

## DESIGN PROBLEM #2

Your team has been contracted by TrussProd, Inc. to make recommendations to them on a quality control test procedure for their new line of trusses. TrussProd originally entered the construction market by producing metallic frames and trusses for industrial construction. They have recently expanded their factory and will be entering the private home market with their new line of trusses for private homes.

Initially they will have two products of the same basic design and total length (of 25 ft). The difference is in the pitch of the two cases: one being for a  $45^\circ$  roof and the other for a  $30^\circ$  roof. The basic design is shown in the accompanying figure with the pitch angle indicated by  $\theta$ . The individual members of the truss are dried pine two-by-sixes and they are joined using galvanized joining plates with a specialized attachment device which is one of the trade secrets which has helped TrussProd become a success to date in the industrial construction market. Although they have patented the procedure, they are still generally unwilling to discuss its implementation in detail and have not provided any details about this to you.

The engineers at TrussProd have researched building codes extensively and have found that the building code of the City of Metropolis is the most conservative. They have therefore decided to design their product to fulfill that code. There are a number of different items that must be fulfilled, but you are asked to consider only the static loads. The pertinent part of the building code is as follows:

*Building Code, City of Metropolis, Section 804.1 (b):* "The truss shall sustain, without collapse and with a deflection of the center point of less than  $S/360$  (where  $S$ =span), its own weight, plus a superimposed test load equal to 50% of its weight plus 150% of the dead load to be added at the site, plus 250% of the design live load".

The engineers at TrussProd have indicated to you that the "dead load added at the site" consists of the roofing material and is typically in the ballpark of  $7 \text{ lb/ft}^2$  although in cases where the best construction materials and procedures are used, these loads can reach  $20 \text{ lb/ft}^2$ . The "live loads" consist of a number of items which the roof will see in use and are defined in the building code:

*Building Code, City of Metropolis, Ch. 7:*

- Roof live loads are the concentrated loads (to account for people, etc.), snow loads, and wind loads.
- Concentrated loads =  $20 \text{ lb/ft}^2$
- Snow loads =  $(34-2r) \text{ lb/ft}^2$  of horizontal projection) for  $2 < r < 12$   
 $10 \text{ lb/ft}^2$  of horizontal projection) for  $r > 12$   
where  $r$  = rise (inches) per foot of run
- Wind loads: design to pressure of  $0.4P$  for slope  $< 30^\circ$   
design to pressure of  $0.9P$  for slope  $> 30^\circ$   
where  $P = 20 \text{ lb/ft}^2$

The engineers have also provided a sketch to help describe many of the terms utilized here. They have also pointed out that, by code, roof trusses are supported 6 inches inboard of the end point to allow room for placement of the soffit boards/panels in the eaves. The basic manner in which the trusses are attached to the structure below can best be modeled by a simple support. Finally, the building code indicates that the maximum allowable spacing between trusses is 30 inches.

The factory will initially have two production lines, one for the  $45^\circ$  truss product (known as TrussProd 25-45), and one for the  $30^\circ$  truss product (known as TrussProd 25-30). Each production line will produce one truss every two minutes. Product 25-45 will each weigh 200 lb., while product 25-30 will each weigh 160 lb. The company is planning to expand its production capability by adding additional production lines in a planned new factory building if initial demand for their new product warrants such a move.

