

Prototype Trials

Part of the overall selection process will involve determining the structural efficiency of your proposed tower design. The following information is designed to assist you in building your prototype tower so that it best models the requirements of the actual tower design. The information below lists the specifications and constraints for the prototype. Only entries that follow the format below will be allowed entry into the prototype trials. **Overall selection is based on a combination of the prototype results and the documentation of the entire design process in your submitted design brief.**

The following materials may be used when developing prototypes:

Pencil for sketching and blueprints	Sketch paper to draw possible designs
Ruler for measuring dimensions	Ink pen to outline blueprints
Foam board for prototype construction	Wax paper to cover blueprint
T-pins to hold balsa wood in place until dry	Easy cutter for precise balsa wood cuts
1/8" graph paper for blueprints	15 pieces of 1/8" X 1/8" X 24" balsa wood sticks
Tacky glue (takes overnight to dry)	The Internet for researching
Microsoft Office for design briefs	Transparent tape to stand towers while drying

Rules of the prototype trials:

1. **Materials:** Only the materials provided (see above) may be used in the tower structure. The final prototype can contain only wood and glue.
2. **Construction:** The base of the tower must be constructed so that it does not fall through an opening that is 200mm X 200mm. The top must support a loading block that is 50mm X 50mm. The overall minimum height must be 350mm. There is no maximum height. No laminations are allowed.
3. **Testing:**
 - a. Testers must wear eye protection during testing.
 - b. The tower must center on the testing stand such that the chain connecting the loading block can pass through its center and hook onto the loading block.
 - c. A wind force simulated by a standing fan will be applied to the tower. The tower must remain upright for fifteen seconds to proceed to Step D. If the tower shifts during testing, but remains on the platform, it remains in its final position before continuing to Step D.
 - d. A chain will hook the loading block to a 5-gallon plastic bucket. The bucket will hang off of the floor.
 - e. Testers will pour sand into the bucket until the tower no longer supports the loading block.
4. **Scoring:**
 - a. Scoring will be based on efficiency. The design should maximize efficiency.
 - b. Structural efficiency will be calculated using the following equation:

$$\text{Structural Efficiency} = \frac{\text{maximum load supported in grams}}{\text{mass of the tower in grams}}$$

