



THE
 CSCE Student competition committee
 Comité des compétitions étudiantes SCGC

Canadian Society for
 Civil Engineering



Société canadienne
 de génie civil

cisc icca

CANADIAN INSTITUTE OF STEEL CONSTRUCTION
 INSTITUT CANADIEN DE LA CONSTRUCTION EN ACIER

PRESENT:

CSCE-CISC CANADIAN NATIONAL STEEL BRIDGE COMPETITION
 COMPÉTITION NATIONALE CANADIENNE DE PONT D'ACIER SGCC-ICCA

- 2019 RULES -

This document, which is available at <http://www.cscecompetitions.ca/cnsbc>, describes the Canadian National Steel Bridge Competition (CNSBC) and the 2019 rules. **Clarifications, which include any revisions to the rules/addendum, are published on the competition’s website.** The website includes other information and the contact for requesting clarifications. Information on this website takes priority over any other source except as noted herein.

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WELCOME AND DISCLAIMERS

The Canadian Society for Civil Engineering (CSCE) and the Canadian Institute of Steel Construction (CISC) support and encourage the equitable opportunity for participation in the Canadian National Steel Bridge Competition (CNSBC) by all interested and eligible individuals without regard to race, ethnicity, religion, age, gender, sexual orientation, nationality, or physical challenges. Bridge teams should be inclusive, open, and fair to all interested and eligible participants. The goal of this competition is to give to Canadian civil engineering students an opportunity to have a first hands-on experience during their curriculum.

CNSBC committee would like to thank the American Institute of Steel Construction (AISC) for the use of the AISC National Student Steel Bridge Competition (NSSBC) rules as a baseline for these rules. Please note that the Imperial system was used in this document for continuity and to facilitate the reading of the document by members of the teams that were used to the imperial system, as they had participated in both the American and Canadian competitions in the past.

There are subtleties and difference to the rules presented compared to the 2019 NSSBC rules document produced by AISC. In order to that please note that you have to read entire CNSBC rules. It is your responsibility to read it all and to understand them.

We will see you in **May 2019** for the fourth edition of the Canadian Bridge Competition, which will be held in **Montreal, Quebec at the École Polytechnique de Montréal.**

SECTION 1 – MISSION AND SUMMARY

VISION & MISSION

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 Canada.

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

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

SUMMARY

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

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

Safety is paramount. CNSBC committee request that competitors, advisors, hosts, and judges take all necessary precautions to prevent injury to competitors, judges, host personnel, and spectators. Risky procedures are prohibited. Load testing is stopped if sway or deflection exceeds specified limits, or if collapse is imminent. Bridges that cannot be constructed and loaded safely are withdrawn from competition. In addition, the rules identify and penalize construction errors that represent accidents in full-scale construction.

The Canadian National Steel Bridge Competition provides design and management experience, opportunity to learn fabrication processes, and the excitement of networking with and competing against teams from other colleges and universities.

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, oral presentation, design aesthetics, efficiency, and economy are listed in “Scoring.” Competition judges and the CNSBC Rules Committee assume the role of the owner or owner’s agent and have authority to accept and reject entries.

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

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

Competitors, judges and host personnel are encouraged to read the 2019 CNSBC rules documents from beginning to end.

That site also is the source of the official scoring spreadsheet which generates forms for recording data. Judges should be familiar with those forms prior to the competition. Results of the previous year’s National Finals are posted at <http://www.cscecompetitions.ca/cnsbc>.

CNSBC LAST PODIUM FINISHERS AND HOST SCHOOLS

2018 UNIVERSITY OF WATERLOO, WATERLOO, ONTARIO - 7 participating universities



UNIVERSITY OF
WATERLOO

1. École de technologie supérieure
2. Université Laval
3. École polytechnique de Montréal

2017 LAVAL UNIVERSITY, QUEBEC CITY, QUEBEC - 8 participating universities



UNIVERSITÉ
LAVAL

1. École de technologie supérieure
2. École polytechnique de Montréal
3. University of British Columbia

2016 MCGILL UNIVERSITY, MONTREAL, QUEBEC - 6 participating universities



McGill

1. École de technologie supérieure
2. University of British Columbia
3. École polytechnique de Montréal

SECTION 3 – PROBLEM STATEMENT

Steel bridges play a very important role in our life when it time to go from one bank to another. In Canada, we know several places where these structures become part of our life and an major economics elements. On large city, nerve centers become the roads network and theirs bridges however these commodity can be sometime motorists' nightmare.

In their effort to maintain and rebuild infrastructure, today's Engineers are called to be innovative and create sustainable and economical structures that meet the many challenging design requirements.

For this competition, participants will have to develop and work on a new steel bridge that will allow the St. Lawrence River to be relocated to relieve Montreal's heavy traffic. Like the New Champlain Bridge, competitors will have to take into consideration the canadian's harsh winters, especially those over this major commercial river.

A feasibility study is being conducted that includes a competition to identify the best design for a limited access, short span bridge to cross a river near ecosystems of protected species.

The bridge must have the ability to support bicycles, pedestrians, park vehicles and emergency vehicles while prohibiting private motor vehicles. Models will be erected under simulated field conditions and will be tested for stability, strength, and serviceability using standardized lateral and vertical loads.

Structural cost, construction cost and duration, and aesthetics are important considerations. Virtual costs are assigned to critical features, including a sliding scale for material that promotes robustness without wastefulness. Engineers associated with the park will judge the competition and will award the design/build contract to the company whose model satisfies specified requirements and best achieves project objectives.

Steel is specified for ease of prefabrication, rapid erection, superior strength to weight ratio, durability, and high level of recycled content. Designs with permanent or temporary piers in the river will not be considered. Ecosystems of protecting species have been found on the periphery of bridge pier also preclude temporary piers elsewhere, as well as restricting the location of footings and the size of construction zones. Remote staging of material and equipment is required and the size and quantity of members to be transported is limited. Models will not include deck, foundations, and approaches.

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

SECTION 4 – ELIGIBILITY

Only one bridge per college or university may compete at the Canadian National Steel Bridge Competition.

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

All team members are required to be **student members of the Canadian Society for Civil Engineering (CSCE)** and will be asked to provide a proof of membership at the official registration (e.g.: membership numbers).

Each team that want to participate to this competition, need to feel up next page form, with all information required. Canadian universities or automatically illegible to CNSBC's competition however international university have to send their form to CNSBC, at cnsbc@cscecompetitions.ca to ensure their eligibility.

