



RULES 2020



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WELCOME

This document is an adaptation to the CNPAM (Concurso Nacional de Puentes de Acero México) of the “SSBC Rules 2020” and you can find it in www.cnpamexico.com, it’s original version is available in www.aisc.org/ssbc. The contest is described in detail below. The clarifications, which include any revision of the rules, are published on the facebook page (CNPAM Concurso Nacional de Puentes de Acero Mexico) and in the website www.cnpamexico.com and do not appear in this document, even if they are formal additions to the rules.

The website includes the form to request any clarification or other information. The information on the website takes priority over any other source, except in this document.

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GLOSSARY

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 and the poster describing the design.

Accident: Fault committed during timed construction and subsequently penalized.

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

Assembled tool: A tool that is created by combining two or more tools during timed construction.

Bolt: An unaltered, commercially available rigid connector that contains a head and has external threads around its full circumference, but the threads need not extend over its full length.

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

Builder: Member of a competing team with the task of building the bridge.

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 of timed construction, 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, construction time, 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 yard.

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

Construction time: Time required to complete construction of the bridge without consideration of 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 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.

East end: End of the bridge designated by a random process after construction (e.g., coin flip) from which L1, L2 and S are measured.

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 yard, but excluding the river.

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.

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

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

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.

North side: Side of the bridge relative to the east end that corresponds to the location where measurement D2 is taken and sway is observed during vertical loading.

Nut: A commercially available, mechanically unaltered portion of a connector that has the shape of a hexagonal prism over its full length and contains internal threads around its full circumference over its full length.

Overall performance: Overall award category based on the sum of construction cost, structural cost.

Personal protective equipment: Equipment used by builders to avoid accidents during construction and loading tests (the teams are responsible for acquiring their protective equipment).

Poster: Informative flat display that must be posted and is judged 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.

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 lateral load is applied and sway is measured during the lateral load test.

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 measured weight of the bridge.

Scoring spreadsheet: Spreadsheet where a team's score is input to obtain the rankings.

Site boundary: Border of the construction site.

South side: Side of the bridge relative to the east end that corresponds to the location where the lateral load is applied, and sway is observed during lateral loading as well as where measurement D1 is taken during vertical loading.

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

Stiffness: Award category based on the bridge's aggregate deflection.

Stringer: Contiguous decking support aligned longitudinally along 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.

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

Temporary pier: Optional device used to partially support a constructed portion of the bridge and tools. The teams are responsible for providing it.

Temporary pier time: time measured since temporary pier is removed from the staging yard until it is returned to it.

Tool: A device provided by a team that is used during construction of 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.

West end: End of the bridge that is opposite the east end of the bridge.



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 Mexico and around the world.

MISSION

Challenge students of putting into practice the knowledge acquired during their training in a design project that will increase their interpersonal and professional skills, encouraging innovation and fostering relationships between students and professionals in the engineering industry.

SUMMARY

The Concurso Nacional de Puentes de Acero Mexico is a competition that drives the learning of students of careers related to construction in Mexico and around the world. This becomes an opportunity for them to put into practice the theoretical knowledge acquired during their training in an exciting and innovating competition.

The participants are future engineers, architects, designers, who face the task of innovating, working on their professionalism, improving their performance when working in teams, nurturing communication skills and learning to work steel in an efficient way.

During the competition there's the opportunity of competitors to share their goals and aspirations in common in an educational context.

Students direct a project from conception and design to manufacturing, assembly and test to which it is submitted. This experience culminates in a steel structure that meets customer specifications and optimizes performance and economy. Competition increases awareness of real problems in the engineering world such as spatial restrictions, material properties, strength, manufacturing, assembly processes, safety, aesthetics, project management and costs.

Success in the competition requires the application of engineering principles and theory as well as teamwork in an efficient way.

The main objective of the competition is for each team to design a scaled steel bridge which follows the rules and regulations of the contest. Students gain maximum benefit if they fabricate the bridge themselves, however, not all schools have adequate facilities for the safe manufacturing of the bridge, which is why they can use the services of a commercial fabricator.

This structure is tested vertically with a load of approximately 2500 pounds for 1 of 6 possible load cases. During the design process, consideration should be given to each of the 6 possible cases. The applicable case for the competition will be defined prior to the first bridge test.

Participating universities will make their team compete against each other to demonstrate their engineering knowledge and innovation skills. Different categories on which the results will depend are oral presentation, aesthetics (including the poster), construction speed, construction economy, stiffness and lightness and some categories added by the host.



