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How to mix concrete by hand

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Introduction:

In our society's world of construction and civil engineering, we often take for granted the cement mixers and delivery methods used for mixing and placing concrete. However, if you are in a position where you do not have access to these devices, knowing how to mix concrete yourself will definitely come in handy. Situations in which you might need to mix concrete by hand can include working internationally, working on a low budget, and more. Besides, it is a good idea for any young construction worker or civil engineer to have this hands-on experience. It can not only give you a better understanding of concrete, but also make you feel more comfortable in the field, more knowledgeable about construction terms, etc.

What is Concrete?

Concrete is the world's most-used construction material. Ton for ton, it is used more than steel, wood, plastics, and aluminum combined. Concrete is a combination of cement, sand, gravel, and water. It starts out "wet" and overtime it hardens while gaining strength. There are numerous varieties of concrete, but we will focus on its most basic form: Portland cement concrete. Basically, it uses this specific type of cement mixed with sand, gravel, and water. We will go into more detail about these materials later.

The Basics

- Mixing concrete essentially involves going over safety hazards, clearing a workspace, gathering materials, mixing the materials in a specific order and fashion, and placing the concrete.
- Mixing a typical, small batch of concrete will take about 10-30 minutes overall.
- The place in which you will mix concrete depends on what is available to you.
    - If there is a construction facility located nearby, it is very easy to find space and materials to mix there.
    - If not, as long as you have a clear, mostly flat surface, you are good to go.
    - For example, if you are mixing outside somewhere, just clear an area of the ground from debris like rocks and sticks.
    - However, you need to know that some of the leftover concrete can dry on the ground and unless you go through means to move it, it will stay permanently.

Cautions/Warnings:

***WARNING**: Please read the following warning before working with concrete.*

Wet concrete has caustic, abrasive, and skin drying properties. These properties can cause skin irritation, severe chemical burns (also known as “cement burns”) and eye injury. Avoid contact whenever possible and wash exposed skin areas promptly with water. If any cement or concrete gets into the eyes, rinse immediately and repeatedly with water and receive prompt medical attention. Keep children and animals away from cement powder and all freshly mixed concrete. When handling concrete, always wear the proper personal protection equipment (PPE):

Personal Protection:

- Wear rubber or construction boots high enough to keep out cement products. Top of boots should fit tightly.
- Wear construction gloves.
- Wear safety goggles.
- Wear long pants, possibly tucked inside boots.
- Wear at least a tee-shirt length sleeve.

***WARNING:** Some of the pictures used show people without proper PPE. Do NOT mix concrete without your PPE.*

***WARNING:** For extra safety, read through each step before actually performing them.*

Required Materials

Portland Cement: Cement is the gray, dry, powdery material usually stored in paper bags. A bag typically contains 94 pounds of cement, or one cubic foot. Technically, Portland cement is the cement that is manufactured from limestone and clay and that hardens under water. Cement acts as the binding agent when mixed with water and aggregates (sand, gravel, or rock).

Sand: Unwashed beach sand will create a mixture that is not quite as strong as products made with sand that has been washed through a screen. Technically, this sand is composed of gneiss, trap rock, limestone, or granite.

Gravel: Gravel is what separates concrete from mortar (or the stuff you use as a "glue" between CMUs, for example). It is a crucial ingredient in concrete and helps add strength and durability to your mix.

Water: Adding water is what forms a paste that will bind the other three materials together until the mix hardens. The strength of the concrete is inversely proportional to the water/cement ratio, but we will not get into that. If you use too much water, the concrete can be too weak or runny. If you do not use enough, the mix will be dryer and less workable.

Shovel: One shovel, or more, is typically required to actually mix the concrete. If this is unavailable, a smaller tool or your own hands are usually sufficient.

