TAUBMAN COLLEGE
ARCHITECTURE & URBAN PLANNING
UNIVERSITY OF MICHIGAN

Arch324
STRUCTURES II

Winter 2025
Recitation

FACULTY: Prof. Peter von Bülow
Mohsen Vatandoost

Arch324: STRUCTURES II

Welcome to Recitation session 02/07

Mohsen Vatandoost {Ph.D., M.Sc., M. Arch}

mohsenv@umich.edu

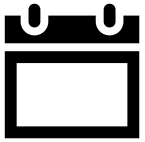
Office: Room 3122

hours:

Fri: 11:00 – 12:00

Mon, Wed: 11:00 - 12:00

walk-ins welcome!



Click here to make an appointment

Please feel free to ask questions.

Arch324: STRUCTURES II

Welcome to Recitation session 02/07

Outline:

- Quick **Recap** of the week
- Provide the solution for the assignment **(---)**
- Answering student's questions
- Lab: **---**
- **Tower Project:** how to start

Please feel free to ask questions.

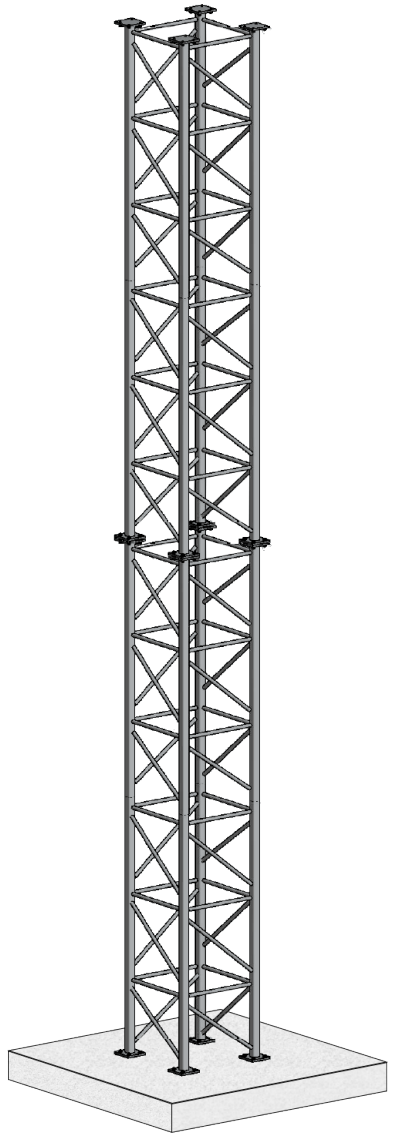
Contact: Mohsenv@umich.edu

Tower Project: How to start

Team up (groups up to 4 persons) and Sign up.

Due date for the Preliminary report is Feb 14

Tower Test : March 24



Tower Project:

Description

This project gives students the chance to apply concepts learned in column analysis to the design of a structural system that carries primarily a compression load – a tower. Work is to be done in groups of up to four people. The project is divided into 3 parts: 1) initial conceptual design, 2) design development and testing, 3) final analysis and documentation.

Tower Project:

Goals

- to explore design parameters of geometry and material under compression.
- to develop a design of a compression member to meet the criteria below.
- to make some rough hand calculation to estimate the expected performance.
- to test the compression member and record the results.
- to document the results in a well organized and clear report format.

Tower Project:

Criteria

- The tower is to be made of wood. Either linear wood (sticks) or wood panels (sheets) can be used. Glue can be used to connect the elements. Gusset plates at the joints are allowed and can also be glued. But **no steel pins** or fasteners may be used.
- Wood: **any species**. **maximum cross-sectional dimension = 1/4"**.
- **NO** paper, mylar or plastic or string or dental floss.
- If a member is made by laminating multiple pieces together, the maximum cross-sectional dimension or thickness still cannot exceed 1/4".
- The **height of the tower = 48"**.
- The tower **must hold at least 50 lbs**.
- The entire tower **can weigh no more than 4 oz**.
- The top of the tower must be loadable. The weights will be stacked on top of the tower, but you may optionally use a loose piece of MDF or plywood as a tray under the weights. (It will not be counted in either weight or load)
- Towers will be graded on their low weight, high load-carrying capacity, and the load/weight ratio. The evaluation formula is:

  (4/weight in OZ) + (load in LBS/50) + (load LBS/weight OZ)x1.5

- The score will be normalized to a range of 50 to 100. It is used together with report scores to assess your project (a detailed evaluation form is given separately).

