Our Cold Plunge / Hot Tub Construction

After spending time at the **Rio Chirripo Resort** in Costa Rica and enjoying their **Wood-Fired Cedar Snorkel Hot Tub** located on the **Chirripo Pacifico River**, we decided we wanted a wood-fired hot tub above and overlooking the waterfall features of one of the mountain streams on our property. However, we did much research and learned that cedar hot tubs can't be left empty for more than a day or the wood staves shrink and the tub then leaks like a sieve and needs to be completely reworked. We considered that keeping a tub full of water year-round wouldn't be convenient or practical for us. We also wanted a tub having much better insulation, easy to clean/maintain, half in-the-ground and half above-ground given our desired location and for easy ingress/egress, be either a cold plunge or hot tub as desired, use a simple low cost pump filtration system with hydrogen peroxide sanitation (instead of carcinogenic chlorine and bromine) to reduce the frequency of tub water filling and draining, have a floating skimmer and vacuum port, be plumbed for easy tub water filling and easy draining, have a LED light, NOT have noisy jets (we only want to hear the sound of our mountain stream and perhaps a crackling fire) and NOT be crazy expensive like **Commercial Cedar or Fiberglass Wood-Fired Hot Tubs** that have a relatively short life and NOT be insanely expensive like **Commercial Stainless Steel Hot Tubs** that eventually suffer from weld corrosion and failure. During our research, we also discovered **Island Hot Tub**, which has considerable information on how to DIY construct low cost hot tubs.

We ultimately decided to DIY construct a generational 6 foot diameter tub having a 316 stainless steel inner liner that is fully encased in reinforced concrete and having an exterior stonework wall and granite caps like all our other property **Stonework Projects**. We also decided that we preferred an external wood-fired heater because, unlike an internal wood-fired heater, an external wood-fired heater doesn't reduce the available people space in the tub. And unlike built-in internal wood-fired heaters, an external wood-fired heater can be easily repaired or replaced if ever needed.

The primary advantage of internal wood-fired heaters over external wood-fired heaters are much faster initial water heating times. Internal wood-fired heaters accomplish this by being about 95% efficient (a good internal wood-fired heater is only about 71% efficient) and by reducing the normal tub volume of water that is actually heated (e.g., the 120,000 BTU/H internal **Snorkel Heater** reduces the 530 gallons of water normally contained in a 6 feet diameter x 36 inch height tub filled to a 30 inches depth to 495 gallons). For comparison understanding, the heating rate for our 530 gallon tub using an internal 10 Kw electric heater is 7.7 degrees Fahrenheit per hour. The heating rate for our 530 gallon tub using an internal 47,000 BTU/H **Chofu Wood-Fired Hot Tub Heater** is 7.5 degrees Fahrenheit per hour. The heating rate for the equivalent 495 gallon **Snorkel Hot Tub** is 30 degrees Fahrenheit per hour...four times faster. However, we personally found that this higher heating rate often results in overheating the water which then requires draining and replacing some of the hot water with cold water. And we also personally found that using some internal wood-fired heaters (e.g., the **Snorkel Heater**) will result in ash getting into the tub water. So, after carefully considering all the advantages and disadvantages of internal and external wood-fired heaters, we selected the external Japanese made **Chofu Wood-Fired Hot Tub Heater** and we provided a large amount of thermal mass within the insulated envelope of our tub to buffer water temperature swings and to better retain the final water temperature to greatly reduce subsequent day heating times (less than 60 minutes at outdoor temperatures above 20 degrees Fahrenheit). We also developed a **Wood-Fired Hot Tub Performance Calculator** to determine the heating time, heating rate, heating energy required, wood required and electricity cost saved. The following provides and illustrates the design and construction details of our DIY cold plunge/hot tub.

The first step of this project was to excavate a 3 feet deep hole so as to have the top of the tub be at the desired ground level elevation for easy tub ingress/egress. Then an engineered, level and compacted 3-4" minus rock pad was constructed and 3/4" minus gravel containing lime was used to cover and create a smoother pad surface. And finally, 2" thick R-10 high density EPS rigid board insulation, specifically designed for under-footing masonry wall construction, was placed on this pad.

