Revision 1: November 7, 2018
Glossary and Section 4.4.2

Student Steel Bridge Competition

2019 Rules

Smarter.
Stronger.
Steel.

WELCOME

This document, which is available at **www.aisc.org/ssbc**, describes the Student Steel Bridge Competition and states the 2019 rules for both regional and national levels. **Clarifications, which include any revisions to the rules, are published at www.aisc.org/ssbc and do not appear in this document although they are formal addenda to the rules.** The website includes the form for requesting clarifications and other information. Information at the website takes priority over any other source except as herein noted.

AISC supports and encourages the equitable opportunity for participation in the Student Steel Bridge Competition (SSBC) by all interested and eligible individuals without regard to race, ethnicity, religion, age, gender, sexual orientation, nationality, or physical challenges. Participation should be inclusive, open, and fair to all interested and eligible students. *Cover Image taken by T. Bart Quimby*

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GLOSSARY

Accident. Fault committed during timed construction and subsequently penalized.

Aesthetics. Award category based on the presentation of the *bridge* exactly as it will be erected during timed construction with all parts of the assembled *bridge* visible for judging.

Aggregate deflection. The sum, rounded to the nearest 0.01 inch, of the absolute values of *deflections* measured at *D1* and *D2*.

Bolt. An unaltered, commercially available rigid connector with external threads around the full circumference.

Box. A right-rectangular prism made out of non-deformable material that is used to measure the maximum allowable size of *tools* and *members*.

Bridge. Structure constructed of *members*, *loose bolts*, and *loose nuts* that spans the *river* and is supported by piers.

Builder. Undergraduate or graduate student who constructs the *bridge* and is part of a competing *team*. See Section 4, “Eligibility”.

Captain. One *builder* designated to represent the *team* for the entire competition, and who signifies when the *builders* are ready to start timed construction, declares the finish, and signs the *data forms*.

Constructed portion. Two or more *members* in contact with one another, with or without *loose nuts* and *loose bolts*, and is assembled during timed construction by *builders* on the *ground* in the *construction zone*.

Construction cost. Dollar amount used to determine a *bridge’s construction economy* based on the number of *builders*, *total time* and *load* test penalties.

Construction economy. Award category based on *construction cost*.

Construction site. The location where all construction activities occur comprising the *river*, *construction zones*, *transportation zones* and the *staging yards*.

Construction speed. Award category based on the *total time* required for construction modified by construction penalties.

Construction zone. Location in the *construction site* where *builders* put the *members* together to construct the *bridge*.

D1, D2. Locations where the vertical *deflections* are measured during vertical *load* testing.

Data form. Forms printed from the official *scoring spreadsheet* used by judges to record data collected for each *team* throughout the competition.

Decking. Grating that spans transversely between *stringers* and is used to hold *load* placed on the *bridge*.

Deflection. Vertical translation of the *bridge* or parts of the *bridge* under *load*.

Footing. Areas marked on the *ground* within the *construction zones* where the *bridge* may contact the *ground*.

Ground. Floor inside the *site boundary*, including *footings*, *construction zones*, *transportation zones*, and *staging yards*, but excluding the *river*.

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Guest team. A *team* from a *school* that is not eligible to compete per section 4.3.2 but has obtained the approval of AISC and the Regional Event host *school* to participate.

Head Judge. Person with full authority over the conduct of the competition, safety and interpretation of the rules.

Judge. Person who assists the *head judge* with the conduct of the competition, *safety* and interpretation of the rules.

L1, L2. Dimensions for positioning *decking* units for the vertical *load* test that also defines locations of observed *deflection* and sway during the vertical *load* test.

Lateral restraint. Means of inhibiting sliding of the bearing surfaces during lateral loading applied by the loading crew.

Left Side. Side of *bridge* in which the longitudinal distance between the piers is longest.

Lightness. Award category based on *total weight* of the *bridge*.

Load. Weight applied to the *bridge* to assess its *stiffness* and strength.

Loose bolt. *Bolt* not installed in or welded to the *constructed portion* of the *bridge*.

Loose nut. *Nut* not installed on a *bolt* or welded to the *bridge*.

Measured weight. The weight of the *bridge*, not including *decking*, *tools*, *lateral restraint* devices, and *posters*, as determined by *scales* provided by the host *school*.

Member. A rigid component of the *bridge*.

Nut. A commercially available, mechanically unaltered portion of a connector with internal threads around its full circumference.

Overall performance. Overall award category based on the sum of *construction cost*, *structural cost*, and any fines incurred as a violation of a Team Contract.

Personal protective equipment. An article of clothing that a *team* provides for *safety*.

Poster. Informative flat display that must be posted during *aesthetics* judging.

Pouch. Optional article of clothing that is used to carry *nuts*, *bolts*, and *tools* and includes *tool* belts, magnets, lanyards, and other accessories worn by *builders* having the same function.

Right Side. Side of *bridge* in which the longitudinal distance between the piers is shortest.

River. A restricted natural feature in the *construction site* that *builders* are not allowed to enter.

S. Dimension for positioning the *decking* unit for the lateral load test that also defines the location where the lateral *load* is applied and sway is measured during the lateral *load* test.

Safety. Prevention of personal injury and damage to the competition location.

Safety supports. Equipment provided by the host *school* used to limit the consequences of a *bridge* collapsing.

Scales. Calibrated equipment provided by the host *school* used to measure the *total weight* of the *bridge*.

School. College or university that a student team represents.

Scoring spreadsheet. Official location where a *team's* score is input by the scoring official at the end of the *team's* competition.

Site boundary. Border of the *construction site*.

Staging yard. Location within the *construction site* occupied by *builders*, *tools*, and materials at the start and finish of timed construction.

Steel. Iron alloy that is strongly attracted to the magnet provided by the host *school*.

Stiffness. Award category based on the *bridge's aggregate deflection* under vertical loading.

Stringer. *Decking* support aligned longitudinally along the *bridge* and contiguous over the full length of the *bridge*.

Structural cost. Dollar amount used to determine a *bridge's structural efficiency* based on its *total weight*, *measured weight*, *aggregate deflection*, and *load* test penalties.

Structural efficiency. Award category based on *structural cost*.

Sway. Horizontal translation of the *bridge*.

Team. Group of students from the *school* that they are representing who are undergraduate or graduate students during all or part of the fall through spring of the current competition academic year.

Template. Equipment provided by the host *school* to measure clearances within the passageway of the *bridge*.

Tool. A device provided by a *team* that is used to construct the *bridge*, but is not part of the completed *bridge*.

Total time. Time required for construction modified by construction penalties.

Total weight. Sum of *measured weight* and weight penalties.

Transportation zone. Portion of *construction site* between the *construction zones* and *staging yards* over which *builders* carry *members*, *tools*, *nuts*, and *bolts*.

Section 1
MISSION AND SUMMARY

VISION

Empower students to acquire, demonstrate, and value the knowledge and skills that they will use, as the future generation of design professionals, to contribute to the structural steel design community and construction industry in the United States.

MISSION

Challenge students to extend their classroom knowledge to a practical and hands-on steel-design project that grows their interpersonal and professional skills, encourages innovation, and fosters impactful relationships between students and industry professionals.

SUMMARY

Civil Engineering students are challenged to an intercollegiate competition that supplements their education with a comprehensive, student-driven project experience from conception and design through fabrication, erection, and testing. This experience culminates in a *steel* structure that meets client specifications and optimizes performance and economy. The Student Steel Bridge Competition increases awareness of real world engineering issues such as spatial constraints, material properties, strength, serviceability, fabrication, erection processes, *safety*, *aesthetics*, project management, and cost. Success in competition requires application of engineering principles and theory, and effective teamwork. Future engineers are stimulated to innovate, practice professionalism, and use structural *steel* efficiently.

Students design and erect a *steel bridge* by themselves but may consult with faculty and other advisors. Students gain maximum benefit if they fabricate the entire *bridge* themselves. However, because appropriate shop facilities and supervision are not available at all *schools*, students may use the services of a commercial fabricator if they develop the work orders and shop drawings and observe the operations. Students are encouraged to maximize their involvement in fabrication.

Safety is paramount. AISC requests that competitors, advisers, hosts, and *judges* take all necessary precautions to prevent injury to competitors, *judges*, host personnel, and spectators. Risky procedures are prohibited. *Load* testing is stopped if *sway* or *deflection* exceeds specified limits, or if collapse is imminent. *Bridges* that cannot be constructed and

loaded safely are withdrawn from competition. In addition, the rules identify and penalize construction errors that represent *accidents* in full-scale construction.

The Student Steel Bridge Competition provides design and management experience, opportunity to learn fabrication processes, and the excitement of networking with and competing against *teams* from other *schools*.

The competition has a long-established tradition of ethical behavior, professionalism, civility, and respect for people and property. *Teams*, their associates, *judges*, and all other participants are expected to maintain and build upon this tradition.

Section 2
INTRODUCTION

The rules simulate a request for proposal that requires a scaled model to demonstrate the efficacy of competing designs. Section 3, "Problem Statement," relates the rules to realistic challenges encountered in bridge design and construction.

Sections titled "Material and Component Specifications," "Structural Specifications," and "Construction Regulations" set standards for strength, durability, constructability, usability, functionality, and *safety* that reflect the volumes of requirements that govern the design and construction of full-scale bridges. Criteria for excellence in the award categories of *stiffness*, *lightness*, *construction speed*, *aesthetics*, *efficiency*, and *economy* are listed in "Scoring." Competition *judges* and the SSBC Rules Committee take the role of the owner or owner's agent and have authority to accept and reject entries.

The rules accommodate a variety of designs and encourage innovation. Designers must consider the comparative advantages of various alternatives. For example, a through *bridge* may be stiffer than a deck *bridge* but slower to construct. Successful *teams* compare alternatives prior to fabrication using value analysis based on scoring criteria. The rules are changed every year to renew the challenge and ensure that competitors design and build new *bridges*.

The rules are intended to be prescriptive, but may require some interpretation. The procedure for requesting clarification of the rules is described in Section 13, "Interpretation of Rules."

Competitors, *judges*, and host personnel are encouraged to read this rules document from beginning to end and then review the Competition Guide at **www.aisc.org/ssbc**. That site also is the source of the official *scoring spreadsheet* which generates forms for recording data. *Judges* should be familiar with those forms prior to the competition.

Results of the previous year's National Finals are posted at **www.aisc.org/ssbc**.