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, structural efficiency and construction economy are listed in “Scoring.” Competition judges and the CNPAM Rules Committee take the role of the owner or owner’s agent and have authority to accept and reject entries.

Designers must consider the comparative advantages of various alternatives. For example, a through truss 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.

Competitors, judges, and host personnel are encouraged to read this rules document from beginning to end.

SECTION 3

PROBLEM STATEMENT

The Katy Trail State Park, located in Missouri, contains a recreational rail trail that runs along the former corridor of the Missouri-Kansas-Texas Railroad. The state park and trail offer opportunities for walkers, joggers, bicyclists, and equestrians to enjoy while stretching 240 miles between Clinton, and Machens, much of which follows the Missouri River. Along the trail are a number of historic steel bridges such as the Lamine River Bridge, a through truss bridge built in 1910, and the Rivaux Creek Bridge, a parker truss bridge built in 1896, which serviced the railroad prior to the establishment of the Katy Trail State Park.

Historic floods along the Missouri River during the spring and summer of 2019 associated with heavy winter snowpack in the upper midwest and above average precipitation have led to a wash out along the Katy Trail. In order to maintain the functionality of the trail for all users, a steel bridge to cross a new waterway created by the flooding is proposed. Steel is chosen as the structural material because of its versatility, ease of prefabrication, superior strength to weight ratio, durability and high level of recycled content, but, especially the ability for rapid erection so as not interfere with activities on Katy Trail.

Due to the configuration of the existing trail and the location of the new waterway, the bridge must be skewed with the new waterway running parallel to the skew.

A feasibility study is being conducted that includes a competition to identify the best design for the limited access bridge. Your company is invited to compete by submitting a 1:10 scale model to demonstrate its concept. The bridge must have the ability to support pedestrians, bicyclists, equestrians, park vehicles, and emergency vehicles. Private motor vehicles are prohibited. Scale 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. 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 the project objectives.

Due to the conditions of the new river, machines or any equipment cannot be placed inside of it. There is currently a very thin bridge created by the villagers, but its conditions allowed to use it to cross and not to place personnel or machines on it for safety. The spaces designated to move cannot be modified to avoid damaging the rail.

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 ELEGIBLE TEAMS

One of the main objectives of the CNPAM is to be an inclusive and open competition for all students interested in it without discrimination based on race, age, gender, sexual orientation, nationality, socioeconomic status or of any kind, as well as bringing students from all over the world to share their engineering knowledge.

Any university around the world can form a team and participate in the competition according to the following:

- Only one team per university will be allowed.
- More than one team will be allowed per university for those with properly identified campuses, faculties or dependent institutes.
- All participants must act with professionalism and respect towards other competitors.
- The maximum number of competing teams will depend on the host institution according to their spatial restrictions.
- The members can be graduated students in a period not exceeding 12 months of the end of their studies.

4.2 REQUIRED CONDUCT

All competition participants shall always act professionally and respectfully. All that physical or verbal aggression towards the other participants, organizers, judges, staff, community of the host institution and guests in general will be reason for the disqualification of the team involved and will be considered as not eligible for all award categories, in addition to be able to compromise their participation in future editions of the competition.

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, cannot be tested and will not be eligible for all award categories.

Sub-Sections 9.4, 9.5, 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 the appropriate boxes on the data forms. If the problem is not listed, the 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.

Any risky procedure is strictly prohibited. The load test will stop if the horizontal displacement or deflection exceeds the allowed limits or if the collapse is imminent. Bridges that collapse, cannot be assembled and / or loaded safely, will be removed from the competition and will not be eligible for the categories of lightness, structural efficiency, construction speed, construction cost and overall performance.



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, those forms are then entered in the scoring spreadsheet. These documents will be available at www.cnpamexico.com from November 31, 2019. 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, unless an error is detected that shows false information.

The "Rankings" worksheet from the spreadsheet summarizes the performance of all teams and is distributed at the award ceremony.

Questions and comments regarding the spreadsheet should be sent to 2cnpam.reglas@gmail.com.

The original data forms shall be retained by the host until the scanned files are submitted and a confirmation email is received indicating that the hard copies are no longer needed or for a period not exceeding 21 calendar days, whichever comes first.

6.2 COMPETITION CATEGORIES

Competition categories are aesthetics, construction speed, lightness, stiffness, construction economy, structural efficiency, oral presentation and some categories depending on the host institution, in addition to the overall performance that includes some already mentioned.

