

WELCOME TO ASCE TRUSS BUSTIN'!!

The Nebraska Section of ASCE (American Society of Civil Engineers), the UNL Student Chapter, and the UNO Student Chapter would like to welcome you to the 2020 edition of the Truss Bustin' Competition! The competition is intended to educate students on the engineering design process, and provide a hands-on approach to learning the basics of structural design. As part of the competition you will design and construct your own balsa wood truss, simulating the real-life engineering design process, and your truss will be load tested to failure at the competition. Prizes of \$300, \$200, and \$100 are up for grabs for 1st, 2nd, and 3rd place, respectively!

Included in this packet are the following items:

Problem Statement

A description of a real-life problem that could be solved with a truss-style bridge is described. Agencies like the Nebraska Department of Transportation (NDOT), City of Lincoln, or the City of Omaha will often advertise their need for design work, and describe the requirements for the design in a document called a "Request for Proposals" or "RFP". Design firms then typically respond to this need, describing why they would be the best firm for the job. The agency selects the firm with the best proposal to do the design work. In the case of this competition, the NDOT is looking for a preliminary design of a new bridge crossing across the Missouri River, and your firm, Warren Engineering has been selected.

Truss Bustin' Rules and Regulations

Designers and contractors typically must follow the agency's standard specifications (often called "specs") which describe how the work must be performed. The specs often define material quality, test methods, safety precautions, and other requirements that the contractor must satisfy. If a contractor's work is found to not meet the spec, the contractor is typically required to fix the problem at no additional cost to the owner. Your truss must meet these rules and regulations in order to qualify for the competition!

Design Analysis Template

Another common submittal for a design firm is a written description of their design, sometimes called a "design analysis." The designer must document decisions made during the design process, and provide supporting calculations and justification for their design. For this competition, you are asked to answer a few questions about your design, documenting your thought process during the design of your truss.

Design Plan Template

The design of a bridge includes a set of construction plans, depicting the design, and describing to the contractor how to build it. A set of plans often includes plan views and elevation views of the design, as well as construction details, and much more. For this competition, you are asked to draw an elevation view (the view from the side) of your truss on the Design Plan Template provided or in CAD.

Submittals and Competition

Trusses and **ALL** submittal materials are due to your high school contact by **Friday, February 7th, 2020**. The competition will take place at the conclusion of Engineer's Week 2019, **Saturday, February 22th, 2020** in the atrium of the Peter Kiewit Institute (PKI) on the University of Nebraska – Omaha campus. Students are encouraged to attend the competition to see how their truss performs, and cheer on their classmates! Snacks and refreshments will be provided at the competition. Your high school contact will be given an approximate time that your truss will be tested. We hope to see everyone at the competition, and hope you enjoy designing and building your truss!

PROBLEM STATEMENT

The NDOT would like to build a new bridge crossing the Missouri River. This replaces the Warren truss bridge completed in 1936. The NDOT has seen increasing traffic and loads as well as considering the age of the bridge due for replacement. The NDOT would like to increase its capacity, add more lanes and a bike trail to make this crossing better meet their customer's demands. This bridge is located in South Omaha and listed on the National Register of Historical Places. Therefore, the bridge must be aesthetically pleasing to maintain the picturesque landscape. The NDOT would like an overhead truss-style bridge due to its efficient use of material, lightweight design, and aesthetically pleasing nature.

Your company, Warren Engineering, has been selected by the NDOT to complete preliminary design work for the new bridge. The design must accommodate the local site conditions, follow the NDOT's standard specifications, and be aesthetically pleasing to the public. The roadway design has already been completed, and the piers have been prepared for the new bridge. Warren Engineering's task is to provide a structurally efficient design for the bridge's truss system. See the attached Site Plan for a depiction of bridge site. The NDOT is requesting that the preliminary design package for the truss bridge include the following:

1. A construction plan, depicting the truss to be built, drawn to scale, complete with dimensions.
2. A design analysis, describing the design.
3. A scale sized balsa wood model of ONE SIDE of the proposed truss design for load testing.