Tower Project: How to start

Scoring	
Preliminary Report	40 pts
Testing	60 pts
Final Report	150 pts

Procedure

1. Develop a structural concept for a tower meeting the above criteria.
2. Analyze the design concept with **either** hand calculations or a computer program (e.g. Dr. Frame)
3. Determine the capacity of the major members and of the overall tower (total capacity in LBS)
4. Estimate your expected score using the formula above.
5. Write the preliminary report.
6. Construct the structural model.
7. Test the model. 5-pound steel bars will be placed on top of the model, until the model fails. (bar size: 1 ½" x 2" x 5 13/16").
8. Produce final report documenting requirements and process. See also score sheet.

Use NDS approach

Find load P and stress F'c for each member

Use 1.0 for all factors except C_P

Analysis

$$f_c = \frac{P}{A} \leq F'_c$$

Capacity

$$P = F'_c A$$

Design

$$A = \frac{P}{F'_c}$$

Tower Project: Preliminary report

Explanation – describe how the design was developed, the basis of the structural concept, and how the principles of column behavior influenced the design decisions.

Illustration – include diagrams/drawings that describe the structure in its entirety. **At least a horizontal cross-section and an elevation of the tower are required**. Dimensions are to be included and the member sizes labeled.

Tower Project: Preliminary report

Analysis – the report should include the following:

- **Choose wood type and stress properties.** Either use values below for typical model grade Basswood or use values in the NDS or find test values online. Indicate in the report which values you choose.
- **Determine the cross-sectional area of each member**. Find the axial force P and the allowable stress F'c. The force P can be determined either by a hand calculated truss analysis or as a second order analysis in Dr. Frame or STAAD.Pro. The stress F'c should be found using the NDS equations for C_P and F'c. Other NDS stress adjustment factors (C_D, C_M, C_t, C_F and C_i) can be taken equal to 1.0. Size members based on the predicted load, P and the allowable stress F'c. Target (or predict) some total capacity load for the tower. A minimum of 50 LBS is required. Then size the members based on the force in each member.
- **Predict the total weight of the tower.** Provide a table with each member type showing, length, section and weight for each. Make an estimate of the weight added by glue joints and/or gusset plates. The total weight should be under 4 OZ.
- **Predict Capacity**. Predict the ultimate capacity in pounds that the entire tower can carry based on the actual cross-sections chosen. Produce a utilization table to show for each member type (e.g. main vertical, horizontal tie, diagonal brace) the utilization ratio fc/F'c based on the predicted total capacity load. This ratio should be below 1.0 for all members.
- **Calculate the buckling capacity of the tower as a whole.** This is done by treating the tower as one column loaded at the top, made up in cross section of multiple columns. Show the moment of inertia of the tower cross-section, and use it to calculate the critical buckling load using the Euler equation. An example of this calculation is given in the slides from the class lecture. The ultimate capacity is the lower of the two capacities (critical member or tower as a whole).

Note: If an excel spreadsheet is used to make calculations, show the equations being used for each cell or column in the table. If STAAD.Pro or Dr. Frame is used to do any of the above, include print-outs showing the applied loads and resulting member forces.

