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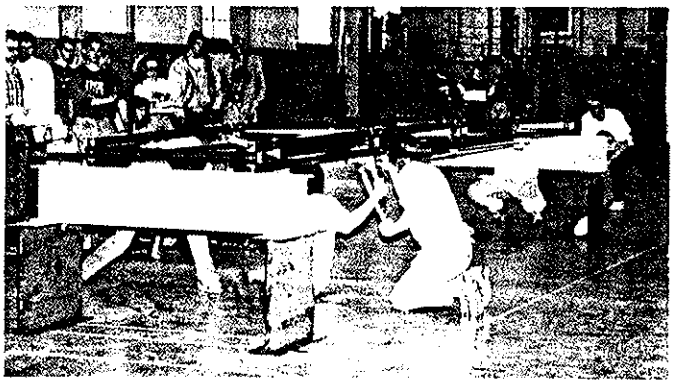
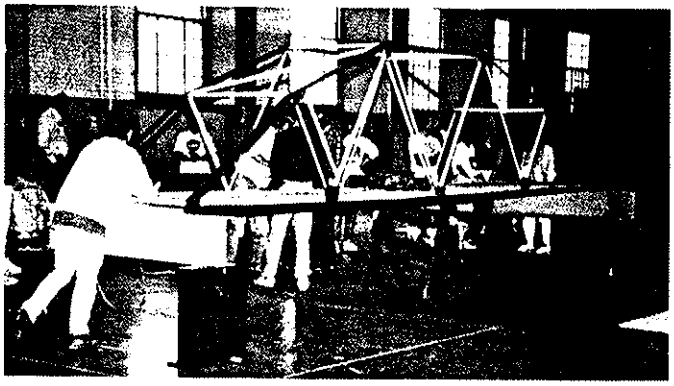
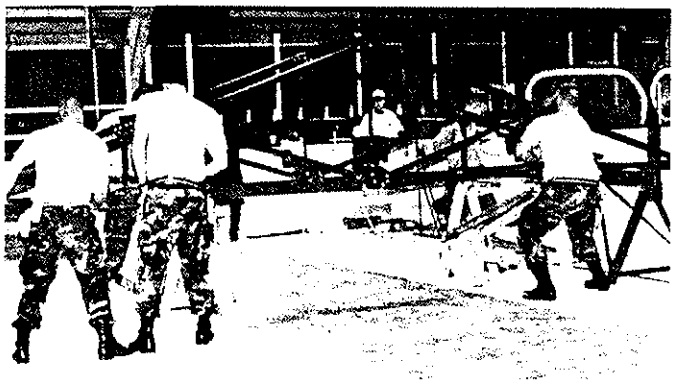
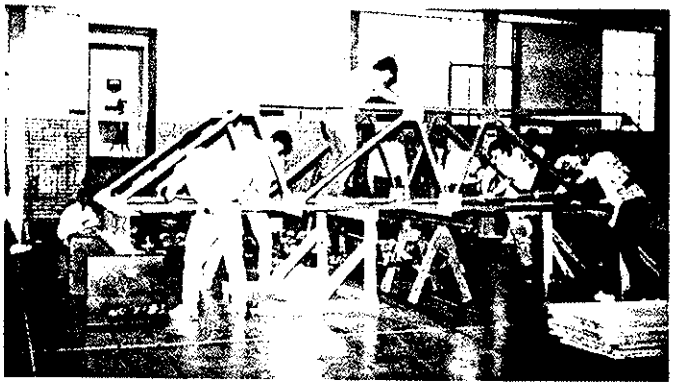
STEEL BRIDGE BUILDING COMPETITION









FOR STUDENT CHAPTERS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS

IN COOPERATION WITH
AMERICAN SOCIETY
OF CIVIL ENGINEERS

STATEMENT

The Steel Bridge-Building Competition is sponsored by the American Institute of Steel Construction. It challenges civil engineering students to a competition that includes design and hands-on experience with structural steel.

Since the educational intent of the competition is to give engineering students exposure to designing, fabricating and erecting a steel bridge, AISC is recommending that the judging panel at each competition accepts only bridges substantially designed and built during the academic year in which the competition is held.

