SAINT LOUIS UNIVERSITY

PARKS COLLEGE OF ENGINEERING, AVIATION AND TECHNOLOGY

2020 Annual Billiken BEAMS Competition

February 15, 2020

OVERVIEW

The Billiken BEAMS Competition is an annual balsa wood bridge competition sponsored by the Civil Engineering Program within Parks College of Engineering, Aviation and Technology at Saint Louis University (SLU). The competition is held each year in conjunction with the national Engineer's Week for St. Louis metropolitan area high school students. This year's competition will be held on **Saturday, February 15, 2020** beginning at 10:00 AM in **Tegeler Hall Auditorium**. It will include the same competition format and integrated trivia competition as the 2019 competition.

INTRODUCTION

The American Society of Civil Engineers notes that the United States has 614,387 bridges and almost 40% of those bridges are 50 years old or more.[1] Bridges are subject to various types of loads ranging from cars to oversized semis and in the case of rail bridges, various types of trains. At any given time, a bridge could experience a wide range of loads along with different frequencies and/or durations of load. While the load capacity and efficiency (strength-to-weight ratio) are important design considerations, engineers must also account for a bridge's resistance to fatigue (repetitive loadings over extended periods of time). Structural engineers use redundancy in their designs, which means they include extra components that may not be necessary for functionality, but in the case of failure of other components, would prevent sudden and complete collapse.

This year's competition will incorporate a bridge's durability by experiencing several load tests, while still accounting for overall strength and economics by evaluating the strength-to-weight ratios. The competition will use a bracket format that will put each bridge through a rigorous set of load tests to evaluate their durability. The surviving bridges will then be loaded to failure and will be evaluated based on their maximum load supported and strength-to-weight ratios. It takes creativity and innovation to design the most impressive structures in the world. Do you have what it takes to design the best balsa wood bridge in St. Louis?

[1] https://www.infrastructurereportcard.org/cat-item/bridges/

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REGISTRATION

A maximum of 32 teams will participate in the Billiken BEAMS Competition. A maximum of two teams per school may participate (maximum of 4 students per team, grades 9-12). Additional teams from a school may register for the competition and will be placed on a waiting list. Those teams will be permitted to compete in the competition **IF** there are open spots at the time registration closes. One waiting list team will be added to the competition for each school based on the order of their registration until all 32 spots are filled.

Registration Sample Scenario

School A registers 5 teams (Team A1, A2, A3, A4, A5). Teams A1 and A2 would automatically be registered for the competition, and Teams A3, A4, and A5 would be placed on the waiting list. School B registers 4 teams (Team B1, B2, B3, B4). Teams B1 and B2 would automatically be registered for the competition, and Teams B3 and B4 would be placed on the waiting list. At the time registration closes, let's say there are four open spots. The teams would be added in the order: A3, B3, A4, B4. Team A5 would be excluded from the competition. This is to ensure an even distribution of teams from all area high schools that wish to participate.

Register online at: https://www.slu.edu/parks/about/pre-college-programs/billiken-beams.php by **November 8, 2019.** The registration fee is $25.00 per team. The fee covers the cost of the bridge construction materials and T-Shirts for all team members. Teams may register after November 8, 2019 until January 10, 2020. However, the registration fee increases to $30.00 per team after November 8, 2019.

Each team should attend a new Introduction to Bridge Design Workshop in McDonnell Douglas Hall on **Saturday, November 16, 2019, Saturday, November 23, 2019** or **Saturday, January 18, 2020.** Each day will feature three, two-hour workshops followed by opportunities for students to create a computer model of their bridge. The workshops will be from 9:00 am—11:00 am, 11:00 am—1:00 pm, and 1:00 pm-3:00 pm. Up to four teams will be scheduled for a specific workshop and each team will be matched with a SLU civil engineering student mentor. Each team should bring their potential bridge design with them and will have the opportunity to create a computer model of their bridge design after their respective workshop. Each team will also receive the materials for their bridge on the same day of the Introduction to Bridge Design Workshop.