Tower Project: Preliminary report

Properties of Basswood: (like in the Media Center)

Density (oven dry)	29 pcf **
E (buckling)	1,650,000 psi **
F (Compression ∥ to grain)	4745 psi *
F (Compression ⊥ to grain)	377 psi *
F (Tension ∥ to grain)	4500 psi (estimate)
F (Tension ⊥ to grain)	348 psi *
F (Shear ∥ to grain)	986 psi *
F (Flexure)	5900 psi *

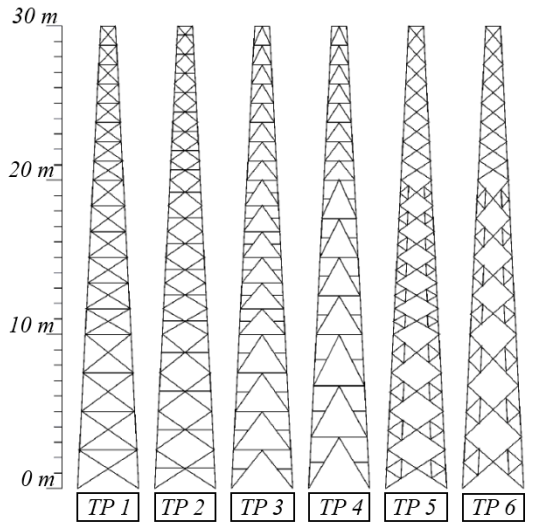
* from http://www.matweb.com/ ** tested by PvB (small pieces in compression)

Tower Project: How to start

- ✓ Team up!
- ✓ Look at examples online: similar towers and high-rise buildings
- ✓ Look at student's work in the last semester in the course website
- ✓ Familiar yourself with Dr. Frame (download it on the course website)
- ✓ Test different material
- ✓ Sketch your idea
- ✓ Develop your design

Tower Project: How to start

- ✓ Taper tower (optional)
- ✓ For the sake of material saving, the top and bottom sections, could be different
- ✓ Control the Lateral stability
- ✓ Test different patterns
- ✓ Test different geometry
- ✓ Be creative!



lattice tower structure

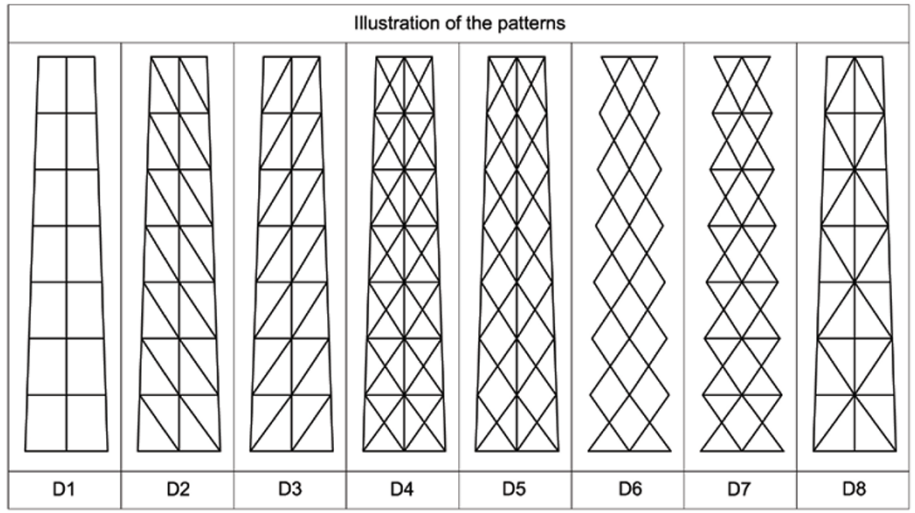


Figure 3: The patterns that are used in designing the lattice tapered towers

Khodadadi, A., & Buelow, P. V. (2014, September). Form exploration and GA-based optimization of lattice towers comparing with Shukhov water tower. In *Proceedings of IASS Annual Symposia* (Vol. 2014, No. 16, pp. 1-8). International Association for Shell and Spatial Structures (IASS).