AISC places great emphasis on safety. The competing teams are asked to observe safety practices as covered in the competition rules.

AISC 1992 STEEL BRIDGE-BUILDING

COMPETITION RULES

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EXECUTIVE SUMMARY

Civil Engineering students are challenged in a competition that includes design, hands-on experience with structural steel and the use of both actual and simulated construction practices in building a structure. Through the competition, you will utilize materials and design knowledge, construction planning, shop experience, training and teamwork.

In the opening Problem Statement, you are given an orientation into some of the real-life design and construction problems commonly encountered in actual practice. The Statement also establishes some background into the selection of the load tests and design/construction restrictions of the competition. The Problem Statement and related rules are basic to construction practices and are minimal when compared to the volumes of real-life regulations.

Member size and weight limitations are given for several reasons. First, it makes the competition representative of a real situation. Second, it causes you to look at several construction alternatives, rather than using a single member to span the entire 20-foot length. Third, it facilitates the handling and transportation of your structure to the competition site. Fourth, it minimizes the risk to you in handling and assembling the pieces.

Material handling rules and related penalties have been established to maintain the integrity of the construction simulation. These rules are related to actual construction problems, just as members are scaled to model those size limitations found in an actual structure.

Several categories of competition are offered, so you should look at several design alternatives to win any or all of the categories. A latticework structure may be the lightest, but take a long time to build. A cable supported structure may be fast and light, but not meet deflection or stability considerations. Beam-type structures may be fast, but heavy and expensive. Several categories of competition allow you to target your objectives and design/build accordingly.

The competition promises design challenges, steel fabrication experience, the use of construction planning and practice, teamwork, plus the fun of competing against fellow students.

PROBLEM STATEMENT

A century-old bridge across a river valley in a mountainous rural region in is need of replacement. The bridge serves not only area residents but also important heavy truck traffic for area mining. No other river crossing of adequate capacity is available for miles in either direction, therefore a quick replacement is necessary.

The State Department of Transportation has sought design/build proposals to construct a replacement bridge. Any type of steel structure will be permitted, but it must meet the following minimum design loads and construction restrictions.

1. the bridge must support a single 75 ton truck at any point on the bridge,
2. the bridge must support a stationary load applied at or near the center of the bridge totalling 250 tons,
3. the bridge must be able to resist a lateral force of 100,000 pounds from river flooding and/or wind forces,
4. no interior piers are permitted, easing environmental clearances,
5. no lateral thrusts or uplift can be applied to the existing abutments, nor can they be reinforced to accommodate such forces,
6. no backstays or anchorages are available beyond the abutment,
7. construction and live load deflection limits must be met,
8. and the bridge must accommodate state-supplied modular bridge deck units salvaged from another bridge, without modification to any unit.

The existing bridge spans in the north-south direction a distance of 200 feet, resting on simple stone abutments. The valley below is relatively flat, roughly 30 feet below the top of the abutments. The north river bank is 50 feet wide, the river itself is 70 feet wide, and the south bank is 80 feet wide. To allow for mining traffic on the banks below the bridge, and also for river flooding, a minimum clear height of 20 feet from river bank to bottom of bridge must be maintained.

The river is fast, not navigable and environmentally sensitive. Flash flooding and environmental concerns prohibit the use of barges, causeways or scaffolding across the river. Temporary shoring can be safely placed on the solid banks of the river.

Storage and staging yards 150 feet square will be cleared for the contractor's use at both ends of the bridge. The yard at the north end of the bridge will be located just 100 feet from the abutment. The yard at the south end will be 300 feet from the abutment. The service road from both yards to the bridge will be widened to 50 feet, and will extend around one end of the abutment wingwalls down to the river banks.

Soil conditions, rough terrain and tight site conditions limit the lifting capacity of all cranes to 30 tons (60,000 pounds). Working in tandem, two cranes could lift a combined total of 50 tons (100,000 pounds). Materials may be delivered by crane to the river valley by using the access roads constructed around the wingwall, or by transferring the materials over the abutments from one crane to the next.

