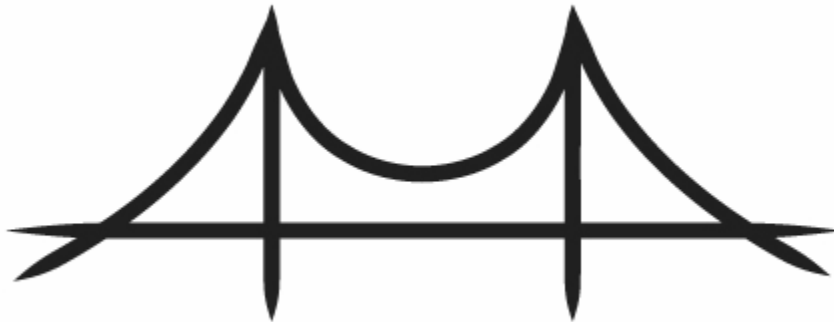




**STUDENT STEEL BRIDGE COMPETITION**

**2011 RULES**



## **MISSION**

The mission of the Student Steel Bridge Competition (SSBC) is to supplement the education of civil engineering students with a comprehensive, student-driven project experience from conception and design through fabrication, erection, and testing, culminating in a steel structure that meets client specifications and optimizes performance and economy. The SSBC increases awareness of real-world engineering issues such as spatial constraints, material properties, strength, serviceability, fabrication and erection processes, safety, aesthetics, and cost. Success in inter-collegiate competition requires effective teamwork and project management. Future engineers are stimulated to innovate, practice professionalism, and use structural steel efficiently.

## **SPONSORS**

Sponsors of the Student Steel Bridge Competition are

- American Institute of Steel Construction (AISC)
- American Society of Civil Engineers (ASCE)

Co-sponsors are

- American Iron and Steel Institute (AISI)
- Bentley Systems, Inc.
- Canadian Institute of Steel Construction (CISC)
- James F. Lincoln Arc Welding Foundation
- National Steel Bridge Alliance (NSBA)
- Nelson Stud Welding
- Nucor Corporation
- Steel Structures Education Foundation (SSEF)

## TABLE OF CONTENTS

	<u>page</u>
1. Introduction	4
2. Executive Summary	5
3. Problem Statement	6
4. Eligibility	7
5. Rule Changes	9
6. Safety	9
7. Scoring	10
8. Schedule of Competition	12
9. Dimensions and Support	14
10. Material and Components	17
11. Construction	19
12. Load Tests	26
13. Equipment Provided by Host	32
14. Interpretation of Rules	34
15. Judging	34
16. Appeals	34
17. Summary of Scoring	36
18. Index of Definitions	39
APPENDIX	
Site and Bridge Diagram	40
Bridge Loading Diagram	41

**Any revisions to the rules in this document are incorporated in clarifications that are published at the bridge competition web site, <http://www.aisc.org/steelbridge>. Revisions and clarifications do not appear in this document but are considered formal addenda to the Rules.**

## Section 1

### INTRODUCTION

Students design and erect a steel bridge by themselves but may seek advice from faculty and student organization advisers. Students gain maximum benefit if they fabricate the entire bridge themselves. However, because appropriate shop facilities and supervision are not available at all universities, students may use the services of a commercial fabricator provided that they develop the work orders and shop drawings, and observe the operations. Students are encouraged to maximize their involvement in fabrication.

Safety is of primary importance. AISC and ASCE request that competitors, advisers, hosts, and judges take all necessary precautions to prevent injury to competitors, judges, host personnel, and spectators.

This document describes the competition and states the rules for competitions conducted during 2011 at both conference and national levels. It is available at <http://www.aisc.org/steelbridge>, together with revisions, clarifications, other information, and the form for submitting requests for clarifications. Information at this site takes priority over any other source except as noted herein.

The rules are changed every year to enhance the competition 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 14, "Interpretation of Rules."

Competitors, judges, and host personnel are encouraged to read this Rules document thoroughly from beginning to end and then review the Competition Guide at <http://www.nssbc.info>. That site also is the source of the official scoring spreadsheet which generates forms for recording data. Judges should be familiar with these forms prior to the competition.

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## Section 2

### EXECUTIVE SUMMARY

Civil Engineering students are challenged to an inter-collegiate competition that includes design, fabrication, and construction of a scaled steel bridge. Participating students gain practical experience in structural design, fabrication processes, construction planning, organization, project management, and teamwork.

The rules of the competition 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.

Standards for strength, durability, constructability, usability, functionality, and safety reflect the volumes of regulations that govern the design and construction of full-scale bridges. Criteria for excellence are represented by the award categories of stiffness, lightness, construction speed, display, efficiency, and economy. Competition judges and the Rules Committee take the role of the owner and have the authority to accept and reject entries.

The safety of competitors, judges, host personnel, and spectators is paramount. Risky procedures are prohibited. Load testing is stopped if sway or deflection exceed specified limits, or if collapse is deemed imminent in the opinion of the judges. 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 rules of the competition accommodate a variety of designs and allow innovation. Designers must consider carefully the comparative advantages of various alternatives. For example, a truss bridge may be stiffer than a girder bridge but slower to construct. Successful teams analyze and compare alternative designs prior to fabrication using value analysis based on scoring criteria.

The Student Steel Bridge Competition provides design and construction planning experience, an opportunity to learn fabrication procedures, and the excitement of networking with and competing against students from other colleges and universities.

## Section 3

### PROBLEM STATEMENT

A new road in a state park will facilitate travel across the park and improve access to remote areas. A bridge will be constructed over a scenic river and also will carry utilities to a new welcome center and camp ground.

The Park Commission has requested design/build proposals for the new bridge. A deck bridge is specified to minimize visual impact. The bridge must provide clearance for recreational boating and longitudinal passageways for utilities.

Steel is specified as the material because of its fast erection and exceptional sustainability rating, based on durability and high level of recycled content. The bridge must be able to carry specified patterns of loads without exceeding sway and deflection limits. Based on past experience with performance and maintenance, the Commission prefers bridges that are relatively light and stiff.

Concern for the environment is essential. To protect the river and adjacent wetland, permanent supports shall be placed only on natural levees along the two banks of the river. Consequently, there must be a cantilever span over the wetland. However, temporary piers may be used anywhere during construction. Construction barges are allowed in the river but terrestrial equipment shall operate from only one side of the river. The wetland is too shallow for barges and too soft for terrestrial equipment. Stock piles of material are restricted to an existing parking lot, and the weight of transported loads is limited to minimize soil compaction.

Your company's design/build proposal is among those that the Park Commission has deemed responsive, and winning the contract would be a step toward becoming a leader in the short-span bridge market. Each competing firm is requested to submit a 1:10 scale model to demonstrate its concept. Models will be erected under simulated field conditions and then load tested. A panel of consulting engineers and park commissioners will judge the models by multiple criteria including durability, constructability, usability, stiffness, construction speed, efficiency, economy, and display. The contract will be awarded to the company whose model best meets the specified needs and requirements. 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 rejection of the model and termination of the company's eligibility.

## **Section 4**

### **ELIGIBILITY**

#### **4.1 LEVELS OF COMPETITIONS**

There are two levels of competition: conference and national. Conference competitions are held in conjunction with ASCE annual student conferences.

#### **4.2 CONFERENCE COMPETITIONS**

**4.2.1** Only one bridge per college or university may compete in an ASCE student conference, and a college or university may compete in only one ASCE student conference.

**4.2.2** The ASCE student organization that is hosting a conference may invite guest teams, which are teams from colleges or universities that do not have ASCE student organizations, or from official ASCE student organizations that are assigned to different conferences. Conference assignments are listed in the ASCE Official Register.

**4.2.3** A team shall consist only of undergraduate and graduate students in good standing with their ASCE student organization. This requirement is waived for guest teams.

**4.2.4** The official scoring spreadsheet shall be used, and all teams (including guest teams) shall be listed on that spreadsheet. The official scoring spreadsheet may be downloaded from <http://www.nssbc.info>.

**4.2.5** The completed official scoring spreadsheet for a conference competition shall be submitted to [aftbq@uaa.alaska.edu](mailto:aftbq@uaa.alaska.edu) before teams from that conference will be invited to the National Student Steel Bridge Competition (NSSBC).

#### **4.3. NATIONAL COMPETITION**

**4.3.1** A team is not eligible to be invited to compete in the NSSBC if it is

- (1) a guest team as defined in 4.2.2, or
- (2) from an organization that is not in good standing with ASCE, or
- (3) from an organization that has not satisfied ASCE requirements regarding participation in its conference, or
- (4) ruled to be ineligible to complete its conference competition.

ASCE requirements for good standing and for conference participation are reprinted in 4.4 but are subject to change.

**4.3.2** The maximum number of eligible teams from a conference that will be invited to compete in the NSSBC is based on the number of teams at that conference that competed (that is, presented bridges and commenced timed construction) but not including guest teams as defined in 4.2.2.

- (1) Only the single best scoring eligible team will be invited from a conference in which two, three or four non-guest teams competed.
- (2) The two top scoring eligible teams will be invited from a conference in which five to ten non-guest teams competed.
- (3) The three top scoring eligible teams will be invited from a conference in which eleven or more non-guest teams competed.

**4.3.3** Teams are not invited to compete in the NSSBC as guests.

**4.3.4** Only one bridge per college or university may be entered in the NSSBC.

**4.3.5** A team must consist only of members who are or were students in good standing with their ASCE student organization during all or part of the academic year leading up to the NSSBC.