Tower Project: How to start

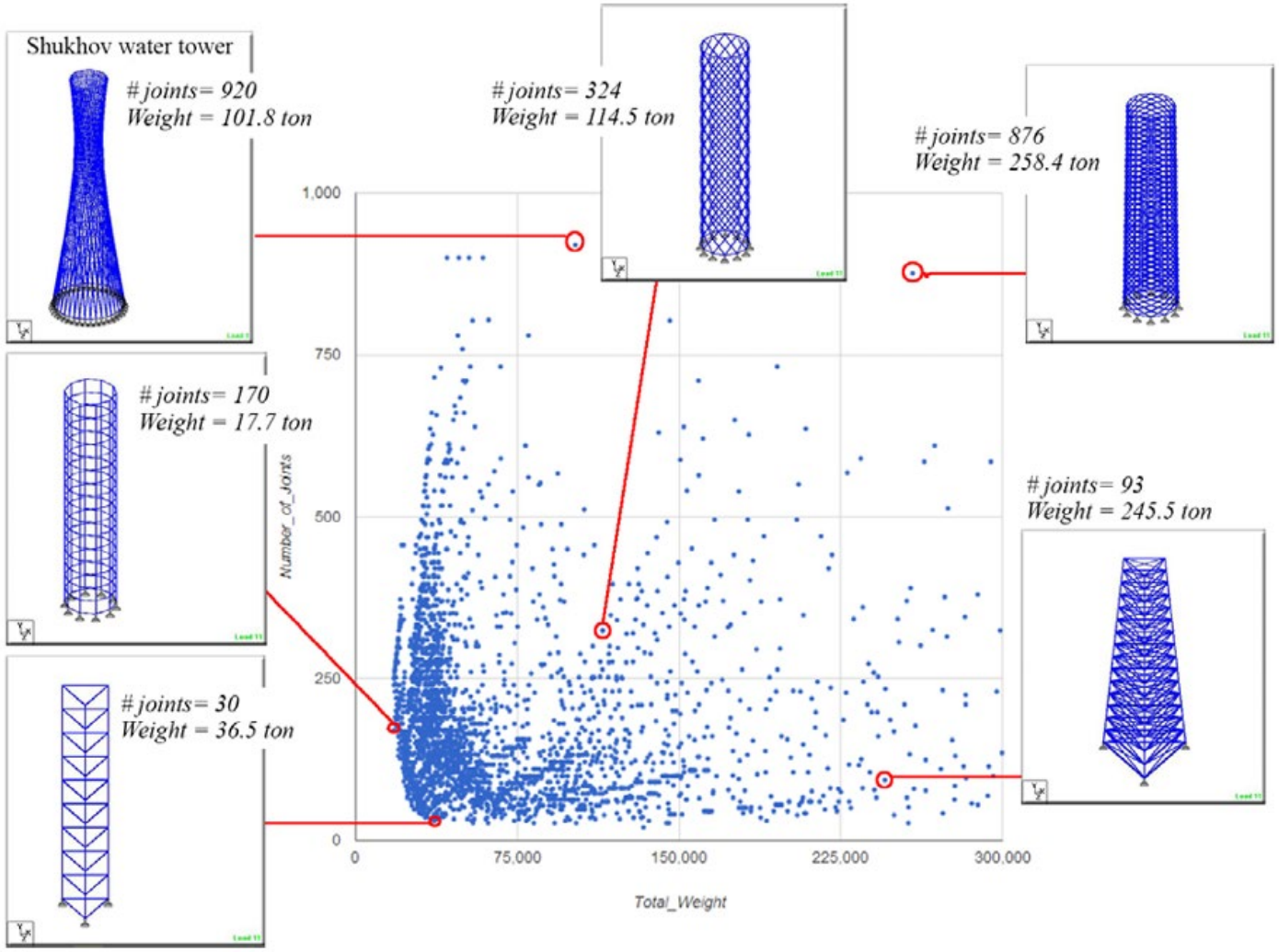


Figure 10: A graph that illustrate the number of joints vs. total weight of the solutions.

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Thank you.

Any question?

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