Cellular Concrete Mix Designs and Economics

When working with cellular concrete and considering mix designs, a cardinal rule is that as density decreases, so does strength. In some instances, such as the material needing to be excavated at a later time, the loss of strength is a benefit. An additional benefit is that as the material becomes lighter, it's thermal and acoustic insulative properties increase as well.

A very basic cellular concrete mix design would consist simply of Portland cement, water, and externally generated foam, which is also referred to sometimes as preformed foam. The water cement ratio can typically vary from .40-.80, and the foam content is commonly as high as 80% , depending on desired density. Typically Type 1 Portland is used, however other Portland types may be used as well. When done so, the benefits for which they're used in other materials also apply to cellular concrete.

Beyond Portland cement, there are many other cementitiuous materials that may be used in cellular concrete. fly ash is very common, but metakaolin, slag, and silica fume are a few other that have also been used in producing cellular concrete. Depending on the application, these alternative materials may be used to help increase the strength of the material, or to further improve the economics of cellular concrete, among other reasons. In to additional cementitious materials, other materials can be used as well, such as fiber.

Typically when densities are below 50 pounds per cubic foot (PCF) (800.92 kg/m³) there are no fine or coarse aggregates used, as they tend to further decrease the strength. When above 50 PCF (800.92 kg/m³) sand may be introduced, primarily as a measure of economics. Portland is the most expensive component of cellular concrete, and when higher densities are required such as to displace water, but higher strength is not needed, it creates a good opportunity and reason to use a cheap filler such as sand. Course aggregates won't typically be introduced until densities are above 100 PCF (1601.85 kg/m,³). In applications where cellular concrete is being used in this density range it is more likely to be a structural or precast application.

As with any concrete product, cellular concrete mix designs are particularly important because the mix design is critical to the performance of the material, relative to the application. Once a mix design is decided upon it's also critical that the density when produced is monitored closely. If the material being produced is too heavy, production yield and money is being lost. If the material is too light, it may not have the required strength for the application.
The water cement ratio of cellular concrete can vary widely. Although most people don't pay much attention to it, it should be noted that the water cement ratio of cellular slurry does increase over the base slurry W/C ratio, due to the water in the foam that's being added. As with any cementitious product, the strength of cellular concrete will increase at any given density when a lower W/C ratio is used. A general range would be .40-.80, with many mix designs falling more commonly between .50 and .65.
Typically W/C ratios should not be lower than .35. When W/C ratios fall below .35 the slurry can pull water from the foam when it's added, causing the foam bubbles to collapse. However high shear mix-

This photo shows base slurry (before foam has been added) going into the hopper on a continuous production machine. This mix is Portland, with 35% fly ash, and a .55 water:cement ratio.

Expected Strengths and Insulative Values of Cellular Concrete

Cured Density	*Strength*	*Foam Volume*	*Insulative Value*	*Mix Design*
PCF	PSI	Ft^3 / Yd^3 Concrete	R value per inch	
Low Density				
20	30 to 900	12 to 25	.75 to 1.85	Neat Cement
30				
40				
50				
Medium Density				
80	400 to 1500	6 to 10	.25 to .30	Sand Mix
90				
100				
High Density				
105	1500 to 4000	3 to 6	.1 to .2	Sand Mix &/or Aggregate
115				
125				

The cellular concrete data above is compiled from industry publications. These are generalized values which should be verified by testing with the use of local materials and equipment for any given project. Local materials, equipment, slurry preparation, along with processing and quality control can produce wide variances in the results for any given mix design.

ers, such as colloidal mixers, and or the use of water reducers and super plasticizers can be used effectively to help avoid this problem and allow the used of lower water cement ratios with good success. When using water reducers, or any type of ad-mixture with cellular concrete, testing must be done to ensure there are no adverse reactions between the foam and ad-mix. A typical result of a reaction would be the ad-mix causing the foam bubbles to collapse.