As the project bridge engineer, your job is to prepare a preliminary design of the new structure, and build the scale sized model of the proposed design for load testing. The model will be load tested to failure to determine the strength of the design. In addition to strength, cost to build and aesthetics are also key design factors.

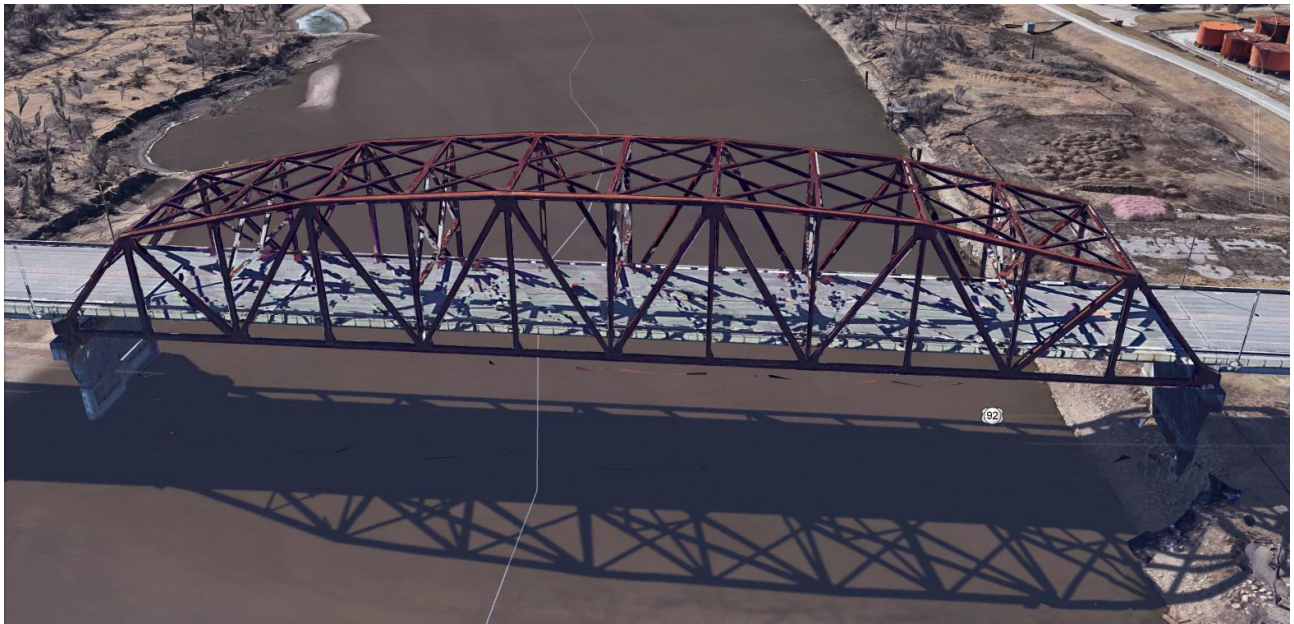


Figure 1 – South Omaha Veterans Memorial Bridge, Omaha, Nebraska

TRUSS BUSTIN' RULES AND REGULATIONS

ELIGIBILITY

1. Competitors must be in high school at the time of the truss is built.
2. Students may work individually, or in teams up to three.
3. Each student may submit up to two trusses, either as a member of a team or individually.

SUBMITTALS

Students need to include truss numbers on **ALL** of their submittals. Truss numbers can be found on the provided "Truss Tags".

1. Design Plans

- a. Provide an elevation view of each truss submitted, drawn on the attached **DESIGN PLAN TEMPLATE** or in **CAD**.
- b. A penalty will be assessed for incomplete or unprofessional submittals (e.g. designs that are illegible or not done in a neat manner). See **2. Submittal Factor** under **SCORING**.

2. Design Analysis

- a. Students need to demonstrate an understanding of the truss design chosen by answering **ALL** questions on the attached **DESIGN ANALYSIS TEMPLATE**.
- b. Students need to explain how their design is the most efficient for the requirements of the site and loading conditions.