A narrow, winding road leads to the bridge from both directions. Because of this, the length of an individual bridge section is limited to 55 feet, with a maximum width and depth of 6'-3". This enables the trucks to make the required turns. Smaller bridges on both sides of the main bridge being replaced limit the weight of an individual piece to 30 tons (60,000 pounds).

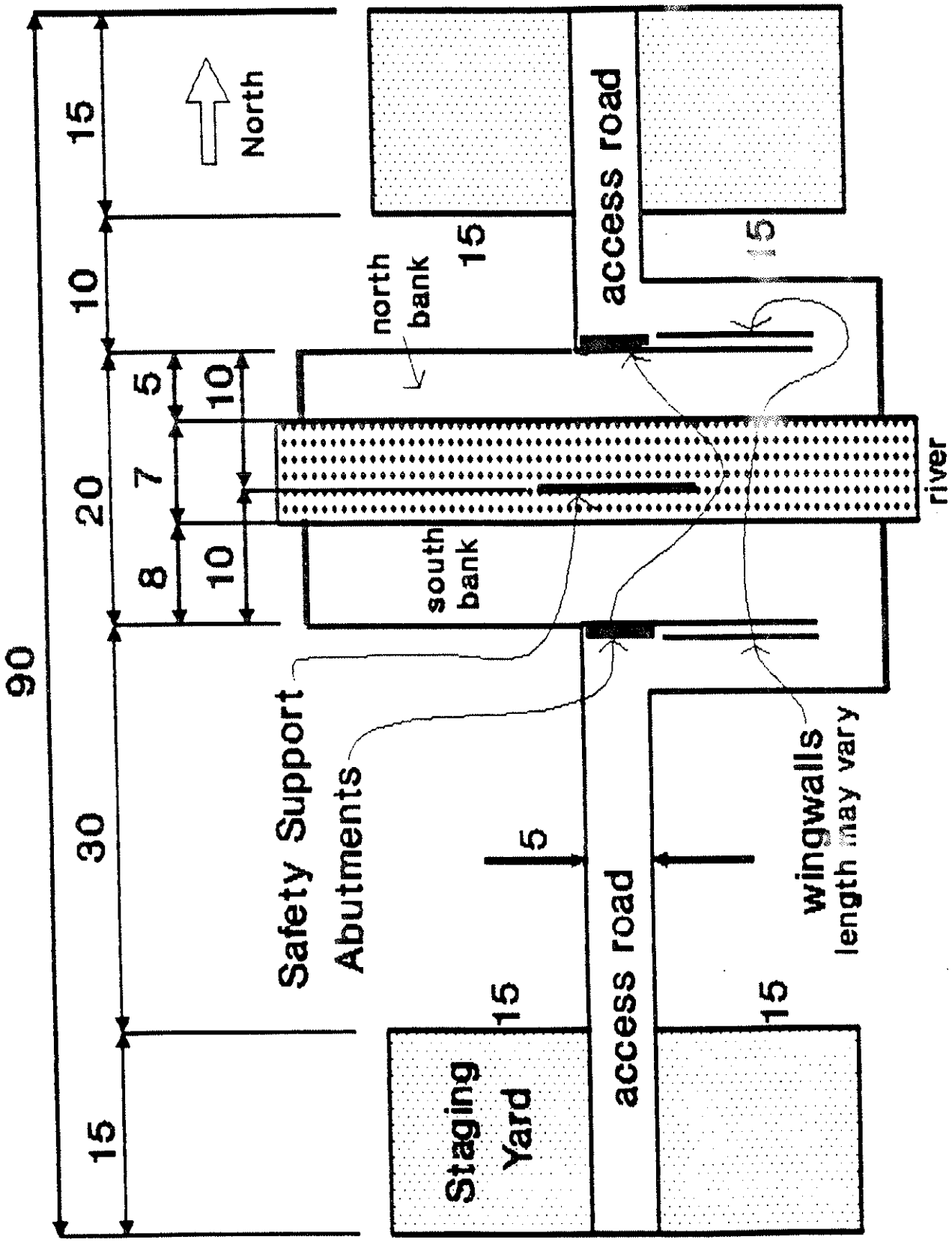
The State will provide prefabricated, 10" deep modular bridge deck units that were salvaged from another bridge. They are the required roadway width, 35 feet in the transverse direction. They are capable of spanning a 35 foot clear distance between supports, and are also capable of cantilevering 5 feet beyond a support. One design drawback to using these units is that can provide no lateral support to the bridge.