6.2.1 Aesthetics (100 points)

All bridges presented for aesthetics judging and staged for timed construction are eligible for this award. Aesthetics is judged by the following criteria:

6.2.1.1 Bridge appearance.

6.2.1.1.1 The bridge appearance includes its balance, proportion, elegance, and finish. Fabrication quality, including welding, shall not be considered because some bridges may be fabricated professionally rather than by students. **(20 points)**

6.2.1.1.2 The bridge is presented exactly as it will be erected during timed construction. If one or more pieces is detected that these have been altered, **1 point** will be subtracted for each one.

6.2.1.1.3 Permanent identification of the bridge consisting of the school's name is required. 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). **(20 points)**

6.2.1.2 Poster

6.2.1.2.1 The poster shall present the following:

Identification of the school, using the same name that appears on the bridge. **(10 points)**

Brief explanation of why the overall bridge configuration was selected. **(10 points)**

Scaled, dimensioned side view of the bridge. **(10 points)**

Free-body diagram of a single beam that represents one of the bridge stringers, with representing the reactions for one of the 6 load cases. **(10 points)**

Shear and moment diagrams of the beam corresponding to the free-body diagram, showing peak magnitudes. **(10 points)**

Brief explanation of the construction sequencing, the construction process, tools used, design features, sequence, procedures used to minimize time, number of builders, etc. A better description will result in a higher score. **(10 points)**

6.2.1.2.2 The poster shall:

- Be flat with maximum dimensions of 2'-0" x 3'-0"
- Present all information on one side,
- Not have attached pages that must be lifted or turned, lights, screens with videos or sound.
- Be preferably in Spanish or English if Spanish is not the predominant language. The language will not influence the rating.

If any of these specifications is violated **15 points** will be subtracted for each one.



6.2.1.2.3 Additional information may be included on the poster as the names of financial sponsors and its logos. This information may be shown on an optional second poster with maximum dimensions of 3'-6" x 5'-0". The additional information or second poster will not factor into aesthetics judging.

6.2.1.2.4 The poster is not part of the bridge but must be displayed during aesthetic judging. The poster and its contents only will be judged. Supports used for the poster will not be considered in judging the poster.

6.2.1.3 Aesthetics is the tie breaker for all competition categories.

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 10.9.3. 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 and 10.4.2. Decking, temporary pier, 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.

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:

$$\begin{aligned} C_c = & \text{Construction time (minutes)} \times \text{number of builders} \times 70,000 \text{ (\$/builder/minute)} \\ & + \\ & \underline{\text{Temporary pier time (minutes)} \times 40,000 \text{ (\$/temporary pier/minute) (in case of using it)}} \\ & + \\ & (\text{Total time} - \text{Construction time}) \times 240,000 \text{ (\$/minute)} \\ & + \\ & \text{load test penalties (\$).} \end{aligned}$$

“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 (Cs) will win in the structural efficiency category. Structural cost is computed as:

- If measured weight does not exceed 175 pounds:

$$\begin{aligned} C_s = & (Total\ weight - Measured\ weight)\ (pounds)\ x\ 5,000\ (\$/pound) \\ & + \\ & Aggregate\ deflection\ (inches)\ x\ 3,150,000\ (\$/inch) \\ & + \\ & Load\ test\ penalties\ (\$). \end{aligned}$$

- If measured weight exceeds 175 pounds but does not exceed 300 pounds

$$\begin{aligned} C_s = & (Measured\ weight - 175)\ (pounds)\ x\ 8,000\ (\$/pound) \\ & + \\ & (Total\ weight - Measured\ weight)\ (pounds)\ x\ 5,000\ (\$/pound) \\ & + \\ & Aggregate\ deflection\ (inches)\ x\ 3,150,000\ (\$/inch) \\ & + \\ & Load\ test\ penalties\ (\$). \end{aligned}$$

- If measured weight exceeds 300 pounds:

$$\begin{aligned} C_s = & (Measured\ weight - 237.5)\ (pounds)\ x\ 16,000\ (\$/pound) \\ & + \\ & (Total\ weight - Measured\ weight)\ (pounds)\ x\ 5,000\ (\$/pound) \\ & + \\ & Aggregate\ deflection\ (inches)\ x\ 3,150,000\ (\$/inch) \\ & + \\ & Load\ test\ penalties\ (\$). \end{aligned}$$

Section 11.5.2 prescribes “load test penalties.”