#### **4.4 ASCE NATIONAL COMPETITION ELIGIBILITY REQUIREMENTS**

ASCE requirements for good standing and for conference participation, as they existed in July, 2010, are reprinted in this sub-section (4.4) but are subject to change. The current version is at <http://www.asce.org/Content.aspx?id=21594>. ASCE has sole authority for determining and enforcing these requirements; questions should be sent by e-mail to [student@asce.org](mailto:student@asce.org).

“In order to facilitate broader participation by ASCE Student Organizations in Student Conference activities, the ASCE Committee on Student Activities (CSA) stresses the importance of the conference as an event that is much more than a qualifying round for national competitions and highlights the required events at a conference. As such, the following qualifications are required of all ASCE Student Organizations in order to participate in an ASCE-sponsored National Competition.

An ASCE Student Organization must:

- Be in good standing with ASCE (annual report and annual dues submitted and received by ASCE prior to the start of the Student Conference).
- Attend and participate in their assigned Student Conference as shown through their school's:
  - a) Good faith participation in the Student Conference Business Meeting (i.e. on time attendance by at least one student representative);



- b) Good faith participation in the Student Conference Paper Competition (i.e. submission and presentation by at least one member of the ASCE Student Organization); and
- c) Meeting any additional requirements of Student Conference participation set by the Student Conference at the previous year's business meeting or in their written and approved by-laws, standing rules, or constitution.

**Note:** *The concrete canoe design paper/oral presentation does not count as an entry into the Student Conference Paper Competition.*

## Section 5

### RULE CHANGES

The following items in this section (5) identify some of the major changes from the 2010 rules. Not all changes are included. Contestants, hosts, and judges are cautioned to **read this entire document carefully and disregard rules and clarifications from previous years.**

- (1) One end of the bridge must be cantilevered.
- (2) Bridge dimensions are different.
- (3) Size limits for members are different.
- (4) A fastener shall not connect more than two members.
- (5) In the construction site, footings are replaced with foundation easements.
- (6) Size limit for tools is different.
- (7) The constructed portion may be modified during timed construction.
- (8) Lateral and vertical load magnitudes and locations are different.
- (9) Sway and vertical deflection limits are different.

## Section 6

### SAFETY

Safety has the highest priority. Judges are empowered to halt any activity that they deem hazardous. Judges will stop construction procedures that could cause personal injury. A bridge that cannot be constructed and loaded safely is not eligible for awards in any category and must be withdrawn from participation. Judges will not allow additional load to be placed on a bridge that has collapsed, that is approaching a collapse that could be dangerous, or that has swayed or deflected in excess of limits specified in section 12, "Load Tests."

## **Section 7**

### **SCORING**

#### **7.1 RECORDING DATA AND SUBMITTING SCORES**

Scoring data should be recorded for every team that competes, using forms printed from the official scoring spreadsheet downloaded from <http://www.nssbc.info>. Data from those forms are then entered on the spreadsheet. After all scoring information has been collected for a team, the scoring official reviews data entry with the captain of that team. The team captain is given adequate time to verify the data.

The completed official scoring spreadsheet for a conference competition shall be submitted to [aftbq@uaa.alaska.edu](mailto:aftbq@uaa.alaska.edu). Conference results are not final until the spreadsheet is submitted by the host organization. Questions and comments regarding the spreadsheet should be sent to [aftbq@uaa.alaska.edu](mailto:aftbq@uaa.alaska.edu).

Teams are encouraged to download, understand, and verify the spreadsheet before the competition. The spreadsheet also is useful for a team to compare alternative designs and construction procedures.

#### **7.2 CATEGORIES OF COMPETITION**

**7.2.1** Categories of competition are display, construction speed, lightness, stiffness, construction economy, and structural efficiency. In addition, overall performance is rated. A bridge that was not approved for load testing is not eligible for awards in any category.

##### **7.2.2 Display**

**7.2.2.1** Display is the tie-breaker for all categories of competition. Judges shall not declare ties in display. The bridge is displayed exactly as it will be erected during timed construction. Display is judged by the following criteria

**7.2.2.2** Appearance of 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.

**7.2.2.3** Permanent identification of the bridge consisting of the name of the college or university exactly as shown on the ASCE student web site, <http://www.asce.org/Content.aspx?id=14843>. The name must appear on the bridge with all letters at least one inch high. The name must be formed from steel or applied to steel with paint or decals. A thirty-pound weight penalty will be imposed if the bridge lacks appropriate identification.

#### **7.2.2.4** Poster describing design. The poster must

- (1) be flat with maximum dimensions of two by three feet and must present all information on one side without attached pages that must be lifted or turned,
- (2) identify the college or university with the same name that appears on the bridge,
- (3) be illustrated with a scaled, dimensioned side view of the bridge,
- (4) present a brief explanation of why the overall configuration of the bridge was selected,
- (5) include a brief computation demonstrating design for one limit state,
- (6) discuss provisions for sustainability, if any, for example, by listing or designating on the drawing those parts of the bridge that were salvaged from previous bridges or projects, or obtained from salvage yards, and
- (7) acknowledge university technicians, faculty, and others who helped fabricate the bridge or provided advice.

Additional information may be included. Names of financial sponsors may be shown on the poster or on an optional second poster that could accommodate their logos. Electronic displays, decorated supports, lights, and sound are not permitted and will result in the worst possible rating for the poster. A fifty-pound weight penalty will be imposed if there is no poster or if it is grossly inadequate. The poster is not part of the bridge but must be in place whenever the bridge is on display.

#### **7.2.3 Construction Speed**

The bridge with the lowest total time will win in the construction speed category. Total time is defined as the time required for construction modified by penalties prescribed in 11.4, 11.8.1, 12.2, 12.4, 12.5, and 12.6, plus 150% of repair time modified by penalties prescribed in 11.4 and 11.8.1 (see 11.10). There is an upper limit on construction time (see 11.8.2).

#### **7.2.4 Construction Economy**

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

$$C_c = \text{Total time (minutes)} \times \text{Number of builders (including barges)} \\ \times \$50,000 \text{ per builder-minute} \\ + \$30,000 \text{ for each temporary pier in the staging yard.}$$

Total time is defined in 7.2.3 and includes penalties. The number of builders includes all members and associates of the competing organization who are within the construction site or physically assist the team at any time during timed construction or repair.

### **7.2.5 Lightness**

The bridge with the least total weight will win in the lightness category. Total weight is the weight of the bridge plus weight penalties prescribed in 7.2.2, 9.3, 9.4, 10.2, 12.4, 12.5, and 12.6. Decking, tools, temporary piers, and posters are not included in total weight.

### **7.2.6 Stiffness**

The bridge with the lowest aggregate deflection will win in the stiffness category. Aggregate deflection is determined from measurements as prescribed in 12.5, or is a penalty value prescribed in that sub-section and in 12.4 and 12.6.

### **7.2.7 Structural Efficiency**

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

$$C_s = \text{Total weight (pounds)} \times \$4000 \text{ per pound} \\ + [\text{Aggregate deflection (inches)}]^{1.5} \times \$1,200,000.$$

Total weight is defined in 7.2.5 and includes penalties. Aggregate deflection is defined in 7.2.6 and includes penalties.

### **7.2.8 Overall Performance**

The overall performance rating of a bridge is the sum of construction cost and structural cost, ( $C_c + C_s$ ). The bridge achieving the lowest value of this total wins the overall competition.

## **Section 8**

### **SCHEDULE OF COMPETITION**

In the months before the competition, students design their bridges, fabricate members, test load, practice construction, and select the captain and builders for timed construction. The following events occur during the competition

- (1) Bridges are erected for public viewing and are judged for display. After the start of display judging, bridges must not be altered, modified, or enhanced in any way except for disassembly, timed construction, and repairs as described in 11.10.
- (2) Bridges are disassembled.
- (3) In a meeting at which all team captains are present, the head judge clarifies rules and conditions of the competition and answers questions.
- (4) The head judge selects the location of the load on the back span and the locations of two of the three vertical deflection targets. See 12.5.1 and the Vertical Load Test elevations on the Bridge Loading Diagram. Selection is done in the presence of the team captains by rolling a die twice. For each possible result S1 of the first roll, Table 8.1 gives the

dimension L for positioning the load on the back span and the dimension TB for placing the vertical deflection target on the back span.

**TABLE 8.1 Determination of L and TB from first roll of die**

S1	1	2	3	4	5	6
L	0	3'0"	6'0"	7'0"	9'0"	12'0"
TB	3'0"	6'0"	9'0"	7'0"	9'0"	12'0"

For each possible result S2 of the second roll, Table 8.2 gives the dimension TC for placing the vertical deflection target on the cantilever.

**TABLE 8.2 Determination of TC from second roll of die**

S2	1	2	3	4	5	6
TC	1'0"	1'6"	1'6"	2'0"	2'0"	2'6"

The same locations will be used for all bridges in the competition.

- (5) Bridge members, fasteners, tools, and temporary piers are staged for construction and inspected by the judges. See section 10, "Materials and Components," 9.4.4, 9.4.5, 11.2, and 11.6 for details.
- (6) Timed construction. See section 11, "Construction," for details.
- (7) Judges inspect assembled bridges. For details, see section 9, "Dimensions and Support," (including 9.4.4 and 9.4.5 as they apply to installation of fasteners), 10.1.3 and 10.1.4.
- (8) Bridges are weighed (if it is impractical to weigh the entire bridge, its parts may be weighed prior to construction).
- (9) Load testing. See section 12, "Load Tests," for details.
- (10) Scores and rankings are determined using the official scoring spreadsheet found at [www.nssbc.info](http://www.nssbc.info).
- (11) The host ASCE student organization submits the completed official scoring spreadsheet by e-mailing it to the address given on that spreadsheet.
- (12) Copies of the summary score sheets are distributed to all teams or posted on the conference host's web site.