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MATERIALS AND CONSTRUCTION SPECIFICATIONS

Each team will receive 36 – 36 in. long 1/8 in. by 1/8 in. pieces of balsa wood, glue, and a single piece of card stock. Teams may only use the materials provided for construction of their bridge. The clear span of the load test setup (support to support) is 28 in. The total bridge length may not exceed 36 in. and the bridge may weigh no more than 0.5 lb (227 grams). The bridge height should be between 5 in. and 10 in. and the bridge width should be between 5 in. and 6 in. There must be a clear space of at least 4 in. by 4 in. inside the bridge throughout the bridge's entire length through which vehicles could pass without obstruction. Each bridge **must accommodate** two 2 in. by 2 in. loading plates through which two loading rods will hang for loading. Fig. 1 and Fig. 2 show the elevation view and plan view of the load test setup, respectively. If a bridge requires added cross-beams to support the loading plates, the weight of the cross-beams will be added to the bridge weight.

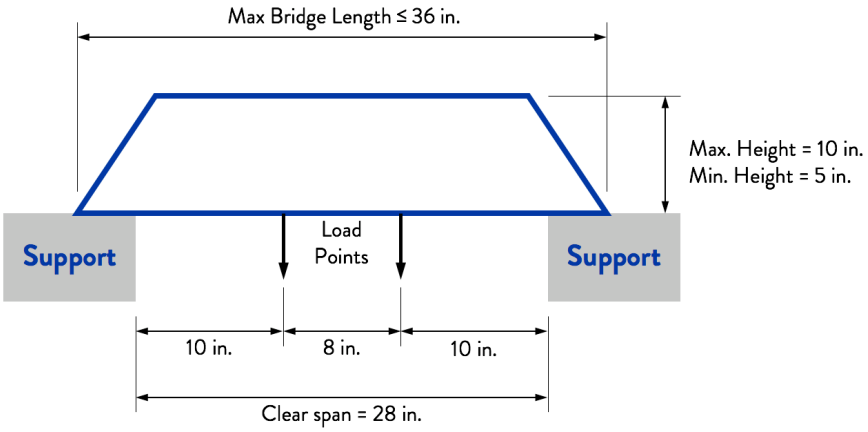

Fig. 1—Elevation View of Load Test Setup

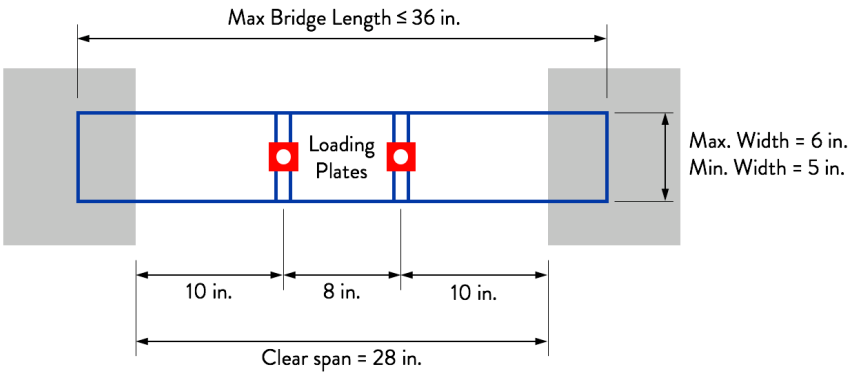

Fig. 2—Plan View of Load Test Setup

The bridge may not be painted, coated, treated, or decorated and no piece of balsa wood may be laminated or bundled together with other pieces of balsa wood. Two pieces of balsa wood may overlap up to 1/2 in. in length, but no piece of balsa wood may be lower than the bottom chord of the bridge. A piece of balsa wood may be glued at their ends or to the gusset plates. The gusset plates may be of any shape, but must be made from the provided card stock and have no dimension greater than 3/4 in. The bridge may only rest on the bearing supports and may not bear against the interior face of the bearing supports. The bridge may have no other supplemental supports. Fig. 3 shows select examples of the permitted and prohibited balsa wood configurations, but is not inclusive of all possible configurations. **Bridges that do not meet the design specifications will be disqualified.**