6.2.7 Oral Presentation

Each team must perform an oral presentation in a professional way with a maximum of 5 minutes (with a tolerance of ± 10 seconds). Students may present the topics listed in “criteria to evaluate” in the order they deem appropriate and / or more attractive.

- The presentation must be in Spanish or English.



- The projected information must be in the same language that the team has decided to use.
- The number of presenters will not be more than 2 people. (The number of presenters does not influence the rating).
- Teams can use of image, video, but not sound is allowed.
- The rest of the team will not be able to answer the questions asked by the judges, add information or be in communication with the presenters.
- The presentation can be heard by members of other teams.
- The judges will make a session of a maximum of 4 minutes with 3 questions once the presentation has finished.
- The order of the teams will be determined with a random process.
- The teams will have 3 minutes to assemble and prepare their material and 3 minutes to remove it.
- The teams will have access to electricity, microphones, projectors, projection screen and computer.
- The use of Power Point® or compatible files is recommended, however, teams may send their software requirements to 2cnpam.reglas@gmail.com at the latest on March 20, 2020, once the email is received, staff will report to the teams any problem with the required software. If the team does not send information about the required software, it is your responsibility to have a computer containing such software and provide the wiring to the projection equipment.
- Universities that wish to use presentations as support material must submit the file during their registration (first day of competition) in order to create a folder and streamline their participation.

6.2.7.1 Evaluation criteria

In order to understand the projects and that the rest of the teams learn from them, they are asked to put into practice their ability to synthesize and select relevant ideas to talk about:

- Conceptual design (why make a beam? Why opt for an arch? Is the design process influenced by some element of the environment described in the problem statement or influenced by some element that gives identity to the team?).
- Representative model (which software was used? Which load considerations were made? Does the software have limitations? How did it solve them?).

- Measurement.
- Connections (what kind of connections were chosen? were they tested? How are they expected to work?).

6.2.7.2 Questions and answers

After concluding the presentation of each team, three judges (random) will ask one question each, related to doubts about the presentation. The question can be answered by any of the members (if there are two presenters).

6.2.7.3 Scoring

The score obtained by the teams will be a maximum of 100 points and will be composed by the following:

- Conceptual design **(20 points)**
- Representative analytical model **(20 points)**
- Measurement **(10 points)**
- Connections **(20 points)**
- Question 1 **(10 points)**
- Question 2 **(10 points)**
- Question 3 **(10 points)**

6.2.8 Overall performance

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

6.3 SPREADSHEET FOR SCORING

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 SPECIAL AWARDS

In addition to the competition category awards, special awards are given to participating teams. These awards will depend on the host institution and sponsors and will be additional and independent from the rest of the categories.



SECTION 7

SCHEDULE OF THE COMPETITION

In the months before the competition, students design their bridges, fabricate members, test load, designate the competition team and practice construction while the host school procures a venue, organizes equipment and recruits judges. Next, the recommended order for the competition and some alternatives are described.

7.1 RECOMMENDED SCHEDULE

- Using a random process, the head judge or host school determines the order in which teams will compete.
- The head judge conducts a meeting with the other judges to clarify any rules concerns and to inspect the construction and loading facilities.
- 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.
- Oral presentations.
- Bridges are disassembled.
- In a meeting at which all captains are present, the head judge clarifies rules and conditions of the competition and answers questions
- Immediately before timed construction of the first bridge, the head judge rolls a dice to determine the locations of decking units and where the lateral load will be applied.
- 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. These designations will guide load test as described in 11.4.1, 11.5.1 and the lateral and vertical load test plan diagrams.

Table 7.1: Load Cases

<i>N</i>	<i>L1</i>	<i>L2</i>	<i>S</i>
1	8'-0"	3'-0"	9'-0"
2	10'-0"	4'-0"	9'-0"
3	11'-0"	7'-0"	9'-0"
4	12'-0"	3'-6"	9'-0"
5	12'-6"	6'-0"	9'-0"
6	13'-0"	8'-5"	9'-0"

The same values of L1, L2 and S will be used for all bridges.

- 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, 10.2.5 and 10.6 for details.
- Timed construction. See Section 10 “Construction Regulations” for details.

- 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, making any of these would make to repeat the construction time.
- Bridges are weighed. All bridges shall be weighed.
- Bridges are load tested. See Section 11 “Load Test Instructions” for details.
- 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

7.2 ALTERNATIVES

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

- Bridges are not modified after the die is rolled.
- Bridges are not modified between aesthetics judging and timed construction.
- No components or tools are added to or removed from the construction site after staging for inspection.