Members of the Student Steel Bridge Competition Rules Committee are

- Christopher Garrell, P.E.,Chief Bridge Engineer, NSBA
- Christina Harber, S.E., P.E., Director of Education, AISC
- Lawrence F. Kruth, P.E., Vice President of Engineering and Research, AISC
- Joel Lanning, Assistant Teaching Professor, University of California, Irvine
- Jason McCormick, Ph.D., P.E., Associate Professor, University of Michigan
- John M. Parucki, Structural Steel Consultant
- Craig Quadrato, Ph.D., P.E., Senior Associate, Wiss, Janney, Elstner Associates
- Matthew Schultz, P.E., S.E., Wallace Engineering Structural Consultants

••• Kimberly Stillmaker, Ph.D., Assistant Professor, California State Univ., Fresno

Section 3
PROBLEM STATEMENT

Steel bridges played an important role when the railroad was introduced to the Hawaiian Islands. These early *steel bridges* provided some of the highest and longest spans along many railroad routes consisting of rugged terrain that normally would be difficult to traverse.

In an effort to rebuild infrastructure destroyed during recent volcanic flows and earthquakes associated with the Kilauea Volcano and make Hawaii Volcanoes National Park accessible, the National Park commission is interested in paying tribute to the historic Hawaiian *steel* railroad *bridges* in the replacement and development of new *bridges* for the park. A feasibility study is being conducted that includes a competition to identify the best design for a limited access, short span *bridge* to cross a *river* near recent and past lava flows. The *bridge* must have the ability to support bicycles, pedestrians, park vehicles and emergency vehicles while prohibiting private motor vehicles. Models will be erected under simulated field conditions and will be tested for stability, strength, and serviceability using standardized lateral and vertical *loads*. Structural cost, construction cost and duration, and *aesthetics* are important considerations. Virtual costs are assigned to critical features, including a sliding scale for material that promotes robustness without wastefulness. Engineers associated with the park will judge the competition and will award the design/build contract to the company whose model satisfies specified requirements and best achieves project objectives.

Steel is specified for ease of prefabrication, rapid erection, superior strength to weight ratio, durability, and high level of recycled content. Designs with permanent or temporary piers in the *river* will not be considered. Recent and past lava flows near the banks of the *river* also preclude temporary piers elsewhere, as well as restricting the location of *footings* and the size of *construction zones*. Remote staging of material and equipment is required and the size and quantity of *members* to be transported is limited. Models will not include deck, foundations, and approaches.

Any attempt to gain advantage by circumventing the intent of the competition as expressed by the rules, including this problem statement, will be grounds for rejecting a model and terminating that company's eligibility.

Section 4
ELIGIBILITY

4.1 REQUIRED CONDUCT

All competition participants shall act professionally and respectfully at all times. Failure to act appropriately can result in letters of reprimand, mandatory behavior management plans, and loss of invitations to future competitions for individual institutions.

4.2 LEVELS OF COMPETITION

There are two levels of Student Steel Bridge Competition: Regional Events and the National Finals. The Regional Events are held throughout the United States of America (USA). *Schools* shall register at **www.aisc.org/ssbc** by December 31 in order to compete in the Regional Event for the following year. Each confirmed participating *school* will be assigned to a local region. Outstanding performance in Regional Events, and only participation in those events, qualifies eligible *teams* for the Student Steel Bridge Competition- National Finals.

4.3 REGIONAL EVENTS

4.3.1 Only one *bridge* per *school* may compete in a Regional Event, and a *school* may compete in only one Regional Event.

4.3.2 A *school* is eligible to compete if it has an engineering program and is licensed or chartered in the USA or a territory of the USA.

4.3.3 A *team* shall consist only of undergraduate and graduate students enrolled at the *school* for which they are representing during all or part of the fall through spring of the current competition academic year.

4.3.4 The official *scoring spreadsheet* shall be used, and all *teams* shall be listed on that spreadsheet. The official *scoring spreadsheet* may be downloaded from **www.aisc.org/ssbc**.

4.3.5 The host *school* shall promptly submit the completed official *scoring spreadsheet* for a Regional Event to **universityprograms@aisc.org**. *Teams* from that Regional Event will not be invited to the Student Steel Bridge Competition- National Finals until the spreadsheet is received and eligibility is confirmed.

4.4 NATIONAL FINALS

4.4.1 A *team* is eligible to be invited to compete in the National Finals if it is ranked for awards at its Regional Event.

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4.4.2 The maximum number of eligible *teams* from a Regional Event that will be invited to compete in the National Finals is based on the number of non *guest teams* at that Regional Event that competed (that is, presented *bridges* and staged them for timed construction).

(1) The single eligible *team* with the best *overall performance* rating will be invited from a Regional Event in which two, three, or four *teams* competed.
(2) The top two eligible *teams* in *overall performance* will be invited from a Regional Event in which five to thirteen *teams* competed.
(3) The top three eligible *teams* in *overall performance* will be invited from a Regional Event in which fourteen to twenty-one *teams* competed.
(4) The top four eligible *teams* in *overall performance* will be invited from a Regional Event in which twenty-two or more *teams* competed.

4.4.3 A *team* competing at the National Finals shall consist only of undergraduate and graduate students who were enrolled at the *school* for which they are representing during all or part of the academic year leading up to the National Finals.

4.4.4 *Bridges* may be modified in preparation for National Finals.

Section 5
SAFETY

Safety has the highest priority; risk of personal injury will not be tolerated. *Judges* are empowered to halt and prohibit any activity that they deem to be hazardous. If a *bridge* cannot compete safely, it must be withdrawn from competition.

SubSections 9.4, 10.2, 10.3, 11.1, 11.2, and 11.5.2 of these rules identify hazardous conditions and actions that will result in withdrawing a *bridge* from competition if not corrected. *Judges* will document these *safety* violations by checking appropriate boxes on the *data forms*. If the problem is not listed, a *judge* should write a brief description of the problem on the *data form*.

Students are requested to practice safe fabrication procedures and seek appropriate instruction and supervision. The Sub-Section 8.2 footnote warns of a welding hazard, and precautions listed in Sub-Sections 11.1, 11.2, 11.5.1.2, and 11.5.2 guide safe *load* testing prior to competition.

Section 6
SCORING

6.1 RECORDING DATA, ANNOUNCING RESULTS, SUBMITTING SCORES

Scoring data shall be recorded for every *team* that competes, using the *data forms* printed from the official *scoring spreadsheet* downloaded from **www.aisc.org/ssbc**. Data from those forms are then entered in the spreadsheet. After all scoring information has been collected for a *team*, the scoring official reviews each data entry with the *captain* of that *team*. The *captain* is given adequate time to verify the data before signing the form. Then a paper or electronic copy of the *team's* "Computation" worksheet from the *scoring spreadsheet* is given to the *captain*, as soon as possible.

Formulas and links in the *scoring spreadsheet* shall not be modified.

The "Rankings" worksheet from the spreadsheet summarizes the performance of all *teams* and is distributed at the awards ceremony, electronically or as paper copies.

The completed official *scoring spreadsheet* for a Regional Event shall be submitted to **universityprograms@aisc.org** by the host *school* as soon as possible after the competition. **Regional Event results are not final until the spreadsheet is submitted.** Questions and comments regarding the spreadsheet should be sent to **universityprograms@aisc.org**.

Data forms shall be retained by the Regional Event host *school* for two weeks after the competition.

6.2 CATEGORIES OF COMPETITION

Categories of competition are *aesthetics*, *construction speed*, *lightness*, *stiffness*, *construction economy*, and *structural efficiency*. In addition, *overall performance* is rated.

6.2.1 Aesthetics

An award is given for *aesthetics*. The *bridge* is presented exactly as it will be erected during timed construction, and all parts of the assembled *bridge* must be visible during *aesthetics* judging. *Aesthetics* is judged by the following criteria.

6.2.1.1 Appearance of the *bridge*, including balance, proportion, elegance, and finish. Quality of fabrication, including welding, shall not be considered because some *bridges* may be fabricated professionally rather than by students.

6.2.1.2 Permanent identification of the *bridge* consisting of the name of the *school*. The name shall be formed from *steel* or applied to *steel* with paint or decals and should be easily legible (lettering at least 1" high is recommended). A *bridge* that lacks appropriate identification will receive a very poor *aesthetics* rating.

6.2.1.3 *Poster* describing design. The *poster* shall present the following

(1) identification of the *school*, using the same name that appears on the *bridge*,
(2) brief explanation of why the overall configuration of the *bridge* was selected,
(3) scaled, dimensioned side view of the *bridge*,
(4) free-body diagram of a single beam that represents one of the *stringers* of the *bridge*, with the same end-to-end length, supports at appropriate locations to represent the piers, *loads* for one of the cases specified in Sub-Sections 7.1(7) and 11.5, and reaction forces,
(5) shear and moment diagrams of the beam corresponding to that free-body diagram, showing peak magnitudes,
(6) provisions for Accelerated Bridge Construction (ABC), such as design features, construction sequencing, and procedures intended to minimize construction time, and
(7) acknowledgement of the *school's* technicians, faculty, and others who helped fabricate the *bridge* or provided advice.

The *poster* shall

(1) be flat with maximum dimensions of two by three feet,
(2) present all information on one side,
(3) not have attached pages that must be lifted or turned, and
(4) be in English.

Additional information may be included. Names of financial sponsors may be shown on the *poster* or on an optional second *poster* that can accommodate their logos.

The *aesthetics* rating will be very poor if there is no *poster* or if it is grossly inadequate. Electronic displays, decorated supports, lights, and sound are not permitted and will result in a poor rating. The *poster* is not part of the *bridge* but must be in place whenever the *bridge* is on display.

If English is not the dominant language where the competition is conducted, an optional additional *poster* may be displayed that is a translation into the local language of the required English language design *poster*.

6.2.1.4 *Aesthetics* is the tie breaker for all categories of competition. *Judges* shall not declare ties in *aesthetics*.

6.2.2 Construction Speed

The *bridge* with the lowest *total time* will win in the *construction speed* category. *Total time* is the time required for construction modified by construction penalties prescribed in 9.4, 10.4.2, 10.4.3, 10.8.1, and 10.9.2. There is an upper limit on construction time (see 10.8.2).

6.2.3 Lightness

The *bridge* with the least *total weight* will win in the *lightness* category. *Total weight* is *measured weight* plus weight penalties prescribed in 8.2, 9.3, 9.5, and 10.4.2. *Decking*, *tools*, *lateral restraint* devices, and *posters* are not included in measured or *total weight*.

6.2.4 Stiffness

The *bridge* with the lowest *aggregate deflection* will win in the *stiffness* category. *Aggregate deflection* is determined from measurements as prescribed in 11.5.

6.2.5 Construction Economy

The *bridge* with the lowest *construction cost* C_c will win in the *construction economy* category. *Construction cost* is computed as

C_c = *Total time* (minutes) x number of *builders* (persons)
x 60,000 ($/person-minute) + *load* test penalties ($).

"*Load* test penalties" are prescribed in 11.5.2. A penalty increment to the number of *builders* is prescribed in 10.4.1.