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

- (1) Bridges are not modified after selection of the load location.
- (2) Bridges are not modified between display 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 repairs as described in 11.10.

## Section 9

### DIMENSIONS AND SUPPORT

#### 9.1 MEASUREMENT

Dimensions and support will be checked with the bridge in its as-built condition after construction and repairs are completed and before the bridge is moved from the construction site or load tested. The bridge must not be modified or distorted from its as-built condition in order to satisfy dimension and support rules. Dimensions will be checked without decking or applied load on the bridge.

#### 9.2 FUNCTIONALITY AND SAFETY

**9.2.1** If any of the following rules in this sub-section (9.2) is violated, the bridge will not be approved for load testing and will not be eligible for awards in any category.

**9.2.2** The back span is the part of the bridge that has supports at both ends. The back span must span the river completely without touching it. See the Site Plan on the Site and Bridge Diagram. However, 9.3.12 prescribes a penalty in lieu of ineligibility for a deviation within the limits set by 9.3.1.

**9.2.3** The cantilever is the part of the bridge that has support at only one end. The bridge must be cantilevered over the wetland. However, 9.3.2 and 9.3.4 prescribe penalties in lieu of ineligibility for deviations within the limits set by 9.3.1.

**9.2.4** The bridge must provide support for the decking along both of the edges that run in the span direction of the bridge. Each of these two decking support surfaces must be smooth, continuous, and extend for the full overall length of the bridge. See the Elevation on the Site and Bridge Diagram. However, 9.3.3, 9.3.7, and 9.3.8 prescribe penalties in lieu of ineligibility for deviations within the limits set by 9.3.1.

**9.2.5** The bridge must provide access for safely placing the decking and load.

**9.2.6** The decking must not be attached or anchored to the bridge, and it must not be used to distort the bridge from its as-built condition.

**9.2.7** The bridge must not be anchored or tied to the floor.

**9.2.8** It must be possible to construct and load the bridge safely using the site and equipment provided by the host student organization. **Bridges must accommodate local conditions.**

### **9.3 USABILITY**

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

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

- (1) 50 pounds for a dimensional violation of ½ inch or less
- (2) 150 pounds for a dimensional violation greater than ½ inch but not exceeding 1.0 inch
- (3) 300 pounds for a dimensional violation greater than 1.0 inch but not exceeding 2.0 inches
- (4) If a dimensional violation exceeds 2.0 inches, the bridge will not be approved for load testing and will not be eligible for awards in any category.

**9.3.2** The decking support surfaces at the end of the bridge that is not cantilevered shall not extend beyond the edge of the foundation easement that is farthest from the river.

**9.3.3** Parts of the bridge (including fasteners and parts that bear on the foundation easement) must not extend beyond the vertical plane defined by the ends of the decking support surfaces at each end of the bridge.

**9.3.4** The length of each decking support surface shall not be less than 21 feet nor greater than 22 feet.

**9.3.5** The inner edges of the two decking support surfaces shall be no less than 2'6" from one another, as measured perpendicularly to the span of the bridge. At no point within this separation shall any part of the bridge be above a plane located 3½ inches below the decking support surfaces.

**9.3.6** The outer edges of the two decking support surfaces shall be no more than 3'0" apart, as measured perpendicularly to the span of the bridge. At no point beyond these limits shall any part of the bridge be above a plane located 3½ inches below the decking support surfaces

**9.3.7** The decking support surfaces must be smooth, without vertical protrusions or abrupt changes in elevation. This rule may be checked by sliding a decking unit or template along the full overall end-to-end length of the decking support surfaces, in either or both directions. The rule is violated if the progress of the decking unit or template is impeded.

**9.3.8** A gap is a discontinuity or depression that extends laterally across the full width of a decking support surface. No gap shall exceed ¼ inch measured in the span direction of the bridge.

**9.3.9** The decking support surfaces must be no more than 2'9" above the surface of the river or ground (including the wetland) at any point. See the Elevation on the Site and Bridge Diagram.

**9.3.10** Vertical clearance must be provided under the bridge at all points directly over the river and ground (including the wetland) except directly over the foundation easements. The clearance must be at least one foot high, measured from the surface of the river or ground (including the wetland). See the Elevation on the Site and Bridge Diagram.

**9.3.11** A straight passageway under the bridge must traverse it completely from end to end. It must be at least 1'6" high measured from the surface of the river and ground (including the wetland), and must be at least 2'6" wide measured perpendicularly to the span of the bridge. See Section B on the Site and Bridge Diagram.

**9.3.12** Regardless of any reason other than that allowed by 11.4.1, after timed construction and repair the bridge shall bear only on the ground within the foundation easements. See the Site Plan on the Site and Bridge Diagram.

#### **9.4 MEMBER-TO-MEMBER CONNECTIONS**

**9.4.1** Violations of the rules in this sub-section (9.4) will result in penalties being added to the weight of the bridge. The penalty for each violation is 25 pounds.

**9.4.2** Each member must be connected directly to every member that it touches by at least one fastener installed during timed construction so that the connection cannot be taken apart without first turning the nut or the bolt and removing the nut from the bolt. Definitions of "member" and "fastener" are given in 10.2.3 and 10.2.4, respectively.

**9.4.3** No fastener shall connect more than two members.

**9.4.4** The bolt must penetrate completely through a hole in each of the members that it connects. Dimension(s) of the hole must be small enough so that neither the head of the bolt nor the nut specified in 10.2.4 can pass through the hole.

**9.4.5** The hole for a fastener shall not be threaded. It must be possible to install and remove the bolt without turning it. A nut welded to a member constitutes a threaded hole.

**9.4.6** The bolt must fully engage the threads of the nut. That is, the end of the bolt must extend beyond, or be flush with, the outer surface of the nut.



## Section 10

### MATERIAL AND COMPONENTS

#### 10.1 SAFETY

**10.1.1** If any one of the rules in this sub-section (10.1) is violated, the bridge will not be approved for construction or load testing, and will not be eligible for awards in any category.

**10.1.2** A member must not weigh more than twenty pounds. See 10.2.3 for definition of “member.”

**10.1.3** A bridge must not incorporate an electric, electronic, fluidic, or other non-mechanical sensor or control system; a non-mechanical energy transmission device such as a wire, duct, or tube; an energy conversion or storage device such as an electromagnet, electric cell, motor, hydraulic or pneumatic piston, turbine, chemical reactor, pressure vessel, pre-loaded spring, or triggering device.

**10.1.4** After completion of construction and repair, energy shall not be transmitted to or from a bridge (for example, by applying or releasing mechanical, magnetic, fluidic, or other force; by sound, light, radio, or other wave or ray; by conduction or convection of heat; or by electric current). The exceptions are forces necessary to the competition (for example, those associated with load testing and with moving the bridge from place to place), and changes in ambient conditions that are not controlled by competitors (such as wind, temperature, and lighting).

#### 10.2 DURABILITY AND CONSTRUCTABILITY

##### 10.2.1 Penalties

Violation of the rules in this sub-section (10.2) will result in penalties being added to the weight of the bridge. The penalty is 25 pounds for each member or fastener that is in violation.

##### 10.2.2 Bridge

A bridge must be constructed only of structural steel members and fasteners. For the purposes of this competition, structural steel is defined as an iron alloy that is strongly attracted to the magnet provided by the host organization. Solder, brazing, and structural adhesives are not permitted. Exceptions: Purely decorative items such as coatings and decals are permitted, and bridge parts may be labeled.

### **10.2.3 Members**

**10.2.3.1** A member is a rigid steel component. A member must retain its shape, dimensions, and rigidity during timed construction and load testing. Hinged, jointed, articulated, and telescoping members are prohibited, as are those with parts that move. This prohibition includes members with parts that are intended to slide, rotate, deflect, or bend relative to the member such as cams, latches, sliding pins, springs, and snap-lock devices. Also prohibited are members incorporating hinges or other devices that do not restrain rigid-body rotation or translation of one part of the member relative to another part. Exception: Deformations caused by mechanical strain (e.g., bending, stretching) during construction and load testing are not violations.

**10.2.3.2** A member must not exceed overall dimensions of 3'0" x 6" x 4". That is, it must fit in a prismatic box of those dimensions.

**10.2.3.3** A member may consist of multiple parts rigidly joined together before timed construction begins. Those parts must remain rigidly joined throughout timed construction and in the completed bridge. Parts shall be joined by welding or with steel connectors such as bolts, screws, and rivets. If nuts are used, their threads must be fully engaged (that is, the end of the bolt or threaded stud must be flush with or extend beyond the outer face of the nut).

### **10.2.4 Fasteners**

**10.2.4.1** A fastener is a steel bolt that is not part of a member, with a steel nut that is not part of a member. Grade and diameter are not restricted. Specialty and custom fabricated bolts and nuts are prohibited. A bolt or nut that is welded to a member does not qualify as part of a fastener

**10.2.4.2** The bolt in a fastener must be no more than 1½-inch nominal length (bottom of head to end) with a hexagonal head. Bolts must be commercially-available tap bolts, machine bolts, or cap screws. Bolts shall not be mechanically altered or modified in any way but may be painted.