SECTION 8

MATERIAL AND COMPONENT SPECIFICATIONS

All bridges must be made of steel, the characteristics and limitations of this are described below.

8.1 MATERIAL

All members must be made of highly magnetic steel, consider that some grades of steel do not have this quality. 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 eligible for awards listed in section 5 paragraph 4.

8.2 COMPONENTS

Violation of the specifications in this Subsection will result in penalties being added to the weight of the bridge.

- A penalty is 35 pounds for each violation to 8.2.2.
- A penalty is 25 pounds for each violation to 8.2.3 and 8.2.4.

8.2.1 Bridge

A bridge shall be constructed only of members, loose bolts, and nuts these can be welded to the members. 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 to a member are threaded parts that are considered part of that member. A member shall not have moving or flexible parts. Exception: deformations caused by load testing.

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 (box) of dimensions of 3'-6" x 6" x 4".

8.2.2.3 Threads shall be continuous around the full circumference around its full length or part of it of an externally threaded part of a member if that part is necessary for compliance with Sub-Section 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, have a head, 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 but need not extend over its full length.

8.2.4 Nuts

8.2.4.1 Nuts, whether loose or welded, shall have the external shape of a hexagonal prism over its full length 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 over its full length.

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 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. 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 subsection is violated, the bridge will not be eligible for awards in any category mentioned in section 5 paragraph 4. 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 stringers, each of which is contiguous. Stringers shall extend from inside each footing on the west end to inside each footing on the east end for the north and south sides of the bridge. 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 between the interior most footings of the bridge.

9.2.3 The decking shall not be attached or anchored to the bridge. This prohibition includes 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 when positioned for lateral and vertical load testing.

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 subsection are illustrated by the Bridge Elevation and Bridge Plan Diagrams.

The penalty for violation of each of the specifications in this subsection will be an addition to the weight of the bridge determined as follows:

- 20 pounds for a dimensional violation not exceeding 1/4"

- 100 pounds for a violation greater than 1/4" but not exceeding 1"
- 200 pounds for a violation greater than 1" but not exceeding 2"
- 400 pounds for a violation greater than 2" but not exceeding 3"

If a violation exceeds 3", the bridge will not be eligible for awards in any category mentioned in section 5 paragraph 4.

9.3.1 The bridge shall not touch the river or the ground outside the footings except when the exception in Sub-Section 10.4.2 is invoked

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 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.

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 20'-0" long, measured along the top.

9.3.7 The stringers of the bridge shall not extend away from the river beyond the vertical planes that pass through the bridge envelope boundary shown on the Bridge Plan Diagram.

9.3.8 The bridge shall provide a straight, clear passageway conforming to the Clearance Template detail on the Bridge Elevation Diagram. The tops of both stringers shall contact the tops of the two rabbets in the template at every location along the length of the stringers between the ends of the north and south side stringers.

9.3.8.1 At no location along the full length of the stringers shall part of the bridge, including nuts and bolts, obstruct passage of the template.

9.3.9 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, 9.4.3 and 9.4.4. Builders will be allowed five minutes to correct only those connections in violation of the rules that are



identified by the judges. If any connection identified by the judges still violates specification 9.4.1, 9.4.2, 9.4.3 and 9.4.4 when that time limit is reached, the bridge will not be eligible for awards in any category mentioned in section 5 paragraph 4 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 externally 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 externally threaded part of a 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 part of the 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 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 and loose bolt shall be tightened sufficiently so that the nut and bolt head contact the outer ply of the connection. **Penalty is one minute added to construction time for each individual violation** regardless of whether the violation is corrected. 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. If any individual threaded end, nut, or bolt head cannot be inspected, the bridge will not be eligible for awards in any category mentioned in section 5 paragraph 4 and will not be load tested.

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
- Safety goggles that meet ANSI standard Z87.1

The time construction will not be done without safety equipment.

10.1.6 There may be multiple constructed portions on the construction site but not in the staging yard and transportation zones. If a member that is part of the constructed portion is removed from contact with the constructed portion, it becomes an individual member again.