We used two 120" long and 42" wide 20 gauge 316 stainless steel sheets to create the tub inner liner. These sheets were riveted together with two seams having 3.5" overlap. Since our 316 stainless steel inner liner will be fully encased in concrete, any water leakage at these seams will be insignificant. We placed the 316 stainless steel inner liner at an exact 36" tub radius to create a 6' interior diameter tub. We wanted the slope of the tub floor slab to go from an 8" outer perimeter thickness to a 6" inner center thickness at the drain to facilitate draining. We used and placed an **Oatey Adjustable Drain** at the center and lowest location in the tub floor. This is 0.0555 inches of fall per inch of 36" radius change (i.e., 2" divided by 36"). We needed to make the concrete floor pour manageable since it will accomplished by hand using a cement mixer.

To address water pressure hoop stress, we constructed a 6" thick primary structure reinforced concrete wall section that spans 36” to 42" of radius using 22 vertical #4 rebar and 3 horizontal #4 rebar hoops placed within the center of this section (i.e., at a 39" radius location). This vertical wall rebar was fastened to horizontal #4 rebar placed in the floor slab using 1.5" height rebar chairs and goes radially from the tub center to the tub outer circumference. A 39" radius has a 245" circumference (i.e., 2 times Pi times 39"). So the vertical rebar was spaced at 11.1" (i.e., 245" divided by 22) which results in the horizontal radial floor rebar being exactly a 12" spacing at the 42" radius form location. The vertical rebar length is 44" (i.e., the 42" 316 stainless steel height plus the 1.5" horizontal radial rebar chair height plus the 0.5” horizontal radial rebar thickness).

A 36" radius form pour has an area of 4071 square inches (i.e., Pi times 36" squared) and average thickness of 7" (i.e., 6” plus 8” divided by 2) and is 28,497 cubic inches (i.e., 4071 square inches area times 7" average thickness) or 16.5 cubic feet and would require 36.6 bags of 60 pound concrete (i.e., 16.5 divided by 0.45 cubic feet per 60 pound bag of concrete). We considered this to be too much concrete to hand pour at one time. A 27" radius form pour has an area of 2290 square inches (i.e., Pi times 27" squared), a 7.5" height (i.e., 6" plus 0.0555 times 27"), an average thickness of 6.75" (i.e., 6" plus 7.5" divided by 2) and is 15,458 cubic inches (i.e., 2290 square inches area times 6.75" average thickness) or 8.9 cubic feet and would require 19.9 bags of 60 pound concrete (i.e., 8.9 divided by 0.45 cubic feet per 60 pound bag of concrete). So, we elected to first do an initial 27" radius 19.9 bag concrete pour and then do a second 9" wide (27 to 36" radius) 16.7 bag concrete pour (i.e., 36.6 bags minus 19.9 bags) to make this concrete floor pour manageable.

So we first needed a 27" radius form with a 7.5" height (i.e., 6" plus 0.0555 times 27") and we also needed a second 36" radius form with an 8" height. We also needed 42" radius forms (i.e., our 36" tub radius plus the 6" thick primary structure reinforced concrete wall section) to create the 44" total height (i.e., the 42" 316 stainless steel height plus the 1.5" horizontal radial rebar chair height plus the 0.5” horizontal radial rebar thickness) for the 6" thick primary structure reinforced concrete wall section. Since we didn't want to risk deforming the 316 stainless steel inner liner, we elected to do one initial 8" height concrete pour to lock in the stainless steel inner liner and then do three subsequent and separate 12” height concrete pours to complete this 6" thick primary structure reinforced concrete wall section. The total tub wall thickness is then the 6" thick primary structure reinforced concrete wall section plus 2" thick R-10 high density EPS rigid board insulation plus a 10" thick decorative concrete/stone wall section (either entirely concrete if below ground or stonework if above ground with a residual cavity space subsequently filled with concrete and also used to route the required electrical/water vertical conduit) or a total of 18" thick. So this 18" thick wall plus 36" tub inner radius minus 2" drain pipe clearance requires 54" of total horizontal radial rebar length.

However, we didn’t want to be tripping on this low horizontal rebar while constructing this tub. So we started with 34" rebar lengths (i.e., 27" radius inner section plus the 9" wide 27” to 36" radius outer section minus the 2" drain pipe clearance) to make pouring the 27" radius inner slab floor easier and to also provide 22 hard rebar stops for subsequently placing the 36" radius form at exactly a 36" radius. We accomplished a 9" rebar overlap within the 9" wide 27” to 36" radius outer section using 29" rebar lengths (i.e., 54" minus 34" plus 9" rebar overlap) to accomplish the required 54" of total horizontal rebar length.