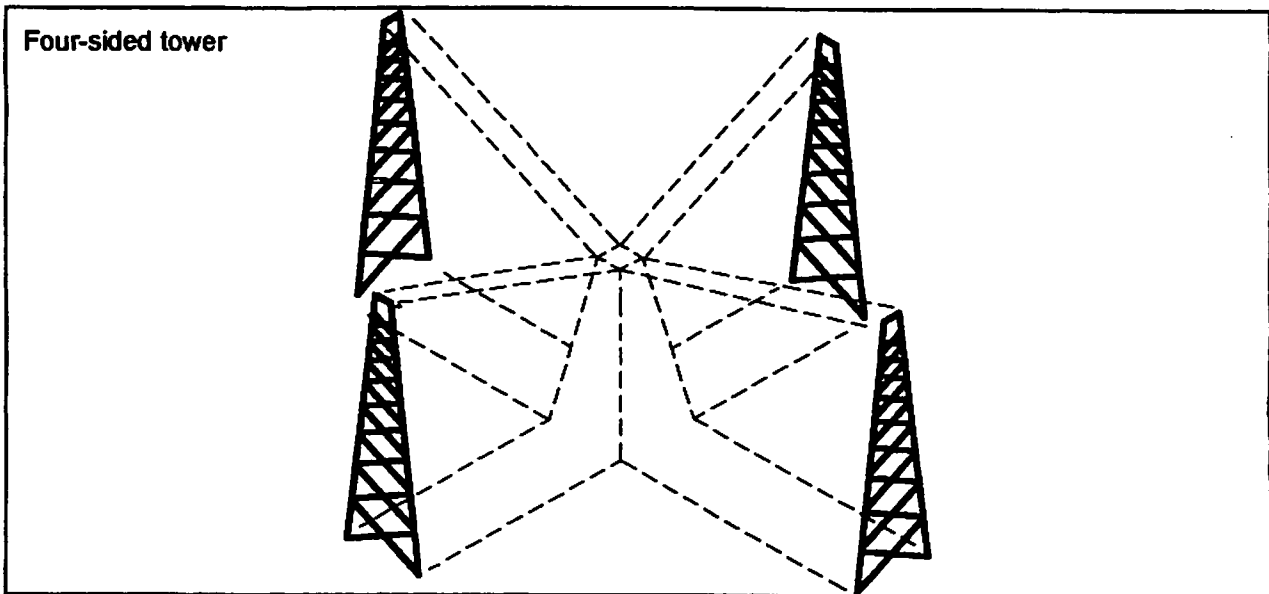
Construction Techniques

No matter how well a tower is designed, if assembled poorly, it will perform poorly. Towers are built to be symmetric and the joints must have precise mitering for tight surface to surface fits. If the joints show gaps between the wood surfaces, the final structure will be very weak and fail quickly at those joints. Winning designs rarely fracture at the joints. Incidentally, glues work best when surfaces being adhered are *flush*. Do not depend on the glue to hold when used as a gap filler. In addition, this excess use of glue will always add excess weight to the whole structure, defeating the project by being both overweight and weak!

Consider the process of construction for assembling the tower. Full-scale towers are designed to be built in sections with materials that are manufactured to specific size and dimensions. When the final construction is done on site, there is very little tolerance deviations. The fit is so well engineered that it practically "falls together." It must be stressed that care be taken when you build your prototype. The fit of each piece must be precise in order to have a much stronger tower when finished.

Let us consider the design of a four-sided tower.

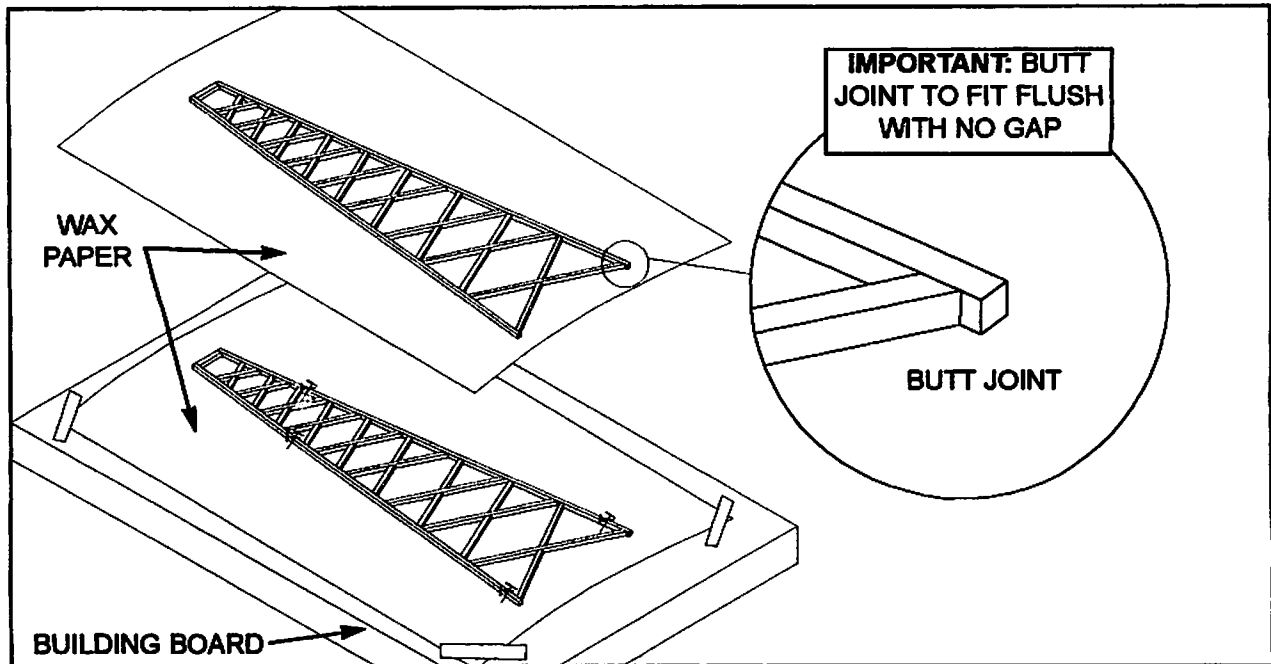
The simplest and heaviest way to build a tower is to simply build four sides and glue them together to form the tower. The only difficult part would be keeping the finished assembly square as the glue dries. Using small paper binders to keep the sides together will help. The problem is that this typically produces the heaviest structures.