3. Balsa Wood Truss

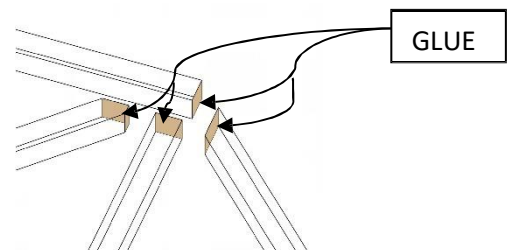
- a. Trusses found to have been built with materials other than those listed in the materials section will be automatically disqualified from competition and will not be load tested.
- b. Deductions will be made for violations of one or more rules.
- c. "Truss Tags" will be provided for each truss. Students shall print name or names legibly in the provided area and staple the tag to the bottom of truss.

MATERIALS

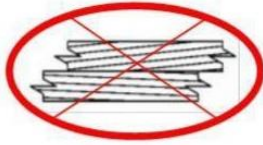
1. $\frac{1}{4}$ " by $\frac{1}{4}$ " balsa wood
2. $\frac{1}{4}$ " balsa wood no larger than $\frac{3}{4}$ " by 1-1/2" (Gusset Plates)
3. Commercially available wood glue

CONSTRUCTION RULES

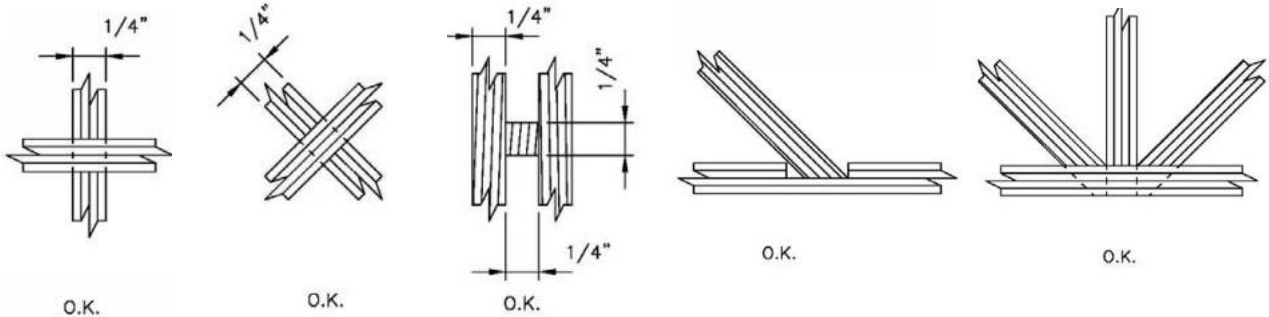
1. Glue may only be applied at the end joints of members and Gusset plate connections. This means that no glue should be applied over the joints. Deductions will be made for excessive use of glue at joints.
See **4. Construction Quality Factor (CF)** under **SCORING**.



2. No two pieces of balsa wood may be glued together side by side to create a single member.

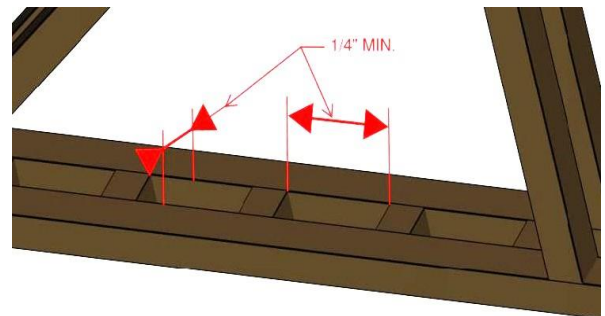


3. Acceptable Joints



GEOMETRY RULES

1. The truss must fit into the design envelope depicted in the **DESIGN PLAN TEMPLATE**.
2. Spacing between parallel members must **meet or exceed $\frac{1}{4}$ "** and the truss is not to exceed a **maximum width of $\frac{7}{8}$ "** at any point.
3. Gusset plates no larger than $\frac{3}{4}$ " by $1\frac{1}{2}$ " may be used at the joints but the truss shall not exceed $\frac{7}{8}$ "
4. The top of the truss must be flat in elevation a minimum 8" about centerline.