The 316 stainless steel inner liner was placed on the exposed horizontal radial floor rebar at the 36” radius location. This allows 2” of concrete to be poured under the horizontal radial rebar and under the 316 stainless steel inner liner while providing 6” of floor concrete height on the lower inner side of the 316 stainless steel inner liner. The 316 stainless steel inner liner entire outer side is fully encased in concrete by the 6" thick primary structure reinforced concrete wall section. An additional benefit of placing the 316 stainless steel inner liner on the horizontal radial rebar is that this electrically bonds it to the entire tub structure. The importance of this is discussed in more detail below.

A 27" radius has a 169.6" circumference (i.e., 2 times Pi times 27") and is the total form length for this 7.5" height form. The rebar hole spacing for the 34" length horizontal radial rebar for this form is 7.71" (i.e., 169.6" divided by 22).

A 36" radius has a 226.2" circumference (i.e., 2 times Pi times 36") and is the total form length for this 8" height form. The rebar hole spacing for the 29" length horizontal radial rebar for this form is 10.28" (i.e., 226.2" divided by 22).

A 42" radius has a 264" circumference (i.e., 2 times Pi times 42") and is the total form length for three 16" height forms to raise the concrete height 12" per pour (i.e., there is 4" of overlap for the lower form strapping). The rebar hole spacing for the 29" length horizontal radial rebar for these forms is 12" (i.e., 264" divided by 22).

A 54" radius has a 339.3" circumference (i.e., 2 times Pi times 54") and the stonework will create this 54" radius or 9' tub exterior diameter except where this section is below ground level thereby requiring an actual 54" radius form and concrete pour of various heights to reach ground level and then enable subsequent stone placement above ground level.

Prior to the second 42" radius concrete pour, the first three ports were installed. These included the wood-fired heater cold water inlet port, the water filtration system suction inlet port and the LED light port. All of the ports used in our tub are **CMP Insider Wall Fittings** which are designed to slide into standard 2"schedule 40 PVC pipe. **Boss Pro 802 Clear Silicone** was used to adhere and seal the ports to the PVC pipe and stainless steel inner liner. These ports and this approach allows the ports to be easily removed and replaced if ever necessary. These ports have a standard 1.5" FNPT which enables screwing in other devices such as an eyeball outlet, LED light, suction screen, etc.

Prior to the third 42" radius concrete pour, the footing rebar for stone placement at the higher ground level section of the tub was installed.

Prior to the last 42" radius concrete pour, the Equipotential Bonding System (EBS) was installed. All metal components (ladder posts, stainless steel inner liner and wood-fired heater stainless pipes) and the structural rebar were bonded together. The stainless steel inner liner was bonded in two locations at the seam locations and the stainless steel inner liner also rests at 22 locations on the structural rebar too. Given the huge area of stainless steel inner liner in contact with the water, this bonds the water too. The structural rebar was bonded to the EBS using 20 clamps rated for direct burial and placed in concrete. Electrical code requires at least 8 AWG copper wire be used for the EBS but we used 6 AWG copper wire for our EBS. Knowing that code is the cheapest and crappest you can legally build, we tend to always far exceed code. This EBS wire was also used to circle the tub a couple times in the soil a couple feet beyond its 18" thick wall and this wire was also placed in and clamped to the structural rebar in all the concrete slabs near the tub. The objective of the EBS is to ensure that there can't be a voltage potential difference anywhere in the tub or the vicinity of the tub that people can experience. If there isn't any voltage potential difference, electrical current can't flow. If electrical current can't flow, people can't get shocked or electrocuted. The voltage in the tub could therefore be very high and you would be perfectly fine just like birds sitting on a high voltage power line warming their feet. Nevertheless, to keep the voltage potential of the tub low, the EBS is connected to the Earth Grounding System (EGS) where the water filtration pump is located and grounded. So any tub high voltage potential also gets reduced to low earth ground voltage potential.