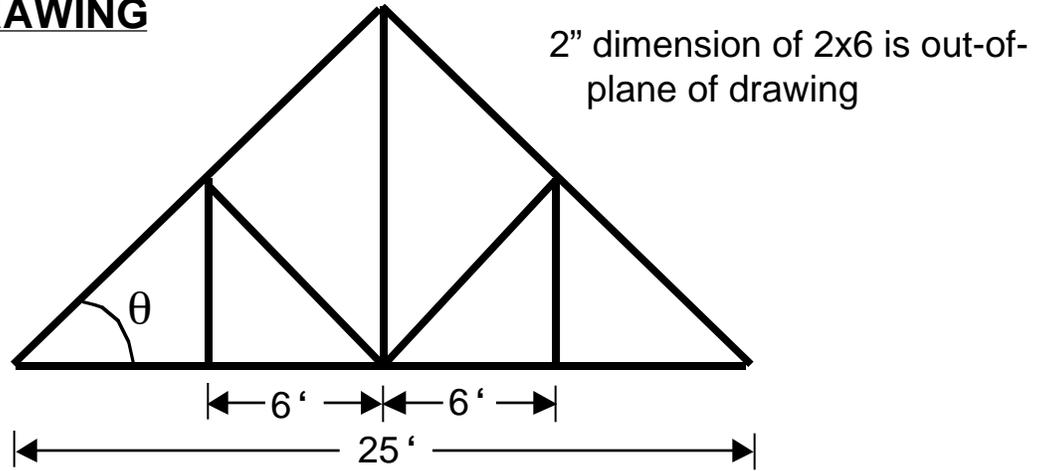
The company wishes to check product quality by testing units as they come off the production line. Your job is to design the test method to insure the quality, defined as meeting the pertinent parts of the Building Code noted in this write-up. You need to consider and discuss such items as how often a unit will be tested (each unit, every second, every fifth, every tenth, ...); the **general** description of the test set-up including placement of loads, the boundary conditions, and suggested mechanical units for such; the expected time to set-up a test (and the associated number of testing stations at the end of the line); as well as the tradeoffs between the various items. Although quality control is the issue, the company is interested in minimizing cost over the long run (purchase of equipment, labor, etc.).

### How and What...

Present your results in an engineering report. The report can be as long as you feel necessary (*I would say that more than 5 single-spaced pages of text is probably getting to be a bit too long. But please submit this double-spaced to make commenting and correcting easier*). The report should provide the proposed solution, the

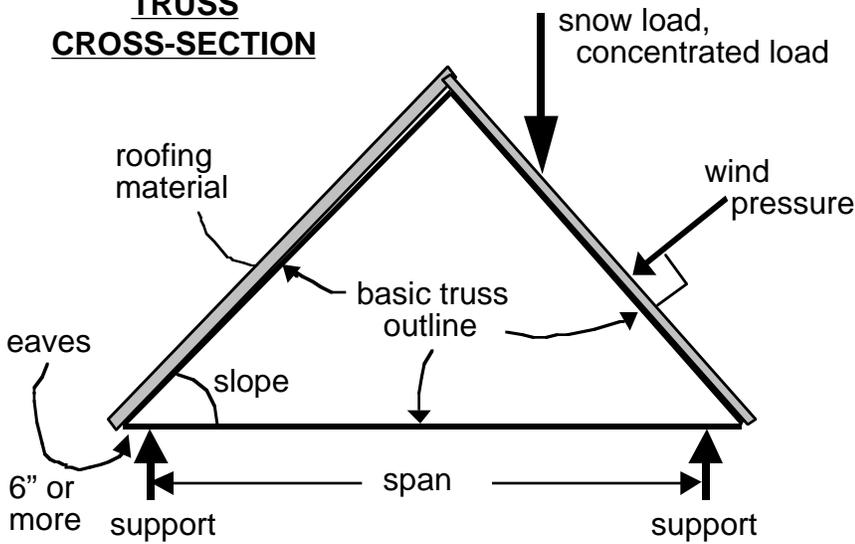
reasoning behind it, and should be subdivided into sections as necessary (Possible sections include: executive summary, introduction, problem statement, assumptions, methodology, results, conclusions and recommendations, options, limitations, additional considerations). The reasoning should be supported by appropriate calculations. Any lengthy calculations should be contained in an appendix. Figures and tables should be used if appropriate. In addition to the engineering report, a covering business letter to the VP of Engineering, Dr. I. M. Atruss, should be sent. He is the official contracting point. The letter merely conveys the actual document and deals with "pleasantries of business" (billing is generally provided under separate cover). No recommendation or discussion of technical matters are contained within.

## PRODUCT DRAWING

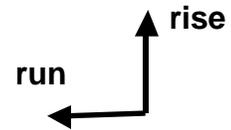


- Notes:
- Configuration drawn for  $\theta = 45^\circ$  (TrussProd 25-45)
  - Individual members -- dried pine 2x6's
  - Standard galvanized steel joining plates with patented TrussProd attachment technique

## TRUSS CROSS-SECTION



## SKETCHES FOR NOMENCLATURE



## ROOF 3-D SKELETON SKETCH