TESTING PROCEDURES

- a. Trusses are loaded by ASCE volunteers.
- b. Load may be applied vertically at any point along the top width of the bridge. The load point will be determined prior the start of competition and will be the same for all trusses.
- c. Trusses will be loaded to failure. Failure indicates reaching the maximum capacity of the truss.
- d. Trusses are braced laterally at each abutment and at the load point such that movement in the lateral plane is resisted.
- e. No truss shall be fixed or fastened to the testing machine, nor any part be allowed to use the testing machine supports for resistance of any longitudinal loads or movement.

SCORING

Scoring is based on a strength factor and three scale factors, defined below.

$$\text{Overall Score} = F_E \times SF \times GF \times CF$$

1. Strength Factor (F_E)

The strength factor is based on the load the truss experiences at failure, and the weight of the truss. The strength factor is calculated with the following equation:

$$\text{Strength Factor}(F_E) = \frac{\text{Load}(lb)}{\text{Weight}(grams)^{1.25}}$$

2. Submittal Factor (SF)

All required materials must be submitted in order for the truss to be entered into the competition. The following scale factors will be applied to the overall score based on the quality of the submitted materials:

- a. 1.0 – Demonstrates accurate and complete knowledge of the truss' mechanics.
- b. 0.9 – Demonstrates some knowledge of the truss' mechanics with some improvement needed.
- c. 0.8 – Student or students have not demonstrated a basic understanding of the truss' mechanics.
- d. 0.0 – Missing one or more of the submittal materials.

3. Geometry Factor (GF)

The geometry factor is applied to the overall score and is based on the truss' geometry and the number of violations.

- a. 1.0 – Truss has 0 geometry violations
- b. 0.9 – Truss has 1 geometry violation less than one inch
- c. 0.8 – Truss has 2 geometry violations, each less than one inch
- d. 0.0 – Truss has 3 or more geometry violations, each less than one inch
- e. 0.0 – Truss has 1 or more geometry violations greater than one inch

4. Construction Quality Factor (CF)

A scale factor is applied to the overall score based on the quality of the constructed truss.

- a. 1.0 – Excellent craftsmanship is displayed. Appropriate amount of wood glue is used and truss geometry is precise. Truss is well constructed.
- b. 0.9 – Excessive amount of wood glue is used at a few joints and/or truss' geometry lacks precision in a few areas.
- c. 0.8 – Excessive amount of wood glue is used at many joints. Lacks craftsmanship and/or truss' geometry lacks precision in a few or all areas.

DESIGN ANALYSIS TEMPLATE

Name: _____

School: _____

Truss Number: _____

Why is your truss geometry the best design for the competition?