**10.2.4.3** The nut for a fastener must match the bolt. That is, the nominal size (inside diameter) must be the same as that of the bolt and the threads of the nut must fully engage the threads on the bolt and permit the nut to be turned onto the bolt. Nuts must be solid and hexagonal, and must be available commercially. Only one bolt and nothing else shall be threaded into a nut. Nuts must not be mechanically altered or modified in any way but may be painted.

**10.2.4.4** Nuts and bolts that connect the parts of a member but do not connect a member to other members are not considered to be fasteners and are not governed by the preceding provisions of this sub-sub-section (10.2.4).

## **Section 11**

### **CONSTRUCTION**

#### **11.1 DEFINITIONS**

**11.1.1** “River,” “wetland,” “staging yard,” “foundation easement,” “moorage” and “construction site boundary” are delineated by the Site and Bridge Diagram.

**11.1.2** “Ground” is the floor inside the construction site boundary, except for the river. Ground includes the wetland and foundation easements.

**11.1.3** “Builders” are undergraduate or graduate student members of a competing student organization. See section 4, “Eligibility.”

**11.1.4** A “barge” is a builder who is designated to begin, remain, and end timed construction in the river. Builders cannot be designated as barges after the start of timed construction and builders so designated remain barges for the duration of timed construction. The use of barges is optional. Barges are counted as builders.

**11.1.5** A “team” is all the builders from the competing organization who are within the construction site boundary during timed construction. The team shall include no more than six builders. No more than three of those builders shall be designated as barges.

**11.1.6** “Personal protective equipment” consists of a hardhat meeting ANSI standard Z89.1 and protective eyewear or safety goggles meeting ANSI standard Z87.1. A team provides its own personal protective equipment.

**11.1.7** A “tool” is a device that is used to construct the bridge and is not part of the completed bridge. A team provides its own tools.

**11.1.8** “Member” and “fastener” are defined in 10.2.3 and 10.2.4, respectively. “Member-to-member connection” is defined in 9.4.

**11.1.9** A “pouch” is an optional article of clothing that may be used to carry fasteners and tools. This definition encompasses tool belts and other accessories worn by builders and having the same function.

**11.1.10** “Temporary piers” are optional devices that bear on the river or ground (including the wetland), and are used to support the constructed portion of the bridge during timed construction. They have no other purpose, are not tools, and are not part of the completed bridge. A team provides its own temporary piers, which must be labeled “pier.” The construction cost,  $C_c$ , includes an increment for every temporary pier in the staging yard at the start of the inspection described in item 5 of section 8, “Schedule of Competition.”

**11.1.11** To be “moored” means that a barge is in the river with one foot on a portion of the line marking the edge of the river that is designated as a moorage. Only one barge can be moored at each moorage.

**11.1.12** The “constructed portion” is comprised of members and fasteners and is created during timed construction. The constructed portion is not required to be contiguous.

## **11.2 GENERAL SAFETY CONDITIONS**

**11.2.1** Timed construction or repair will not commence or will be stopped if any provision of this sub-section (11.2) is violated.

**11.2.2** Builders, judges, host personnel, and spectators must not be exposed to risk of personal injury.

**11.2.3** Only builders and judges are permitted within the construction site boundary during timed construction and repair. Spectators, including coaches, faculty, advisers, and other associates of the team, must remain in designated areas at a distance from the construction site that assures they are not at risk and cannot interfere with the competition.

**11.2.4** At all times during timed construction and repair every builder must wear personal protective equipment in the proper manner (e.g., hardhat with peak in front).

**11.2.5** Welding machines and tools requiring external power connections must not be used during timed construction or repair.

**11.2.6** A tool must not weigh more than twenty pounds and must not exceed 3’0” in any linear dimension when fully assembled and extended.

**11.2.7** A temporary pier must not weigh more than twenty pounds and must not exceed 1’6” in any horizontal dimension when in use. That is, it should fit inside a vertical cylinder with diameter of 1’6”.

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

## **11.3 SAFE CONSTRUCTION PRACTICES**

**11.3.1** If any rule in this sub-section (11.3) is violated during timed construction or repair, the judge will stop the clock and explain the violation. Before the clock is restarted, builders, tools, members, fasteners, and temporary piers will be returned to the positions they occupied before the violation. Then the team will be asked to resume construction using safe procedures. A team will have the opportunity to construct its bridge safely. However, if the team is not able to construct its bridge completely using safe procedures, construction will cease and the bridge will not be approved for load testing and will not be eligible for awards in any category.

**11.3.2** Construction of every non-contiguous part of the constructed portion shall commence by placing a member on a foundation easement. That member becomes part of the constructed portion. When a member or fastener is placed in contact with the constructed portion it becomes part of the constructed portion and is no longer considered to be a member or fastener.

**11.3.3** A member shall not be in contact with another member but may be in contact with a former member that is now part of the constructed portion.

**11.3.4** Surfaces of the constructed portion that bear on the foundation easements shall be the same surfaces that will bear on the same foundation easements in the completed bridge and, after being placed, must continuously support the constructed portion for the remaining duration of timed construction and repair.

**11.3.5** A member shall not be supported by a temporary pier unless it is simultaneously supported by a builder.

**11.3.6** A temporary pier shall not be moved while it is supporting the constructed portion.

**11.3.7** A builder shall not remove an item of personal protective equipment nor wear it incorrectly (e.g., hardhat with peak in back).

**11.3.8** Throwing anything is prohibited.

**11.3.9** A builder shall not cross from one side to the other of the wetland or from the ground on one side of the river to the ground on the other side.

**11.3.10** Outside the staging yard, a builder shall not contribute simultaneously to moving or supporting more than one of the following items: a member, a temporary pier, the constructed portion, or a non-contiguous part of the constructed portion. In other words, a builder cannot simultaneously move or support more than one of those items.

**11.3.11** A pouch or other article of clothing shall not be removed from a builder's person nor held in a builder's hand(s).

**11.3.12** A builder must not use the bridge, a portion of the bridge, a temporary pier, or a tool to support the builder's body weight. For example, lying, standing, sitting, or kneeling on those objects is prohibited. However, a builder may lean on 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 both feet on the floor.

**11.3.13** A builder must not depend on another builder or builders for support or balance.

## **11.4 ACCIDENTS**

**11.4.1** In general, the clock is not stopped when there is an "accident," i.e., an infraction of one of the provisions of this sub-section (11.4).

A time penalty is assessed for every accident. If an accident is continuous (for example, a builder who is not a barge 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, temporary piers, and fasteners will be returned to the positions they occupied before the accident. Exception: Construction may proceed if it is no longer possible to hold all bearing surfaces within the foundation easements simultaneously. In this situation, the team captain may request that the clock be stopped in order to demonstrate the difficulty to the judge. If the judge is convinced, no additional accidents will be cited for bearing surfaces touching the ground outside the foundation easements (rule 11.4.5), the clock will be restarted, construction will resume, and a penalty will be assessed for a two-inch violation of rule 9.3.12 (even if the bearing surfaces fall within the footings when the bridge is completed).

**11.4.2** A temporary pier falls over or collapses while in use. Penalty is 1/2 minute (30 seconds) for every occurrence.

**11.4.3** A builder who is not a barge or that builder's clothing touches the river, wetland, or floor outside the boundary of the construction site. Penalty is 1/2 minute (30 seconds) for every occurrence. Exception: There is no penalty for stepping out of bounds or entering the river or wetland to retrieve an object that has been dropped, such as a member, tool, nut, bolt, or personal protective equipment.

**11.4.4** A barge or a barge's clothing touches ground (which includes the wetland) or floor outside the boundary of the construction site. Penalty is 1/2 minute (30 seconds) for every occurrence. Exception: There is no penalty for stepping out of bounds or on ground to retrieve an object that has been dropped, such as a member, tool, nut, bolt, or personal protective equipment.

**11.4.5** A member, constructed portion, tool, nut, bolt, or personal protective equipment touches river, ground (which includes the wetland), or floor outside the staging yard. Penalty is 1/4 minute (15 seconds) for every item during every occurrence. Exceptions: (1) There is no penalty for the constructed portion touching the ground within the foundation easements. (2) There is no penalty if a tool used exclusively for measuring touches the ground during use while being held by a builder.

## **11.5 CONSTRUCTION SITE**

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

**11.5.2** Only builders and judges are permitted within the construction site boundary during timed construction. Only judges are permitted near the construction site. Spectators, including coaches, faculty, advisers, and other associates of the team, must observe from areas designated by the judges and host student organization. These areas must be far enough from the construction site so that spectators are not at risk, cannot physically assist builders, and cannot interfere with the competition.

## **11.6 START**

**11.6.1** Before construction begins, only the following items are in the staging yard: all members, fasteners, tools, and temporary piers. Temporary piers must be labeled "pier." Every member, tool, temporary pier, and fastener must be in contact with the ground within assigned areas of the staging yard as designated on the Site and Bridge Diagram. No object shall be in contact with another object except that fasteners may be in contact with other fasteners. Builders who are not barges are in the staging yard. Every barge is moored at a different moorage. Barges start without tools and fasteners, which may be passed to them by other builders after timed construction begins. Builders, including barges, are wearing personal protective equipment as well as optional clothing such as pouches.

**11.6.2** Judges inspect members, tools, fasteners, and temporary piers after the team arranges them in the staging yard and signifies readiness for inspection. After the beginning of inspection and throughout timed construction and repairs, additional members, tools, fasteners, temporary piers, 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.