4.1 REQUIRED CONDUCT

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



CNSBC-CBCPA 2019 COMPETITION

MAY 8-11TH 2019

ÉCOLE POLYTECHNIQUE DE MONTREAL, QUEBEC, CANADA

Each team that want to participate to this competition, need to fill up next page form, with all information required. Canadian universities or automatically illegible to CNSBC's competition however international university have to send their form to CNSBC, at cnsbc@cscecompetitions.ca to ensure their eligibility.

TEAM REGISTRATION FORM

ONE PER TEAM

SCHOOL : _____

TEAM NAME: _____

CAPTAIN'S NAME: _____

EMAIL ADDRESS (CAPITAIN): _____

COCAPTAIN'S NAME : _____

EMAIL ADDRESS (COCAPTAIN): _____

WHEN YOUR TEAM HAS BEEN FORM : _____

HOW MANY MEMBERS ARE YOU IN THE ALL TEAM : _____

HOW MANY MEMBERS DO YOU PLAN TO BRING AT 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, it must be withdrawn from competition.

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

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

SECTION 6 – SCORING

6.1 RECORDING DATA, ANNOUNCING RESULTS, SUBMITTING SCORES

Scoring data shall be recorded for every team that competes, using judges' scoring forms. Data from those forms are then entered in the spreadsheet. After all scoring information has been collected for a team, the scoring official review 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 may be given to the captain if requested.

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

6.2 CATEGORIES OF COMPETITION

Categories of competition are the following: design aesthetics, oral presentation, construction speed, lightness, stiffness, construction economy and structural efficiency. The overall winner team is the one with the highest overall score as described in Section 6.3.

6.2.1 Design Aesthetics

6.2.1.1 Architectural design

Bridges will be evaluate on the basis of the originality of the design compared to the other CNSBC bridges, which will take into account innovative ideas, originality and the level of difficulty regarding the bridge structural design. In addition:

- ◆ The appearance of the bridge, including balance, proportion, elegance, and finish will be evaluated. The bridge must be presented exactly as it will be erected during timed construction.
- ◆ Quality of fabrication, including welding, shall not be considered because some bridges may be fabricated professionally rather than by students.
- ◆ Permanent identification consisting of the name of the college or university must be on the bridge. The name shall be formed from steel or applied to steel with paint or decals, and should be easily legible (lettering at least 1" high is recommended). A bridge that lacks appropriate identification will receive a very low architectural design rating.

An award is given for design aesthetics, only one prize will be given to the team that leads in point, in the categories outlined in sections 6.2.1.1 and 6.2.1.2. Specific criteria will be based on the following points:

DESCRIPTIONS / ARCHITECTURAL DESIGN	POINTS
Originality and innovation (comparison between each bridge, unique global or part design)	/5
Bridge's complicity to built	/5
Appearance of the bridge (balance, proportion, elegance and finish) (The paint is not a factor to be considered. However, the quality and the appearance of the welding will be considered.)	/3
Permanent identification of the bridge (0/2 if not identified, 1/2 if identified but doesn't respect the criteria: made of steel or applied with paint/decal and is at least 1" high, 2/2 if meets all the criteria)	/2
Deductions* * -1 for each of these rules if not respected	
TOTAL	/15

6.2.1.2 Poster

The poster shall present the following information:

- ◆ Identification of the college or university, using the same name that appears on the bridge,
- ◆ brief explanation of why the overall configuration of the bridge was selected,
- ◆ scaled, dimensioned side view of the bridge,
- ◆ free-body diagram of the bridge for one of the load cases specified in section 7,
- ◆ shears and moment diagrams for the bridge considered as a single spanning beam. The diagrams shall correspond to the free-body diagram, and peak magnitudes shall be shown,
- ◆ provisions for Accelerated Bridge Construction (ABC), such as design features, construction sequencing, and procedures intended to minimize construction time, and
- ◆ The poster shall be:
 - ✓ flat with maximum dimensions of two by three feet,
 - ✓ present all information on one side,
 - ✓ not have attached pages that must be lifted or turned, and
 - ✓ be in English or French.

Additional information may be included. Acknowledgement of university technicians, faculty, and others who helped fabricate the bridge or provided advice,-names of financial sponsors may be shown 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 lowest possible rating for the poster. A zero score rating 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.

DESCRIPTIONS / POSTER	POINTS
Identification of school (same as on the bridge)	/1
Explanation of the choice of the bridge's configuration	/3
Scaled, dimension side view of the bridge	/3
Free-body diagram of one load case	/2
Shears and moments diagrams (Shears and moments diagrams considered as single spanning, same load case as the free-body diagram.)	/4
Provisions for Accelerated Bridge Construction (Design features, construction sequency, procedures to intend to minimize construction time, ect.)	/2
Deductions*	
* -1 for each of these non-respected rules:	
1) Shall be flat with the maximum dimensions of 2'x3'.	
2) All the information must be on one side.	
3) The poster does not have attached pages that must be lifted or turned	
TOTAL	/15

6.2.2 Oral presentation

An oral presentation (maximum 5 minutes) is required for each participating university. All presentations shall be conducted in a professional manner (defined as a presentation that the engineers' team would give to the client).

- ◆ Oral presentations shall be in English or French.
- ◆ Access to the staging area will be limited to the presenters. Presenters may be any of the registered participants. A maximum of three (3) people shall speak during the live presentation. Teams shall make a live presentation. The use of video is permitted (without sound).
- ◆ Presentation order will be selected randomly before the competition begins.
- ◆ An additional five (5) minute period shall be permitted for judge's questions immediately following the presentation.
- ◆ Teams will have a four (4) minute period to set up equipment and an additional four (4) minute period to take it down.

The presentation will take place after the bridges exhibition. The teams will have access to electricity, microphones, a large projection screen and a computer projection unit for use during the oral presentation.

The teams shall discuss the following but not limited to: ingenuity of the design and construction, added value of the selected design, risk mitigation analysis, estimated construction time and budget. Teams are encouraged to refer to their poster during their presentation.