6.2.6 Structural Efficiency

The *bridge* with the lowest *structural cost* C_s will win in the *structural efficiency* category. *Structural cost* is computed as

If *measured weight* does not exceed 120 pounds,
C_s = (*Total weight* – *measured weight*) (pounds) x 5000 ($/pound)
+ *Aggregate deflection* (inches) x 3,250,000 ($/inch)
+ *Load* test penalties ($).
If *measured weight* exceeds 120 pounds but does not exceed 200 pounds,
C_s = (*Total weight* – 120) (pounds) x 5000 ($/pound)
+ *Aggregate deflection* (inches) x 3,250,000 ($/inch)
+ *Load* test penalties ($).
If *measured weight* exceeds 200 pounds,
C_s = (*Total weight* – 184) (pounds) x 25,000 ($/pound)
+ *Aggregate deflection* (inches) x 3,250,000 ($/inch)
+ *Load* test penalties ($).

Section 11.5.2 prescribes "*load* test penalties."

6.2.7 Overall Performance

The *overall performance* rating of a *bridge* is the sum of *construction cost* C_c, *structural cost* C_s and any fines incurred as a violation to a *Team* Contract (Student Steel Bridge Competition National Finals only). The *bridge* achieving the lowest value of this total wins the overall competition.

6.3 SPREADSHEET FOR SCORING

The *scoring spreadsheet* is available in the Competition Guide at **www.aisc.org/ssbc**. Questions and comments regarding the spreadsheet should be sent to **universityprograms@aisc.org**. The spreadsheet also is useful for comparing alternatives when designing a *bridge*. *Teams* are encouraged to download, understand, and verify the spreadsheet before the competition.

6.4 NATIONAL FINALS SPECIAL AWARDS

Special awards are given to *teams* competing at the Student Steel Bridge Competition National Finals. These awards do not factor into the *overall performance* rating of a *bridge* as defined in 6.2.7.

6.4.1 Robert E. Shaw, Jr. Spirit of the Competition Award

The award is named for Robert E. Shaw, Jr. who founded the Student Steel Bridge Competition in the spring of 1987 as a means of challenging university and college students to use their engineering skills to design, fabricate, construct and test a scaled-version of a steel bridge in a friendly competition.

The Robert E. Shaw, Jr. Spirit of the Competition Award is presented to a *team* that demonstrates outstanding *team* comradery, professionalism, positive work ethic and respect for their competition peers.

6.4.2 Frank J. Hatfield Ingenuity Award

The award is named for Frank J. Hatfield who was the Chair of the Student Steel Bridge Competition Rules Committee during its first three decades of existence. He was responsible for orchestrating the many evolutions of the rules since the first Student Steel Bridge Competition in 1992 and was involved in the competition from its inception.

The Frank J. Hatfield Ingenuity Award is presented to a *team* that shows the most engineering ingenuity in the design and construction of their *bridge* based on the requirements of the competition rules.

Section 7
SCHEDULE OF COMPETITION

In the months before the competition, students design their *bridges*, fabricate *members*, test *load*, designate the competition *team*, and practice construction. The regional host *school* procures a venue, organizes equipment (Section 12), and recruits *judges* (Section 14). *Judges* are prepared by reviewing current year rules and all clarifications (Section 13). Clarifications, some of which may have been posted immediately prior to the competition, are found at **www.aisc.org/ssbc**.

7.1 RECOMMENDED SCHEDULE

(1) The official *scoring spreadsheet* is downloaded from **www.aisc.org/ssbc**, and *data forms* are generated from that spreadsheet.

(2) Using a random process, the *head judge or host school determines the order in which teams* will compete.

(3) The *head judge* conducts a meeting with the other *judges* to clarify any rules concerns and to inspect the construction and loading facilities.

(4) *Bridges* are erected for public viewing and are judged for *aesthetics*. After the start of *aesthetics* judging, *bridges* shall not be altered, modified, or enhanced in any way.

(5) *Bridges* are disassembled.

(6) In a meeting at which all *captains* are present, the *head judge* clarifies rules and conditions of the competition, and answers questions.

(7) Immediately before timed construction of the first *bridge*, the *head judge* rolls a die to determine the locations of *decking* units and where the lateral *load* will be applied. These designations will guide *load* tests as described in 11.4.1, 11.5.1, and the Lateral and Vertical *Load* Test Plan Diagrams. For each possible result of the roll (N), Table 7.1 gives the dimensions for positioning *decking* units and locations where the lateral and vertical *load* is applied and vertical deflection and sway are measured.

TABLE 7.1 Determination of *L1*, *L2*, and *S*

N	*L1*	*L2*	*S*
1	11’-0”	6’-0”	11’-6”
2	12’-0”	8’-0”	11’-6”
3	13’-6”	10’-0”	0’-0”
4	14’-0”	8’-4”	0’-0”
5	14’-6”	10’-8”	0’-0”
6	15’-5”	10’-5”	11’-6”

The same values of *L1*, *L2* and *S* will be used for all *bridges* in the same Regional Event. The longer span between piers will be designated as the *left side*. The *left side* shall be considered north and the *right side* shall be considered south which will define the west and east ends of the *bridge*.

(8) *Bridge members*, *tools*, *nuts*, and *bolts* are staged for construction and inspected by the *judges*. See Section 8, "Material and Component Specifications," and Sub-Sections 10.2.3, 10.2.4 and 10.6 for details.

(9) Timed construction. See Section 10, "Construction Regulations," for details.

(10) *Judges* inspect assembled *bridges*. For details, see Section 9, "Structural Specifications." Between corrections described in Section 9.4 and the start of *load* testing, force shall not be applied to the *bridge* except as necessary to move it. For example, leaning or sitting on the *bridge* is not allowed.

(11) *Bridges* are weighed (if it is impractical to weigh the entire *bridge*, its parts may be weighed). **All** *bridges* **shall be weighed, including those that fail as well as those which are withdrawn from competition and not ranked for awards.**

(12) Bridges are *load* tested. See Section 11, "*Load* Test Instructions," for details.

(13) Data entry is conducted. After a *team* has completed all phases of the competition, data for the *team* is transcribed from the *data forms* into the official *scoring spreadsheet* and checked by the *captain*. After data entry has been completed, a copy of the *team's* "Computation" worksheet from the *scoring spreadsheet* is given to the *captain* electronically or on paper.

(14) Scores and rankings are determined using the official *scoring spreadsheet*.

(15) Paper or electronic copies of the "Rankings" worksheet of the official *scoring spreadsheet* are distributed to *captains* of all *teams* at the awards ceremony.

(16) The host *school* submits the completed official *scoring spreadsheet* by e-mailing it to the address given on that spreadsheet as soon as possible after completion of the competition.

(17) The host *school* retains *data forms* for two weeks in case of appeals

7.2 ALTERNATIVES

The order recommended above may be altered. However, it is essential that

(1) *Bridges* are not modified after the die is rolled.

(2) *Bridges* are not modified between *aesthetics* judging and timed construction.

(3) No components or *tools* are added to or removed from the *construction site* after staging for inspection.

(4) Modifications between timed construction and *load* testing are limited to connection corrections described in Sub-Section 9.4.

Section 8
MATERIAL AND COMPONENT SPECIFICATIONS

8.1 MATERIAL

Some grades of *steel* are not magnetically attractive. If any *member*, *nut*, or *bolt* is not strongly magnetic *steel* or incorporates parts that are not strongly magnetic *steel*, the *bridge* will not be ranked for awards in any category listed in 6.2. The *bridge* may be constructed and *load* tested at the *head judge's* discretion if that can be done safely within available time. See 8.2 for specifications on "*members*", "*loose bolts*", "*loose* and welded *nuts*" and "holes in members".

8.2 COMPONENTS

Violation of the specifications in this Sub-Section (8.2) will result in penalties being added to the weight of the *bridge*. The penalty is 25 pounds for each individual noncompliant *nut* and *loose bolt*, and 35 pounds for each individual noncompliant *member*. See 8.2.2, 8.2.3, and 8.2.4 for specifications on "*members*", "*loose bolts*" and "*loose* and welded *nuts*".

8.2.1 Bridge

A *bridge* shall be constructed only of *members*, *loose bolts*, and *loose nuts*. Solder, brazing, and adhesives are not permitted. Exceptions: Purely decorative items such as coatings and decals are permitted, and *bridge* parts may be labeled.

8.2.2 Members

8.2.2.1 Parts of a *member* are welded* together. *Bolts* and *nuts* that are welded[1]* to a *member* are threaded parts that are considered part of that *member* and are not considered to be *loose bolts*, and *loose nuts*. A *member* shall retain its shape, dimensions, and rigidity during timed construction and *load* testing. A *member* shall not have moving or flexible parts. Exception: Deformations caused by mechanical strain (e.g., bending, stretching) during construction and *load* testing are not violations.

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[1]* **Health advisory:** The bright silvery or colored coating on *bolts*, *nuts*, threaded rods, and other hardware contains zinc and cadmium. At welding temperature, both elements create hazardous fumes. Inhalation of zinc fumes causes symptoms resembling those of influenza. Cadmium gas can damage lungs and kidneys and is a potential carcinogen. **Only plain (uncoated) hardware should be welded.**

8.2.2.2 All *members* shall fit into a right rectangular prism (i.e., *box*) of dimensions of 3'-6" x 6" x 4".

8.2.2.3 Threads shall be continuous around the full circumference of an externally threaded part of a *member* if that part is necessary for compliance with 9.4.1.

8.2.3 Loose Bolts

8.2.3.1 *Loose bolts* shall not have parts that flex or move. *Loose bolts* shall be commercially available and shall not be mechanically altered or modified in any way but may be painted.

8.2.3.2 Nominal length of *loose bolts* shall not exceed 3" measured from the bottom of the head to the end. *Loose bolts* shall have external threads that extend around the full circumference.

8.2.4 Loose and Welded Nuts

8.2.4.1 *Nuts* shall have the external shape of a hexagonal prism and not have parts that flex or move. *Nuts* shall be commercially available and shall not be mechanically altered or modified in any way but may be painted.

8.2.4.2 *Nuts* shall have internal threads that extend for the full circumference.

8.2.5 Holes in Members

Holes for *loose bolts* or externally threaded parts of *members* shall not be threaded. Exception: A *nut* that is welded to a *member* and conforms to the specifications of Sub-Section 8.2.4 is not a violation.