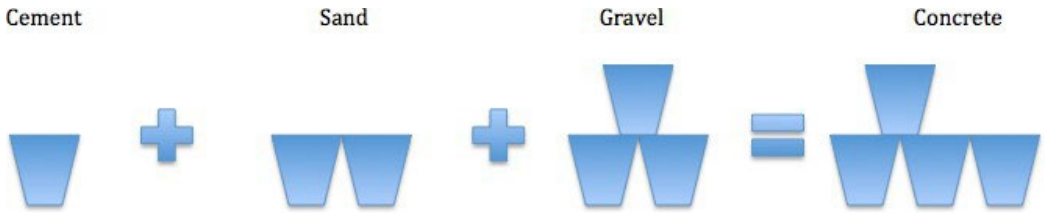
Buckets: You will need buckets or something similar to not only measure out the other materials, but to transport the concrete wherever you are placing it. For measuring, any size bucket is acceptable, as long as you are consistent. A wheelbarrow or something similar can also be used for transportation of the concrete.

PPE: As mentioned before, *always* wear your proper personal protection equipment when mixing or handling concrete.

Proportions

To produce a strong, durable, and workable concrete mix, the correct ratio of aggregate to sand to cement is crucial. One standard recipe calls for one part cement, two parts sand, and three parts aggregate, or gravel. This is also known as a 1:2:3 volumetric mix ratio. In other words, one bucket of cement is mixed with two buckets of sand and three buckets of gravel.

Figure 1: Mix Ratio



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As mentioned earlier, the size of the bucket (or the amount of buckets used) does not matter as long as you are consistent and follow the 1:2:3 ratio. For example, if you want to mix a larger batch of concrete, it is perfectly acceptable to use two buckets cement, four buckets sand, and six buckets gravel. Likewise, if you want a smaller mix, you can do a half buckets cement, one bucket sand, and one and a half buckets gravel.

For further explanation, see the table below. It represents the amount of cement, sand, and gravel needed for 1 cubic meter of concrete. This table might be more useful in estimating total materials needed rather than for use when mixing concrete.

Materials Needed for 1 Cubic Meter of Concrete (!:2:3: Mix Design)

Cement (m^3)	Sand (m^3)	Gravel (m^3)	Yield (m^3)
0.25	0.50	0.75	1.0

Lists of Steps

1. **Going Over Safety Hazards**
   This is a crucial step when mixing concrete, and it is often over-looked. Please see the "Cautions/Warnings" section on page ___for this step. If you are working with a group of people, it is often helpful to assign someone as "Safety Manager" and have them lead a quick safety session in which they go through all the possible hazards.

Figure 2: Proper PPE

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2. **Clearing a Workspace**
   No matter where you mix concrete, the technique is the same. Make sure to choose a place that is as close to where you actually need the concrete as possible. It is important, however, to clear your workspace of loose dirt, rocks, or other materials that risk getting into your mix. Also, make sure your workspace is dry. The chemical processes involved with mixing concrete do not start until water is added. The time at which you add water is very important and if the cement is laid on a wet surface to begin with, it will harden prematurely and can ruin your mix.

3. **Gathering Materials**
   Once the first two steps are complete, you are ready to gather your materials. As you should already know this includes:
   - Buckets
   - Portland Cement
   - Sand
   - Gravel
   - Water
   - Shovel(s)

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Again, make sure that the ingredients *do not get wet* prior to the water step. Store the materials near your workspace. Typically, you will keep your cement in the bag until it is used, and leave the sand and gravel in piles.

4. **Measuring the Cement**
   This step is based around the "Proportions" section. Therefore, the specific amount of cement you use will be based on how much concrete you need. If you are not sure, try using one bucket (*so two buckets sand and three gravel*). For this example, we will be using this amount. If you are using a different amount, just multiply or divide the ratio as necessary. Now that we have established how much cement is required for this example, use your shovel to fill the bucket with cement.

Figure 4:
Measuring Cement

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5. **Placing the Cement**
   Pick up the bucket that is filled with the cement and bring it to your workspace. Use caution: the bucket will be heavy. CAREFULLY and slowly dump out the cement low to the ground. If you pour too fast or from too high up, it will fly out everywhere and can get in your eyes. You should now have a pile of sand in your workspace.