10.1.7 Temporary pier is an optional device and is used to partially support the bridge and tools during construction. It has no other purpose; it is not a tool and is not considered part of the bridge. Each team must provide temporary pier in case of using it. It may be made of any material if it accomplishes the established dimensions in subsection 10.2.6. The support can be placed anywhere within the construction area except for the river. The construction cost will increase as indicated in section 6.2.5. The teams shall accept 10.2.9. penalties for temporary pier are described in 10.2.6, 10.2.7, 10.2.8 and 10.4.4.

10.2 PRE-CONSTRUCTION CONDITIONS

Timed construction will not commence if any provision of this subsection 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 without considering temporary pier.

10.2.3 During time construction shall not be used:

- Welding machines and tools requiring external power connections
- Tools powered by batteries or other internal energy
- Welding
- Adhesives

10.2.4 A tool must not weigh more than twenty pounds and shall fit within a right rectangular prism of dimensions of 3'-6" x 6" x 4".

During timed construction, multiple tools may be combined to form an assembled tool that does not need to meet the requirements of sub-section 10.2.4.

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

10.2.6 Only temporary pier will be allowed. Which must enter entirely into a rectangular prism with the following dimensions 1' x 1' x 2', even if it has moving parts, it must enter the prism with the moving parts deployed. A temporary pier that exceeds the mentioned dimensions cannot be used.

10.2.7 The temporary pier cannot weight more than 15 pounds, if its weight exceeds 15 pounds, cannot be used.

10.2.8 The temporary piers that includes containers for nuts and bolts cannot be used, only hooks can be placed as a support for tools.

10.2.9 In case of teams use a temporary pier shall notify to judges, so they can assign a person to count the temporary pier time.

10.3 SAFE CONSTRUCTION PRACTICES

If any rule in this subsection is violated during timed construction, the judge will stop the clock and explain the violation. Before the clock is restarted, builders, tools, members, temporary pier, 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 eligible for awards in any category mentioned in section 5 paragraph 4.

10.3.1 Builders, judges, host personnel, and spectators shall not be exposed to risk of personal injury

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, transfer to another builder 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 can cross the river using the hallway. Builders can not cross by the corners between the river and the hallway.

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.

10.3.15 Temporary support may only be on one side of the river and may change position only within the selected construction zone.

10.4 ACCIDENTS

Accident types are described in Sections 10.4.1, 10.4.2, 10.4.3 and 10.4.4. 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 1** when the spreadsheet computes construction cost C_c , but the number of builders 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, the clock will be restarted, construction will resume, and a 200 lb weight penalty will be assessed, even if the bearing surfaces of the bridge are within the footings when it is completed. All penalties applied associated with this rule prior to the exception being taken remain.

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.

10.4.4 The temporary pier is the only element that can touch the floor in the construction zone but not in the transportation zone. If there is a violation to 10.3.15. **Penalty is 3 minutes added to the time construction for each individually occurrence.**

10.4.5 Nuts and bolts cannot be placed on the temporary pier. **Penalty is 1/4 minute (15 seconds) added to the time construction for each individually occurrence.**

10.5 CONSTRUCTION SITE

See the Site Plan Diagram for the construction site layout. 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, temporary pier and tools. Every member, loose nut, loose bolt, temporary pier and tool must be in contact with the ground and must fit entirely within the assigned area of the staging yard as designated on the Staging Yard detail on the Site Plan Diagram. Loose nuts may not 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 (empty). 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. Only the elements on the staging yard can be used.

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.

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:

- If a builder or judge sees a condition that could cause injury.
- When a safety regulation has been violated (see 10.3).
- 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).
- 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 twenty-five minutes, the scoring spreadsheet will count construction time as 180 minutes. Accidents (10.4) that occur after twenty-five minutes will not be penalized but safety regulations (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 40 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 mentioned in section 5 paragraph 4, 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 is complete when:

- The bridge has been completed by connecting all the members that were in the staging yards at the start of timed construction.
- All builders are in the staging yard.
- All tools are in contact with the ground in the tool section of the staging yard.
- 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 yard.

10.9.2 The clock is stopped when the captain informs the judge that construction is complete. If the requirements of Sub-Section 10.9.1 are not met when the clock is stopped, builders, tools, members, nuts, and bolts will be returned to the positions they occupied immediately before the clock was stopped. The clock will then be restarted, and builders will be required to complete construction as designated in Sub-Section 10.9.1 prior to the clock being stopped when the captain again informs the judge that construction is complete.

10.9.3 After construction is complete, assembled tools must be in a disassembled state such that all tools satisfy the requirements of Sub-Section 10.2.4 and are 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.

