CIEG212: Solid Mechanics
Spring 2002
Group Project #1

Winds Prove Tough for Billboards

Years ago, manufacturers used billboards along the interstate highway system as a means to sell liquor, tobacco, hotels rooms and many other consumer products and services to the traveling public. The means and the message has changed over the years, as has the design and construction of the classical billboard.

Supported on telephone poles buried in the ground, billboards of old were usually no more than 10 to 20 feet off the ground. Today, however, it is not uncommon to see a permanent billboard or sign towering 100 or more feet above the ground. Because of their height, the wind load on these very high signs can be tremendous. These structures require careful design and analysis to be sure that it can withstand the immense loads caused by wind.

Your firm has been hired to conduct a detailed analysis of a sign structure that is located on I-95. A sketch of the sign is shown in the attached diagram. The sign is over 100 feet tall, from the base to the top of the sign. The sign "pole" is made of steel and has a hollow-tube cross-section. The pole has a "tapered" design, changing cross-section at heights of 30 ft and 60 ft above the ground. The sign itself measures 25-by-15 feet and weighs 4500 lbs.

The wind load on the sign acts as a distributed pressure. Under a steady uniform wind, the pressure can be assumed to be uniformly distributed over the sign with a magnitude of 35 pounds per square foot. For the uniform load the sign will tend to flex and bend, but not twist along its axis. However, under unsteady wind, designers must consider the possibility that the pressure will not act uniformly over the surface but will instead be stronger on one side than the other. In this case the wind pressure varies across the sign as shown in the diagram (note that the pressure does not vary over the height of the sign). As a result, the sign will be subjected to a torsion load at the top of the pole. This type of load will tend to twist the pole along its axis and in the process develop torsional stresses in the pole and produce torsional deformation. The pole must be designed for the normal forces caused by its own weight, and the flexural (bending) and torsional forces due to the wind.

For this project your firm will be conducting a detailed analysis of <u>just the normal force and torsional force effects on the structure</u>. You do not need to concern yourself with the flexural (bending) behavior (we will learn how to deal with that later in the semester).

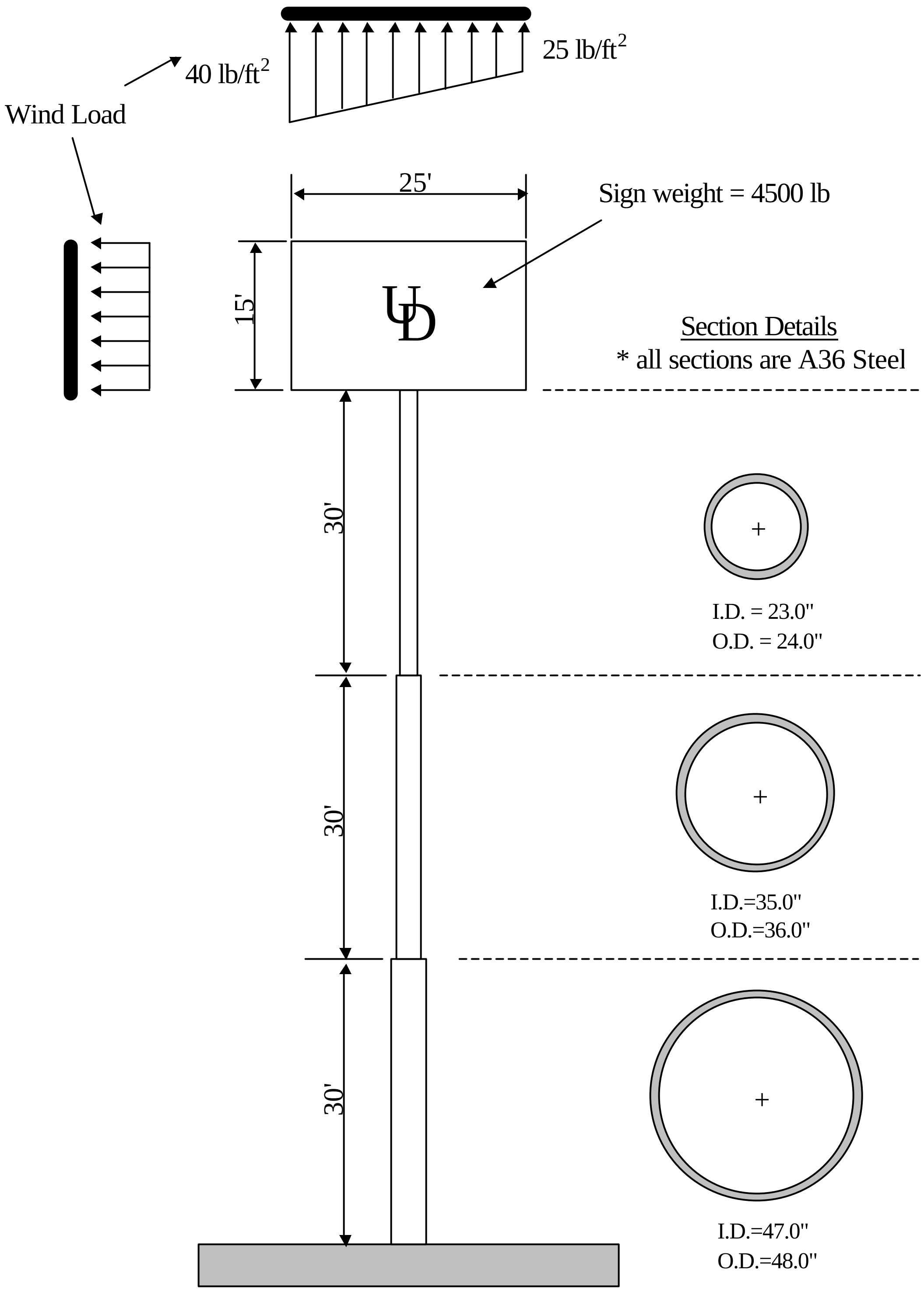
For this project your group is to conduct an analysis of the effect of the normal forces in the pole. This should include

- A plot of the normal force distribution in the pole (i.e., normal force versus height).
- A plot of the normal stress distribution in the pole (i.e., normal stress versus height).
- Calculate the axial deformation of the pole at heights of 30, 60 and 90 feet.
- Answer the questions:
  - Where is the absolute maximum normal stress in the pole?
  - Where is the absolute maximum axial deformation in the pole?

In addition, conduct an analysis of the effect of the torsion on the pole. This should include

- A plot of the torsion distribution in the pole (i.e., torque versus height).
- A plot of the peak shear stress distribution due to torsion in the pole (i.e. peak shear stress versus height).
- A plot of the distribution of shear stress *within* the cross-section. Create plots for each of the three different cross-sections.
- Calculate the torsional deformation (i.e., angle of twist) due to torsion of the pole at heights of 30, 60 and 90 feet.
- Answer the questions:
  - Where is the absolute maximum shear stress in the pole?
  - Where is the absolute maximum torsional deformation in the pole?

Your results are to summarized in a typed technical report. Details on report format requirements will be provided later.



Wind Load
40 lb/ft2
25 lb/ft2
25'
Sign weight = 4500 lb
15'
UD
Section Details
* all sections are A36 Steel
30'
I.D. = 23.0"
O.D. = 24.0"
30'
I.D.=35.0"
O.D.=36.0"
30'
I.D.=47.0"
O.D.=48.0"