An award is given for the oral presentation and the specific criteria will be based on the following points:

DESCRIPTIONS / ORAL PRESENTATION	POINTS
Ingenuity	/3
Selected Design	/5
Risk mitigation	/3
Time and budget	/4
Presentation visual	/3
Presentation delivery	/3
Questions and answers	/4
Deductions* -1 for each of these non-respected rules: For each 10 second over or under 5 minutes	
TOTAL	/25

Request oral submission for 6th May (considering that the competition is held from May 8 to 11, 2019). A penalty of -1 points will be applied on the final score of the oral (25 points) on each day of delay (whereas a day ends at 11:59 pm)

6.2.3 Construction Speed

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

Teams are requested to submit an estimation of the construction time prior to 6th May, if the estimate is not sent before 11:59pm (6th May), a penalty of 30 sec will be applied to the final assembly time of the university if this deadline is not respected.

6.2.4 Lightness

The bridge with the least total weight will win in the lightness category. Total weight is measured weight plus weight penalties prescribed in 8.2, 9.3, 9.5, and 10.4.2.

Measured weight is the weight of the bridge as determined by the scales provided by the organization. Decking, tools, lateral restraint devices and posters are not included in total weight.

6.2.5 Stiffness

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

6.2.6 Construction Economy

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

$$C_c = \text{Total time (minutes)} \times \text{number of builders (persons)} \\ \times 60,000 (\$/\text{person-minute}) + \text{load test penalties } (\$).$$

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

6.2.7 Structural Efficiency

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

If measured weight does not exceed 120 pounds,

$$C_s = (\text{Total weight} - \text{measured weight}) (\text{pounds}) \times 5000 (\$/\text{pound}) \\ + \text{Aggregate deflection (inches)} \times 3,250,000 (\$/\text{inch}) \\ + \text{Load test penalties } (\$).$$

If measured weight exceeds 120 pounds but does not exceed 200 pounds,

$$C_s = (\text{Total weight} - 120) (\text{pounds}) \times 5000 (\$/\text{pound}) \\ + \text{Aggregate deflection (inches)} \times 3,250,000 (\$/\text{inch}) \\ + \text{Load test penalties } (\$).$$

If measured weight exceeds 200 pounds,

$$C_s = (\text{Total weight} - 184) (\text{pounds}) \times 25,000 (\$/\text{pound}) \\ + \text{Aggregate deflection (inches)} \times 3,250,000 (\$/\text{inch}) \\ + \text{Load test penalties } (\$).$$

Section 11.5.2 prescribes “load test penalties.”

6.3 OVERALL SCORING

The overall scoring is divided into three categories: design aesthetics, oral presentation and overall performance. The overall performance rating of a bridge is the sum of the construction cost C_c and structural cost C_s and is worth 60 % of the overall scoring. The oral presentation and design aesthetics are worth 25% and 15 % respectively.

The points attributed for each category will be based upon the team’s overall ranking (OR) in a given category and the number of teams competing (n). The overall score (OS) is computed using equation (1) where OR_{DA} , OR_{ORAL} and OR_{OP} are respectively the overall ranking of design aesthetics, oral presentation and overall performance of the bridge categories:

$$OS = \left(1 - \left(\frac{OR_{DA} - 1}{n}\right)\right) \times 15\% + \left(1 - \left(\frac{OR_{ORAL} - 1}{n}\right)\right) \times 25\% + \left(1 - \left(\frac{OR_{OP} - 1}{n}\right)\right) \times 60\% \quad (1)$$

All the teams will be finally ranked from 1st to nth where n is the number of teams based on the overall score (OS). The team with the highest overall score wins the competition. In the case of a tie, the bridge with the highest overall performance of the bridge wins the tie breaker.

RANKING		
AESTHETICS DESIGN	ORAL PRESENTATION	TOTAL OVERALL COST
15 %	25 %	60 %

6.3.1 Scoring spreadsheet

The scoring spreadsheet will be available in the 2019 COMPETITION INFORMATIONs at <http://www.cscecompetitions.ca/cnsbc>. Questions and comments regarding the spreadsheet should be sent to cnsbc@cscecompetitions.ca. 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.

SECTION 7 – SCHEDULE OF COMPETITION

In the months before the competition, students design their bridges, fabricate members, test load, designate the competition team, and practice construction. The Canadian National host school procures a venue, the Officials for the **CSCSE Student competition committee** organizes equipment (Section 12), and recruits judges (Section 14). Judges are prepared by reviewing current year rules and all clarifications (Section 13). Clarifications, some of which may have been posted immediately prior to the competition, are found at <http://www.cscecompetitions.ca/cnsbc>.

7.1 RECOMMENDED SCHEDULE

- 1- The official scoring spreadsheet is downloaded from <http://www.cscecompetitions.ca/cnsbc>, and data forms are generated from that spreadsheet.
- 2- Using a random process, the official determines the order in which teams will compete.
- 3- The head judge conducts a meeting with the other judges to clarify any rules concerns and to inspect the construction and loading facilities.
- 4- Bridges are erected for public viewing and are judged for architectural design. After the start of architectural design judging, bridges shall not be altered, modified, or enhanced in any way. (day #1)
- 5- Bridges are disassembled.
- 6- The oral presentation will be held in the same day (day #1)
- 7- In a meeting at which all captains are present, the head judge clarifies rules and conditions of the competition, and answers questions. (day #2)
- 8- Immediately before timed construction of the first bridge, the head judge rolls a die to determine the locations of decking units and where the lateral load will be applied. These designations will guide load tests as described in 11.4.1, 11.5.1, and the Lateral and Vertical Load Test Plan Diagrams. For each possible result of the roll (N), Table 7.1 gives the dimensions for positioning decking units and locations where the lateral and vertical load is applied and vertical deflection and sway are measured. (day #1)

TABLE 7.1 Determination of L1, L2, and S

N	L1	L2	S
1	11'-0"	6'-0"	11'-6"
2	12'-0"	8'-0"	11'-6"
3	13'-6"	10'-0"	0'-0"
4	14'-0"	8'-4"	0'-0"
5	14'-6"	10'-8"	0'-0"
6	15'-5"	10'-5"	11'-6"

The same values of L1, L2 and S will be used for all bridges in the same 2019 competition. The longer span between piers will be designated as the left side. The left side shall be considered north and the right side shall be considered south which will define the west and east ends of the bridge.

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

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

11- 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.

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

13- Bridges are load tested. See Section 11, “Load Test Instructions,” for details.

14- 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.

15- Scores and rankings are determined using the official scoring spreadsheet.

16- Paper or electronic copies of the “Rankings” worksheet of the official scoring spreadsheet are distributed to captains of all teams at the awards ceremony.

17- The Officials for the CSCE Student competition committee submit the completed official scoring spreadsheet by emailing it to the address given on that spreadsheet as soon as possible after completion of the competition.