Section 9
STRUCTURAL SPECIFICATIONS

9.1 MEASUREMENT

Conformance with the specifications in this section (9) will be checked with the *bridge* in its as-built condition after termination of timed construction and before the *bridge* is moved from the *construction site* or *load* tested. The *bridge* shall not be modified or distorted from its as-built condition in order to conform to these specifications except as prescribed by Sub-Section 9.4. Dimensions will be checked without *decking* or applied *load*. ***Judges*** **may touch the *bridge* but shall not turn *nuts* or *bolts* or alter the condition of the *bridge* in any other way.**

9.2 FUNCTIONALITY

If any specification in this sub-section (9.2) is violated, the *bridge* will not be ranked for awards in any category. The *bridge* may be *load* tested at the *head judge's* discretion if that can be done safely within available time.

9.2.1 The *bridge* shall have exactly two straight *stringers*, each of which is contiguous over the full length of the *bridge* so that *decking* can be placed on the tops of the *stringers* anywhere along the span. Sections of the *stringer* may be part of *members* that serve other functions in the *bridge*. See the Bridge Elevation Diagram.

9.2.2 The *bridge* shall provide access for safely placing 3'-6" wide *decking* and *load* along any point of the *bridge*.

9.2.3 The *decking* shall not be attached or anchored to the *bridge*. This prohibition includes but is not limited to protrusions, irregularities, and textures that inhibit movement of *decking* relative to *stringers*.

9.2.4 *Decking* shall not distort the *bridge* from its as-built condition.

9.2.5 The *bridge* shall not be anchored or tied to the floor.

9.2.6 *Teams* shall accept and *bridges* shall accommodate conditions at the competition site.

9.3 USABILITY

Specifications in this sub-section (9.3) are illustrated by the Bridge Elevation Diagram.

A weight penalty will be assessed for each specification in this sub-section (9.3) that is violated, rather than for every violation of that specification. If there are multiple violations of the same specification, the penalty will be based on the largest violation.

The penalty for violation of each of the specifications in this sub-section (9.3) will be an addition to the weight of the *bridge* determined as follows

(1) 20 pounds for a dimensional violation not exceeding 1/4",
(2) 100 pounds for a violation greater than 1/4" but not exceeding 1",
(3) 200 pounds for a violation greater than 1" but not exceeding 2", and
(4) if a violation exceeds 2", the *bridge* will not be ranked for awards in any category.

The *bridge* may be *load* tested at the *head judge's* discretion if that can be done safely within available time.

9.3.1 The *bridge* shall not touch the *river* or the *ground* outside the *footings*.

9.3.2 The *bridge* shall not extend more than 5'-0" above the *ground* or *river*.

9.3.3 The *bridge* shall not be wider than 5'-0" at any location along the span.

9.3.4 Vertical clearance shall be provided under the *bridge* at all points directly over the *ground* and *river*. The clearance shall be no less than 7.5", measured from the surface of the *ground* or *river*. Parts of the *bridge*, including *nuts* and *bolts*, shall not extend below this limit. Exception: No clearance is required over the *footings* except as necessary to accommodate restraint applied during the lateral *load* test described in Sub-Section 11.4.1.

9.3.5 The tops of the *stringers* shall be no more than 1'-11" and no less than 1'-7" above the surface of the *river* or *ground* at any location along the span.

9.3.6 Each *stringer* shall be at least twenty-two feet long, measured along the top.

9.3.7 The extension of the *stringer* beyond the *footing* on the *right side* of the east end of the *bridge* to meet the requirements of 9.3.6 shall be in the same horizontal plane as the rest of the *stringer*.

9.3.8 At the ends of the *bridge*, parts of the *bridge* shall not extend away from the *river* beyond the vertical planes that pass through the *construction zone* boundaries.

9.3.9 The *bridge* shall provide a straight, clear passageway conforming to the Clearance *Template* detail on the Bridge Elevation Diagram. To verify compliance with 9.3.9 and 9.3.10, *judges* will slide the *template* along the tops of the *stringers* while holding it plumb and perpendicular to the span of the *bridge*. At no location along the full length of the *stringers* shall part of the *bridge*, including *nuts* and *bolts*, obstruct passage of the *template*. The penalty for non-compliance with 9.3.9 is based on the projection of an obstruction onto the *template*, measured perpendicularly from the obstructed edge.

9.3.10 The tops of both *stringers* shall contact the tops of the two rabbets in the *template* at every location along the full length of the *stringers* during the verification procedure described in 9.3.9. The penalty for non-compliance with 9.3.10 is based on the vertical distance down from the top of a rabbet to the top of the corresponding *stringer*. If the same obstruction causes a violation of both 9.3.9 and 9.3.10, the *judge* will record only the larger violation.

9.3.11 Tops of *stringers* shall be free of holes, splits, separations, protrusions, and abrupt changes in elevation or slope, except that between adjacent *members* that comprise a *stringer* there may be a horizontal separation not exceeding 1/4" and a change in elevation not exceeding 1/8".

9.4 CONNECTION SAFETY

After termination of timed construction and inspection by *judges*, *builders* are required to attempt to correct violations of specifications 9.4.1, 9.4.2, and 9.4.3, and will be granted the option to correct violations of specification 9.4.4. Only *tools*, *loose nuts*, and *loose bolts* that were in the *staging yards* at the start of timed construction shall be used. Safe construction practices (10.2 and 10.3) are required, but *accidents* (10.4) will not be penalized. *Builders* will be allowed five minutes to correct all connections. If any connection still violates specification 9.4.1, 9.4.2, or 9.4.3 when that time limit is reached, the *bridge* will not be ranked for awards in any category and will not be *load* tested. ***Judges*** **may touch the *bridge*, *bolts*, and *nuts*, but shall not turn *nuts* or *bolts*, or alter the condition of the *bridge* in any other way.**

9.4.1 Each individual *member* shall be connected to each *member* that it touches by at least one *loose bolt* or externally threaded part of a *member* secured by a loose or welded *nut* so that those connected *members* cannot be separated without first unscrewing and removing the *loose bolt* or externally threaded *member* that connects them, or without first unscrewing and removing the *loose nut* from that *loose bolt* or threaded *member*. The *loose bolt* or externally threaded part of a *member* shall pass through holes in all the *members* that it connects. A *loose bolt* or threaded part of a *member* may connect more than two *members*. **Penalty is five minutes added to construction time for each individual violation.**

9.4.2 Each individual loose or welded *nut* shall at least fully engage the threads of the matching *bolt* or externally threaded part of a *member*. That is, the terminal threads of the *bolt* or *member* shall extend beyond or be flush with the outer face of the *nut*. The threads of the *nut* shall match the *bolt* or externally threaded *member* so that installation and removal require relative rotation. **Penalty is five minutes added to construction time for each individual violation.**

9.4.3 Each individual hole in a *member* for a *loose bolt* or externally threaded part of another *member* shall be completely surrounded by the *member*. Furthermore, such holes in the outer plies of a connection shall be small enough that the *nut* or *bolt* head cannot pass through. **Penalty is five minutes added to construction time for each individual violation.**

9.4.4 Each individual *loose nut* or *loose bolt* shall be tightened sufficiently so that the *nut* or *bolt* head contacts the outer ply of the connection. **Penalty is one minute added to construction time for each individual violation.** However, if a fastening consists of a *loose nut* on a *loose bolt*, only one penalty will be applied for that fastening.

9.5 INSPECTABILITY

Each individual *nut*, head of a *loose bolt*, and threaded end of a *bolt* or *member* shall be visible in the completed *bridge* so that compliance with specifications in Sub-Section 9.4 can be verified. **A penalty of 25 pounds will be added to the weight of the *bridge* for each individual threaded end, *nut*, and *bolt* head that cannot be inspected.**

Section 10
CONSTRUCTION REGULATIONS

10.1 GENERAL CONSTRUCTION REGULATIONS

10.1.1 The *team* designates one *builder* to serve as *captain* for the entire competition.

10.1.2 All construction activities are conducted within the *site boundary*. The host *school* marks the *site boundary* and its enclosed features on the floor before the competition, as illustrated by the Site Plan Diagram.

10.1.3 *Builders* on the *ground* in the *construction zones* put *members* together to assemble the *bridge*.

10.1.4 *Builders* carry *members*, *tools*, *nuts*, and *bolts* across the *transportation zones*.

10.1.5 Builders shall wear hardhats that meet ANSI standard Z89.1 and protective eyewear or safety goggles that meet ANSI standard Z87.1 as *personal protective equipment* during all construction activities.

10.1.6 There may be multiple *constructed portions*. If a *member* that is part of the *constructed portion* is removed from contact with the *constructed portion*, it becomes an individual *member* again.

10.2 PRE-CONSTRUCTION CONDITIONS

Timed construction will not commence if any provision of this subsection (10.2) is violated.

10.2.1 Only *builders* and *judges* are permitted within the *site boundary* during timed construction. Other *team* members and associates of the *team*, coaches, faculty, advisers, and spectators shall remain in designated areas at a distance from the *construction site* that assures they are not at risk and cannot interfere with the competition.

10.2.2 There shall be no more than six *builders*.

10.2.3 Welding machines and tools requiring external power connections shall not be used during timed construction. *Tools* powered by batteries or other internal energy supplies are acceptable.

10.2.4 A *tool* or unassembled part of a *tool* must not weigh more than twenty pounds and shall fit within a right rectangular prism (i.e., *box*) of dimensions of 3'-6” x 6” x 4”.

10.2.5 Containers of lubricant shall not be in the *construction site* at any time.

10.3 SAFE CONSTRUCTION PRACTICES

If any rule in this sub-section (10.3) is violated during timed construction, the *judge* will stop the clock and explain the violation. Before the clock is restarted, *builders*, *tools*, *members*, *nuts*, and *bolts* will be returned to the positions they occupied immediately before the violation. *Builders* will then be asked to resume construction using safe procedures. *Builders* will have the opportunity to construct their *bridge* safely. However, if they are not able to construct the *bridge* completely using safe procedures, construction will cease and the *bridge* will not be ranked for awards in any category.

10.3.1 *Builders*, *judges*, host personnel, and spectators shall not be exposed to risk of personal injury. Only *builders* and *judges* may be in the *construction site*.

10.3.2 At all times during timed construction every *builder* shall wear *personal protective equipment* in the proper manner.

10.3.3 A *pouch* or other article of clothing shall not be removed from a *builder's* person or held in a *builder's* hand(s).

10.3.4 *Nuts*, *bolts*, or *tools* shall not be held in the mouths of *builders*.

10.3.5 Throwing anything is prohibited.

10.3.6 A *builder* shall not cross from the *ground* on one bank of the *river* to the *ground* on the other bank.

10.3.7 A *builder* who is outside a *staging yard* shall not simultaneously support or touch, directly or with *tools*, more than one *member* that is not in a *constructed portion*.

10.3.8 A *builder* shall not use the *bridge*, a *constructed portion* of the *bridge*, a *member*, or a *tool* to support all or part of the *builder's* body weight. However, a *builder* may be partially supported by a *constructed portion* if the *builder* is kneeling on the floor on both knees, kneeling on the floor on one knee with the other foot on the floor, or standing with the heels and toes of one or both feet on the floor.