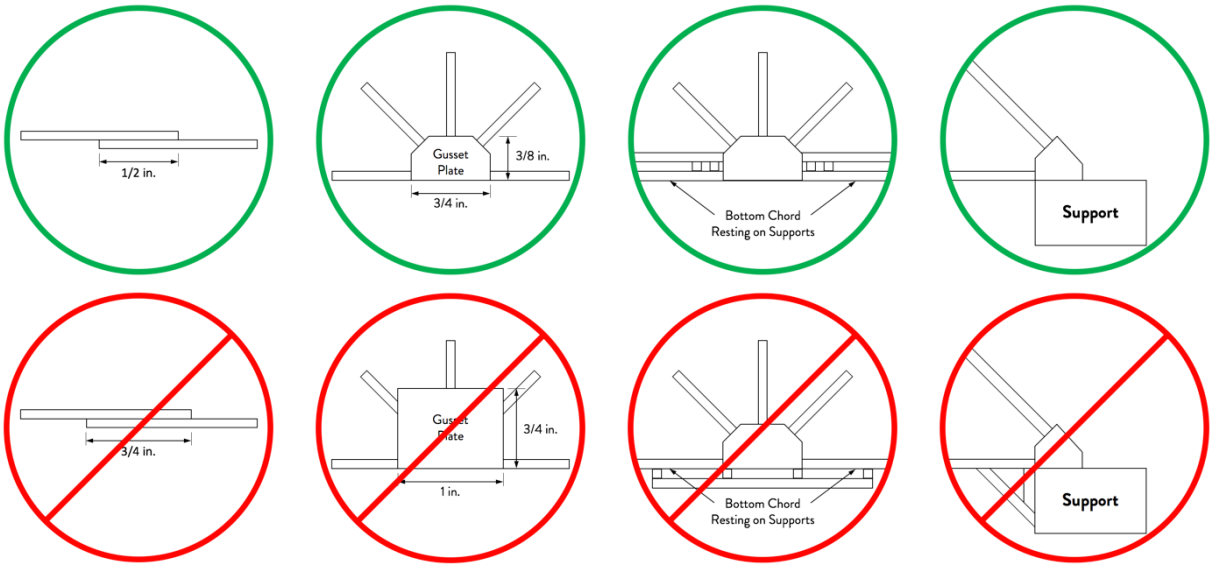

Fig. 3—Examples of permitted and prohibited balsa wood configurations

PROJECT REPORT GUIDELINES

The project report must include an overall summary of the design and construction of the bridge along with the lessons learned by the students during the design and construction of the bridge. It should also include two figures associated with the design process and two figures associated with the construction process. A fillable pdf file will be emailed to each team. **The report is due by 11:59 pm on Friday, February 7, 2020.** Each team should email their pdf file to billikenbeams@slu.edu. **Microsoft Word files will not be accepted**. Teams submitting late reports will receive 0 points for the Project Report portion of their overall score.

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COMPETITION FORMAT

This year's competition will keep the 2019 format that evaluates bridges based on their ability to resist repetitive loadings along with their maximum load supported and strength-to-weight ratio. The 32 teams will be placed in four 8-team brackets similar to the format shown in Fig. 4. Efforts will be made to ensure that teams from the same schools are placed in different brackets. Teams in each 8-team bracket will compete in head-to-head matches to determine a bracket winner based on their ability to resist repetitive loads. The four bracket winners will then compete in the Final Four that evaluates the four bridges based on their maximum load supported, strength-to-weight ratios, bridge specifications, the project report, and the aesthetics of the bridge, along with their trivia score.

