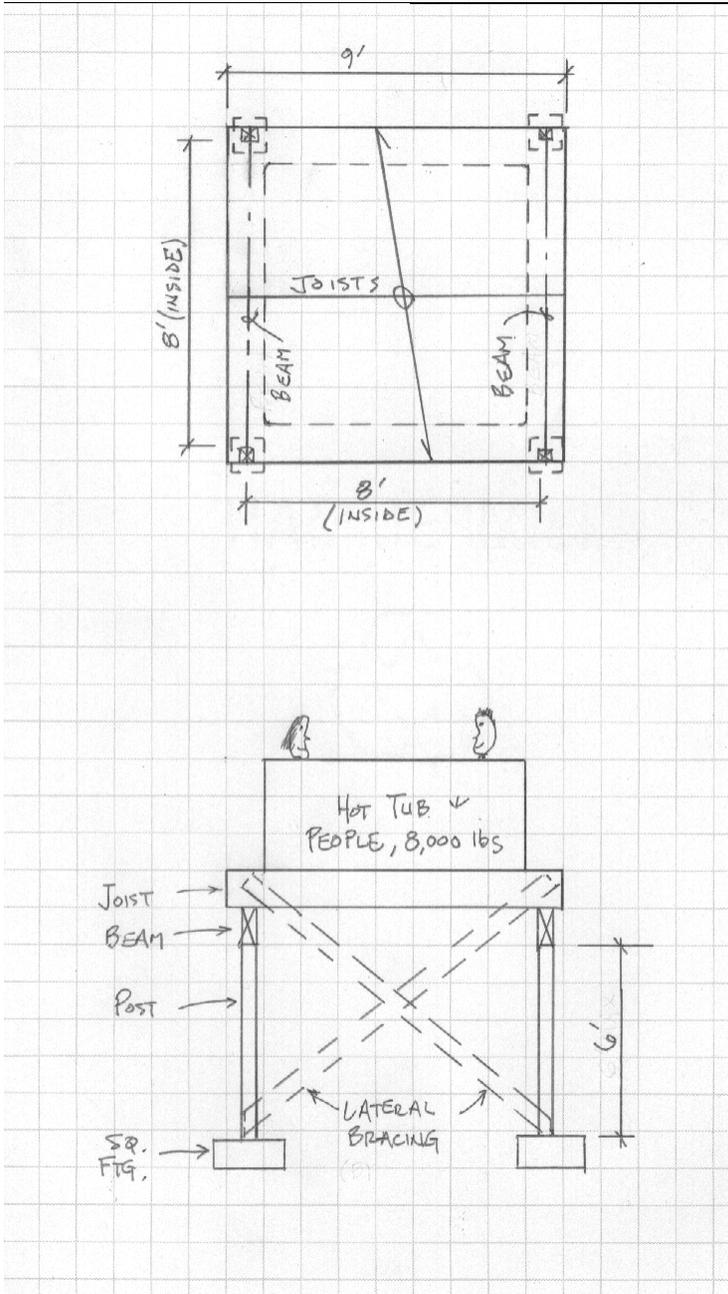# Example Hot Tub Deck Design Using ConstructionCalc Software, v2.0

Note: The following example assumes you are a beginner. You should expect this to go slowly at first. However, with a little practice, getting solutions with ConstructionCalc is about a one minute job. Awesome.

1) **General**. In all ConstructionCalc programs you can type in a name of the member you're designing, job name, date, etc. in the three cells at the top.

2) **Joist Design**. We have to assume a joist spacing to start. Let's try 16" spacing.

a) We need to know the live and dead load.

   i) Live Load: Live load will come from the tub and its occupants; in our example the manufacturer tells us the maximum load will be 8,000 lbs. We will assume this load is spread evenly over the tub's footprint, thereby loading the joists equally (verify with tub manufacturer to be sure). The footprint is 8'x8' = 64 square feet, so the "psf" (pounds per square foot) live loading is: 8,000 / 64 = 125 psf.

   ii) Dead Load: Dead load for a deck is the weight of the decking material and the joists themselves, say 15 psf approximately (check out ConstructionCalc General Loads Calculator for more on this topic).