10.3.9 A *builder* shall not depend on another *builder* or *builders* for support or balance.

10.3.10 Construction of the *bridge* shall commence by creating a *constructed portion*. Each *constructed portion* shall be started on the *ground* within a *footing*.

10.3.11 A *builder* who is outside a *construction zone* shall not touch (or touch with *tools*) a *constructed portion*, and shall not install a *member*, *nut*, or *bolt* on a *constructed portion*.

10.3.12 At no time shall a *builder* or *builders* support the entire weight of a *constructed portion*. However, a *builder* or *builders* may remove a single *member* from a *footing* or from a *constructed portion*.

10.3.13 No part of a *constructed portion* shall extend beyond the *site boundary* at any time.

10.3.14 A *team* shall construct its *bridge* safely using the site and floor surfaces provided by the host *school*. ***Bridges*** **and participants shall accommodate local conditions.**

10.4 ACCIDENTS

Accident types are described in Sections 10.4.1, 10.4.2, and 10.4.3. In general, the clock is not stopped when there is an *accident*.

A penalty is assessed for each separate *accident*. If an *accident* is continuous (for example, a *builder* stands in the *river*, or a dropped item is not retrieved promptly) it will be counted as multiple occurrences until corrected. *Builders* involved in *accidents* may continue to build. Items involved in *accidents* shall be recovered promptly and may be used.

Construction cannot depend on deliberately committing an *accident*. Therefore, the clock will be stopped if any work is accomplished by committing an *accident*. Before timed construction is resumed, *builders*, *tools*, *members*, *nuts*, and *bolts* will be returned to the positions they occupied immediately before the *accident*.

10.4.1 A *builder*, builder's footwear, *pouch*, or article of clothing touches the *river* or the floor outside the *site boundary*. For each occurrence, the number of *builders* is increased by one when the spreadsheet computes *construction cost* C_c, but the number of *builders* actually constructing the *bridge* does not change. Exception: There is no penalty for stepping out of bounds or entering the *river* to retrieve an object that has been dropped, such as a *member*, *tool*, *nut*, *bolt*, or *personal protective equipment*.

10.4.2 A *member*, *constructed portion*, *tool*, *nut*, *bolt*, or *personal protective equipment* touches the *river*, the *ground* outside the *staging yard*, or the floor outside the *site boundary*. **Penalty is 1/4 minute (15 seconds) for each item during each occurrence.** Exception: There is no penalty for a *member* or *constructed portion* touching the *ground* within a *footing*. However, construction may proceed if it is no longer possible to hold the bearing surfaces of a *constructed portion* within the *footings*. In this situation, the *captain* may request that the clock be stopped while the difficulty is demonstrated to the *head judge*. If the *head judge* is convinced, no additional *accidents* will be cited for a *constructed portion* touching the *ground* outside the *footings* (regulation 10.4.2), the clock will be restarted, construction will resume, and a 200-pound weight penalty will be assessed, even if the bearing surfaces of the *bridge* are within the *footings* when it is completed.

10.4.3 Outside the *staging yards*, a *member* that is not part of a *constructed portion* touches or is in contact with another *member* that is not part of a *constructed portion*. **Penalty is 1/4 minute (15 seconds) for each occurrence.** Exception: There is no penalty if a *member* that is on the *ground* within a *footing* touches another *member*.

10.5 CONSTRUCTION SITE

See the Site Plan Diagram for layout of the *construction site*. The host *school* lays out the site before the competition. The *construction site* shall be laid out so that the tape that designates lines is wet or out of bounds. That is, the edges of tape, not the centerlines, designate the lines shown on the drawing.

10.6 START

10.6.1 Before construction begins, only the following are allowed in the *staging yards*: all *builders*, *members*, *loose nuts*, *loose bolts*, and *tools*. Every *member*, *loose nut*, *loose bolt*, and *tool* must be in contact with the *ground* and must fit entirely within the assigned area of a *staging yard* as designated on the *Staging Yard* detail on the Site Plan Diagram. *Loose nuts* may be installed on *loose bolts*. *Tools* or parts of *tools* cannot touch each other. *Builders* are wearing *personal protective equipment* as well as optional clothing such as *pouches*. At the start, *builders* cannot touch *members*, *tools*, *nuts*, or *bolts*, which may only be picked up and passed from one *builder* to another after timed construction begins. There shall be nothing within the *construction site* that is not in a *staging yard*.

10.6.2 *Judges* inspect *members*, *loose nuts*, *loose bolts*, and *tools* as they are placed in the *staging yard*. *Tools* that do not conform to regulation 10.2.3 and 10.2.4 shall be removed from the *staging yard* and shall not be used. After inspection and throughout timed construction, additional *members*, *tools*, *nuts*, *bolts*, or other items shall not be brought into the *construction site* nor shall anything be removed. Additional *builders* shall not enter the *construction site* after the beginning of timed construction.

10.6.3 Timing and construction begin when the *captain* signifies that the *team* is ready and the *judge* declares the start.

10.7 TIME

10.7.1 Time is kept from start to finish of construction. The clock will be stopped under the following conditions

(1) if a *builder* or *judge* sees a condition that could cause injury, or
(2) when a *safety* regulation has been violated (see 10.2 and 10.3), or
(3) when work has been accomplished by committing an *accident*. The clock is not stopped if the *accident* does not contribute to the construction process (see 10.4), or
(4) if a *builder* or *judge* is injured or incapacitated.

10.7.2 Construction ceases while the clock is stopped. After the situation has been corrected, *builders*, *tools*, and *bridge* components are returned to the positions they occupied immediately before the interruption, the clock is restarted, and construction resumes.

10.8 TIME LIMIT

10.8.1 If construction time not including penalties exceeds thirty minutes, the *scoring spreadsheet* will count construction time as 180 minutes. *Accidents* (10.4) that occur after thirty minutes will not be penalized but *safety* regulations (10.2 and 10.3) will still be enforced. *Judges* may inform the *team* when this time limit is approaching and shall inform them when it is reached.

10.8.2 If construction time not including penalties exceeds 45 minutes, *judges* will halt construction. If local conditions allow and the *head judge* approves, the *team* may move its *bridge* off site for continued, untimed construction if it can be done safely. The *bridge* will not be eligible for awards in any category, but it may be *load* tested at the discretion of the *head judge* if that can be done safely within available time.

10.9 FINISH

10.9.1 Construction ends and the clock is stopped when

(1) the *bridge* has been completed by connecting all the *members* that were in the *staging yards* at the start of timed construction,
(2) all *builders* are in the *staging yards*,
(3) all *tools* are in contact with the *ground* in the *tool* section of the *staging yard*,
(4) all extra *nuts* and *bolts* are held in the hands of *builders*, or are in clothing worn by *builders*, or are on the *ground* in the *staging yards*, and
(4) the *captain* informs the *judge* that construction is complete.

10.9.2 At the end of timed construction all *tools* must be disassembled to satisfy the requirements of 10.2.4 and be in contact with the *ground* in the *tool* section of the *staging yard*. **A one-time penalty of 5 minutes will be added to the construction time if any *tool* does not meet the specification.**

10.9.3 Installation of *decking* is not included in timed construction.

10.9.4 The *bridge* shall not be modified after construction, except for correction of connections as prescribed in Sub-Section 9.4.

Section 11
LOAD TEST INSTRUCTIONS

11.1 DAMAGE

A *bridge* with damage that would reduce its strength or stability (such as a fractured weld, missing or broken *member*, broken *bolt*, or missing *nut*) will not be approved for *load* testing and will not be ranked for awards in any category. Repair and modifications are not permitted after timed construction except as prescribed in Sub-Section 9.4.

11.2 SAFETY PRECAUTIONS

It is the responsibility of *judges*, host personnel, and competitors to employ effectively all precautions, which are summarized in this sub-section (11.2). Competitors should follow the same precautions when proof testing *bridges* in preparation for competition.

11.2.1 General Precautions

11.2.1.1 An activity shall be halted if a *judge* considers it to be hazardous. If a *team* cannot load its *bridge* safely, loading will cease and the *bridge* will not be ranked for awards in any category.

11.2.1.2 Competitors who are not participating in loading, faculty, advisers, and other spectators shall observe from a safe area designated by the *judges* and host *school*.

11.2.1.3 While participating in *load* testing, competitors shall wear *personal protective equipment* consisting of hardhats meeting ANSI standard Z89.1, protective eyewear or safety goggles meeting ANSI standard Z87.1, work gloves, and leather construction boots. This *safety* equipment is provided by each *team*. *Judges* will not permit *load* testing by competitors who are not wearing the specified *personal protective equipment* or are wearing it improperly.

11.2.2 Lateral Load Test Precautions

11.2.2.1 There shall be no more than three students in the crew that participates in a lateral *load* test.

11.2.2.2 A *bridge* that *sways* in excess of one inch during lateral *load* testing shall not be loaded vertically and will not be ranked for awards in any categories.

11.2.3 Vertical Load Test Precautions

Bridges may collapse suddenly without warning, and a failure may involve only one side so that the *load* falls or slides sideways off the *bridge*. The intent of the provisions of this subsection (11.2.3) is to prevent personal injury if a *bridge* collapses.

11.2.3.1 The number of people near the *bridge* shall be minimized during vertical *load* tests. The loading crew is limited to three students, but substitutions may be made during the loading process.

11.2.3.2 *Safety supports* shall be provided by the host *school*, and shall be of adequate strength, height, and number to arrest falling *load* if a *bridge* collapses.

11.2.3.3 *Safety supports* shall be in place under the *decking* units before *load* is placed on the *bridge*.

11.2.3.4 The number and location of *safety supports* under a *decking* unit shall be sufficient to arrest the *load* even if only one side or one end of the *bridge* collapses. Therefore, *safety supports* are needed under the sides and ends of the *decking* units, not just in the middle. *Safety supports* should be directly under *decking* units rather than under *bridge* trusses or cross braces, if possible.

11.2.3.5 *Safety supports* shall be adjusted individually for each *bridge* so that *load* cannot drop more than approximately four inches. If the height of the *safety supports* is not adjustable in appropriate increments, they shall be augmented with pieces of wood or other suitable material provided by the host *school*.

11.2.3.6 No one shall reach, crawl, or step under a *bridge*, or stand inside a *bridge* while any portion of vertical *load* is in place. If *safety supports* must be adjusted during loading, the *load* shall first be removed without disturbing the *bridge*, adjustments made, and the *load* replaced as it was before being removed.

11.2.3.7 *Bridges* that inhibit safely placing vertical *load* shall not be tested and will not be ranked for awards in any category.

11.2.3.8 *Judges* shall continuously observe *sway* carefully during vertical *load* testing. If *sway* exceeds one inch, loading shall cease and *load* shall be removed carefully.