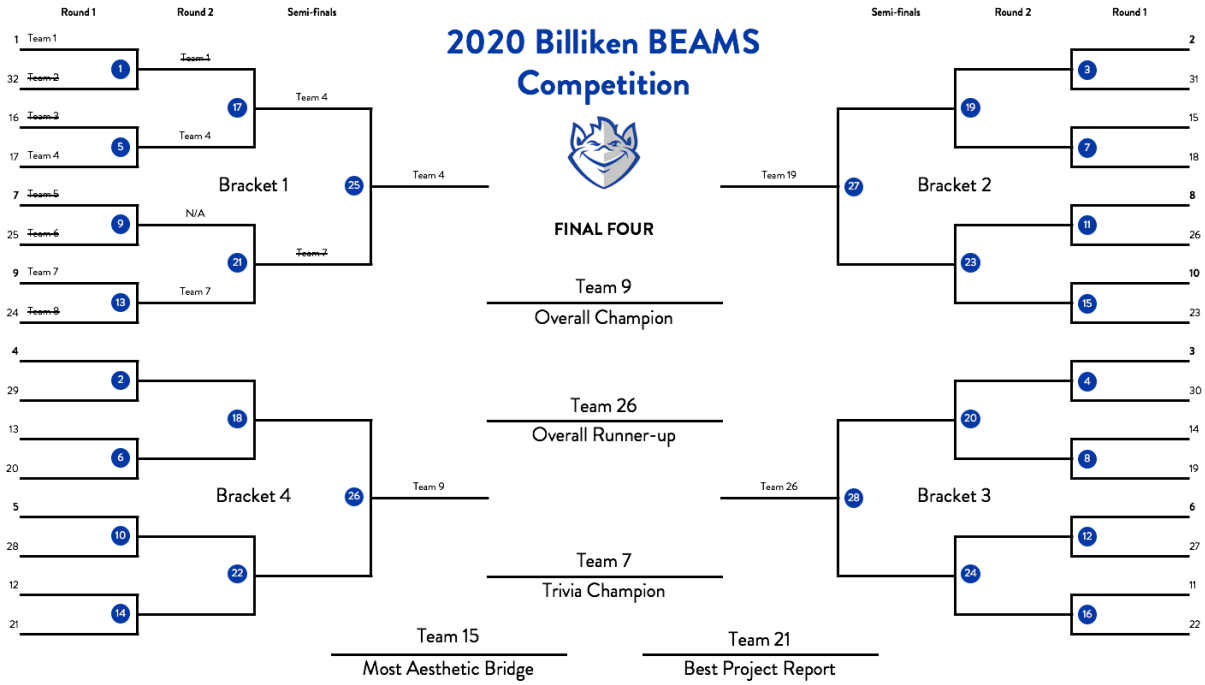

Fig. 4—Billiken BEAMS Competition Bracket

Upon checking in the morning of the competition, each bridge will be weighed and checked for compliance with the construction specifications. The load will be applied to the upper side of the bottom chord of each bridge using two loading plates as previously shown. During the head-to-head matches, the load will be applied in 2 lb increments as directed by competition judges until complete failure of one bridge. During the Final Four round, each bridge will be loaded by pouring sand into a

suspended bucket containing a 10 lb weight until complete failure of each bridge. Each team in the Final Four round will have five minutes to load test their bridge after placing it in the load test frame. In both rounds, failure of a bridge is defined as complete collapse of the bridge or excessive deflection of the bridge to the point it is no longer functional. Functionality is at the discretion of the judges.

Sample Competition Scenario

In Round 1-Match 1, Team 1 and Team 2 would load their bridges simultaneously on two separate load frames with 2 lb load increments. In this scenario, let's say that Team 1 and Team 2 both loaded their bridges until they were both supporting 30 lb. During the next load step, Team 2's bridge breaks as the 2 lb load is applied, but Team 1's bridge successfully supports the additional 2 lb of load for a total of 32 lb. Team 1 advances to Round 2.

In Round 1-Match 5, Team 3 and Team 4 would load their bridges simultaneously on two separate load frames with 2 lb load increments. In this scenario, let's say that Team 3 and Team 4 both loaded their bridges in 2 lb increments until they were both supporting 50 lb. During the next load step, Team 3's bridge breaks as the 2 lb load is applied, but Team 4's bridge successfully supports the additional 2 lb load for a total of 52 lb. Team 4 advances to Round 2 to face Team 1.

In Round 1-Match 9, Team 5 and Team 6 would load their bridges simultaneously on two separate load frames with 2 lb load increments. In this scenario, let's say Team 5 and Team 6 both loaded their bridges until they were both supporting 60 lb. During the next load step, Team 5's bridge and Team 6's bridge both break before either team reaches 62 lb. There is no winner to move on to Round 2.

In Round 1-Match 13, Team 7 and Team 8 would load their bridges simultaneously on two separate load frames with 2 lb load increments. In this scenario, let's say Team 7 and Team 8 both loaded their bridges until they were both supporting 24 lb. During the next load step, Team 8's bridge breaks as the 2 lb load is applied, but Team 7's bridge successfully supports the additional 2 lb load for a total of 26 lb. Team 7 advances to Round 2.

In Round 2-Match 17, Team 1 and Team 4 would load their bridges simultaneously on two separate load frames with 2 lb load increments. In this scenario, let's say that Team 1 and Team 4 both loaded their bridges until they were both supporting 70 lb. During the next load step, Team 1's bridge breaks as the 2 lb load is applied, but Team 4's bridge successfully supports the additional 2 lb of load for a total of 72 lb. Team 4 advances to the Semi-finals.