**11.6.3** Timing and construction begin when one of the builders signifies that the team is ready and the judge declares the start.

## **11.7 TIME**

**11.7.1** 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 rule has been violated (see 11.2 and 11.3), 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 11.4), or
- (4) if a builder or judge is injured.

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

## **11.8 TIME LIMIT**

**11.8.1** If the total of construction time, not including penalties, plus repair time, not including penalties, but factored by 1.5 exceeds thirty minutes, construction time will be counted as 180 minutes for scoring. “Accidents” (11.4) that occur after thirty minutes will not be penalized but safety rules (11.2 and 11.3) will still be enforced. Judges will inform the team when this time limit is approaching and again when it is reached.

**11.8.2** If the total of construction time, not including penalties, plus repair time, not including penalties, but factored by 1.5 exceeds 45 minutes, judges may halt construction or may move the bridge off site for continued, untimed construction if it can be done safely. The bridge will not be eligible for awards in any category.



## **11.9 FINISH**

### **11.9.1** Construction ends and the clock is stopped when

- (1) the bridge has been completed by connecting all the members that were in the staging yard,
- (2) builders who are not barges are back in the staging yard,
- (3) every barge is moored at a moorage, with no more than one barge at each moorage,
- (4) every temporary pier is in the part of the staging yard designated on the Site and Bridge Diagram,
- (5) every tool is held by a builder, or is in clothing worn by a builder, or is on the ground in the part of the staging yard designated on the Site and Bridge Diagram, and
- (6) a builder informs the judge that construction is complete.

**11.9.2** Extra fasteners may be in the designated part of the staging yard or held by or in the clothing of builders.

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

**11.9.4** After construction is finished the bridge must not be modified except for repairs as permitted by 11.10.

## **11.10 REPAIRS**

Before the judges inspect and measure the bridge, and before the bridge is moved from the construction site, two builders will be given one opportunity to inspect the bridge and plan any needed repairs. They will be given five minutes to accomplish this. They shall not modify the bridge and they shall not touch the bridge except as necessary to use measuring devices. Following this inspection, builders will be permitted, but not required, to repair construction mistakes found by their inspectors. Repairs are made with the clock restarted and begin with builders and necessary items arranged in the staging yard as prescribed by 11.6. Safety precautions (11.2 and 11.3) are enforced and accidents (11.4) are counted. The time limits specified in 11.8.1 and 11.8.2 apply. The repair period ends when the conditions listed in 11.9.1 are fulfilled and shall not be resumed. Judges will not inspect the bridge prior to the end of the repair period.

The scoring spreadsheet will multiply the time required to make repairs and any time penalties assessed during repairs by 1.5 and will add that product to the construction time to compute total time.

It is not necessary to inspect, measure, or repair a bridge that exceeded the 45-minute time limit prescribed in 11.8.2.

## **Section 12**

### **LOAD TESTS**

#### **12.1 SAFETY PRECAUTIONS**

An activity will be halted if the judge considers it to be hazardous.

A bridge could suddenly collapse or sway in any direction during load tests. Therefore, the number of people near the bridge while it is being tested shall be minimized. Usually, the load should be placed on the bridge by only two competitors. Competitors who are not participating in loading, faculty, advisers, and other spectators must observe from an area designated by the judges and host student organization.

Load on the cantilever should be placed from the sides; people should be kept clear of the unsupported end of the cantilever.

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

During testing, safety supports must be in place below the decking. The safety supports shall be of sufficient height, strength, number, and extent that none of the load will fall more than approximately six inches if the bridge collapses.

All preparations for load testing, including placement of safety supports, must be completed before any load is on the bridge so that it will not be necessary for anyone to reach, crawl, or step under the loaded bridge. However, if safety supports must be adjusted during loading, the load must first be removed without disturbing the bridge, adjustments made, and the load replaced as it was before being removed.

If team members cannot load their bridge safely, loading will cease and the bridge will not be eligible for awards in any category.

Do not exceed 400 psf uniform load or 500 pounds concentrated load on the decking.

## **12.2 DAMAGE**

A bridge will not be tested in a condition that compromises its strength or stability.

If a nut falls off its bolt while the bridge is being transported or prepared for load testing, or if the threads of a nut are not fully engaged, the connection will be repaired, the nut will be reinstalled correctly, and a penalty of two minutes will be added to construction time for every nut that was reinstalled.

A bridge with damage that would reduce its strength or stability (such as a missing or broken member or fastener) will not be approved for load testing and is not eligible for awards in any category. Repairs are not permitted after commencement of load testing.

## **12.3 PREPARATION**

Temporary piers are not used during load testing.

The judge designates the “A” and “B” sides of the bridge by a random process.

Teams must accept imperfect field conditions such as bent decking and sloping floors.

## **12.4 LATERAL LOAD TESTS**

**12.4.1** The provisions of this sub-section (12.4) are illustrated by the two Lateral Load Test plans on the Bridge Loading Diagram. “Sway” is translation in any horizontal direction.

The lateral load tests are conducted with one unit of decking placed at the center of the back span and approximately 75 pounds of weight on the decking near the “B” side of the bridge. This load is intended to prevent the bearing surfaces of the bridge from lifting off the floor when lateral load is applied.

Bearing surfaces are prevented from sliding by lateral restraint applied as close as possible to the ground at two abutments. This lateral restraint does not restrain rotation of the abutments and is identical for all bridges.

### **12.4.2 Lateral Load Test of the Back Span**

A sway target is established for measurement on the “A” side of the bridge, eight feet from the end of the decking support surface at the end of the bridge that is not cantilevered. The sway target is located as close as possible to the top of the decking support surface, which is the same as the bottom of the decking.

Apply a 75 pound lateral pull at the sway target and measure the sway. To pass the lateral load test, the sway must not exceed 1/2 inch.

If the bridge does not pass this lateral load test it is not approved for further testing. **Do not conduct any other load test.** Check the appropriate box on the judge's data form. The spreadsheet will add a penalty of 900 pounds to the weight of the bridge, a penalty of thirty minutes to the construction time, and will apply an aggregate deflection of thirty inches when the judging data is entered.

If the bridge passes the lateral load test of the back span, proceed with the lateral load test of the cantilever.

### **12.4.3 Lateral Load Test of the Cantilever**

A sway target is established for measurement on the "A" side of the bridge, at the end of the decking support surface at the unsupported end of the cantilever span. The sway target is located as close as possible to the top of the decking support surface, which is the same as the bottom of the decking.

Apply a 75 pound lateral pull at the sway target and measure the sway. To pass the lateral load test, the sway must not exceed 1/2 inch.

If the bridge does not pass this lateral load test it is not approved for further testing. **Do not conduct any other load test.** Check the appropriate box on the judge's data form. The spreadsheet will add a penalty of 900 pounds to the weight of the bridge, a penalty of thirty minutes to the construction time, and will apply an aggregate deflection of thirty inches when the judging data is entered.

If the bridge passes this lateral load test, remove the load and decking, and proceed with the vertical load test.

## **12.5 VERTICAL LOAD TEST**

**12.5.1** The provisions of this section are illustrated by the three Vertical Load Test elevations on the Bridge Loading Diagram.

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

Decking units are three feet long in the longitudinal (span) direction of the bridge. Place one decking unit at a distance  $L$  from the end of the decking support surfaces at the end of the bridge that is not cantilevered.  $L$  is determined at the beginning of the competition as described by Table 8.1 in section 8, "Schedule of Competition." Place the other decking unit at a distance of one inch measured from the end of the decking support surfaces at the unsupported end of the cantilever. Decking units are placed square with the bridge and centered laterally with the main bars spanning laterally over the decking support surfaces. Decking units must not be attached to the bridge and must not distort it (see 9.2.5 and 9.2.6).

Three targets are established for measuring vertical deflections at locations determined by the following dimensions

- TB from the end of the decking support surface at the end of the bridge that is not cantilevered, on the "A" side of the bridge
- TC from the end of the decking support surface at the cantilevered end of the bridge, on the "B" side of the bridge
- One inch from the end of the decking support surface at the cantilevered end of the bridge, on the "A" side of the bridge.

TB and TC are determined at the beginning of the competition as described by Tables 8.1 and 8.2 in section 8, "Schedule of Competition." Vertical deflection targets are located as close as possible to the top of the decking support surface and may be on the bridge or on the decking close to decking support surfaces.

At their discretion, judges may impose a penalty for a bridge that incorporates parts having the primary function of interfering with placement of targets or measuring devices.

Position measuring devices on the three vertical deflection targets.

Uniformly distribute 200 pounds of preload on the decking unit on the back span. Then uniformly distribute 50 pounds of preload on the decking unit on the cantilever span. Preloads are laterally centered on the decking units. Preloads are distributed and aligned identically for every bridge.

If a competitor disturbs a measuring device after it has been initialized and before loading is completed and all measurements have been recorded, the judge will require the team to disassemble the bridge and repeat timed construction beginning with the initial conditions prescribed in 11.6. Scoring will be based on the run that results in the larger construction cost,  $C_c$ , but will not exceed 125% of  $C_c$  for the initial run.