11.2.3.9 *Judges* shall continuously observe *deflections* carefully. If any *deflection* exceeds three inches downward, loading shall cease and *load* shall be removed carefully.

11.2.3.10 *Judges* shall continuously observe the behavior of the *bridge*. Loading shall cease and the *load* shall be removed carefully if, in the opinion of a *judge*, collapse is imminent.

11.3 PREPARATION

The *captain* shall observe the *load* tests and may handle *load*. A *captain* who does not handle *load* shall comply with 11.2.1.3 but does not count toward the three-person limit.

Teams shall accept imperfect field conditions such as bent *decking*, sloping floors, and unfavorable floor surfaces.

Positions *L1* and *L2* of the *decking* units and position *S* for the *decking* unit for the lateral *load* are determined at the beginning of the competition as described by paragraph 7.1 (7) and illustrated by the Lateral *Load* Test Plan and Vertical *Load* Test Plan on the *Load* Test Plan Diagrams.

At their discretion, *judges* may impose a penalty for a *bridge* that incorporates parts having the primary function of interfering with placement of *decking*, *load*, or measuring devices. If the *bridge* cannot be loaded safely, or *sway* or *deflection* cannot be measured in accordance with the provisions of this section (11), the *bridge* shall not be *load* tested and will not be ranked for awards in any category.

Typically, *sway* is determined by using a plumb bob attached to the *bridge* at a specific point, but *sway* limits apply even if the plumb bob is displaced by contact with another part of the *bridge*.

11.4 LATERAL LOAD TEST

The provisions of this sub-section (11.4) are illustrated by the Lateral *Load* Test Plan on the Lateral *Load* Test Plan Diagram.

11.4.1 Set Up

Lateral *load* tests are conducted with one *decking* unit positioned at a distance *S* from the east end of the *stringers* and approximately 75 pounds of weight on that *decking* near the *left side* of the *bridge*. This *load* is intended to restrain the bearing surfaces of the *bridge* from lifting off the floor when lateral *load* is applied. No additional uplift restraint will be used, even if bearing surfaces lift.

Bearing surfaces are prevented from sliding by *lateral restraint* applied by the loading crew. This *lateral restraint* shall not restrain rotation or uplift. The restraint is applied as close to the floor as possible, at the locations shown on the Lateral *Load* Test Plan on the Lateral *Load* Test Plan Diagrams. *Teams* may provide and use optional devices to prevent sliding. However, the device must prevent sliding only. Devices designed to prevent vertical uplift will not be permitted. The lateral *load* test is failed if the *bridge* is restrained in other than the lateral direction, or if the restraint is not applied close to the *ground*, or if the restraint is not effective.

11.4.2 Lateral Load Test

A fifty-pound lateral *load* is applied and *sway* is measured on the *right side* of the *bridge*, centered on the *decking* unit positioned at *S*. Lateral *load* is applied at the level of the *decking* or top of the *stringer*, which is the bottom of the *decking*. The *sway* measurement is made as close as possible to the location of the lateral *load*.

The test is failed if *sway* exceeds one inch.

If the *bridge* fails the lateral *load* test it will not be ranked for awards in any category. Do not conduct the vertical *load* test. Check the appropriate box on the *data form*.

If the *bridge* passes the lateral *load* test, proceed with the vertical *load* test.

11.5 VERTICAL LOAD TEST SEQUENCE

The provisions of this section are illustrated by the Vertical *Load* Test Plan and Vertical *Load* Test Elevation on the Vertical *Load* Test Plan Diagram.

11.5.1 Set Up

11.5.1.1 *Decking* units are 3'-0" long in the longitudinal (span) direction of the *bridge* so that the main bars of grating span laterally. Two *decking* units are used. *Decking* units are placed square with and centered on the *stringers*. *Decking* units shall not be attached to the *bridge* and shall not distort it (see 9.2.3 and 9.2.4).

Two *decking* units are placed at distances *L1* and *L2* from the east end of the tops of the *stringers*.

A *decking* unit that does not contact the top of a *stringer* at a location where *deflection* will be measured will be clamped to the *stringer* at or near that location. The clamp will be removed when sufficient *load* is in place to hold the *decking* unit in contact with the top of the *stringer*.

11.5.1.2 *Safety supports* are placed under the *decking* units so that no portion of the *load* will drop more than approximately four inches if the *bridge* collapses.

11.5.1.3 *Deflections* are measured as close as possible to the tops of *stringers*, which are at the same level as the bottom of the *decking*. Measurements are made at the following locations

- *D1* centered on the *left side* of the *decking* unit positioned at *L1*.
- *D2* centered on the *right side* of the *decking* unit positioned at *L2*.

Sway is observed on the *left side* of the *bridge*, at the center of the *decking* unit positioned at *L2*.

11.5.2 General Loading Procedure

Load is laterally centered on the *decking* unit and distributed over the length of the *decking* unit as uniformly as possible. *Load* is distributed and aligned identically for each *bridge*. *Load* shall be placed at a steady pace, without hesitation. Crews shall stand outside the *bridge* while placing *load*.

As *load* is being placed, continuously observe *deflection* and *sway*. Stop loading if

(a) *sway* exceeds one inch, or
(b) any measured *deflection* exceeds three inches downward, or
(c) *decking* or any part of the *bridge*, other than the intended bearing surfaces, comes to bear on a safety support or the floor, or
(d) a *decking* unit or some of the *load* falls off the *bridge*, or
(e) the *bridge* collapses or a dangerous collapse is imminent in the opinion of the *judge*.

If loading is stopped for any of the situations a, b, c, d, or e, the *bridge* is not approved for further *load* testing and will not be ranked for awards in any category. **Do not continue *load* testing.** Ask the crew to remove the *load* carefully. Check the appropriate box on the *data form*.

Deflections measured while the vertical *load* is in place will be used by the *scoring spreadsheet* to compute *aggregate deflection* by adding the absolute values of *deflections* at *D1* and *D2*, and then rounding the sum to the nearest 0.01 inch. If any measured *deflection* exceeds two inches, the *scoring spreadsheet* will add penalties of $4,000,000 to the *Construction Economy* score and $10,000,000 to the *Structural Efficiency* score.

11.5.3 Vertical Load Test

(1) The crew distributes 100 pounds of preload on the *decking* unit positioned at *L1* and 100 pounds of preload on the *decking* unit positioned at *L2*. The preload is distributed uniformly, centered laterally on the *decking* unit, and positioned identically for each *bridge*.
(2) Initialize the *sway* measurement device.
(3) Initialize the two *deflection* measuring devices at *D1* and *D2* or record the initial readings.
(4) The crew places 1400 pounds of additional *load* on the *decking* unit at *L1*.
(5) The crew places 900 pounds of additional *load* on the *decking* unit at *L2*.
(6) Record the final readings for *D1* and *D2*.

11.5.4 Loss of Data

If *deflection* data is lost or compromised, the *judge* will require the *team* to disassemble the *bridge*, repeat timed construction beginning with the initial conditions prescribed in 10.6, and redo lateral and vertical *load* tests. Compliance with specifications in Section 8 and

SubSection 9.3 will not be checked again, but compliance with specifications in 9.4 and 9.5 will be verified. Scoring will be based on the run that results in the larger *construction cost* C_c (not including *load* test penalties), but will not exceed 110% of C_c (not including *load* test penalties) for the initial run.

11.6 UNLOADING

Load on the *decking* unit at *L2* is removed before the *load* on the *decking* unit at *L1*. If the *bridge* collapses during unloading (situation c, d, or e in 11.5.2), it is not eligible for awards in any category.

Section 12
EQUIPMENT PROVIDED BY HOST

12.1 SOURCES OF INFORMATION

Equipment for hosting a competition is listed in this section and described in the Competition Guide at **www.aisc.org/ssbc**. This site also includes competition procedures and illustrations of *bridge* details that demonstrate compliance and noncompliance with specifications and regulations. Host personnel, *judges*, and competitors are encouraged to review the site.

Although the equipment described in this section (12) will be provided by the host *school*, competitors should acquire similar equipment for *load* testing before the competition.

All *teams* are required to accept/accommodate local conditions and equipment, including floor, *decking*, *safety supports*, *load*, *templates*, *boxes*, *deflection* measurement devices and *scales*.

12.2 DECKING

Preferred *decking* is *steel* bar grating identified as W-19-4 (1" x $^{1}/_{8}$"). The dimensions of a unit of grating are approximately 3'-6" x 3'-0" x 1" and the weight is approximately fifty pounds. Grating has significant bending strength only in the direction of the main bars, which are 3'-6" long. The grating will be installed with the main bars perpendicular to the length of the *bridge*, creating a roadway that is 3'-6" wide. Therefore, support for the grating is needed for the edges that are parallel to the length of the *bridge* but not for the edges that are perpendicular to the length.

12.3 SAFETY SUPPORTS

Safety supports must be used during *load* tests and are intended to limit the consequences of a *bridge* collapsing. *Safety supports* shall be of sufficient height, strength, number, and extent so that none of the *load* will fall more than approximately four inches if the *bridge* collapses. *Safety supports* may be *steel*, nested stacks of plastic buckets, jack stands, timbers, sand bags, or masonry units.

12.4 LOAD

A total *load* of 2500 pounds should be supplied in pieces of uniform size and weight that can be handled safely. When in place, the *load* should not provide significant *stiffness* in the longitudinal direction of the *bridge*. The recommended *load* consists of 25-pound lengths of 4" x 4" x 3/8" or 5" x 5" x $^{5}/_{16}$" *steel* angle placed perpendicular to the length of the *bridge*.

Alternatively, sacks of material, containers of liquid, concrete blocks, or jacking systems can be used. *Decking* is not included as part of the 2500-pound *load*. If a jacking system is used, loading forces may be concentrated nine inches in from each end of the *decking* units.

12.5 TEMPLATE

A *template* as dimensioned in the Clearance *Template* detail on the *Bridge* Elevation Diagram shall be used to check clearances. Plywood is recommended. Holes for handholds are helpful but optional.

12.6 BOX

A *box* with inner dimensions of 3'-6" x 6" x 4" should be supplied to ensure that *members* and *tools* meet dimensional requirements specified in 8.2.2.2 and 10.2.4. Wood or other non-deforming material is recommended.

12.7 SCALES

Four calibrated *scales* should be supplied to be used under the four *bridge* supports to measure the *total weight* of the *bridge*. The *scales* should be checked prior to competition for measurement accuracy. If it is impractical to weigh the whole *bridge* at once, then each individual piece of the *bridge* can be weighed separately on a single scale and summed to determine the *total weight* of the *bridge*.

