absorbs water (like cardboard) the concrete will stick to it. You may want to coat the form in a thin coat of oil (anything from vegetable to motor oil – it doesn’t matter) to help the concrete release. Try to avoid forms that have intricate designs. It is often hard to get the concrete out without breaking.
* Don’t worry too much about measuring exactly. Concrete is pretty flexible and will get hard with a wide range of properties. Just try to get the approximate ratios correct.
* The most important thing is the consistency of the concrete. Once you start mixing evaluate the consistency. It should be thicker than something like a brownie or cornbread mix and not runny like a cake mix. It should be able to hold its shape, but not be dry and sandy like. It’s a bit of trial and error. Just keep adding water or cement and sand until you think it looks good.
* Make sure you consolidate the filled forms by tapping or banging on table. This gets any air pockets to rise to the surface. Smooth off the surface if you are not decorating it. As for decorations – anything goes! This is where the younger kids can have a lot of fun putting things in concrete. You can have them bring items from home to decorate with.
* Make sure you clean everything before the concrete gets hard – its way easier! Make sure everyone washes their hands afterward. Concrete is very alkaline (opposite of acid) and it can burn the skin if left on for a long period. In most cases, it just dries out the skin a bit. If anyone has sensitive skin they can wear gloves or everyone can.
* You MUST let the concrete set for a least a day before removing it from the form. Concrete gains strength with time and the longer it sets the stronger it will be and less likely it will break when removing the forms. If it is a more intricate form wait a bit longer for the concrete to be stronger.

Teacher Instructions:

Prepare ahead of time

* Make sure you have enough supplies (first page) for all students. Students can work in groups. You may need to run the design yourself to determine the approximate amounts of cement and sand. The cement is available at any hardware store (Lowes, Home Depot, etc.). Look for Type I/II **cement** (not the premixed stuff with aggregate in it – no quickcrete or “concrete mix” for example [https://www.homedepot.com/p/Ash-Grove-92-6-lb-Portland-Cement-Concrete-Mix-100-92-AG/202075616)](https://www.homedepot.com/p/Ash-Grove-92-6-lb-Portland-Cement-Concrete-Mix-100-92-AG/202075616)%20)  They are typically in 90 lb bags and don’t cost much (you will have plenty of leftover). Any playground or similar sand will do.
* Print out copies of instructions to give to students or have electronic copies available.
* This is a multi-day activity. The concrete will need at least one day (the longer the better – suggested time is one week) to cure before removing the forms.

Introduce the challenge (20 min video + 5 min discussion)

* Show the video on how concrete gets hard.
* Talk with students about: Where do we use concrete? What concrete is composed of? What are the goals in our concrete mix design (is it just about strength)? How do we evaluate concrete?
* Go over activity instructions and goals.

Design concrete mix (15 min)

* Give students about 15 min to complete the concrete mix design. They can measure their forms and determine the amounts of cement, water, and sand to use. For the younger students (k-3) teachers may complete the design for them and then just let the students batch the concrete.
* Let them compare the mix designs with other groups. If they have the same forms (volume), they should all have the same answers. Part of engineering is double checking work and having others review the work. Consider letting students share the design with another group to see if there are any mistakes.

Mix concrete and pour into forms (20 min)

* Have the students mix the concrete according to the instructions provided. Concrete is alkaline which can dry out skin for a short exposure and lead to chemical burns for prolonged exposures. If the students touch the concrete, have the students wash hands soon after handling concrete or wear gloves.
* Make sure they evaluate the concrete before they pour it – is it at the right consistency?
* Put the specimens someplace safe to cure overnight to one week.

Remove the forms (5 min)

* Take the concrete out of any forms and let the students keep the finished product. What do they think about what they made?

Discussion (15 min)

* Ask some of these questions to help students think about their design.
* How easy was it to mix and work with your concrete? Remember concrete has to be placed in its fluid state. Adding extra water makes it easier to work with but reduces the strength. Would you want to use this concrete on a job site? What changes could be made to the mix design to make it easier to work with?
* How quickly did your concrete get hard? How does concrete go from the fluid state to the hardened one?
* What do you think about your piece of concrete art? What would you do differently if you did it again?