7.2 ALTERNATIVES

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

1- Bridges are not modified after the die is rolled.

2- Bridges are not modified between aesthetics judging and timed construction.

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

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

SECTION 8 – MATERIAL AND COMPONENT SPECIFICATIONS

8.1 MATERIAL

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

8.2 COMPONENTS

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

8.2.1 Bridge

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

8.2.2 Members

8.2.2.1 Parts of a member are welded* together. Bolts and nuts that are welded¹ to a member are threaded parts that are considered part of that member and are not considered to be loose bolts, and loose nuts. A member shall retain its shape, dimensions, and rigidity during timed construction and load testing. A member shall not have moving or flexible parts. Exception: Deformations caused by mechanical strain (e.g., bending, stretching) during construction and load testing are not violations.

8.2.2.2 All members shall fit into a right rectangular prism (i.e., box) of dimensions of 3'-6" x 6" x 4". **Otherwise each member will weigh a maximum of 20 lbs each.**

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

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

8.2.3 Loose Bolts

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

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

8.2.3.3 The size of the bolts and nuts imposed are 1/4 "in diameter.

8.2.4 Loose and Welded Nuts

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

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

8.2.5 Holes in Members

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

SECTION 9 – STRUCTURAL SPECIFICATIONS

9.1 MEASUREMENT

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

9.2 FUNCTIONALITY

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

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

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

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

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

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

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

9.3 USABILITY

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

9.4 CONNECTION SAFETY

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

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

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

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

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

9.5 INSPECTABILITY

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

SECTION 10 – CONSTRUCTION REGULATIONS

10.1 GENERAL CONSTRUCTION REGULATIONS

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

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

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

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

10.1.5 Builders shall wear hardhats that meet CSA Z94.1-05 and protective eyewear or safety goggles that meet CSA Z94.3.3-16 as personal protective equipment during all construction activities.

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

10.1.7 Only Judges, officials, local committee and builders will have access to the construction area. All offenses will lead to 15 sec. of penalty to the university (per person, each time of offense).

10.2 PRE-CONSTRUCTION CONDITIONS

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

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

10.2.2 There shall be no more than six builders.

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

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

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

10.3 SAFE CONSTRUCTION PRACTICES

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

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

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

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

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

10.3.5 Throwing anything is prohibited.

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

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

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

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

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

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

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

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

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

10.4 ACCIDENTS

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

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

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

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

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

clock will be restarted, construction will resume, and a 200-pound weight penalty will be assessed, even if the bearing surfaces of the bridge are within the footings when it is completed.

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

10.5 CONSTRUCTION SITE

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

10.6 START

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

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

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

10.7 TIME

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

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

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

10.8 TIME LIMIT

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

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

10.9 FINISH

10.9.1 Construction ends and the clock is stopped when

- 1- the bridge has been completed by connecting all the members that were in the staging yards at the start of timed construction,
- 2- all builders are in the staging yards,
- 3- all tools are in contact with the ground in the tool section of the staging yard,
- 4- **all extra nuts and bolts are held in the hands of builders, or are in clothing worn by builders only, not acceptable to be on the ground in the staging yards.**
- 5- the captain informs the judge that construction is complete.

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

10.9.3 Installation of decking is not included in timed construction.

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

SECTION 11 – LOAD TEST INSTRUCTIONS

11.1 DAMAGE

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

11.2 SAFETY PRECAUTIONS

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

11.2.1 General Precautions

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

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

11.2.1.3 While participating in load testing, competitors shall wear personal protective equipment consisting of hardhats meeting CSA Z94.1-05, protective eyewear or safety goggles meeting CSA Z94.3.1-16, work gloves, and leather construction boots in compliance to CSA Z195.1-16. This safety equipment is provided by each team. Judges will not permit load testing by competitors who are not wearing the specified personal protective equipment or are wearing it improperly.

11.2.2 Lateral Load Test Precautions

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

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

11.2.3 Vertical Load Test Precautions

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

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

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

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

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

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

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

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

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

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

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

11.2.3.11 The teams will have to evaluate the total deformation: “aggregate deflection” of their steel bridge after vertical load, the 2500 pounds will be applied on the structure – wherever at the positions L1 and L2 of the decking and position S.

- ◆ Teams are requested to submit their evaluation for each of the six load cases (as presented in the Table 7.1) by May 6th at 11:59 p.m.

If this evaluation is not sent before this time and the deadline not respected, a penalty of 250,000\$ will be applied to the Structural Efficiency.

- ◆ In the alternative, if a given team is more or less 15% of the evaluation, 250,000\$ will be subtracted to the Structural Efficiency.
- ◆ In this purpose during the load test, a monitor will be available for the team members to visualize deformation graphic (load, deflection).

In consideration of the above, CNSBC encourages teams to properly understand their design and all the six load cases. This more educative and professional horizon aims to get engineering students to always innovate more and promote their prototype.

11.3 PREPARATION

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

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

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

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

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

11.4 LATERAL LOAD TEST

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

11.4.1 Set Up

Lateral load tests are conducted with one decking unit positioned at a distance S from the east end of the stringers and approximately **100 pounds** of weight on that decking near the left side of the bridge. This load is intended to restrain the bearing surfaces of the bridge from lifting off the floor when lateral load is applied. No additional uplift restraint will be used, even if bearing surfaces lift.

Bearing surfaces are prevented from sliding by lateral restraint applied by the loading crew. This lateral restraint shall not restrain rotation or uplift. The restraint is applied as close to the floor as

possible, at the locations shown on the Lateral Load Test Plan on the Lateral Load Test Plan Diagrams. Teams may provide and use optional devices to prevent sliding. However, the device must prevent sliding only. Devices designed to prevent vertical uplift will not be permitted. The lateral load test is failed if the bridge is restrained in other than the lateral direction, or if the restraint is not applied close to the ground, or if the restraint is not effective.

11.4.2 Lateral Load Test

A **75 pound** lateral load is applied and sway is measured on the right side of the bridge, centered on the decking unit positioned at S. Lateral load is applied at the level of the decking or top of the stringer, which is the bottom of the decking. The sway measurement is made as close as possible to the location of the lateral load.

The test is failed if sway exceeds one inch.

If the bridge fails the lateral load test it will not be ranked for awards in any category.

Do not conduct the vertical load test. Check the appropriate box on the data form.