Section 13
INTERPRETATION OF RULES

The website **www.aisc.org/ssbc** lists clarifications of the rules. Students, *judges*, and host personnel may submit questions via a form on that website but should **first read the previously posted clarifications, reread this rules document carefully in its entirety, and review the Competition Guide at www.aisc.org/ssbc**. Submitters' names and affiliations must accompany clarification requests and will be posted with the questions and answers. Questions shall be limited to interpretation of rules; specific designs and procedures will not be validated. Deliberation by the SSBC Rules Committee typically requires one to two weeks but possibly longer. Questions must be submitted before 5:00 PM Eastern Daylight-Saving Time, May 6, 2019.

Section 14
JUDGING

The host *school* will recruit *judges*. *Judges* are empowered to halt any activity that they deem to be hazardous. The *head judge* has full authority over conduct of the competition and interpretation of the rules. Decisions, scoring, and ranking are the sole responsibility of the *judges* and will be final. The host *school* will assure that the *judges* are fully informed of the rules and procedures, and fully equipped for their tasks. More information for host *school* and *judges* is available at **www.aisc.org/ssbc**, where the official *scoring spreadsheet* may be downloaded and the Competition Guide reviewed.

Section 15
APPEALS

15.1 REGIONAL EVENTS

15.1.1 At the beginning of the competition each *team* will identify its *captain*. The host *school* will identify the regional *head judge* (RHJ).

15.1.2 A penalty, decision, measurement, score, condition of competition, or interpretation of rules may be appealed only by the *captain* and only to the RHJ. The RHJ will not hear the appeal if he or she is approached by anyone other than the *captain*. The RHJ will refuse to hear protests regarding *bridges* other than the *captain's*. The appeal must be made as soon as possible after the situation becomes apparent. The RHJ will hear the appeal as soon as possible and may interrupt the competition. If the *captain* does not consent to the decision of the RHJ, he or she shall write an explanation on the *data form* before signing it. Participants are reminded that civility and ethical behavior are expected during the competition and particularly concerning appeals.

15.1.3 After the Regional Event, the SSBC Rules Committee will consider only those appeals that allege errors in interpretation of rules, and only if those appeals were made to the RHJ during the Regional Event in conformance with 15.1.2. Appeals should be submitted by e-mail to Ms. Maria Mnookin **mnookin@aisc.org** and shall include

(1) name of the college or university making the appeal,
(2) *captain's* name, e-mail address, and telephone number,
(3) faculty advisor's name, e-mail address, and telephone number,
(4) brief description of the problem, including citation of pertinent rules,
(5) action taken at the competition to deal with the problem,
(6) action that the appealing *team* feels should have been taken, and
(7) data showing that the *team* should have qualified for national competition.

The SSBC Rules Committee may ask the host *school* to provide *data forms* documenting the problem and may confer with the RHJ.

15.1.4 Appeals must be made by e-mail. An appeal will be considered only if the e-mail is received by 5:00 PM Eastern Daylight-Saving Time on the Wednesday immediately after the Regional Event. Ms. Mnookin will forward the appeal to the SSBC Rules Committee for their evaluation. The SSBC Rules Committee will not respond to an appeal until the official *scoring spreadsheet* for that Regional Event has been submitted by the host *school* to **universityprograms@aisc.org**. The only redress that may be made is an invitation to participate in the National Finals if the SSBC Rules Committee is convinced that the appeal is

valid and that the appealing *team* should have qualified for the National Finals. Decisions and rankings made by regional *judges* will not be overturned.

15.2 NATIONAL FINALS

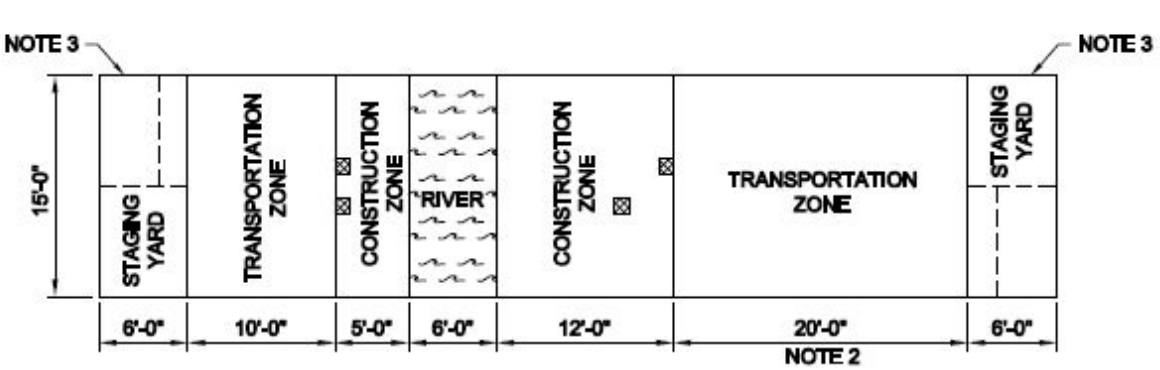
15.2.1 *Judges* will refuse to hear protests from a *team* concerning any *bridge* other than their own.

15.2.2 A penalty, decision, measurement, score, condition of competition, or interpretation of rules may be appealed only by a *captain* and only to the station *head judge* (SHJ). The SHJ will not hear the appeal if he or she is approached by anyone other than the *captain*. The appeal must be made as soon as possible after the situation becomes apparent and before the conditions at issue are changed (e.g., by further construction, loading, or disassembly of the *bridge*). The SHJ will hear the appeal as soon as possible and will make a ruling. The conditions at issue will not be changed during deliberation. *Teams* are reminded that civility and ethical behavior are expected during the competition and particularly concerning appeals.

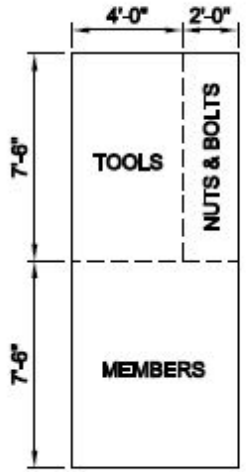
15.2.3 After hearing the SHJ's ruling, the *captain* may request a five-minute recess to discuss the issue with the *team*. During the recess, the conditions at issue will not be changed. Immediately after that recess, if the *team* has justification to contest the SHJ's ruling, the *captain* has the option to appeal that decision to the national *head judge* (NHJ). The NHJ will hear the appeal as soon as possible and will make a ruling. The NHJ may consult with the SSBC Rules Committee. The conditions at issue will not be changed during deliberation.

15.2.4 If the *team* has justification to contest the NHJ's ruling, the *captain* has the option to appeal that decision directly to the SSBC Rules Committee within fifteen minutes after hearing the NHJ's ruling. The Committee may request information from the NHJ and SHJ but those *judges* will not vote on the final ruling.

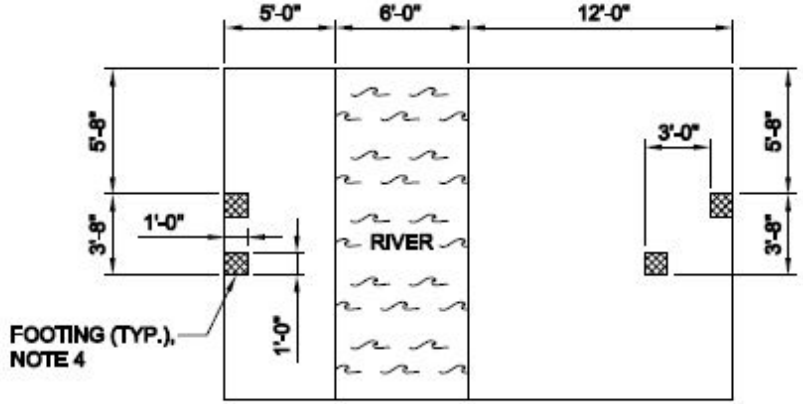
15.2.5 The decision of the SSBC Rules Committee is final; there are no further appeals. However, AISC welcome written suggestions for improving future competitions.



CONSTRUCTION SITE PLAN



STAGING YARD DETAIL



CONSTRUCTION ZONE AND RIVER DETAIL

1 SITE PLAN

NOTES:
1. DRAWINGS ARE NOT TO SCALE
2. DIMENSION MAY BE REDUCED TO FIT LOCAL CONDITIONS.
3. DIMENSIONS AND LOCATIONS ARE IDENTICAL FOR STAGING YARDS AT BOTH ENDS.
4. ALL FOUR FOOTINGS ARE THE SAME SIZE.

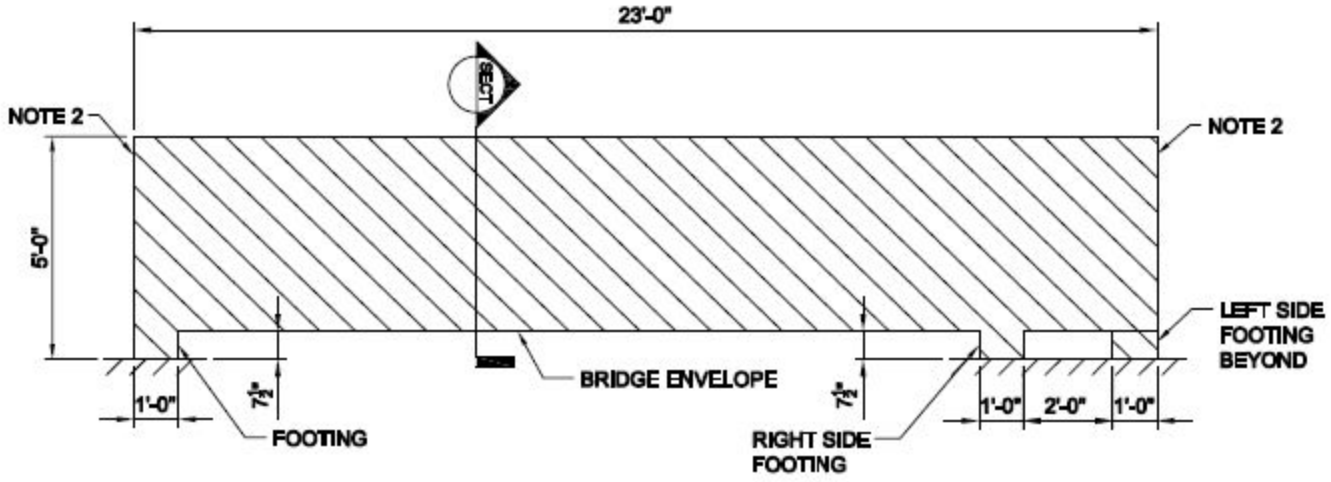
AISC
2019 STUDENT STEEL BRIDGE COMPETITION

