Engineering

Pipe Encasement Flotation – Archimedes was the Man!

Executive Summary. Ever prepped to pour a concrete encasement and lost sleep over whether or not it would float during the pour? Learn here how easy it is to calculate that buoyancy force.

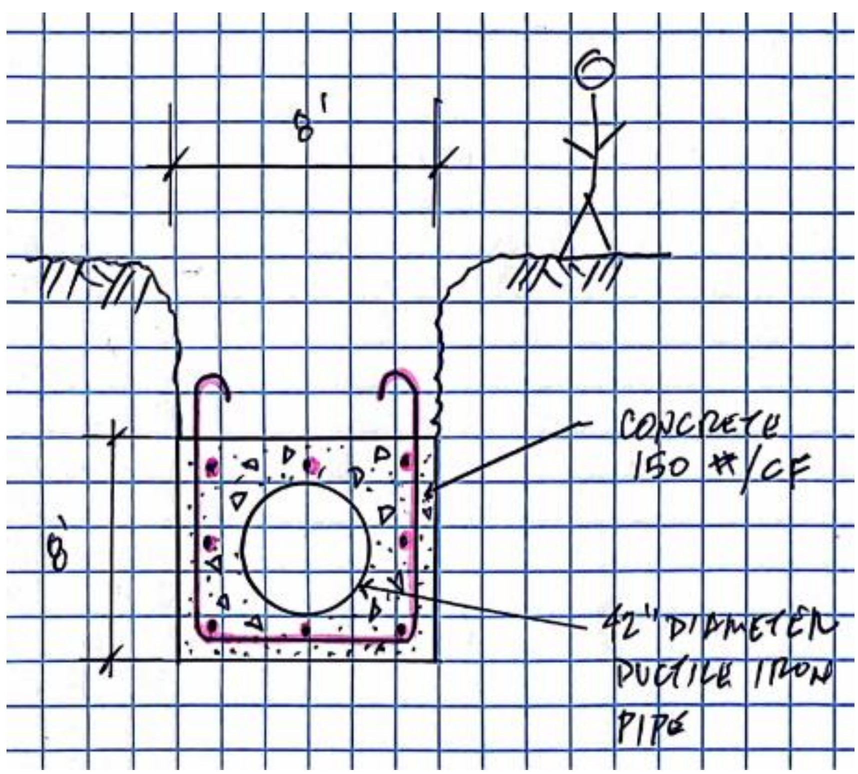
ARCHIMEDES' PRINCIPLE

a body immersed in a fluid is subjected to an upwards force equal to the weight of the displaced fluid.

Archimedes was the man. Archimedes was a Greek mathematician that, back in the 200s BC, devised Archimedes' Principle. The principle is simple at left.

What is buoyancy and how does this relate to construction? Let's start with a household example: take a glass of water and then try to push a ping pong ball into that water. It takes a little bit of force, right? The force it takes, in say pounds, is equal to the pounds of water you're displacing with the volume of the ping pong ball. Notice I said *water* – water *is the displaced fluid*.

Now relate this to construction. Let's take a ductile iron pipe that's encased. You know the drill: the pipe is set in the trench and then the concrete is poured around it. The question then is "how do I calculate the uplift force on the pipe during the pour so that I can design adequate tiedown for the pipe?"



