# Design Project 2 - ProMechanica
# ME 370 – Design of Transmission Tower
# Due: Wednesday, 1 May 2013

## Introduction

Transmission towers are structures used to support overhead power lines to transmit electrical energy over long distances. They are a widely used and low cost method for power transmission of large quantities of electrical energy.

Transmission towers are subjected to various types of loading conditions including self weight, forces from the power lines, adverse weather conditions, etc. It is critical that transmission towers are designed with adequate strength to withstand these conditions as well as minimal material usage to minimize costs.

**Fig. 1 – Transmission Tower**

## Design Requirements

The normal operating conditions of the transmission tower include the tower's own weight, the weight of the power lines **[F(weight)]**, and the tension in the power lines **[F(wire)]**. Additional considerations must be made to maintain structural integrity due to wind loads during inclement weather and uneven loading due to breakage of power lines.

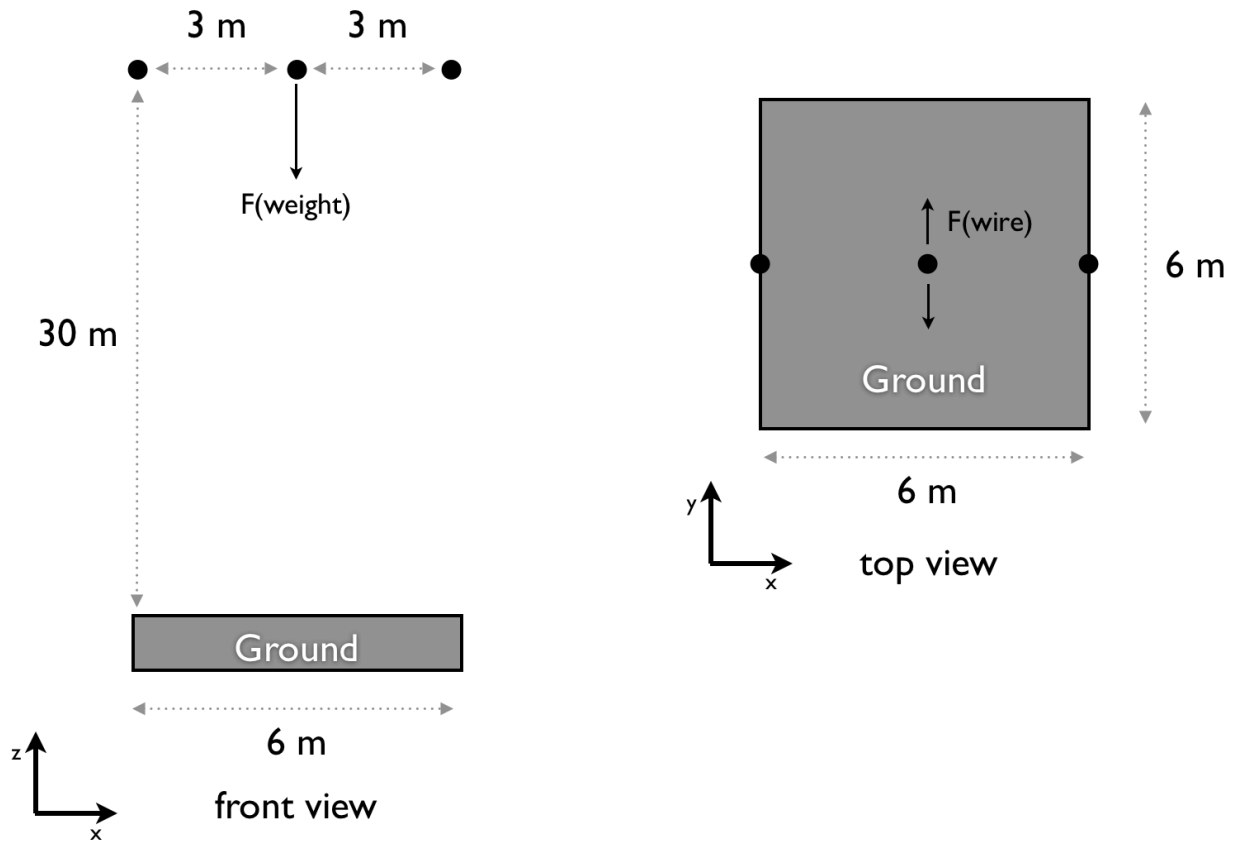


**Fig. 2 – Structural design schematic**

**Working Load and Adverse Conditions**

The transmission tower should be able to support three high voltage power lines at a height of 30 m (indicated by black circles). These conditions result in a vertical load due to the weight of the wire of F(weight) = 20 kN in the negative z-direction, and a horizontal load due to the wire tension of F(wire) = 5 kN in the positive and negative y-direction. Assume that the transmission tower components are made of structural steel with a yield strength of 250 MPa and a density of 7800 Kg/$m^{3.}$

The important geometric requirements which need to be met in terms of the overall dimensions of the crane are as shown above. In addition to supporting the wire weight and tension during normal operating conditions, the transmission tower must be able to maintain structural integrity in the case of wind loads and asymmetry induced by breakage of power lines.

**Weight of the structure**

In order to model the effect of structure's own weight in the analysis, first calculate the total weight of the structure (based on the density, the area of cross-section of the element and the total length of all links/ elements used). And assume that this weight is distributed equally amongst the joints and concentrated at the joints. For example if there are 30 joints, and the total weight of the structure comes out to be 6 kN, then each joint experiences a concentrated force of 200N towards the ground.

**Wind Loads**

Additionally, the crane should be designed to operate under heavy wind speeds of 40m/s which is found to exert a total force of 5 kN on the total structure. Assume that this load is equally shared between every joint of the structure. For example if there are 30 joints, then each joint experiences a force of 100N in the direction specified in the figure above.