10.9.4 Installation of decking is not included in timed construction.

10.9.5 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 eligible for awards in any category mentioned in section 5 paragraph 4. 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 subsection. 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 eligible for awards in any category mentioned in section 5 paragraph 4.

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:

- Hardhats meeting ANSI standard Z89.1
- 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 four 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 eligible for awards in any category mentioned in section 5 paragraph 4.



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 is to prevent personal injury if a bridge collapse.

11.2.3.1 The number of people near the bridge shall be minimized during vertical load tests. The loading crew is limited to four 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 collapse.

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 enough 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.

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 the vertical load is in place. Safety supports may be adjusted during loading safely. Once the load test is finished even if was stopped, the load shall be removed without disturbing the bridge.

11.2.3.7 Bridges that inhibit safely placing vertical load shall not be tested and will not be eligible for awards in any category mentioned in section 5 paragraph 4.

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 four-person limit.

Teams shall accept imperfect field conditions such as bent decking, sloping floors and unfavorable floor surfaces. **Commencing the lateral load or vertical load test indicates acceptance of all starting conditions.**

For each bridge, the judge will determine by a randomizing process.

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 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, the bridge shall not be load tested and will not be eligible for awards any category mentioned in section 5 paragraph 4.

Typically, sway is determined by using a plumb bob attached to the bridge or decking 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 subsection 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 south side stringer and approximately 75 pounds of weight on that decking near the north 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 south 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 sway measurement device may be attached to the decking at the discretion of the judges.

The test is failed if sway exceeds one inch.

If the bridge fails the lateral load test, it will not be eligible for awards in any category mentioned in section 5 paragraph 4. Do not conduct the vertical load test.

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.

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 top of the south side stringer.

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. Deflection measurement devices may be connected to the decking. Measurements are made at the following locations:

- D1 centered on the south side of the decking unit positioned at L1.
- D2 centered on the north side of the decking unit positioned at L2.

Sway is observed on the north side of the bridge, at the center of the decking unit positioned at L1

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. Angles shall be placed perpendicular to the span of the bridge to maintain safety in the event of a failure or a collapse. 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:

- Sway exceeds one inch
- Any measured deflection exceeds three inches downward
- Decking or any part of the bridge, other than the intended bearing surfaces, comes to bear on a safety support or the floor
- Decking unit or some of the load falls off the bridge
- The bridge collapses or a dangerous collapse is imminent in the opinion of the judge.

If loading is stopped for any of the situations the bridge is not approved for further load testing and will not be eligible for awards in any category mentioned in section 5 paragraph 4.

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 2 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

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, next:



- Initialize the sway measurement device.
- Initialize the two deflection measuring devices at D1 and D2 or record the initial readings.
- The crew places 1400 pounds of additional load on the decking unit at L1.
- The crew places 900 pounds of additional load on the decking unit at L2.
- 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 all rules will be checked except those in Section 8 and SubSection 9.3. 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 or there is a situation mentioned in 11.5.2, it is not eligible for awards any category mentioned in section 5 paragraph 4

SECTION 12

EQUIPMENT PROVIDED BY HOST

12.1 SOURCES OF INFORMATION

Although the equipment described in this section 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.

Participants may send questions regarding the equipment to the following email address: 2cnpam.reglas@gmail.com

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. Jack stands with welded plates are the recommended safety supports because of their flexibility in height, ease of placement, and stability.

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 determine the measured 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 measured weight of the bridge.

SECTION 13 INTERPRETATION OF THE RULES

The website www.cnpamexico.com It has a form to request clarification of these 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. 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 Committee typically requires one to two weeks. **Questions must be submitted before March 15, 2020.**

SECTION 14 JUDGES

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 the 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.

The official scoring spreadsheet **will be available from November 31, 2020.**



SECTION 15

APPEALS

15.1 At the beginning of the competition, each team will identify its captain. The host school will identify the head judge.

15.2 A penalty, decision, measurement, score, condition of competition, or interpretation of rules may be appealed only by the captain and only to the head judge. The head judge will not hear the appeal if he or she is approached by anyone other than the captain. The head judge will refuse to hear protests regarding bridges other than the captains. The appeal must be made as soon as possible after the situation becomes apparent. The head judge will hear the appeal as soon as possible and may interrupt the competition. If the captain does not consent to the decision of the head judge, 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. (See section 4)

15.3 After the competition is over, the rules committee will only consider appeals where errors are made in the interpretation of the rules and only if they were registered during the competition.