To allow for a new bridge design, new approaches will be constructed that can go as high as 7'-1" above the top of the existing abutment. Allowing for the 10" depth of the state-supplied modular deck unit, the structure depth at abutments can be as deep as 6'-3", the same as the maximum member depth.

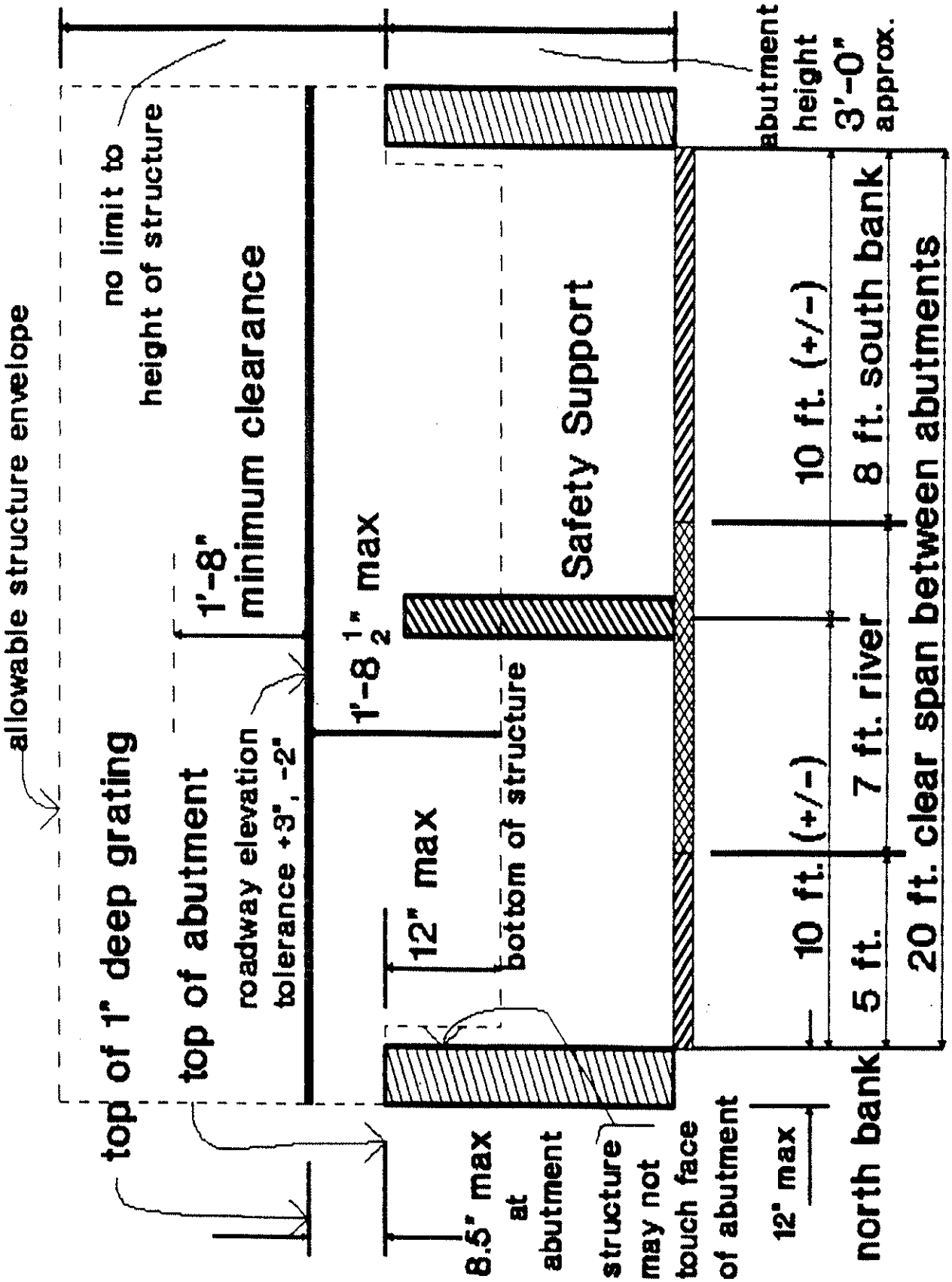
Your company's design/build proposal has been deemed responsive by the State Department of Transportation. To make a selection, the State has asked your firm and the other competing firms to construct a 1:10 model bridge, demonstrate the erection method to be used, then subject it to load testing. The State is concerned about many things in its evaluation -- strength, speed of construction, cost, stiffness and aesthetics. Using a ranking system, it will use the competition to select a contractor winner. If your bridge is judged the best, your firm will receive a negotiated contract to build this bridge, and possibly several others. You and your firm could become leaders in the national bridge replacement market.