The two steps (increments) of vertical loading produce four measurements

- (1) DB1 = absolute value of vertical deflection at the target on the “A” side of the back span that occurs during step 1 (loading the back span).
- (2) DCA = absolute value of vertical deflection at the target on the “A” side of the cantilever that occurs during step 2 (loading the cantilever with the load from step 1 remaining in place).
- (3) DCB = absolute value of vertical deflection at the target on the “B” side of the cantilever that occurs during step 2 (loading the cantilever with the load from step 1 remaining in place).
- (4) DB2 = absolute value of vertical deflection at the target on the “A” side of the back span that occurs from the beginning of step 1 to the end of step 2.

The scoring spreadsheet computes aggregate deflection as the sum of DCA, DCB, and the larger of DB1 and DB2.

### **12.5.2 Step 1 – Vertical Load Test of the Back Span**

Load the decking unit on the back span and measure the deflection, using the following procedure

- (1) The two preloads remain in place.
- (2) Initialize the sway measurement device on the back span.
- (3) Initialize the sway measurement device on the cantilever.
- (4) Initialize the vertical deflection measuring device on the back span or record the initial reading.
- (5) Team members place 1600 pounds of additional load on the decking unit on the back span. The load is laterally centered on the decking unit and is distributed over the length of the decking unit as uniformly as possible at all times during loading. Load is distributed and aligned identically for every bridge. Load shall be placed at a steady pace, without hesitation.
- (6) As the load is being placed, observe the deflection target on the back span and both sway targets. Stop loading if
  - (a) sway at either sway target exceeds 0.5 inch from the beginning of step 1, or
  - (b) deflection at the deflection target on the back span exceeds 1.5 inches downward from the beginning of step 1, 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. Remove the load and **do not continue load testing**. Check the appropriate box on the judge's data form. The scoring spreadsheet will add an 800-pound penalty to the weight of the bridge, a penalty of thirty minutes to the construction time, and will apply an aggregate deflection of thirty inches when the judging data is entered.

If the bridge passes step 1, record the first measured value DB1.

### 12.5.3 Step 2 – Vertical Load Test of the Cantilever

Load the decking unit on the cantilever span and measure the deflections, using the following procedure

- (1) The two preloads and the load from step 1 remain in place.
- (2) Do **not** initialize the vertical deflection measuring device on the back span.
- (3) Do **not** initialize the sway measurement devices on the back span and cantilever.
- (4) Initialize the vertical deflection measuring devices on the cantilever.
- (5) Team members place 650 pounds of additional load on the decking unit on the cantilever. The load is laterally centered on the decking unit and is distributed over the length of the decking unit as uniformly as possible at all times during loading. Load is distributed and aligned identically for every bridge. Load shall be placed at a steady pace, without hesitation.
- (6) As the load is being placed, observe the three deflection targets and both sway targets. Stop loading if
  - (a) sway at either sway target exceeds 0.5 inch from the beginning of step 1, or
  - (b.1) deflection at the deflection target on the back span exceeds 1.5 inches downward from the beginning of step 1, or
  - (b.2) deflection at either deflection target on the cantilever exceeds 0.5 inch downward from the beginning of step 2, 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.1, b.2, c, d, or e, the bridge is not approved for further load testing. Remove the load and **do not continue load testing**. Check the appropriate box on the judge's data form. The scoring spreadsheet will add a 700-pound penalty to the weight of the bridge, a penalty of thirty minutes to the construction time, and will apply an aggregate deflection of thirty inches when the judging data is entered.

If the bridge passes step 2, record the measured values DCA, DCB and the second measured value DB2.

## **12.6 Unloading**

Remove all load from the cantilever before removing any load from the back span.

If the bridge collapses during unloading (situation c, d, or e), it shall be penalized as if it had failed to pass step 2.

## **Section 13**

### **EQUIPMENT PROVIDED BY HOST**

#### **13.1 SOURCES OF INFORMATION**

The Competition Guide at <http://www.nssbc.info> should be reviewed by judges, host personnel, and competitors. It has detailed descriptions and illustrations of contest procedures and hosting equipment. The following provisions of this section (13) describe some of the equipment that is needed for the competition and is intended to help competitors know what to expect. Competitors should acquire similar equipment for use in practice and testing before the competition.

#### **13.2 FLOOR**

The floor in both the construction site and loading area shall be solid, stable and as nearly flat and level as possible.

#### **13.3 LATERAL LOAD DEVICE**

The lateral load device should be capable of applying a force of 75 pounds in the horizontal direction.

#### **13.4 SWAY MEASUREMENT**

Sway is horizontal translation and is measured at two points by any accurate method. A suggested method is to suspend a plumb bob from the sway target and measure sway from a point marked on the floor.

#### **13.5 DEFLECTION MEASUREMENT**

Deflection is vertical translation and is measured at three points by any accurate method.



### **13.6 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. However, the host may provide a different type of decking with approximately the same dimensions. 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 of the grating that are perpendicular to the length.

### **13.7 SAFETY SUPPORTS**

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

### **13.8 LOAD**

A total load of 2500 pounds should be supplied in uniform pieces of 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 5" x 5" x 5/16" steel angle placed perpendicular to the length of the bridge. Sacks of material, containers of liquid, concrete blocks, or jacking systems could be used. Decking is not included as part of the 2500 pound load.

### **13.9 OFFICIAL SCORING SPREADSHEET AND DATA FORMS**

Results will not be official until the completed official scoring spreadsheet is submitted to [aftbq@uaa.alaska.edu](mailto:aftbq@uaa.alaska.edu) to report outcomes. It may be downloaded at <http://www.nssbc.info>. Judges' forms for recording data are accessed from the spreadsheet.

## **Section 14**

### **INTERPRETATION OF RULES**

The web site <http://www.aisc.org/steelbridge> lists clarifications of the rules. Competitors, judges, and host personnel may submit questions via a form on that web site but should **first read the previously posted clarifications, reread this Rules document carefully in its entirety, and review the Competition Guide** at <http://www.nssbc.info>. Submitters' names and affiliations must accompany clarification requests and will be posted with the questions and answers. Internet 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 2, 2011.

## **Section 15**

### **JUDGING**

The host student organization will recruit judges. Judges are empowered to halt any activity that they deem to be hazardous. Judges have 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 student organization will assure that the judges are fully informed of the Rules and procedures, and fully equipped for their tasks. More information for host organizations and judges is available at <http://www.aisc.org/steelbridge> and at <http://www.nssbc.info>, where the official scoring spreadsheet may be downloaded and the Competition Guide reviewed.

## **Section 16**

### **APPEALS**

#### **16.1 CONFERENCE COMPETITIONS**

**16.1.1** At the beginning of the competition each team will identify its captain. The host organization will identify the conference head judge (CHJ).

**16.1.2** A penalty, decision, measurement, score, or condition of competition may be appealed only by a team captain and only to the CHJ. The CHJ will not hear the appeal if he or she is approached by students other than the team captain. The CHJ 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 CHJ will not hear the appeal if he or she is approached by students other than the team captain. The CHJ will hear the appeal as soon as possible and may interrupt the competition. Participants are reminded that civility and ethical behavior are expected during the competition and particularly concerning appeals.

**16.1.3** After the conference competition, the team captain has the option to appeal the decision of the CHJ by sending an e-mail message to Ms. Maria Mnookin <mnookin@aisc.org> followed by a letter mailed to Ms. Mnookin (AISC, Suite 700, One E. Wacker Dr., Chicago, IL 60601-2001) with a copy mailed to ASCE Student Services (ASCE, 1801 Alexander Bell Dr., Reston, VA 20191-4400). The e-mail message and letter shall include

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

**16.1.4** Appeals must be made by e-mail followed by letter. An appeal will be considered only if the e-mail is received and the letter is postmarked by 5:00 PM Eastern Daylight Saving Time on the Wednesday immediately after the conference competition. Ms. Mnookin will forward the appeal to the SSBC Rules Committee for their evaluation. The Committee will not respond to an appeal until the official scoring spreadsheet for that conference has been submitted by the host organization to [aftbq@uaa.alaska.edu](mailto:aftbq@uaa.alaska.edu). The only redress that may be made is an invitation to participate in the national competition if the Committee is convinced that the appeal is valid and that the appealing team should have qualified for the national competition. Decisions and rankings made by conference judges will not be overturned.

## **16.2 NATIONAL COMPETITION**

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

**16.2.2** A penalty, decision, measurement, score, or condition of competition may be appealed only by a team captain and only to the station head judge (SHJ). The SHJ will not hear the appeal if he or she is approached by students other than the team 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. Participants are reminded that civility and ethical behavior are expected during the competition and particularly concerning appeals.

**16.2.3** After hearing the SHJ's ruling, the team 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.

**16.2.4** If the team has justification to contest the NHJ's ruling, the team 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.

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

## **Section 17**

### **SUMMARY OF SCORING**

#### **17.1 SCORING**

This form summarizes section 7, "Scoring." However, official scoring data shall be recorded on the scoring spreadsheet that is available in the Competition Guide at <http://www.nssbc.info>. That spreadsheet also is useful for a team to compare alternative designs and construction procedures. The completed official scoring spreadsheet for a conference competition shall be submitted to [aftbq@uaa.alaska.edu](mailto:aftbq@uaa.alaska.edu). Conference results are not final until the spreadsheet is submitted by the host organization. Questions and comments regarding the spreadsheet should be sent to [aftbq@uaa.alaska.edu](mailto:aftbq@uaa.alaska.edu).