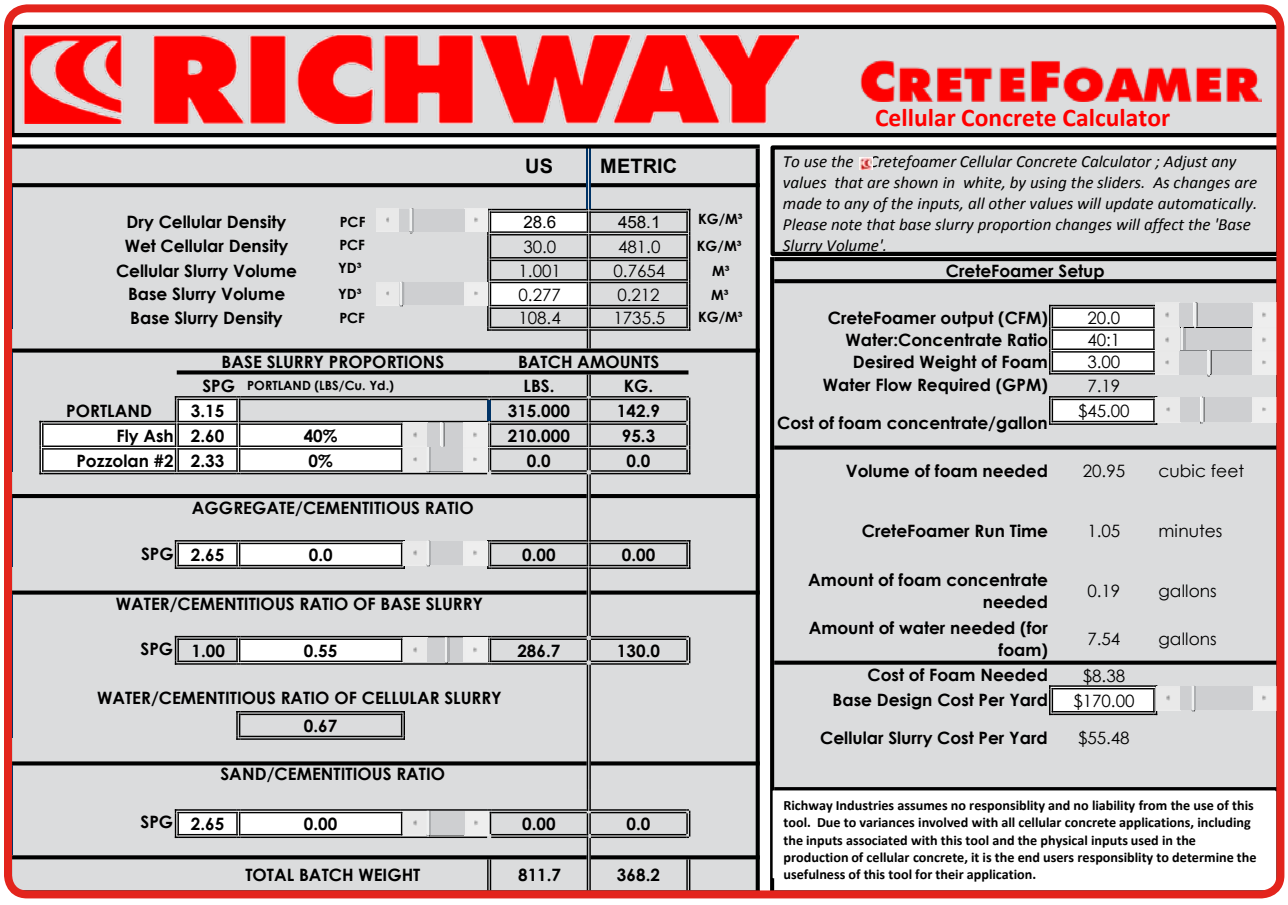
The compressive strength for any given density is one of the common topics that people are interested in. Shown above is a table with expected strengths and insulative values for a variety of cellular concrete densities. The strength will vary based upon a myriad of factors, including final mix design, foam concentrate, foam generator, and base slurry preparation, among other factors. As with other cementitious materials cellular concrete typically has compression testing done at 28 days.

One of the biggest challenges with cellular concrete mix designs is calculating the proportions for both the base slurry, and the required amount of foam to achieve any given density. An experienced practitioner can do much of the calculations off the top of their head, and exact calculations with scratch paper and a calculator. However over the years Richway has developed a mix design calculator that makes mix design calculations and proportions a fairly simple process. In addition to calculating necessary batch weights and volumes, another extremely useful feature of the calculator is it's ability to also provide cost analysis. A simple example of how cellular concrete cost is figured is as follows. Roughly speaking one yard (.91 m) of finished foam can cost between $10-$15, depending on water: concentrate ratio, foam density, and cost per gallon of foam concentrate. If a 30 PCF (480.55 kg/m^3) material

Cellular concrete strength depends on a number of factors, including mix design, foam concentrate, foam generation, and base slurry preparation, among other factors.

that starts with one yard of neat cement and has a .50 water cement ratio, it would require 2060lbs (934.4 kg) of Portland and 1030 lbs (467.22 kg) of water. To this we'd add 80 cubic feet (22.65 m³) of foam, to achieve 30 PCF (480.55 kg/m³) (wet density) cellular concrete. The total yield would then be 3.75 cubic yards (2.87 m³) of material. If the cost of the base slurry were $175 (delivered via local ready mix), we'd be adding $36 of foam (based on $50/gallon (3.79 L) foam cost, 3 PCF (48.06 kg/m³) foam density, and 40:1 water concentrate ratio). The total cost for materials would be $211.00. This cost divided by 3.75 cubic yards (2.87 m³) total yield, would equal a cost of $56.26 per yard of cellular concrete.

The Richway cellular concrete calculator is an Excel based spreadsheet and can be downloaded free from our website; www.cretefoamer.com. As can be seen in the screenshot, it will calculate the required batch amounts based on a desired density and desired volume of material. It's setup for producing one yard of 30 PCF (480.55 kg/m³) cellular material (wet density). To do this .277 yards (.25 m) of base slurry is needed, requiring 315lbs (142.88 kg) of Portland, 210 lbs 95.25 kg) of fly ash (40%), and 286 lbs (129.73 kg) of water, for a .55 water:cement ratio. Approximately 21ft³ (.59 m³) of foam is then added to make one yard (.91 m) of cellular concrete. The calculator will also display the required amounts of water and foam concentrate needed, and as already discussed, helps in providing cost analysis for your project.



Download the Richway Cellular Concrete Calculator for free at www.cretefoamer.com