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

11.5 VERTICAL LOAD TEST SEQUENCE

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

11.5.1 Set Up

11.5.1.1 Decking units are 3'-0" long in the longitudinal (span) direction of the bridge so that the main bars of grating span laterally. Two decking units are used. Decking units are placed square with and centered on the stringers. Decking units shall not be attached to the bridge and shall not distort it (see 9.2.3 and 9.2.4). Two decking units are placed at distances L1 and L2 from the east end of the tops of the stringers.

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

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

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

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

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

11.5.2 General Loading Procedure

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

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

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

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

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

11.5.3 Vertical Load Test

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

11.5.4 Loss of Data

If deflection data is lost or compromised, the judge will require the team to disassemble the bridge, repeat timed construction beginning with the initial conditions prescribed in 10.6, and redo lateral and vertical load tests. Compliance with specifications in Section 8 and SubSection 9.3 will not be checked again, but compliance with specifications in 9.4 and 9.5 will be verified. Scoring will be

based on the run that results in the larger construction cost C_c (not including load test penalties), but will not exceed 110% of C_c (not including load test penalties) for the initial run.

If the team decides not to repeat the timed construction, their overall performance score will be fixed to 0 and be given the last rank.

11.6 UNLOADING

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

SECTION 12 – EQUIPMENT PROVIDED BY HOST

12.1 SOURCES OF INFORMATION

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

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

12.2 DECKING

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

12.3 SAFETY SUPPORTS

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

12.4 LOAD

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

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

12.5 TEMPLATE

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

12.6 BOX

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

12.7 SCALES

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

SECTION 13 – INTERPRETATION OF RULES

To apply to the Canadian competition, any question must be addressed to the CNSBC head judge and answered by CNSBC up to 2 weeks before the Canadian competition. The last questions will be answered until April 24th 2019 (11:59pm).

Specific *Requests for Information* (RFI) for the Canadian Competition should be directed via e-mail to the Official from the Committee of the Canadian National Steel Bridge Competition at cnsbc@cscecompetitions.ca. Official responses will be posted to the CNSBC Facebook page. **The cut-off date for submitting a RFI is Wednesday, April 24th, 2019 (11:59pm).** Those received after this date will not be acknowledged or addressed. RFIs will be accumulated and published in RFI summaries by the CNSBC on or about November 15th 2018, December 21st 2018, February 15th 2019, and March 15th 2019, finally April 26th 2019. **Teams are strongly encouraged to contact the CNSBC to avoid misinterpretation of rules at the competition. All RFIs will be made public.**

The CNSBC has a Facebook Page (CNSBC-CNCFA) to post relevant information including RFI responses. Teams are also responsible for all information provided in the Rules, the general questions and answers posted to the Facebook Page, and information given at competitions from the date of the release of the information. This page is not intended for the submission of RFIs and any posted to the page will not be addressed by the CNSBC.

For the CNSBC to respond to the questions submitted via e-mail in a timely manner, indicate the section(s) being referenced in the “Subject” of the e-mail (for example, “Section 8.2.4 Loose and Welded Nuts”), provide the particular sentence or paragraph in question along with the question(s) being asked. Please be as specific as possible when providing the questions.

SECTION 14 – JUDGING

The CSCE Student Competition Committee 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 will be available on a website, which will be available later this year.

GLOSSARY

ACCIDENT. Fault committed during timed construction and subsequently penalized.

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

AGGREGATE DEFLECTION. The sum, rounded to the nearest 0.01 inch, of the absolute values of deflections measured at D1 and D2.

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

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

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

BUILDER. Undergraduate or graduate student who constructs the bridge and is part of a competing team. See Section 4, "Eligibility".

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

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

CONSTRUCTION COST. Dollar amount used to determine a bridge's construction economy based on the number of builders, total time and load test penalties.

CONSTRUCTION ECONOMY. Award category based on construction cost.

CONSTRUCTION SITE. The location where all construction activities occur comprising the river, construction zones, transportation zones and the staging yards.

CONSTRUCTION SPEED. Award category based on the total time required for construction modified by construction penalties.

CONSTRUCTION ZONE. Location in the construction site where builders put the members together to construct the bridge.

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

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

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

DEFLECTION. Vertical translation of the bridge or parts of the bridge under load.

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

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

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. Similar applies for the official from the CSCE Student competition committee

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

LATERAL RESTRAINT. Means of inhibiting sliding of the bearing surfaces during lateral loading applied by the loading crew.

LEFT SIDE. Side of bridge in which the longitudinal distance between the piers is longest.

LIGHTNESS. Award category based on total weight of the bridge.

LOAD. Weight applied to the bridge to assess its stiffness and strength.

LOOSE BOLT. Bolt not installed in or welded to the constructed portion of the bridge.

LOOSE NUT. Nut not installed on a bolt or welded to the bridge.

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

MEMBER. A rigid component of the bridge.

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

OFFICIAL. Person that ensures the competition is conducted well and smoothly, respecting safety requirements and assisting the head judge in the interpretation of the rules. They must be from the CSCE Student competition committee

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

PERSONAL PROTECTIVE EQUIPMENT. An article of clothing that a team provides for safety.

POSTER. Informative flat display that must be posted during aesthetics judging.

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

RIGHT SIDE. Side of bridge in which the longitudinal distance between the piers is shortest.

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

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

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

SAFETY SUPPORTS. Equipment provided by the host school used to limit the consequences of a bridge collapsing.

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

SCHOOL. College or university that a student team represents.

SCORING SPREADSHEET. Official location where a team's score is input by the scoring official at the end of the team's competition.

SITE BOUNDARY. Border of the construction site.

STAGING YARD. Location within the construction site occupied by builders, tools, and materials at the start and finish of timed construction.

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

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

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

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

STRUCTURAL EFFICIENCY. Award category based on structural cost.

SWAY. Horizontal translation of the bridge.