b) Let's open the ConstructionCalc Wood Beam Calculator and enter data:

   i) Span: This is the inside of bearing to inside of bearing dimension of a typical joist. If the joists bear on a beam at each end, span is the distance between the beams. In our example: 8 feet. (Note: only enter numbers, no symbols, spaces, or units – the program does that for you.)

   ii) Maximum Allowed Deflection: This is the amount of deflection (sag) we're willing to allow for the joists (see red triangle note for more). Let's use the default values of L/360 for live load deflection and L/240 for total deflection.

   iii) Load Duration: Since we're designing floor joists which will have the live load there all the time, let's select 10 yrs.

   iv) Add Self-Weight? Since the joist's self-weight is already included in the 15 psf dead load from above, and we don't want to add it twice, we'll select No.

   v) Loads Other Than Uniform Loads? These joists won't ever see a point (concentrated) load, or other unusual load, so select No.

   vi) Uniform Loads Over the Full Length of Member: Our joist will feel its load over its entire length, so this is our section to input load data. Our load is a Floor Load, so under that row enter:

      (1) 125 for live load

      (2) 15 for dead load

      (3) Tributary width will be the joist's spacing in feet, which is 16/12 = 1.3 (Cool tip: because you're using a ConstructionCalc product, if you enter the following: =16/12 and then press Tab, you'll see 1.3 displayed automatically. In other words you can do math right in the cell by starting with an equals sign. Try it. Very cool, very powerful.)

   vii) Done. Click on Calculate Now and let's check our results.

c) Allowable Solutions

i) This section shows all the types and sizes of members that will work. We're only interested in 2x material, so that section is all we'll look at. Certainly if we wanted to use a TJI or any other type of member shown we could.

ii) In the Section **4x and Smaller (Lumber)**, let's select the type of lumber we want. Since this is an exterior application which will get rained on, we want to use Hem Fir, pressure treated. (Note, there is nothing that specifically says "pressure treated", but that's okay. Pressure treated lumber has slightly lower strength values than non-pressure treated, but as long as we make sure our final selected design is okay by at least 10%, we're fine.) We know the lumber yard has lots of No 2 grade in stock, so we'll select No 2.

iii) Repetitive Member Use? We're designing joists which will be spaced less than 24" apart and will share the applied load, so we want to select Yes.

iv) With Hem Fir, No 2 selected, we see that 2x10 will work (we could also use double 2x8's and some other odd sizes that show up in the table). Remember, our joist spacing (tributary width) from above is 1.3', or 16".

d) Final Selection. We could stop at this point knowing a 2x10, HF #2 works, but let's continue and see how efficient that member is.

i) Final Member: We want to use Hem Fir No. 2, which is Sawn Wood.

ii) Final Size: 2x10

iii) Minimum Bearing Length: Upon making the above selection, the minimum bearing length (to avoid crushing of the joist at the bearing point) is calculated and displayed. In our case, the joist must sit on the beam over a length of at least 1.5 inches; or the joist could sit in a hanger with a minimum cup length of 1.5 inches.

iv) Reactions. This section shows the force applied to the bearing beam at each end of the joist.

v) Efficiency of Member: this section shows by how much the selected member is over-designed for the three code-required design criteria. Usually, I just look at the bottom sentence that says in our case: **This member makes it by 18.0%.** A good safe design, even if we use pressure treated material.

vi) Add'l Detail – Not Including Self Weight. This section shows a bunch of engineering information that may or may not be of interest to you.

e) Printout. You may want to print this design. Because this ConstructionCalc product is nothing more than a fancy Excel spreadsheet, you have tons of printing options via File, Page Setup. Also, you can hide various parts of the display via the ConstructionCalc **Hide / Show Loads** and **Miscellaneous** dropdowns toward the top of the page.