6. **Measuring & Placing the Sand**
   For this example we are using two buckets of sand. Use your shovel to shovel the sand into the bucket. Bring the bucket to your workspace. Again, be careful because it will be heavy. CAREFULLY and slowly dump out the sand low to the ground. To avoid the cement flying up, it is often smart to place the sand right beside the cement. Repeat for the next bucket.

7. **Mixing the Cement & Sand**
   It is now time to mix the cement with the sand (yes – before the gravel is added!). Use the shovel to mix. Just take a scoop of sand, place it on the cement & vice versa. Keep scooping & mixing until the mix resembles one color with a consistent texture. This can

be thought of as mixing the dry ingredients for a cake. Only this time your mix is a lot bigger and you are using a shovel.

Figure 5:
Cement-Sand Mix

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8. **Measuring & Placing the Gravel**

Once the cement-sand mix is uniform, you are ready to add the gravel. For this example, we are using three buckets of gravel. Go to your gravel pile and use your shovel to fill the bucket with gravel. Bring the bucket to your workspace. Place the gravel just like you did the sand. CAREFULLY and slowly dump out the gravel low to the ground. To avoid the cement-sand mixture flying up, it is often smart to place the gravel around and right beside the mixture. Repeat for the next two buckets.

Figure 6: Placing the Gravel

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9. **Mixing in the Gravel**

Mix the gravel with the cement-sand mixture, just like you did with the cement and sand earlier. Use the shovel to mix. Take a scoop of gravel, place it on the mixture & vice versa. Keep scooping & mixing until the gravel is placed evenly throughout the mix. Again, you can think of this mixing method like mixing the dry ingredients for a cake.

Figure 7: Mixing in the Gravel

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10. Creating the "Volcano" Shape

This step might sound confusing, but it is actually pretty simple. Scoop an indentation into the center of your dry mix using your shovel. This molding of a wide "volcano" is necessary so that the water can be added smoothly. Basically you want to create a space for the water where the rest of the mix will keep it from running out. When the water is added, the reaction at the surface of the volcano acts as a barrier so that water doesn't penetrate through.

Figure 8: Volcano with Water

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11. Adding the Water

There is no specific amount of water that should be added. The water amount will vary from site to site and also based on the characteristics of the gravel. As a starting amount for the volume of water, I recommend adding approximately half of a bucket of water, and then adding water in small amounts until the desired consistency is reached.

Fill your bucket with the desired amount of water and bring it over to your “volcano” mix. Carefully and slowly pour the water into the center of the volcano. The water will slowly dissolve into the volcano’s crater and wherever else it is touching. To ensure that the concrete will be mixed evenly, you need to continue to mix immediately. (See the next step.)

Figure 9: Adding Water

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12. Mixing in the Water

Since you want all of the concrete to be a good mixture, dry mixture outside of the crater is added to the rim to build up the sides. Basically, use your shovel to scoop the dry mix on the outside right into and around the water. There will come a time when the water starts seeping out and that’s when you know you really need to start moving. Mix the concrete by taking a scoopful of water and dry mix and flipping it over onto another part of the mix. Continue this motion while moving around the mix in a circle.

Figure 10: Mixing in Water

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If the concrete is looking too dry, add small amounts of water as necessary. The wetter the concrete is, the weaker it will be. However, the drier the concrete is the less workable it will be. The trick is to find the perfect consistency. The concrete should have

the consistency of a lumpy, thick cake batter that can stand up on its own if dumped in a pile.

Make sure the concrete is evenly mixed. There should be no dry pockets at this point. Mix as thoroughly as possible.