Prior to the fourth and last 42" radius concrete pour, the last five ports were also installed. These included the wood-fired heater hot water outlet port, the water filtration system outlet port, the skimmer/vacuum port, the water fill port and the water overflow drain port. The water filtration system outlet port was placed so as to direct the hot water coming from the wood-fired heater toward the opposite side of the tub near the ladder. The water filtration system suction inlet port is located near the bottom of the tub so it ingests the colder water and mixes it with the wood-fired heater hot water. The skimmer/vacuum port was also located near the ladder for convenience and to benefit from this active flow direction too.

The following photos illustrate the construction of our Cold Plunge / Hot Tub which was self-constructed single-handed by Bob like all **Our "Sunny Falls" Remote Southern Oregon Retirement Mountain Retreat Home** projects:

Construction of Our Garage/Shop/Guest Quarters

Construction of Our Residence

Construction of Our Water Filtration System

Construction of Our "Los Gatos Casita" Pole Barn

Note: Additional details and photos will be added as this project progresses to completion.

Excavating the Hole


United Rentals

Building Engineered Pad & Taking Delivery of Concrete & Stainless Steel Sheet

Placing Floor Insulation and 27" Radius Form

The Poured 27” Radius Form

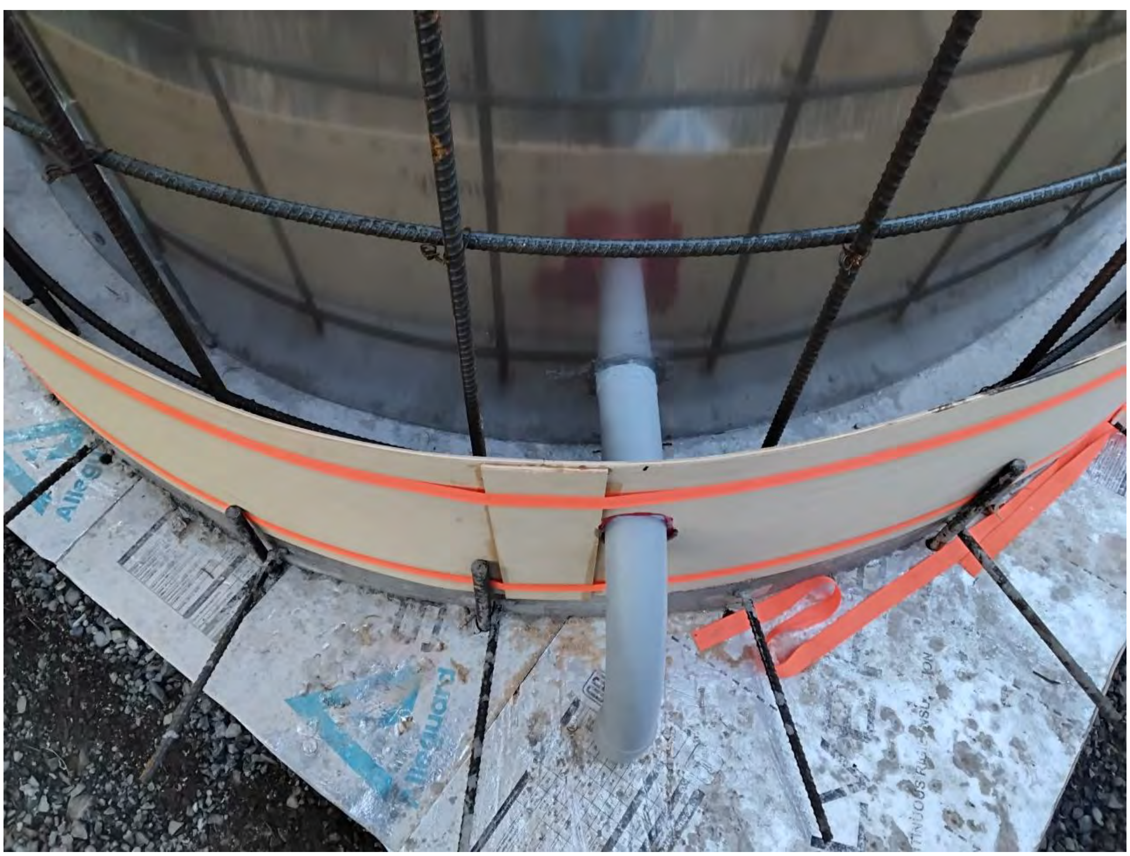
Placing the 36” Radius Form

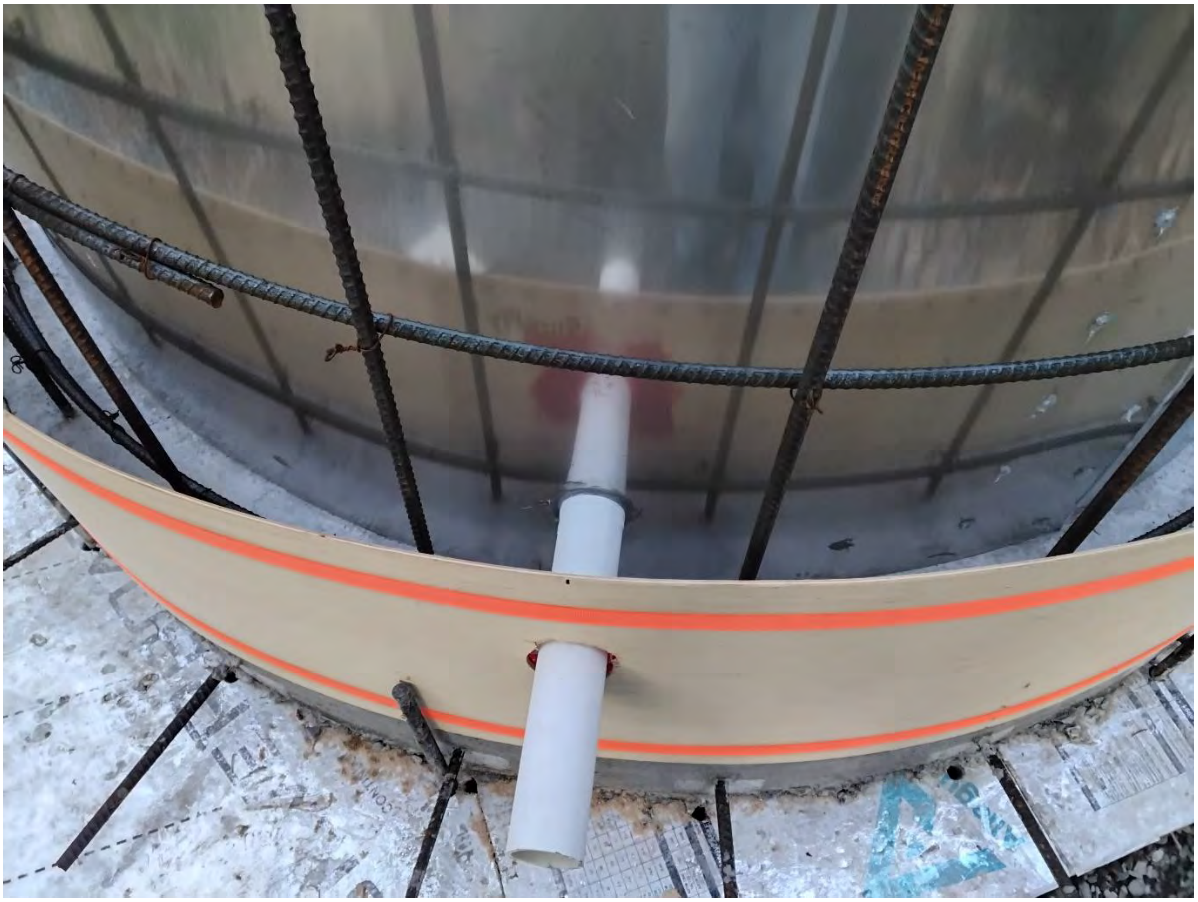
The Poured 27” and 36” Radius Forms

Placing and Riveting the Stainless Steel Sheet

Locking in the Stainless Steel Inner Liner with First 42” Radius Pour

Installing the Lower Three Ports and Placing Second 42” Radius Form





The Poured Second 42” Radius Form

Placing the Third 42” Radius Form and Above-Ground Section Rebar

The Poured Third 42” Radius Form

Creating the Equipotential Bonding System (EBS)

Installing the Upper Five Ports and Placing the Fourth/Last 42” Radius Form

The Poured Fourth/Last 42” Radius Form