3) **Beam Design** (This example will go a little faster because I won't repeat the basic stuff learned in the joist design above.)

   a) Let's input the required data into the Wood Beam Calculator:

      i) General: Change Beam ID from Joist to Beam (optional).

      ii) Span: Inside of post to inside of post is 8' (pure coincidence that this turns out the same as the joists span; it usually doesn't work this way).

      iii) Deflection: Use L/360 and L/240 defaults

      iv) Load Duration: Ten years live

      v) Add Self Weight? Yes we want to add the beam's self weight to the design because the 15 psf dead load we'll use in a minute does not include the beam's self-weight (though it does include the weight of the joists and decking).

      vi) Loads Other Than Uniform? No, because the loads applied to this beam comes from uniformly spaced joists of equal length and loading. In other words, the beam's load is uniform across the beam's length – there's no point loads or other weird loads.

      vii) Uniform Loads Over Full Length of Member: Let's use the same Floor Load row as before:

         (1) Live: 125, same as before

         (2) Dead: 15, same as before

         (3) Tributary Width: This is the only loading criteria that changes. This beam gets its load from the joists, and in particular half the span of the joists goes to this beam. The other half of the joist's load goes to the beam on the other side of the deck. So the tributary width for this beam is half of the joist's span: 8/2 = 4'.

      viii) Done, now let's check results.

   b) Allowable Solutions.

      i) We need Hem Fir, pressure treated again, so let's give ourselves a couple options:

         (1) Tripled 2x. In the **4x And Smaller** section; first, this beam gets no help from another member, i.e. it acts alone so we select No to Repetitive Member Use?. Make sure Hem Fir, No. 2 is selected in the drop-downs and you can see that (3) 2x10's work.

         (2) Single Beam. In the **5x and Larger** section, select Hem Fir, No. 2 and a 6x12 or 8x10 are all that will work.

          (3) But Wait. Back in the **4x and Smaller** section we see that a 4x12 also works. This may come in handy if we want to use 4x posts.

c) Final Member

  i) I like the 4x12 because I want to use 4x posts and want my beam to match up well. Selecting it shows it makes it by 14.8% - okay, even for a pressure treated member.

  ii) Minimum Bearing Length is 1.58" – okay. This beam will sit on posts of at least 4x4 dimension, so there will be plenty of space to accommodate 1.58" bearing length.

  iii) Print the results if you wish.

  iv) Check your work. If you're worried you may have goofed something on the input and want a rough check, first, look at the Load and Span Diagram in the upper right of the sheet. The span is shown in feet on the horizontal axis and the loads on the vertical. A uniform load will look like a rectangular box over the entire beam.

    Now take a look at the Reactions at the bottom of the sheet. We know the tub and occupants weighs 8,000 lbs; plus the deck itself (dead weight) will be a couple or few hundred pounds. So the beam we just designed should carry half of this total weight or about 4,200 lbs give or take (the beam on the other side of the deck carries the other half). Because our beam is loaded uniformly, we'd expect each end to have the same reaction, which should be half of our 4,200 lbs = 2,100 lbs, give or take. The printout shows reactions at each end of our beam of 2,240 lbs. Close enough; we're good to go.

4) Post Design

   a) Open ConstructionCalc Column Calculator

   b) General Input

      i) Beam ID, Job Name, etc.; similar as before.

      ii) Length: This is the length from the bottom of beam (applied load) to bottom of column (top of footing), in our example = 6'. Note: to be conservative, always use the maximum probable length, particularly in cases where you're designing a typical column and some are longer than others. With columns and studs, length has everything to do with strength: the longer the column, the more prone to buckling (weaker). Thus short columns and studs are stronger than long ones of the same dimensions.

      iii) Maximum Live Deflection: This is for columns or studs subject to wind loading. Not applicable in our case, so stay with the default value of L/175.

      iv) Type of Column, Stud, or Post: Select the most appropriate. This has to do with lateral bracing and resistance to buckling. If in doubt, Unbraced Column or Post is the most conservative. In our case Unbraced Column or Post is what we have.

      v) Load Duration: Our post will be subjected to 10 yrs live, just like the beam and joist from which its load came.

      vi) Off Center or Other Bending Loads: This is for columns or studs subjected to bending either from compression loads applied off-center from the middle of the member (such as from a nailed-on ledger) or other means, such as a knee-brace. In our case, the post will be loaded only from the beam which will sit directly on top of the post, thus we select No.

   c) Applied Gravity Loads

      i) This section can be used in several ways. You can input "psf" loads and tributary areas, or simply input previously known compressive loading. Since we already calc'd the beam which applies load to our post, we'll simply input those known live and dead loads in the row called Other Point Load…:

         (1) Description: From beam Reactions.