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

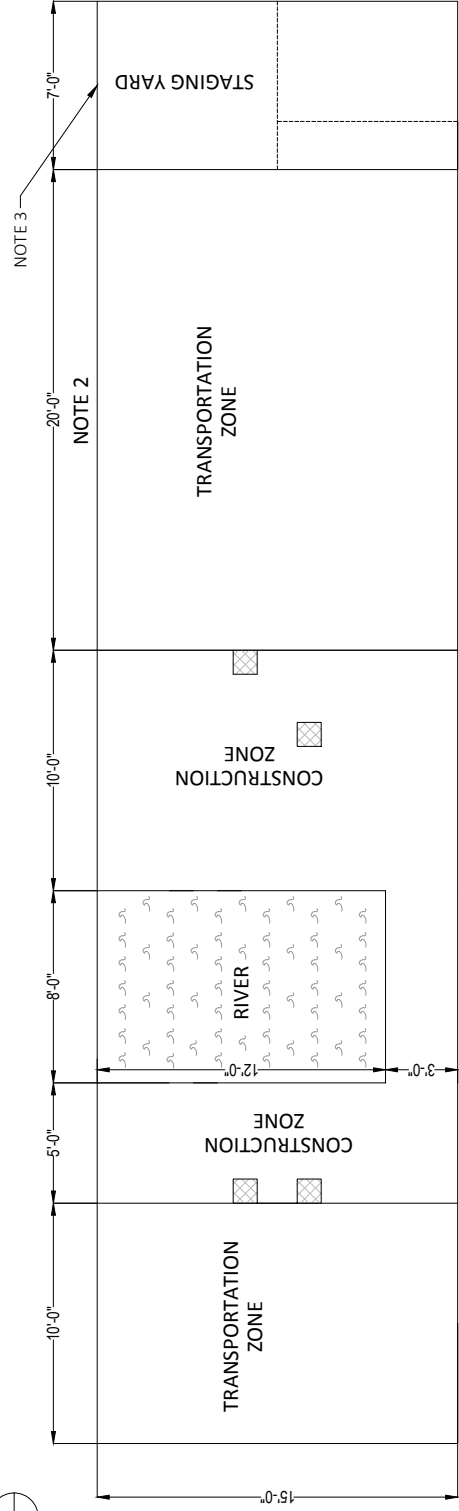
TEMPLATE. Equipment provided by the Official to measure clearances within the passageway of the bridge.

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

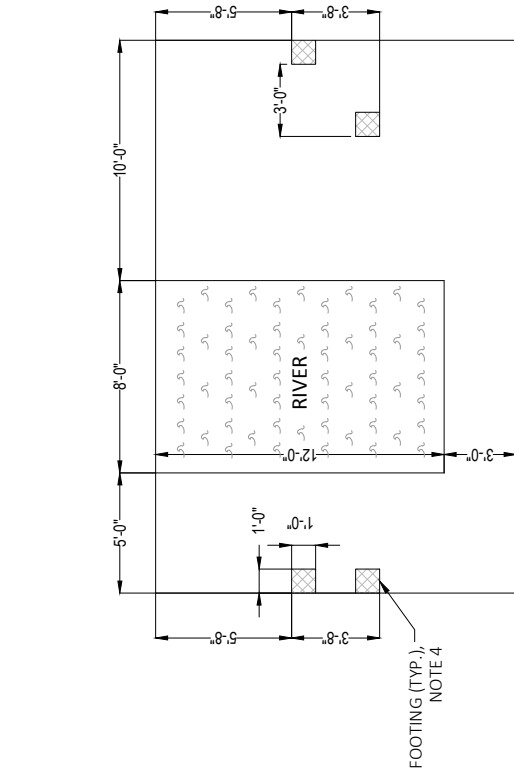
TOTAL TIME. Time required for construction modified by construction penalties.

TOTAL WEIGHT. Sum of measured weight and weight penalties.

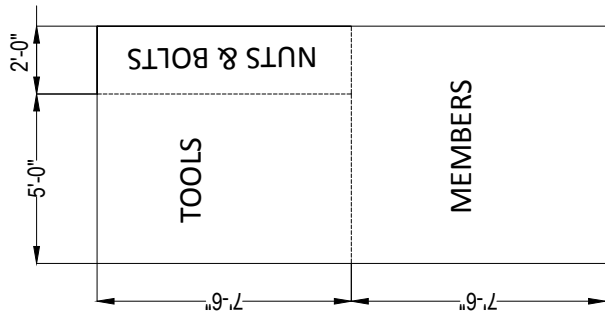
TRANSPORTATION ZONE. Portion of construction site between the construction zones and staging yards over which builders carry members, tools, nuts, and bolts.



CONSTRUCTION SITE PLAN



CONSTRUCTION ZONE AND RIVER DETAIL



STAGING YARD DETAIL

1 SITE PLAN

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



CANADIAN NATIONAL
STEEL BRIDGE
COMPETITION

CNSBC 2019 RULES

NO.	DESCRIPTION	DATE
NO.	REVISIONS	DATE

DRAWING TITLE:

DRAWING BY:	MARIE-PIER LIOITTE
CHECKING BY:	MARIE-PIER LIOITTE
DATE:	SEPTEMBER 2018

PROJECT NO.:	CNSBC RULES 2019
DRAWING	CNSBC-2019-01
SITE PLAN	PAGES 1/4



CANADIAN NATIONAL
STEEL BRIDGE
COMPETITION

CNSBC 2019 RULES

NO.	DESCRIPTION	DATE
NO.	REVISIONS	DATE

DRAWING TITLE:

