Water Tank Support System for the School in Raypa
Statics course, Fall 2005, U Mass Lowell

The goal of this miniproject is to provide you with a chance to apply the theory and tools of the engineering statics course to an actual system and an opportunity to help a school in a remote community in the Andes Mountains of Perú. You will help to analyze a support structure for a water supply tank. With your knowledge of force moments and static equilibrium, you will estimate forces in the support members.

> Raypa is a town located near Huarmey, Peru, at about -10 degrees south latitude. There are roughly 200 students between elementary and high school in two different sessions every day. One of the vital necessities in the school is water for different uses, such as hand washing that is obviously important for public health. For many years now this school has water flowing to it only for a couple of hours early in the morning from the town at a higher elevation. Our job is to design and evaluate a tower upon which to place a 2500 liter polyethylene tank to store water so that the water is available all the time. The height should be at least 4 meters above the ground level, and the cross members at the top have to accommodate the tank base (1.55 meters in diameter). This height will result in a static water pressure of roughly 6 psi. Photos of a tank and tower that we designed rather quickly on the spot for another town are shown below. This miniproject is part of a larger Village Empowerment project of UML (http://energy.caeds.eng.uml.edu/Peru/index.shtm).

The basic tasks of the miniproject are:

- As a first step in designing a tower for the Raypa school water tank, estimate the forces in all the members shown in Fig. 1.
- Estimate the minimum width at the bottom so that the tower will not blow over.

Assume that all the members are connected by pin joints. Assume that the vertical distance between each cross bar is roughly 1 meter and the width of the tower at the top 1.75 m. The wind loading from the side is estimated at 3000 N, based on a 100 mph wind (building codes usually required designs based on 90-100 mph wind loading). Assume that the tower legs rest on rocks or a cement pad on the ground and are not pinned to the ground.

Specifications of a water tank available locally near Raypa

Volume (liters)	Height (meters)	Diameter (meters)	Mass (empty, kg)
2500	1.620	1.550	37.02

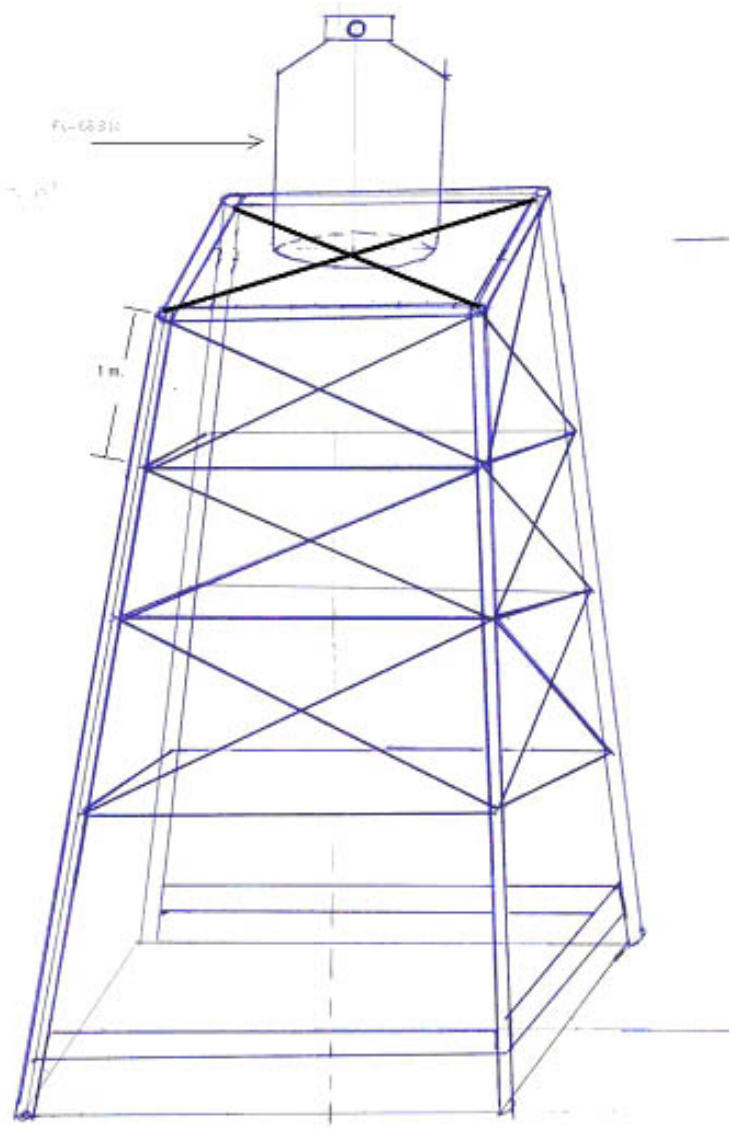
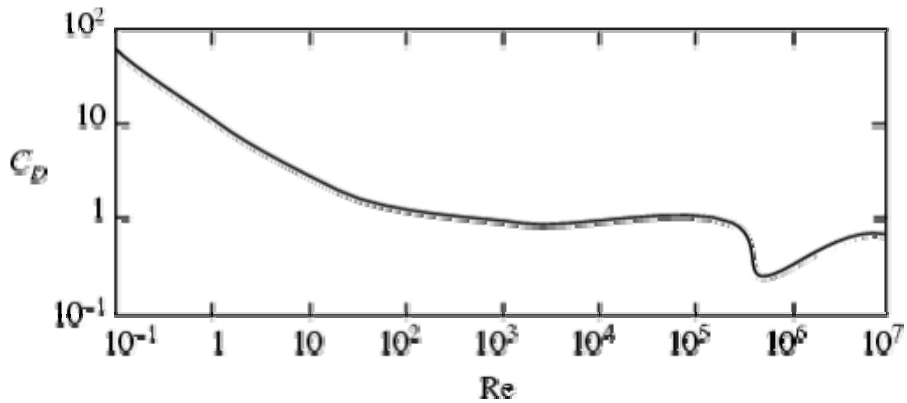