         (2) Live: 2000 (from beam design output under Reactions)

         (3) Dead: 240 (from beam design output under Reactions)

   d) Wind Load. This post will be subjected to no significant wind loading, thus we leave this section blank. It is important to note however, that diagonal bracing must be installed on all four sides as shown in the sketch or the entire deck can fall over sideways.

   e) Acceptable Solutions. We can choose from any type of wood shown in the tables.

    i)   Ours is an outdoor application, so we'll choose Hem Fir

    ii) We know the lumber yard has lots of No. 2 grade on hand so we'll select that.

    iii) We see that a 4x4 makes it. Good because this is an inexpensive member and will match up nicely with our 4x12 beam. Certainly we could use anything larger too; the tables only show minimum sizes.

f)   Final Selection

    i)   Choose Sawn Wood, 4x4 and we see this member makes it by 77.4% - way okay, even for pressure treated.

5) Footing Design

a) Open ConstructionCalc Square Footing Calculator

b) Applied Footing Loads

Similar to the column calculator, this section can be used in several ways. You can input "psf" loads and tributary areas, or simply input previously known loading. We can use the same loads we used for the post design except we should also add a little extra dead load to account for the weight of the post itself, say 20 pounds extra:

i) Description: From beam Reactions + 20lb

ii) Live: 2000 (from Beam design output under Reactions)

iii) Dead: 260 (240 lb from Beam design output under Reactions plus 20 lbs for post self-weight).

c) Soil and Footing Input.

i) Soil Bearing Capacity. Use 1,500. See red triangle popup note for typicals.

ii) Permit Soil Bearing Capacity Increase for Size and Depth? The UBC code allows the soil bearing capacity to be bumped up for large, deep footings. This toggle allows you to use that or not. It is conservative to select No, particularly if you don't have a geotechnical report and aren't sure how good your soils are. If your footings are small and shallow, either selection is okay because your design won't be affected.

iii) Depth to Bottom of Footing. This is the vertical distance from original native ground to bottom of footing. We'll use 2 feet.

iv) Depth of Soil Over Top of Footing. If there will be soil piled on top of the finished footing, input that depth here. For our example, use 0.

v) Square Footing Width. Make a guess as to what you'd like the footing width to be. You may come back and change this later, but for now just make your best guess. We'll start with 1.5 feet.

vi) Footing Depth. Make a stab at what thickness you'd like. You may wind up changing it later. We'll start with 8 inches.

vii) Post or Bearing Plate Narrowest Dimension. We're using a 4x4 post, so the narrowest dimension will be 3.5 inches.

d) Concrete and Rebar Input

i) Concrete Strength. Use standard 5 sack concrete = 2,500 psi

ii) Steel Yield Strength. Rebar comes in two grades: 40 and 60. Grade 40 has a yield strength of 40,000 and grade 60 is 60,000. If in doubt use 40,000

iii) Rebar Cover. This is the distance from bottom of footing to lowest rebar. Use 3 inches. Note, 3 inches is the code minimum for concrete placed against ground (an un-formed surface).

iv) Rebar Size. Use #4 (1/2" diameter). #4 is easily obtainable and simple to work with.

v) Number of Bars Each Direction. Let's try 3. We may come back to this.

e) Results

i) The program calculates automatically after each input. As you can see, we guessed quite well; we have a satisfactory design.

ii) Just for grins, let's try to make a 12 inch square footing work by changing the width to 1 foot. Checking the Results shows the footing is now undersized by 57%, no good.

iii) Now let's use the Design Now feature. Click on that button and the program automatically comes up with a satisfactory design, ironically the same one we started with.

f) Final Design. This section simply restates your input if your design is satisfactory. Nothing will show in this section if there is a problem with your design.

g) Miscellaneous Report Detail. This section shows certain engineering data that may or may not be of interest to you.