#### **17.2 DISPLAY**

See 7.2.2 for detailed description. Judges shall not declare ties in display. The following criteria are included

- (1) Appearance: balance, proportion, elegance, finish
- (2) Name of college or university on bridge in letters at least one inch high
- (3) Poster describing design and fabrication, no larger than 2 x 3 feet

DISPLAY SCORE = \_\_\_\_\_

### 17.3 CONSTRUCTION SPEED AND TIME PENALTIES

Construction clock time, CT	_____	minutes
Repair time, RT x 1.5 (see 11.10)	_____	minutes
If $(CT + 1.5 \times RT) \leq 30$ minutes, enter CT		
If $30 < (CT + 1.5 \times RT) \leq 45$ , enter 180 (see 11.8)	_____	minutes
Time penalties during construction (see 11.4)		
11.4.2, 3, & 4: violations _____ x 1/2	+	_____ minutes
11.4.5: violations _____ x 1/4	+	_____ minutes
Repair time, RT (see 11.10) _____ x 1.5	+	_____ minutes
Time penalties during repair (see 11.4, 11.10)		
11.4.2, 3, & 4: violations _____ x 1/2 x 1.5	+	_____ minutes
11.4.5: violations _____ x 1/4 x 1.5	+	_____ minutes
Time penalty, damage (see 12.2)	+	_____ minutes
Time penalty, load tests, 30 min (see 12.4, 12.5, & 12.6)	+	_____ minutes
	TOTAL TIME =	_____ minutes
		Lowest total wins.

### 17.4 CONSTRUCTION ECONOMY

Number of builders, including barges	(_____ builders
Total time (from 17.3)	x _____ minutes
	x <u>\$50,000</u> )
Number or temporary piers	+ (_____
	x <u>\$30,000</u> )
	CONSTRUCTION COST: $C_c = \$$ _____
	Lowest cost wins.

### 17.5 LIGHTNESS AND WEIGHT PENALTIES

Bridge weight	_____	pounds
Weight penalties,		
7.2.2, "Display" (30, 50, or 80)	+	_____ pounds
9.3, "Usability"		
Rules violated $\leq \frac{1}{2}$ inch _____ x 50	+	_____ pounds
Rules violated $\frac{1}{2}$ - 1 inch _____ x 150	+	_____ pounds
Rules violated 1 - 2 inch _____ x 300	+	_____ pounds
9.4, "Member-to-member Connections"		
Number of violations _____ x 25	+	_____ pounds
10.2, "Durability & Constructability"		
Number of violations _____ x 25	+	_____ pounds
12.4, .5, and .6 "Lateral Load" and "Vertical Load" (900, 800 or 700)	+	_____ pounds
	TOTAL WEIGHT =	_____ pounds
		Lowest weight wins.

## 17.6 STIFFNESS

AGGREGATE DEFLECTION:

(Larger of DB1 or DB2) + DCA + DCB  
or 30 (from 12.4, 12.5, or 12.6)

$$= \underline{\hspace{2cm}} \text{ inches}$$

Lowest deflection wins.

## 17.7 STRUCTURAL EFFICIENCY

Total weight (from 17.5)

$$\left( \underline{\hspace{2cm}} \text{ pounds} \right)$$
$$\times \underline{\$4000}$$

Aggregate deflection (from 17.6)

$$+ \left[ \left( \underline{\hspace{2cm}} \text{ inches} \right)^{1.5} \right]$$
$$\times \underline{\$1,200,000}$$

$$\text{STRUCTURAL COST: } C_s = \$ \underline{\hspace{2cm}}$$

Lowest cost wins.

## 17.8 OVERALL PERFORMANCE

$$C_c \text{ (from 17.4) } \underline{\hspace{2cm}} + C_s \text{ (from 17.7) } \underline{\hspace{2cm}} = \$ \underline{\hspace{2cm}}$$

Lowest total wins.

## 17.9 RANKS

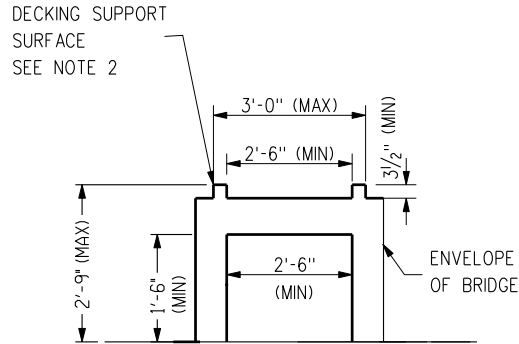
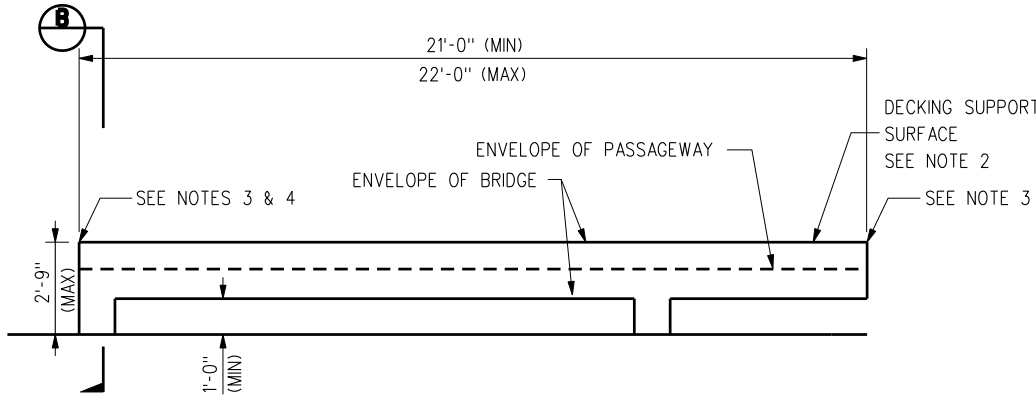
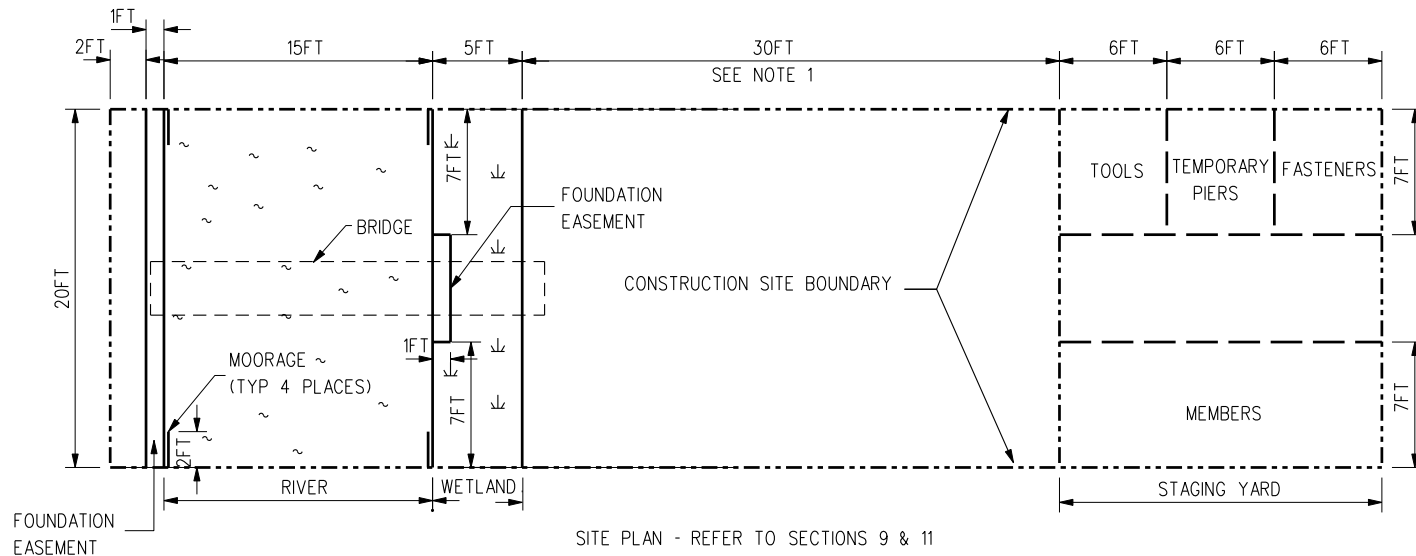
Display is the tie-breaker for all categories. A bridge will not be ranked if it was not approved for construction or load testing.