Figure 1. Sketch of proposed tower for the Raypa school. The height should be at least 4 meters.

Appendix: Estimation of wind loading from the side due a maximum wind of 100 mph (called for in most building codes).

Drag force in a cylinder



For an infinite circular cylinder of diameter *d*, the drag coefficient is given by

$$C_D = \frac{D_f}{\frac{1}{2}\rho U^2 A} \qquad \text{Re} = \frac{\rho \times U \times D}{\mu}$$

D_f: drag force exerted on cylinder (F)
A = Projected frontal area
A= (cylinder diameter x Length) (L^2)

ρ = density of the fluid (M/L^3)
U= free-stream fluid velocity (L/T)
D= diameter of the cylinder (L)
μ= viscocity of the fluid

. The coefficient displays three distinct regimes as a functions Reynolds number Re. For $\text{Re} < 100$, $C_D \propto \text{Re}^{-1}$, for $100 < \text{Re} < 10^5$, $C_D \approx 1$, and for $\text{Re} > 3 \times 10^5$, C_D drops then rises. The latter transition corresponds to the onset of turbulence in the boundary layer

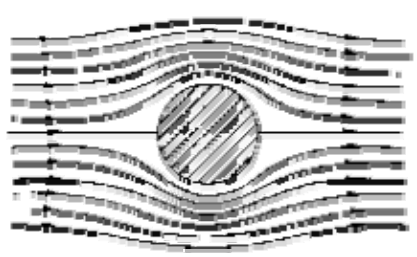


Figure: Streamlines for low Reynolds number steady viscous flow around a circular cylinder.

Calculations

$$Re=\frac{\rho \times U \times D}{\mu}$$ (Assuming 1 amt and 25 C)

ρ = density of the fluid (M/L^3) (air)
ρ = 1.19 kg/m3

μ= viscocity of the fluid

μ= 18x10^-6 $N.s/m^2$

U= free-stream fluid velocity (L/T)
U= 100 mph= 44.704 m/s

A = Projected frontal area
A= (1.55 x 1.620) ($m^{2)}$
A= 2.511 m^2
D= diameter of the cylinder (L)
D= 1.55 m

$$Re=\frac{1.19 \times 44.704 \times 1.55}{18 \times 10^{-6}}$$

Re=4580918.22

Re = 4.5 x 10^7

For this result CD is going to be close to =1 according to the graph

$F_D =$ C_D x $\frac{1}{2}\rho \times U^2 \times A =$ 1 x 0.5x 1.19x44.7^2x2.511= 2970 N = 675 pounds force

Units of FD: kg/m^3*m^2/s^2*m^2 = kg*m/s^2 = N