DRAWING BY: MARIE-PIER DIOITTE
CHECKED BY: MARIE-PIER DIOITTE

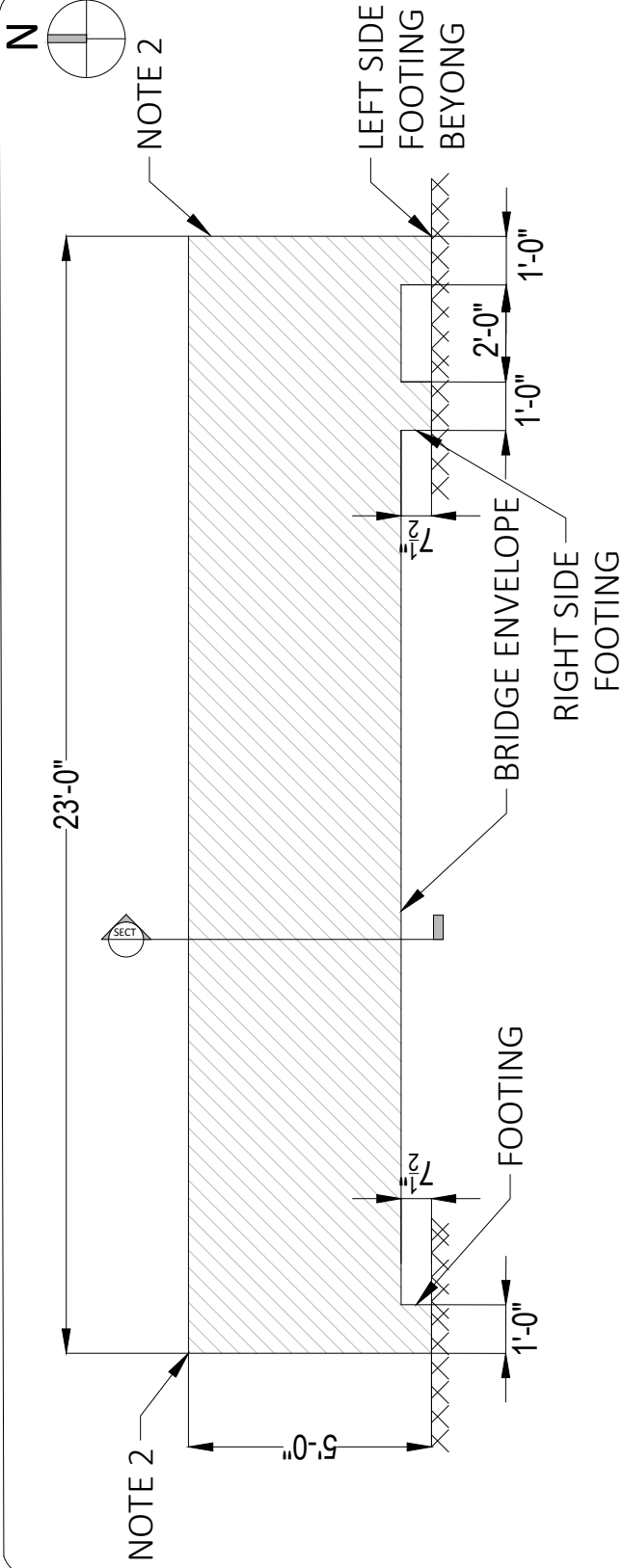
DATE: SEPTEMBER 2018

PROJECT NO.: CNSBC RULES 2019

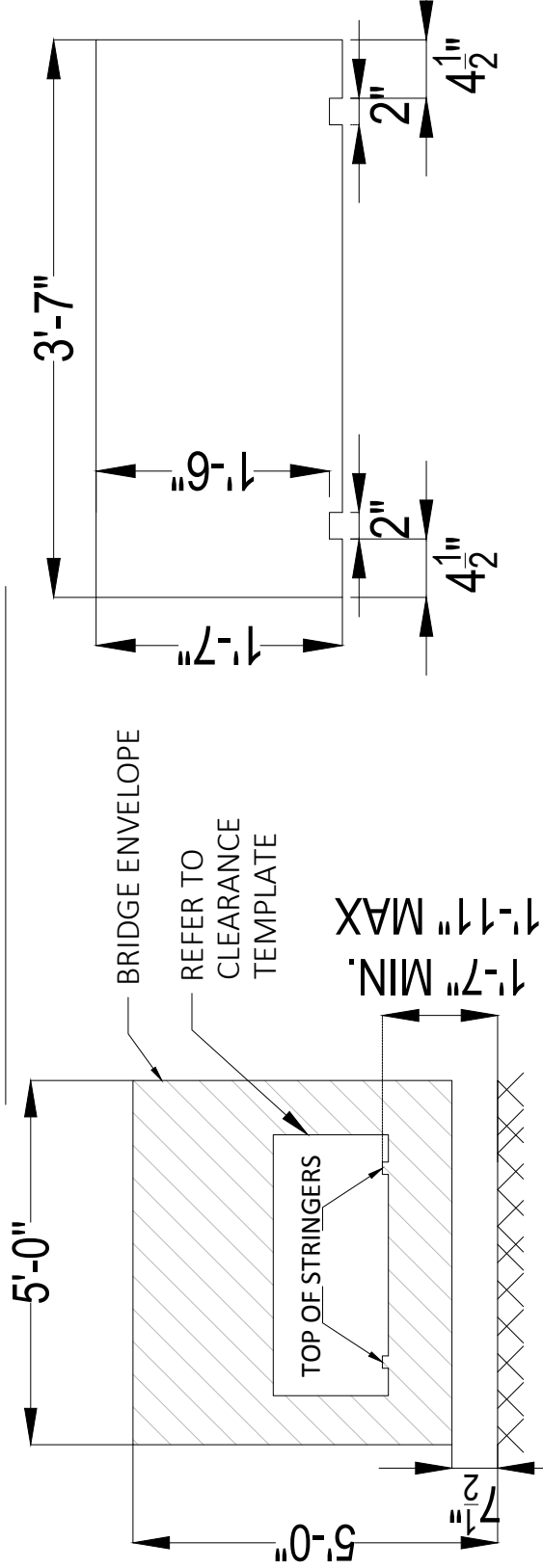
BRIDGE
ELEVATION

DRAWING
CNSBC-2019-02

PAGES
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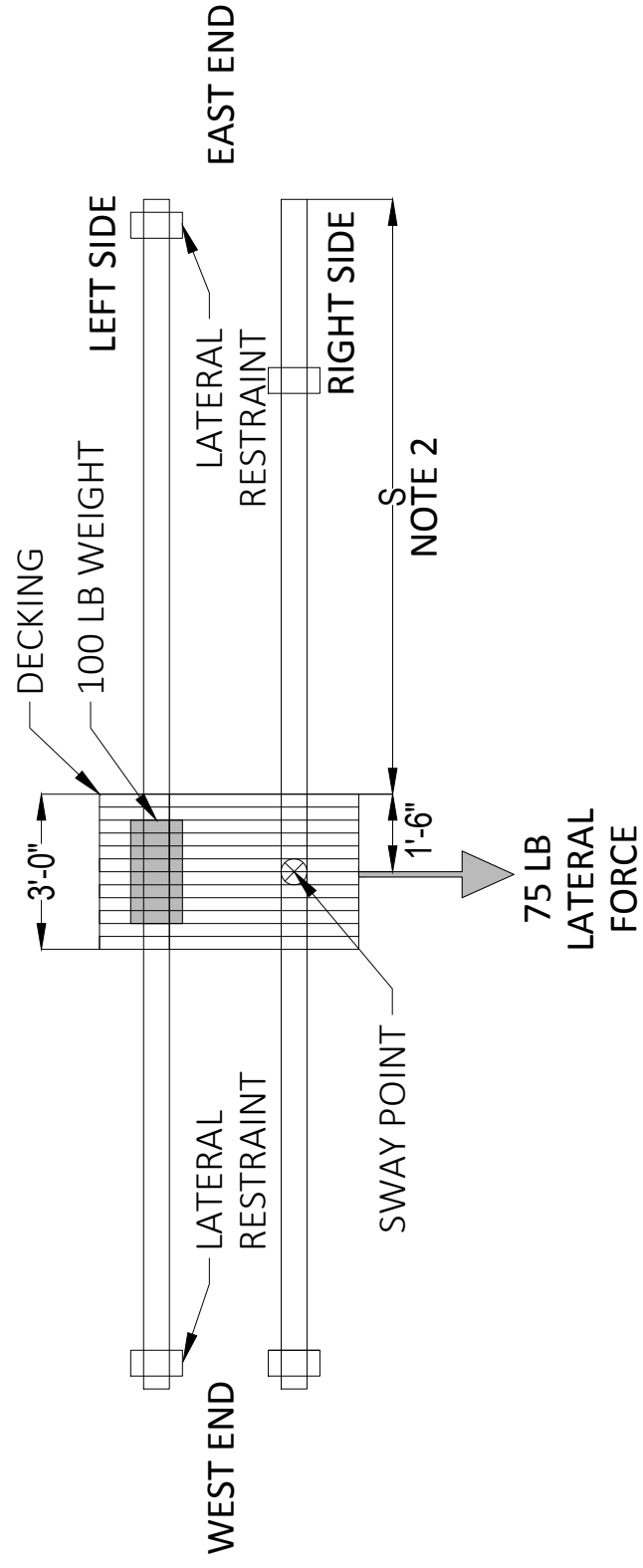
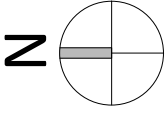
RIGHT SIDE ELEVATION



CLEARANCE TEMPLATE

1 BRIDGE ELEVATION

- NOTES:
1. DRAWINGS ARE NOT TO SCALE.
 2. NO PART OF THE BRIDGE SHALL EXTEND AWAY FROM THE RIVER BEYOND LIMITS OF THE CONSTRUCTION ZONE (9.3.8).
 3. TOPS OF STRINGERS SHALL BE AT LEAST 22 FT. LONG (9.3.6).



1 LATERAL LOAD TEST PLAN

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



CANADIAN NATIONAL
STEEL BRIDGE
COMPETITION