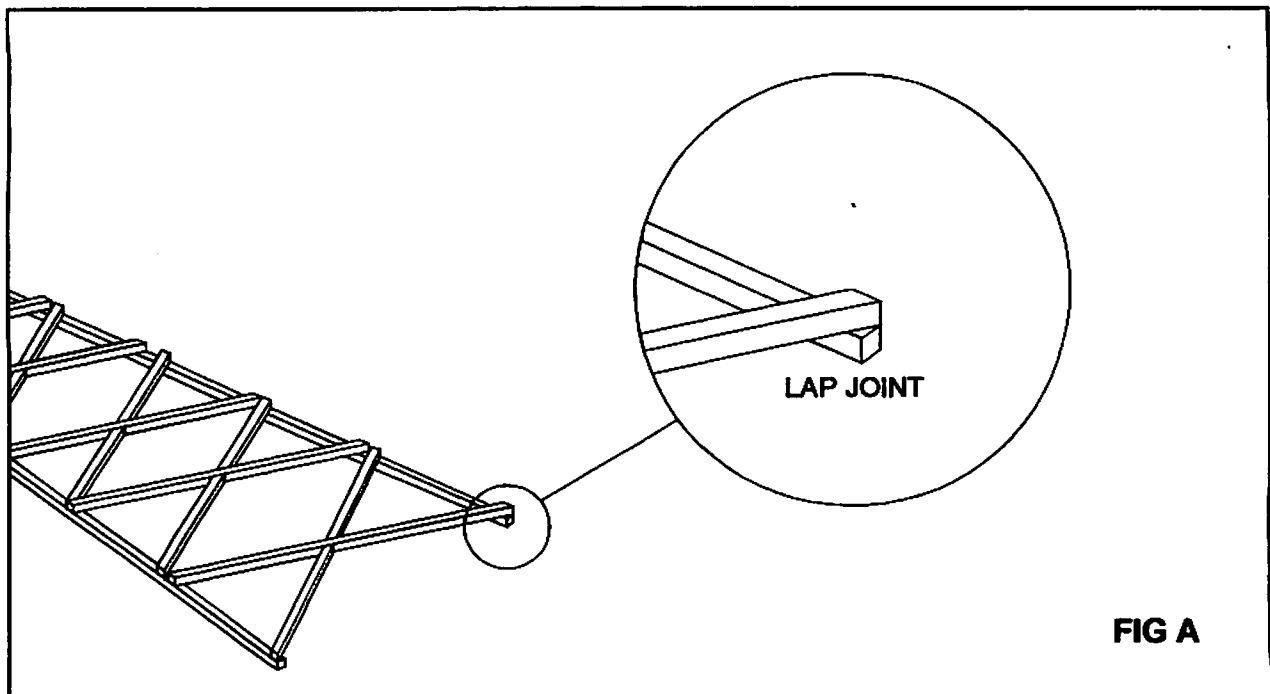
Can a four-sided tower be designed differently? Yes! In fact the basic procedure can be infinitely modified to achieve more efficient results.

Tips For Building Your Tower:

1. Start by drawing the legs to fit the outside dimensions of the testing stand.
2. Carefully draw in the cross members such that they form triangles or trusses to connect the two legs together.
3. Tape your drawing to your work board and cover with wax paper.
It is most important that the structure be built in a consistent manner.
4. Number each cross member in its assembly sequence and make use the first to replicate three more.
5. If your design uses butt joints, leave the first side in place once it is built.
6. Cover this side with wax paper and build another side directly on top of it. This is the most consistent way to be sure two sides are exactly the same.
7. Let both sides dry 12 hours before proceeding to final assembly.