Display \_\_\_\_\_ Construction Speed \_\_\_\_\_ Lightness \_\_\_\_\_  
Stiffness \_\_\_\_\_ Construction Economy \_\_\_\_\_ Structural Efficiency \_\_\_\_\_  
Overall Performance \_\_\_\_\_

## Section 18

### INDEX OF DEFINITIONS

Accident 11.4  
Aggregate deflection 12.5.1  
Back span 9.2.2  
Barge 11.1.4  
Builder 11.1.3  
Cantilever 9.2.3  
Clearance 9.3.10  
Conference participation 4.4  
Constructed portion 11.1.12  
Construction cost 7.2.4  
Construction economy 7.2.4  
Construction site boundary 11.1.1  
Construction speed 7.2.3  
Data form 7.1, 13.9  
DB1, DB2, DCA, DCB 12.5.1  
Decking 13.6  
Decking support surface 9.2.4  
Deflection 13.5  
Display 7.2.2  
Fastener 10.2.4  
Foundation easement 11.1.1  
Gap 9.3.8  
Good standing 4.4  
Ground 11.1.2  
Guest team 4.2.2  
Judge 15  
L 8, 12.5.1  
Lateral load device 13.3  
Lightness 7.2.5  
Load 13.8  
Member 10.2.3  
Member-to-member connection 9.4  
Moorage 11.1.1  
Moored 11.1.11  
Official scoring spreadsheet  
7.1, 13.9  
Overall performance 7.2.8  
Passageway 9.3.11  
Personal protective equipment  
11.1.6  
Pouch 11.1.9  
Preload 12.5.1  
Repairs 11.10  
River 11.1.1  
S1, S2 8  
Safety 6, 9.2, 10.1, 11.2, 11.3, 12.1  
Safety supports 13.7  
Staging yard 11.1.1  
Steel 10.2.2  
Stiffness 7.2.6  
Structural cost 7.2.7  
Structural efficiency 7.2.7  
Sway 12.4.1, 13.4  
TB, TC 8, 12.5.1  
Team 4.2.3, 4.3.5, 11.1.5  
Temporary pier 11.1.10  
Tool 11.1.7  
Wetland 11.1.1



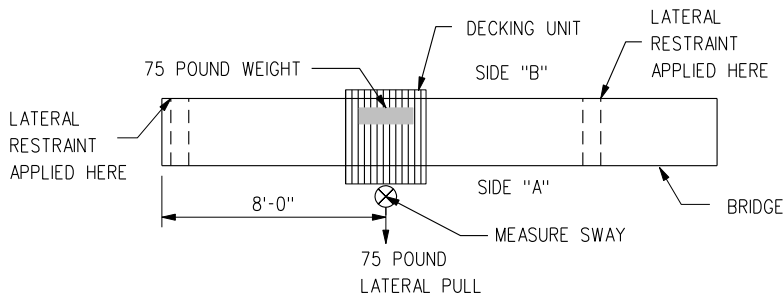
**NOTES:**

1. LENGTH CAN BE ADJUSTED TO FIT SITE CONDITIONS.
2. BRIDGE SHALL ACCOMODATE DECKING THROUGHOUT OVERALL LENGTH OF DECKING SUPPORT SURFACES.
3. NO PART OF BRIDGE SHALL EXTEND BEYOND DECKING SUPPORT SURFACE.
4. DECKING SUPPORT SURFACES SHALL NOT EXTEND BEYOND FOUNDATION EASEMENT AT THIS END.
5. SITE SHALL BE LAID OUT SO THAT TAPE DESIGNATES LINES AS WET OR OUT OF BOUNDS. THE LINES ON THIS SITE PLAN DESIGNATE THE EDGES OF TAPE.

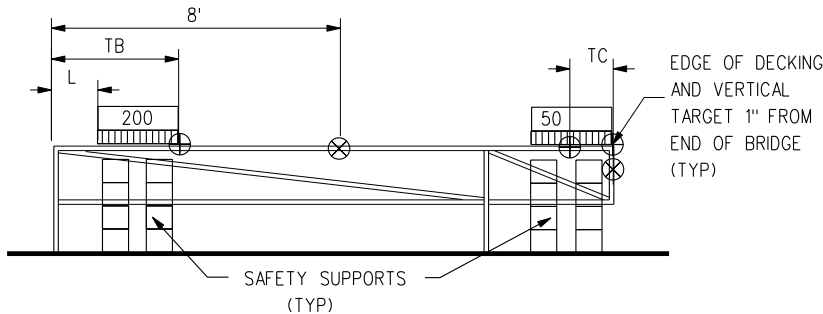
**B** SECTION  
NO SCALE

							DESIGNED BY F. HATFIELD	<b>ASCE - AISC</b> <b>STUDENT STEEL BRIDGE CONTEST</b> 	SITE AND BRIDGE		CONTRACT NO.	
							DRAWN BY D. SEPULVEDA		DIAGRAM		DRAWING NO. DRAWING 1	REV.
							CHECKED BY RULES COMM.				SCALE NONE	
							IN CHARGE N. GAVLIN				SHEET NO.	
A	8-14-09						DATE 8-1-2010					
REV	DATE	BY	APP	REG NO	EXPIRES	SEAL HOLDER	DESCRIPTION					
							2011 SSBC RULES					

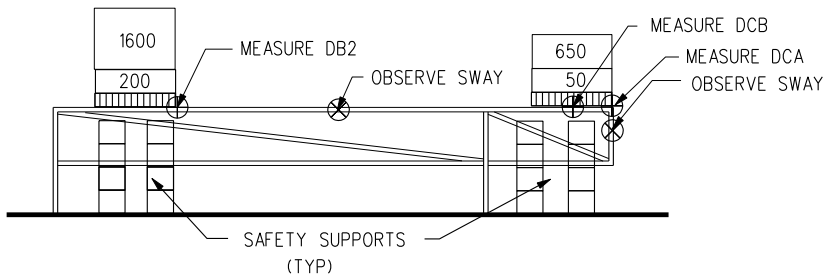




**A** LATERAL LOAD TEST OF BACKSPAN - PLAN  
REFER TO 12.1 THROUGH 12.4



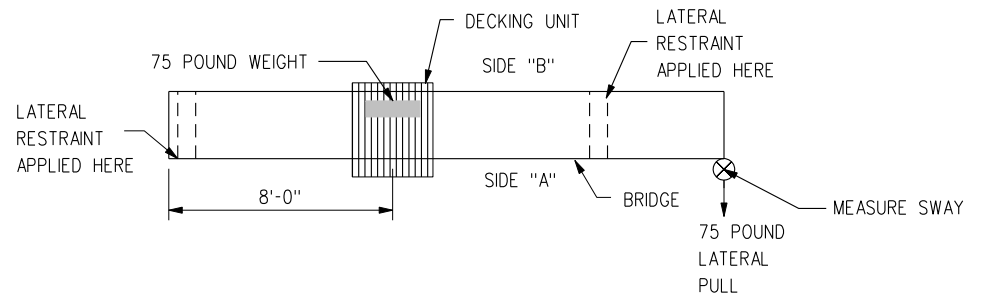
**0** VERTICAL LOAD TEST - PRELOAD SEE NOTE 8  
REFER TO 12.1, 12.2, 12.3, AND 12.5



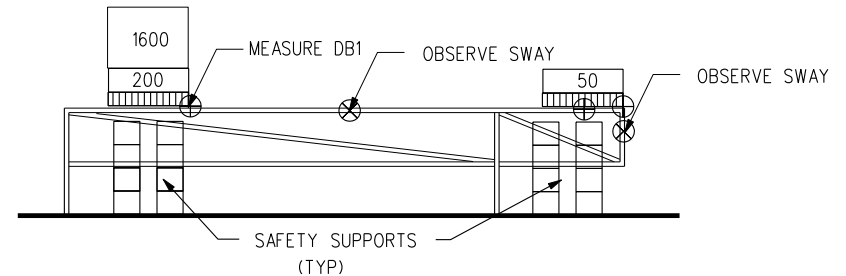
**2** VERTICAL LOAD TEST - STEP 2  
REFER TO NOTES DURING LOADING PROCESS

LEGEND

⊕ TARGETS FOR MEASURING VERTICAL DEFLECTION    ⊗ TARGETS FOR MEASURING SWAY



**B** LATERAL LOAD TEST OF CANTILEVER - PLAN



**1** VERTICAL LOAD TEST - STEP 1  
REFER TO NOTES DURING LOADING PROCESS

NOTES

- LOADS ARE CENTERED Laterally ON DECKING UNITS AND DISTRIBUTED OVER THE LENGTH OF THE DECKING UNIT AS UNIFORMLY AS POSSIBLE DURING LOADING.
- DURING STEPS 1 AND 2, OBSERVE THE SWAY TARGETS ON THE "A" SIDE OF THE BACK SPAN AND CANTILEVER. LOADING TERMINATES IF THE SWAY AT EITHER OF THOSE TARGETS EXCEEDS 1/2".
- DURING STEP 1. OBSERVE THE VERTICAL TARGET ON THE "A" SIDE OF THE BACK SPAN. LOADING TERMINATES IF DEFLECTION AT THAT TARGET EXCEEDS 1-1/2 ".
- DURING STEP 2, OBSERVE THE VERTICAL TARGETS ON THE "A" SIDE OF THE BACK SPAN AND ON BOTH SIDES OF THE CANTILEVER. LOADING TERMINATES IF DEFLECTION AT THE TARGET ON THE BACK SPAN EXCEEDS 1-1/2 " OR DEFLECTION AT EITHER TARGET ON THE CANTILEVER EXCEEDS 1/2".
- SAFETY SUPPORTS TO BE IN PLACE AT ALL TIMES DURING LOADING.
- BRIDGE TO BE UNLOADED IN THE REVERSE ORDER OF LOADING.
- ALL LOADING SAFETY PROCEDURES TO BE FOLLOWED.
- LOCATIONS OF DECKING UNITS, VERTICAL TARGETS, AND SWAY TARGETS REMAIN THE SAME THROUGHOUT THE VERTICAL LOAD TEST.

							DESIGNED BY F. HATFIELD	<b>ASCE - AISC</b> <b>STUDENT STEEL BRIDGE CONTEST</b>  		BRIDGE LOADING		CONTRACT NO.
							DRAWN BY D. SEPULVEDA			DIAGRAM		DRAWING NO. DRAWING 2
							CHECKED BY RULES COMM.			SCALE NONE		
							IN CHARGE N. GAVLIN			SHEET NO.		
							DATE 8-1-2010					
REV	DATE	BY	APP	REG NO	EXPIRES	SEAL HOLDER	DESCRIPTION	SUBMITTED	APPROVED			
A	8-14-09						2011 SSBC RULES					