Figure 11: Example of Consistency

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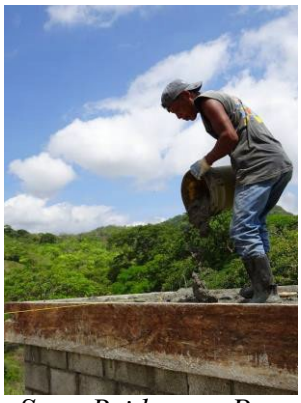
13. Placing the Concrete

At this point, the concrete has been consistently mixed. However, you need to place it right away to ensure that it does not start hardening in the wrong spot. Use your bucket, a wheelbarrow, or something similar to transport the concrete where you need it to be. Simply use your shovel to fill whatever you choose, bring it to your site, and carefully pour it wherever you need it.

Figure 12: Placing Concrete



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14. Cleaning the Tools

After you have placed all the concrete, rinse off your shovel and bucket using a hose or another source of water. Any wet concrete will end up drying and sticking to the tool. This solid concrete will be very hard to remove once it is hard.

Troubleshooting Tips

What do I do if I have leftover concrete and I've already finished the job?

Dispose of it as solid waste. Do not wash it into your lawn or down your drain. It can end up killing vegetation by raising the pH of your soil or harden in and clog your drain.

How do I store leftover concrete? Can I use it later?

You cannot store leftover concrete or use it later. Once the water has added, it starts the hardening process. Concrete that is semi-dry cannot be reworked into a project because it will lose its strength.

I've added too much water to the mix. How do I get it back to a good consistency?

Add more cement and sand. If you are making a small batch, it will not mess up the chemistry and you can continue to mix.

I do not have access to sand that has been run through a screen already. What do I do?

Either buy a screen or make one. It is important that your sand does not have big rock chunks in it that can mess up the strength and workability of your concrete.

I am planning on mixing a very large batch of concrete. Is there a limit to how big I can make the 1:2:3 ratio?

Technically no – as long as you are consistent with the ratio. However, the bigger the batch, the more work it will take to mix it. It is important to have other people helping if the batch is too large. Take turns and stay hydrated. Mixing concrete can be a lot of work.

Can I still mix concrete if it is raining outside?

Yes, but only if you have a tarp or something else covering your mix at all times. The rain can either cause the chemical process to occur prematurely or add too much water to your mix. With too much water, your concrete will not be strong enough.

I cannot tell if my concrete is at the correct consistency. Is there a way I can test it to make sure I used good proportions?

Yes there is. After you have finished mixing your concrete and you are somewhat satisfied with the consistency, you can perform a slump test. A slump test requires a metal rod or a thin piece of rebar as well as a slump cone. A slump test will test your concrete by seeing to what degree can it stand up on its own. For more information on slump tests visit: http://www.concrete.org.uk/fingertips-nuggets.asp?cmd=display&id=559

Works Cited

"Bridges to Prosperity - Penn State University." *Bridges to Prosperity - Penn State University*. Projects, n.d. Web. 8 Apr. 2016. <http://www.bridgestoprosperitypsu.org/>.

"Concrete Sand vs. Mason Sand vs. White Sand." *Braen Stone*. N.p., 10 July 2013. Web. 4 Apr. 2016. <http://www.braenstone.com/2013/07/concrete-sand-vs-mason-sand-vs-white- sand/>.

"Mix Concrete by Hand." *Mix Concrete by Hand*. Lowe's, n.d. Web. 8 Apr. 2016. <http://www.lowes.com/projects/other-activities/mix-concrete-by-hand/project>.

Palmer, Bill. "Concrete Mix." *Concrete Network*. N.p., n.d. Web. 02 Apr. 2016. <http://www.concretenetwork.com/concrete-mix-design/>.

"Sand and Gravel in Concrete." *The Shelly Company*. N.p., 29 Jan. 2014. Web. 2 Apr. 2016. <http://www.shellyco.com/sand-gravel-concrete/>.

"Slump Test." *The Concrete Society*. N.p., n.d. Web. 2 Apr. 2016. <http://www.concrete.org.uk/fingertips-nuggets.asp?cmd=display&id=559>.