NO.	DATE	DESCRIPTION

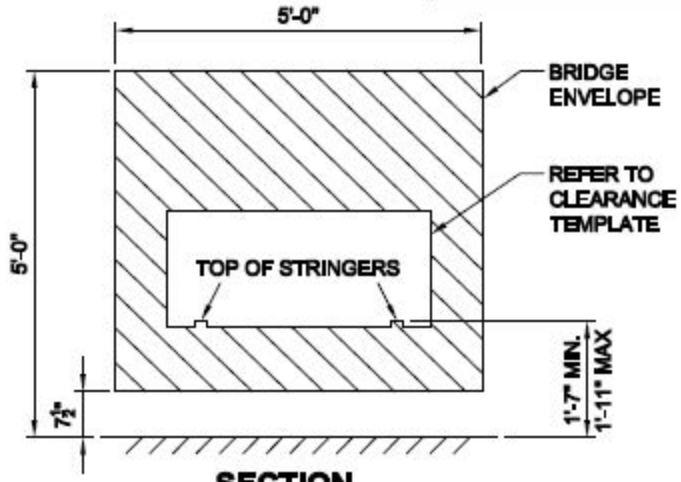
PROJECT NO:	DRAWN BY:
2019	EJB
DATE: 01/01/2019	CHECKED BY: CRC

DRAWING TITLE: SITE PLAN

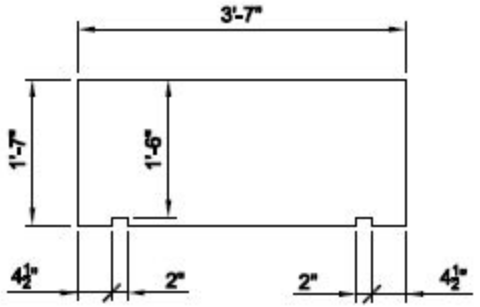
DRAWING NUMBER: DWG 1



RIGHT SIDE ELEVATION



SECTION



CLEARANCE TEMPLATE

1 BRIDGE ELEVATION

NOTES:
1. DRAWINGS ARE NOT TO SCALE.
2. NO PART OF THE BRIDGE SHALL EXTEND AWAY FROM THE RIVER BEYOND LIMITS OF THE CONSTRUCTION ZONE (9.3.6).
3. TOPS OF STRINGERS SHALL BE AT LEAST 22 FT. LONG (9.3.6).

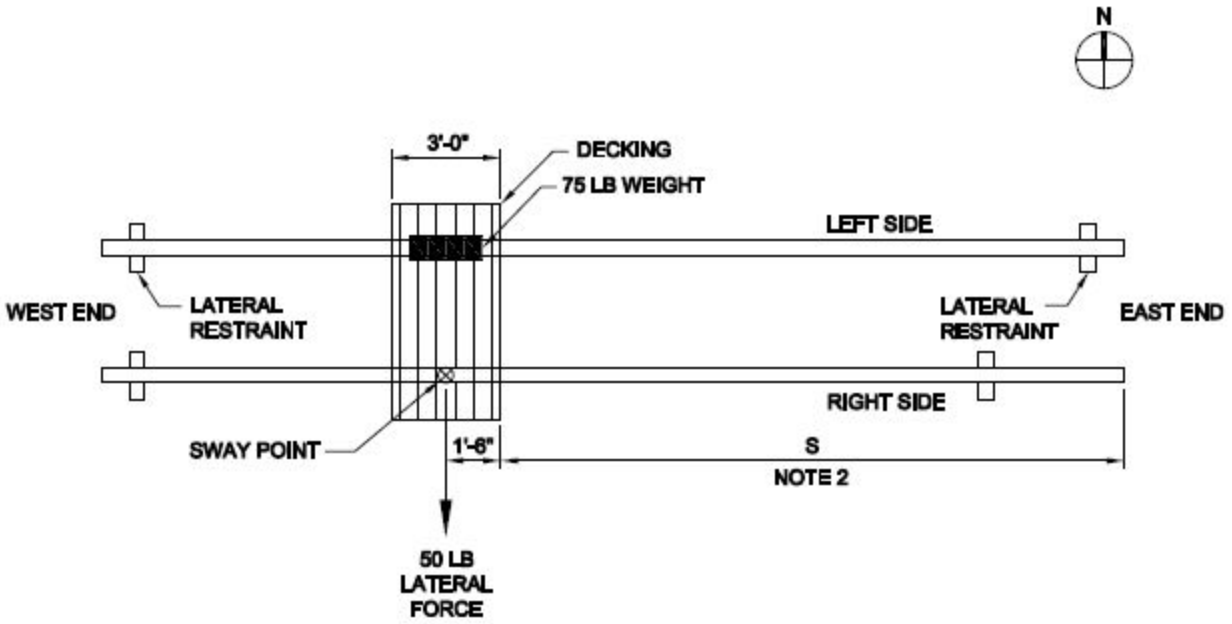
AISC
2019 STUDENT STEEL BRIDGE COMPETITION

NO.	DATE	DESCRIPTION

PROJECT NO:	DRAWN BY:
2019	EJB
DATE: 01/01/2019	CHECKED BY: CRC

DRAWING TITLE: BRIDGE ELEVATION

DRAWING NUMBER: DWG 2



1 LATERAL LOAD TEST PLAN

NOTES:
1. DRAWING NOT TO SCALE
2. DECKING LOCATION "S" IS RANDOMLY DETERMINED AND IS THE SAME FOR ALL BRIDGES.
3. RIGHT AND LEFT SIDES ARE RELATIVE TO TRAVEL FROM WEST TO EAST.
4. LOCATIONS OF LATERAL PULL, LATERAL RESTRAINT, AND SWAY MEASUREMENTS ARE SPECIFIC TO LEFT AND RIGHT SIDES (11.4).

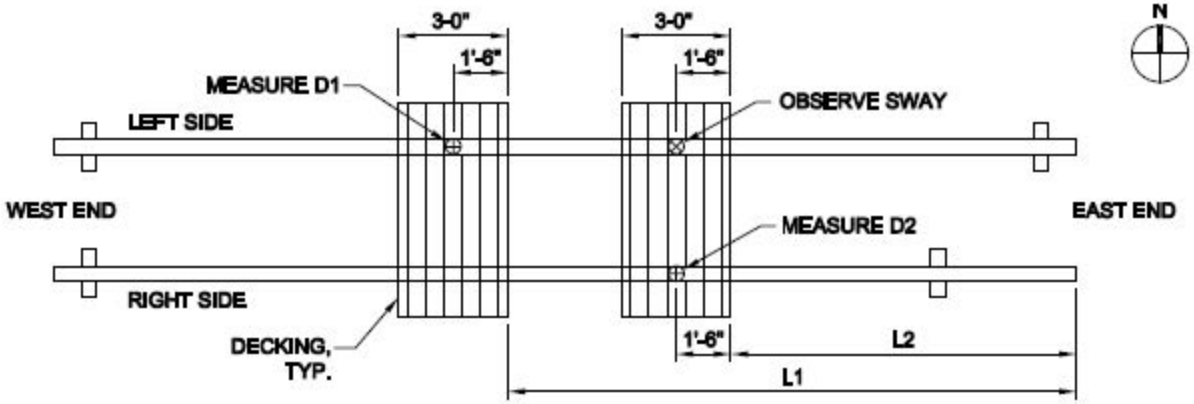
AISC
2019 STUDENT STEEL BRIDGE COMPETITION

NO.	DATE	DESCRIPTION

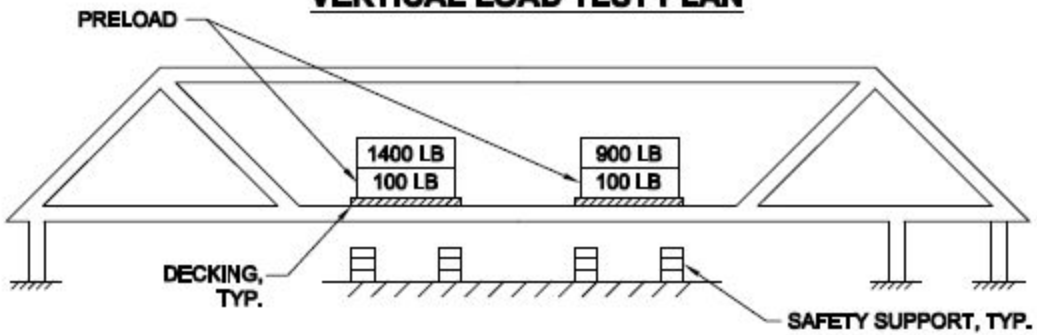
PROJECT NO: 2019	DRAWN BY: EJB
DATE: 01/01/2019	CHECKED BY: CRC

DRAWING TITLE: LATERAL LOAD TEST PLAN

DRAWING NUMBER: DWG 3



VERTICAL LOAD TEST PLAN



VERTICAL LOAD TEST ELEVATION

1 VERTICAL LOAD TEST PLAN AND ELEVATION

NOTES:

1. DRAWINGS ARE NOT TO SCALE
2. DECKING LOCATIONS "L1" AND "L2" ARE RANDOMLY DETERMINED AND ARE THE SAME FOR ALL BRIDGES.
3. DECKING LOCATIONS "L1" AND "L2" ARE MEASURED FROM THE EAST END.
4. LEFT AND RIGHT SIDES ARE RELATIVE TO NORTH AND SOUTH SIDES.
5. SAFETY SUPPORTS ARE REQUIRED UNDER BOTH DECKING UNITS AT ALL TIMES.
6. THE 100 LB PRELOAD IS PLACED FIRST, FOLLOWED BY INITIALIZATION OR INITIAL READINGS OF DEFLECTION AND SWAY MEASURING DEVICES.
7. THE PRELOAD REMAINS IN PLACE, AND 1400 LB OF LOAD IS PLACED ON THE DECKING UNIT LOCATED AT "L1", FOLLOWED BY 900 LB OF LOAD ON THE DECKING UNIT LOCATED AT "L2".
8. LOCATIONS OF DEFLECTION AND SWAY MEASUREMENTS ARE SPECIFIC TO THE LEFT AND RIGHT SIDES (11.5.1.3)
9. DEFLECTIONS D1, D2, AND SWAY ARE MONITORED CONTINUOUSLY.
10. STOP LOADING IF ANY DEFLECTION EXCEEDS 3 IN. OR SWAY EXCEEDS 1 IN.
11. DEFLECTIONS ARE RECORDED AFTER ALL LOAD IS IN PLACE.

AISC
2019 STUDENT STEEL BRIDGE COMPETITION

NO.	DATE	DESCRIPTION

PROJECT NO:	DRAWN BY:
2019	EJB
DATE: 01/01/2019	CHECKED BY: CRC

DRAWING TITLE: VERTICAL LOAD TEST PLAN AND ELEVATION

DRAWING NUMBER: DWG 4