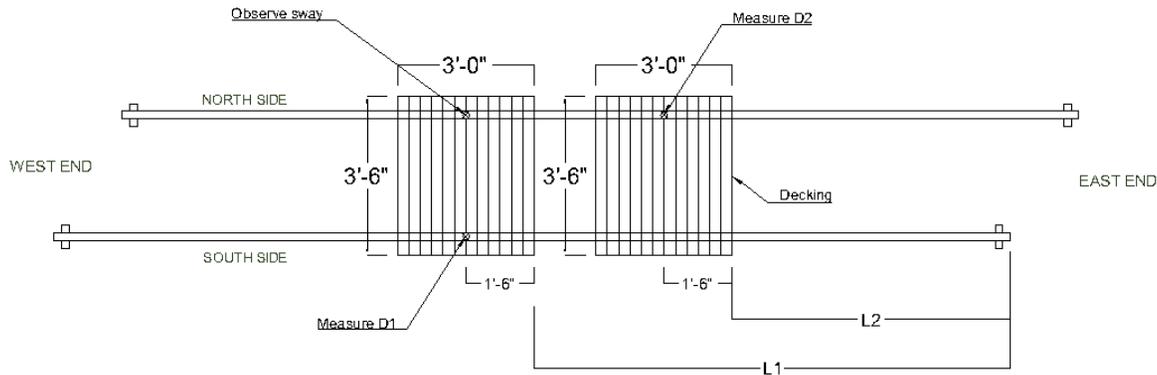
15.4 Appeals must be made by e-mail. An appeal will be considered only if the e-mail is received before 9:00 PM on April 17, 2020, filling out the form available at www.cnpamexico.com. This form will be **available from April 1, 2020**.

15.5 After hearing the head judge 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.

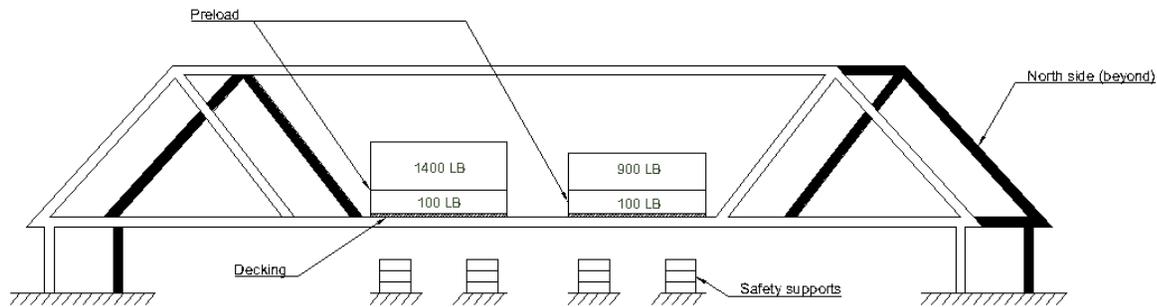
15.6 The head judge may consult with the Rules Committee

15.7 If the team has justification to contest the head judge ruling, the captain has the option to appeal that decision directly to the CNPAM Rules Committee

15.8 The decision of the Rules Committee is final; there are no further appeals.



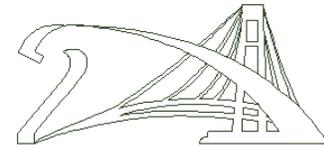
VERTICAL LOAD TEST PLAN



VERTICAL LOAD TEST ELEVATION

NOTES

- 1.- Drawings are not 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 on the South side stringer.
- 4.- Safety supports are required under both decking units at all times.
- 5.- The 100 lb preload is placed first, followed by initialization or initial readings of deflection and sway measurement devices.
- 6.- 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.
- 7.- Locations of deflection and sway measurements are specific to the north and south sides (11.5.1.3).
- 8.- Deflections D1, D2 andn sway are monitored continuously.
- 9.- Stop loading if any defelction exceeds 3 in or sway exceeds 1 in..
- 10.- Deflections are recorded after load is in place.



CONCURSO NACIONAL DE
PUENTES DE ACERO MÉXICO

No.	DATE	DESCRIPTION
Project No: 2020		Original drawing: AISC
Modifications: 2 CNPAM COMMITTEE		
Name: VERTICAL LOAD TEST PLAN AND ELEVATION		
Date: 24/08/2018	Host: UNIVERSIDAD AUTÓNOMA DEL ESTADO DE MÉXICO	