Tank Weight Estimation

Introduction

Estimating the weight of a tank can be important for seismic work, consideration of tank overturning during high winds, flooding and storms, or for cost estimating purposes. PEMY has run across the problem of obtaining tank weights so frequently that we developed our own Tank Weight Estimation Tool (TWET) that eliminates the need for detailed specifications, designs, and use of tank design software.

As an example, in preliminary design stages of a seismic analysis, it is difficult to determine whether a tank will comply with API 650 Annex E because not all of the components or details of the tank have been decided or designed; changes in the design will impact the weight of the tank, which can inhibit some designers from determining the seismic stability of tanks. This is where TWET comes in handy.

The tool only uses height and diameter as input variables. The output yields an approximation of the tank weight.

How it Works

When developing the tank weight calculator, four main components were considered:

1. weight of the bottom
2. shell
3. roof/framing
4. product

The weights of each of these components were estimated independently, and the weight of the tank was approximated as the sum total of these different weights. Other weights can be determined by using only a subset of the four components (e.g. the weight of the bare metal tank can be determined by excluding the weight of the product). In order to minimize the amount of data or inputs needed to calculate the tank weight, several assumptions were made as to the design of the tank:

- steel is A36 (with density of 0.284 lb/in^3);
- product of the tank was assumed to have a specific gravity of 0.7
- shell course heights of 8 ft
- bottom thickness 0.25” with no annular ring
- roof thickness 3/16” and slope of 3/4” per foot

These assumptions were taken as typical values for storage tanks and the user of TWET should be aware of the assumptions.

For the tank shell, the thickness of each shell was calculated based upon the 1-foot method. The design thickness, hydrostatic thickness, and the minimum thicknesses were calculated as per API 650 Section 5.6, based on the tank diameter, height, material (A36) and specific gravity (0.7). Each of the thicknesses were rounded up to the nearest 1/16th of an inch. These thicknesses were calculated for each course, where the height of each course was taken to be 8’ for each shell course.

The most difficult part of the tank weight estimation comes from determining the weight of the tank roof/framing. At this stage, we determine the type of roof that the tank will have, and from there determine which weights to calculate. Figure 1

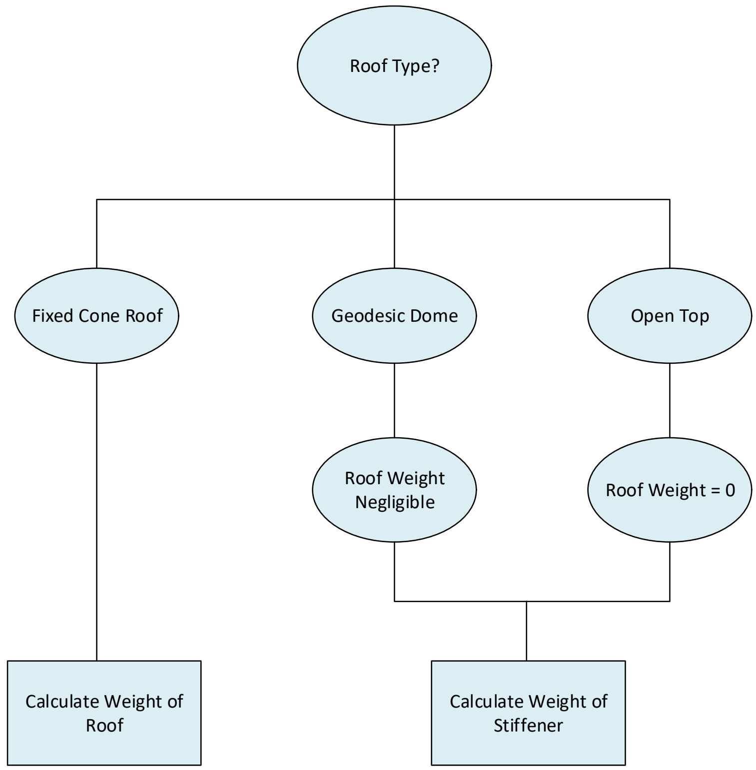

Figure 1 - Flow Chart of Roof Weight Calculation

For fixed cone roof, the weight of the roof itself is straightforward. However, the complication arises when we need to consider the addition of columns, girders and rafters; additional calculations and significant design considerations would need to be taken into account to determine the appropriate size, number, and spacing for these different components. In order to provide an estimation of the roof and framing, PEMY performed detail design calculations for several different cases the appropriate designs for columns, girders and rafters; each case varied in diameter, and the corresponding weights of the columns, girders and rafters were then computed at a given diameter. These data were then plotted (see Figure 2) and a trendline was added; the equation of the trendline was used as the estimation tool for the tank roof and framing.