In Round 2-Match 21, Team 7 automatically advances to the Semi-finals to face Team 4 because Team 5's and Team 6's bridges both broke in Round 1.

In the Semi-finals-Match 25, Team 4 and Team 7 would load their bridges simultaneously on two separate load frames with 2 lb load increments. In this scenario, let's say that Team 4 and Team 7 both load their bridge until they were both supporting 60 lb. During the next load step, Team 7's bridge breaks as the 2 lb load is applied, but Team 4's bridge successfully supports the additional 2 lb of load for a total of 62 lb. Team 4 advances to the Final Four.

Let's now say that Team 4 won Bracket 1, Team 19 won Bracket 2, Team 26 won Bracket 3, and Team 9 won Bracket 4. All four bridges have now been loaded multiple times with various amount of load and have proven their ability to resist fatigue. During the Final Four, each team will test their bridges one at a time until complete failure or until the load reaches a maximum of 100 lb. No bridges will be loaded beyond 100 lb.

STRUCTURAL ENGINEERING TRIVIA

The competition will also feature 30 trivia questions related to structural engineering. Each team will receive an iClicker at check-in and will have an opportunity to answer each question through the duration of the competition. One multiple choice question will be presented at a time as teams are placing their bridges for an individual match and teams will have 30 seconds to submit an answer. The questions will all be related to structural engineering.

SCORING

Bracket Rounds will serve as qualifying rounds and solely judge bridges based on their ability to successfully advance through head-to-head matches and verify their ability to resist fatigue. The

Bracket Round will **NOT** consider the strength-to-weight ratio, maximum load supported, bridge specifications violations, project report, aesthetics, or trivia.

The Final Four round will incorporate the Maximum Load Supported (25%), Strength-to-weight ratio (25%), Bridge Specifications (15%), Project Report (15%), Aesthetics (10%), and Trivia (10%).

AWARDS

The 2020 Competition will include five awards:

1. Overall Champion (only teams from the Final Four are eligible)
2. Overall Runner-Up (only teams from the Final Four are eligible)
3. Most Aesthetic Bridge (independent of Final Four, any team can win)
4. Best Project Report (independent of Final Four, any team can win)
5. Trivia Champion (independent of Final Four, any team can win)

QUESTIONS

Questions about the competition rules may be sent to: billikenbeams@slu.edu until Friday, January 31, 2020 – 11:59 pm. Each question will be posted to a Google Doc for all participants to see at: https://docs.google.com/document/d/1U7krCJlX_HwoSGcGIxHcUK7SxFab8KmBSvGkgGCeMoQ/edit?usp=sharing. Questions not related to the rules (e.g. logistics) may be submitted until the day of the competition.

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IMPORTANT DATES

Early Registration Deadline
Friday, November 8, 2019 – 11:59 pm
Website: https://www.slu.edu/parks/about/pre-college-programs/billiken-beams.php

Late Registration Deadline
Friday, January 10, 2020 – 11:59 pm
Website: https://www.slu.edu/parks/about/pre-college-programs/billiken-beams.php

Introduction to Bridge Design Workshops and Material Pick-ups
Date: Saturday, November 16, 2019 – 9 am, 11 am, 1 pm
Date: Saturday, November 23, 2019 – 9 am, 11 am, 1 pm
Date: Saturday, January 18, 2020 – 9 am, 11 am, 1 pm
Location: McDonnell Douglas Hall, 3450 Lindell Blvd, St. Louis, MO 63103

Competition Question Deadline
Date: Friday, January 31, 2020 – 11:59 pm
Email to: billikenbeams@slu.edu
FAQs Website:
https://docs.google.com/document/d/1U7krCJIX_HwoSGcGIxHcUK7SxFab8KmBSvGkgGCeMoQ/edit?usp=sharing

Project Reports Deadline
Date: Friday, February 7, 2020 – 11:59 pm
Email to: billikenbeams@slu.edu

Billiken BEAMS Competition
Date: Saturday, February 15, 2020 – 10 am until approximately 1 pm
Location: Tegeler Hall Auditorium, 3550 Lindell Blvd, St. Louis, MO 63103