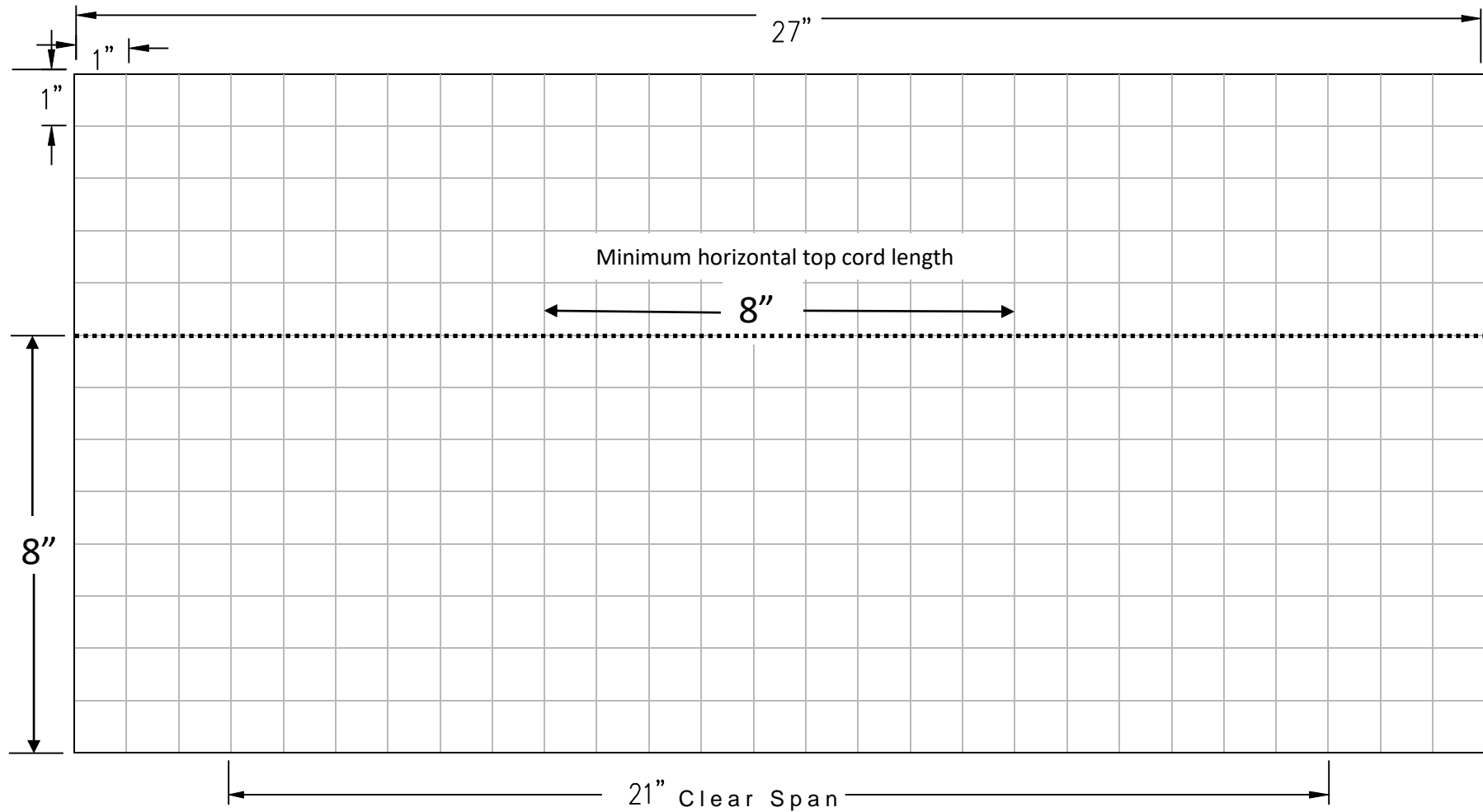
Which part of your truss is the strongest, and why?

Which part of the truss do you think is most likely to break first, and why?

Items to consider building your truss

1. The load will be applied to the top of the truss either at the center or 4" to the left or right. Since there is no front or back of the truss, it depends which direction it is loaded in the machine. So it could be either way. Those areas of the truss that will be taking the direct load and should be strong and able to transfer the load down to the "abutments".
2. The "abutments" at the bottom will be taking the load. The better the design and quality of construction to fit flat to the bearing surface will give the better load transfer. The better quality of the bearing surface being square and true will also prevent the truss from twisting resulting in a reduced load carrying capacity.
3. Joints that are cut true and fit together tight have less of a chance of breaking under load. The use of jigs that hold the joints together tightly while the glue is drying may create a better joint.
4. Selection of pieces of wood that have straight continuous grains will handle loads better. Watch out for grains that look like they may break.
5. Gusset plate are allowed this year. Although they will add strength at the joints, they will add weight. Use wisely and the minimum dimension needed to save weight.

TRUSS ELEVATION



cut along dotted line for truss identification tag below

2020 ASCE TRUSS BUSTIN' COMPETITION

NAME: _____

SCHOOL: _____

TRUSS NUMBER: _____