## Objective

Your transmission tower must be anchored to the ground on the 6m x 6m platform shown in the figure. It must support the three high voltage power lines at a height of 30m as depicted in the schematic.

Your crane structure should roughly occupy the regions shown on the sketch in the above figure. The number of links/elements/joints that you use is not restricted. But please note that the weight of the overall structure increases with increase in the number of elements. All members are made of structure steel and they may have any cross-section so as to handle the stresses. Different types of cross-sections are allowed, but the number of different elements should be minimized to simplify manufacturing the assembly. Note that the base of the structure is firmly fixed to the ground and the nodes at the base will be modeled by constraining all the DOFs associated with those nodes.

## Performance of the structure and Grading Criterion

The crane structure needs to be designed for the worst-case loading as depicted in the figure above. For this load, your design must satisfy the following criteria:

**1. Stiffness**. The power line supports must not deflect more than 1 m vertically.

**2. Strength.** No element should be stressed to its yield stress. A reasonable factor of safety should be used.

**3. Weight.** In addition, it is desirable that the weight of the structure be minimized, both to keep the purchase cost low and to reduce the cost of transporting and erecting the transmission tower.

The project will be graded based on the following parameters:

1. One-page report (50 %)
2. Design meets required constraints (20%)
3. Strength of the Structure and analysis (15%)
4. Weight of the Structure and analysis (15%)

## Reporting

Complete this project either groups of two people (same as project 1). Your design report should follow the same format as the first design project: a one-page summary, followed by appendices to explain your design and support your technical conclusions.

Be selective in choosing what to put in the appendices. Be sure to include pictures of the overall structure, and its deflection under load. You must document the geometry of your design, providing enough information to allow it to be built. It is not necessary to include large files of output from your finite element analyses; you can extract the important data and report it. You must explain clearly how the finite element model was supported and loaded, as well as how you analyzed the data to determine if all of the design criteria were satisfied. Be sure to report the total weight of your structure, the deflections at the loading point, the maximum element stresses, and any other critical information.

Detailed design of the joints is not required. Joint design can be quite important to strength, and one often adds gussets or other reinforcement at critical joints. However, this is mainly a strength issue, while stiffness comes from the overall geometry of the frame and the sizes of its members.

Final report and ProMechanica file must be uploaded to Compass2g by 8:00 pm of due date.