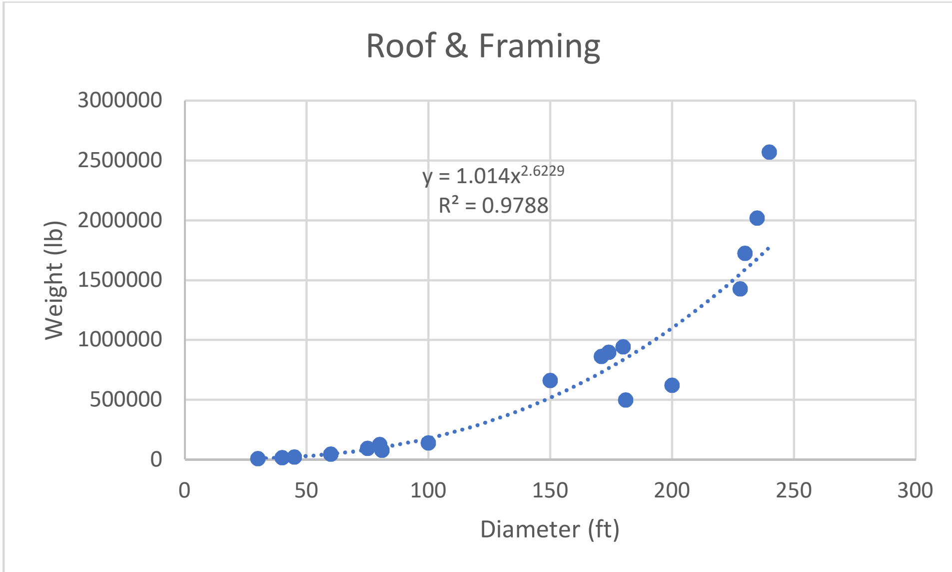

Figure 2 - Roof and Framing Weight Estimation for Fixed Cone Roofs

For a given diameter, the weight of the roof and framing could be approximated as $1.014D^{2.6229}$; this was used as the weight for our tank weight estimation tool.

Geodesic domes and open top tanks have negligible roof weights. However, when considering these tanks, the weight of the roof stiffener must be taken into account. Using a similar approach to the calculation of fixed coned roofs, several tanks were designed with varying diameters and appropriate stiffener sizes. These values were then plotted to determine the weight of the roof stiffener as a function of tank diameter (see Figure 3).

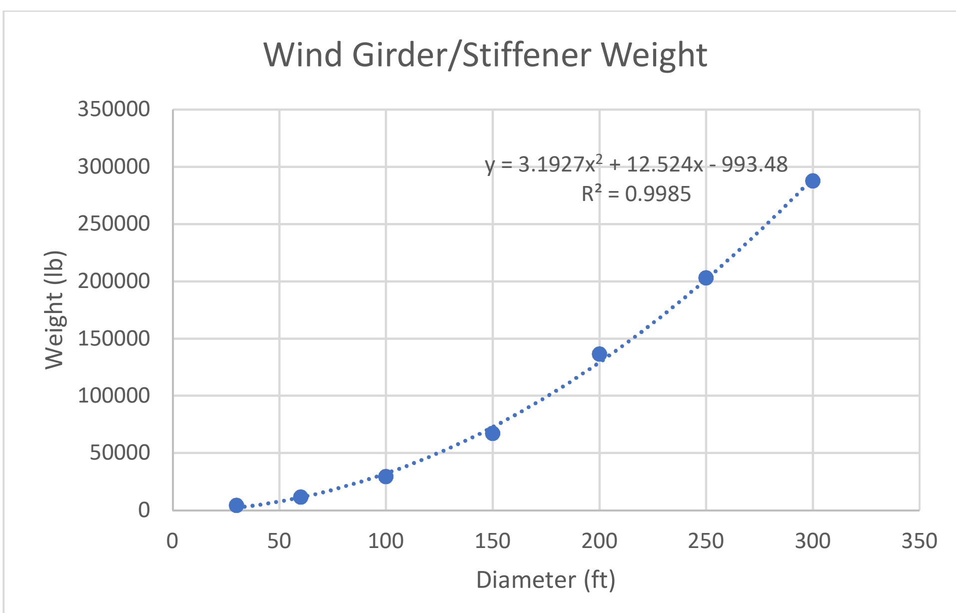

Figure 3 - Stiffener Weight Estimation

Conclusion

Through combining these tank weights, the total weight of the tank could then be estimated by summing the different components. Because of the different assumptions that were made, a user of the tool need only to provide the tank diameter and height in order to get a quick and approximate value for the tank weight, which can then be used for seismic design considerations (as well as other considerations that require the tank weight, like the tank foundation). A more sophisticated application was also developed that allowed users more control over different aspects of the tank—being able to choose the specific gravity, bottom thickness, roof thickness, roof slope, and so on. This provides greater accuracy in the tank weight estimation tool, but also increases the amount of inputs and data that is needed to run the tool. Regardless of which tool users would want to use, the benefits and advantages are clear—quick and efficient means for determining the weight of the tank.