If you want to know the force pushing up on that pipe per lineal foot,

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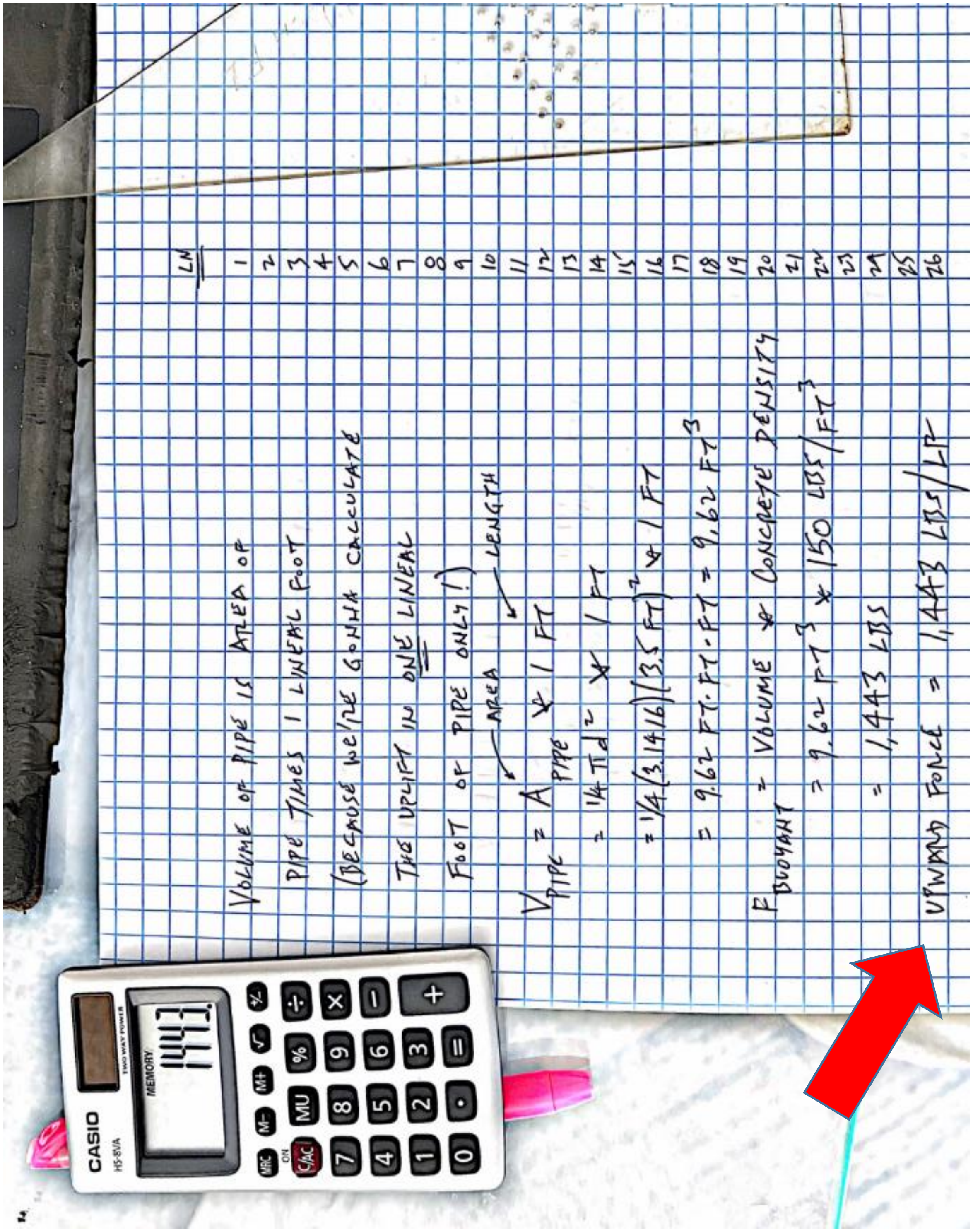
simply calculate the volume of *1 lineal foot of* pipe. Then multiply that by the density of concrete (150 pounds per cubic foot). Like this:



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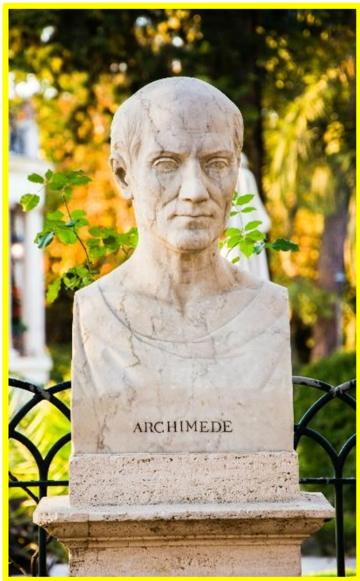
Little help please with the calculation above. There are only two calculations above: volume of 1 LF of pipe and then that volume multiplied by the density of concrete (not water!).

The volume of a cylinder (the pipe) is the area of the pipe times the length. Area is $\prod r^2$ or $0.25\prod d^2$ (I used $0.25\prod d^2$). You can see that on line 16 and then line 18 where I multiplied it by the 1 LF. Then I just take that volume and multiply by the density of concrete. Density of concrete is commonly taken at 150 pounds per cubic foot (you can see that on my trench drawing on the first page). On line 22 I take the volume calculated from line 18 and multiply it by the density. The final answer is on line 24 – the force is 1,443 pounds. This it the pounds of uplift in one lineal foot. Therefore, I can state on line 26 that the pounds of uplift per lineal foot is 1,443 lbs/LF.

It's not exact – it's a guide! This is a K.I.S.S. calculation. There are other variables not taken into effect like

- the fact that pours are usually poured from one side (this will imbalance the tiedown system) – don't pour too quick or lopsided!
- the weight of the pipe (this will help your situation – it helps with tiedown)
- whether or not the pipe has water in it from your hydrostatic test
- cure time of concrete – pouring slow is your best friend! Let the concrete set up a bit because your liquid concrete turns into a solid (no more buoyance issues!)



Although these numbers are fun to work with on a Friday night at the bar, the real answers come from the superintendent who's learned the hard way. He or she will know how to hold the pipe down, with or without calculations!

My story. I've done these calculations before and the numbers get big quick (imagine the total force on one 20-foot pipe: 20 LF * 1,443 lbs/LF = 28,860 lbs!). This is also a popular calculation on bottom plugs for sheetpile cofferdams. The concept is the same. It's still Archimedes' Principle!

Work safe!

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