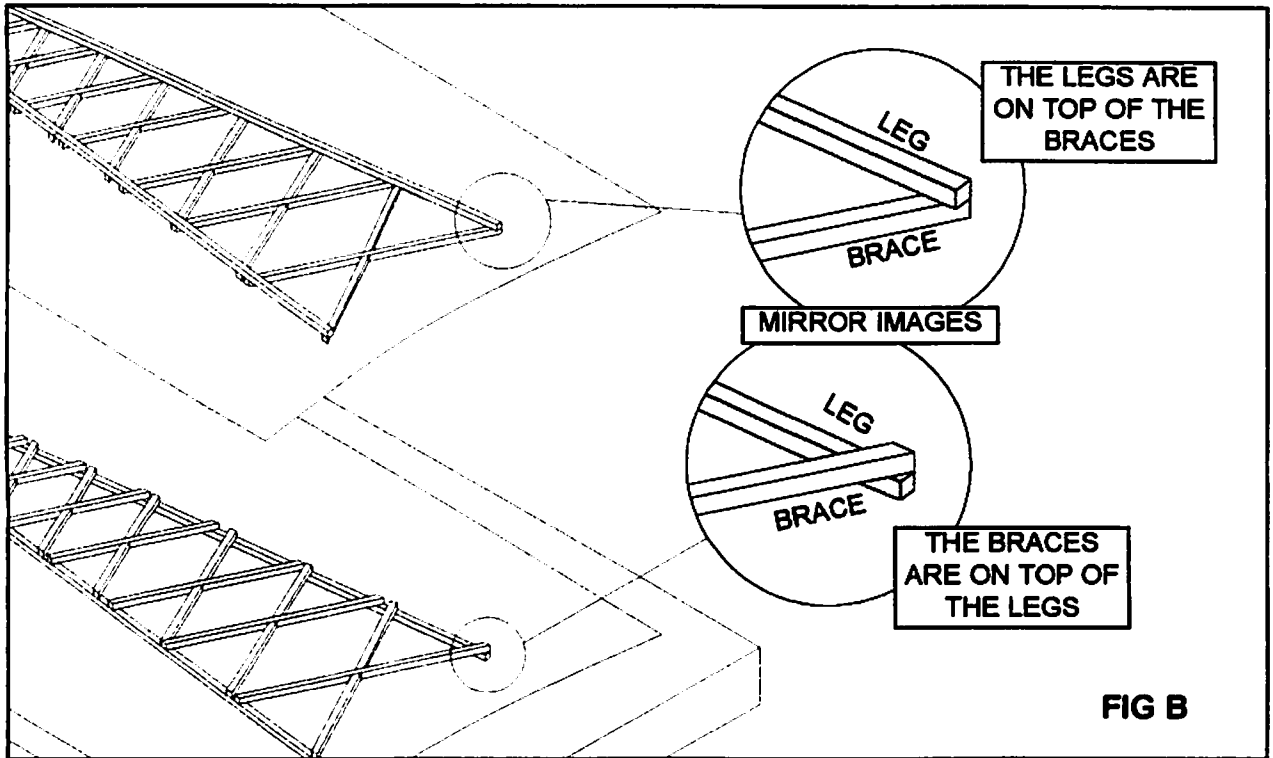


If you choose to design a tower where the cross members *lap* over the legs, (Fig A) then you have chosen a very strong joint system. This does cause a problem when you try to build matching sides though. The two primary sides must be constructed separately, as they do not fit easily on top of each other during construction like the butt joint system does. Instead, you can build mirror image sides as an adaptation. (Fig B)



Final assemblies require some patience. It is important that cross members be glued to the structure within their numbered sequence.

1. Pin the four legs down so that the two completed sides are standing opposite each other.
2. Carefully fill in the truss work with the pre-numbered and cut cross members. (Fig C)
3. Let this assembly dry at least 24 hours.



After building your first tower, you may attempt to improve your design along with your own construction process to build a more efficient tower.