CNSBC 2019 RULES

NO.	DESCRIPTION	DATE
NO.	REVISIONS	DATE

DRAWING TITLE:

DRAWING BY:	MARIE-PIER LORTIE
CHECKING BY:	MARIE-PIER LORTIE
DATE:	SEPTEMBER 2018

PROJECT NO.:	CNSBC RULES 2019
LATERAL LOAD TEST PLAN	
DRAWING	CNSBC-2019-03
PAGES	3/4



CANADIAN NATIONAL
STEEL BRIDGE
COMPETITION

CNSBC 2019 RULES

NO.	DESCRIPTION	DATE
NO.	REVISIONS	DATE

DRAWING TITLE:

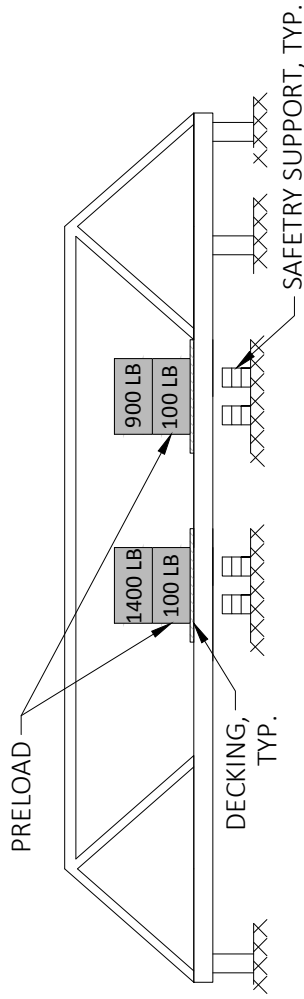
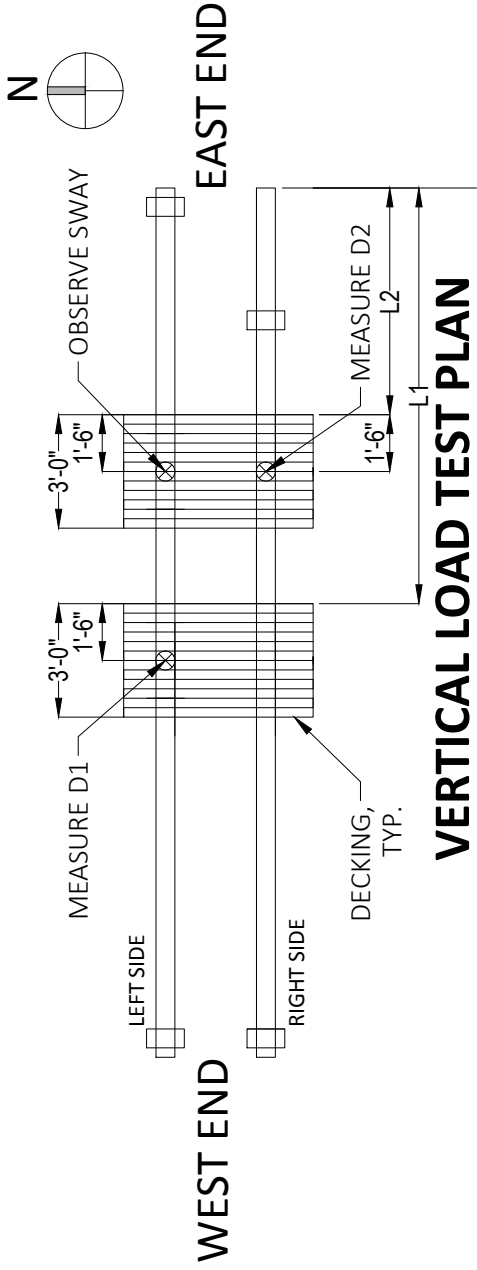
DRAWING BY: MARIE-PIER DIOITTE
CHECKED BY: MARIE-PIER DIOITTE

DATE: SEPTEMBER 2018

PROJECT NO.: CNSBC RULES 2019

VERTICAL LOAD TEST
PLAN AND ELEVATION

DRAWING
CNSBC-2019-04
PAGES
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1 VERTICAL LOAD TEST PLAN AND ELEVATION

NOTES:

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