(SEE NEXT TWO PAGES FOR SITE PLAN
AND BRIDGE AREA CROSS-SECTION)

SITE PLAN


North
15
10
5
10
20
7
8
10
30
15
90
north bank
15
access road
5
river
south bank
Safety Support Abutments
5
wingwalls
length may vary
Staging Yard
15
access road
15

BRIDGE AREA CROSS-SECTION



CATEGORIES OF COMPETITION

1. Fastest bridge construction
2. Lightest bridge
3. Highest capacity
4. Best capacity-to-weight ratio
5. Lowest cost bridge
6. Aesthetics

The bridge must pass the minimum design load tests (Tests 1, 2 and 3) to qualify in Categories 1 through 5. Grating weight is not considered to be part of the bridge weight, and is not used in determining bridge weights or capacities.

JUDGING GUIDELINES

The "fastest bridge construction" category uses total team time, in person-minutes. This is the number of team members times the amount of time used to erect the bridge.

For the "highest capacity" category, in the likely event that more than one bridge supports the total 2,500 pound applied live load in Test 4, the least vertical deflection will determine the winner.

To establish a capacity for the "best capacity-to-weight ratio" category, in the event more than one bridge supports the 2,500 pound load, use the following formula:

Capacity = 3"/actual deflection in inches * 2,500 pounds

The "lowest cost" category is a combination of weight and time. Basis for cost evaluation:

Structural steel, including bolts and welds	$0.40 / pound
Steel cable, including fittings	6.00 / pound
Field labor cost	$0.50 / person-minute
Temporary shoring	No cost
Safety support	No cost

Aesthetics is judged by a non-partisan jury following completion of the bridge, but prior to load testing. It is not necesary to pass the minimum load tests (Test 1, 2 and 3) to win the individual category of aesthetics. (See Judging Form for items to consider.)

SCALE FOR MODEL

for dimensions -- 10:1 (except deflections and tolerances)	10 ft. = 1 ft. 1 ft. = 1.2 in. 1 in. = 0.1 in.
for design loads -- 1000:1	1000 # = 1 # 1 ton = 2 #

PIECE AND UNIT SIZE AND LIFTING LIMITS

Individual Pieces

maximum length	5'-6"	(55')
maximum width and depth	7.5 in.	(6'-3")
maximum piece weight	60 #	(30 tons)

Cable length is not limited, but weight is still limited to 60 # per individual length. Cable may not be pre-attached to structural steel units.

Steel parts may be pre-assembled and treated as an individual piece provided that the assembled unit meets the above criteria and is rigidly bolted or welded together.

It is recommended to the judging panel to penalize accordingly the situations where unit sizes are exceeded. (See Safety and Material Handling Violations.)

Units Assembled in Yard - Handled by 2 or More People

maximum length	11'-0"	(110')
maximum width and depth	3'-6"	(35')
maximum weight	100 #	(50 tons)

Units assembled in yard may consist of combined steel and cable pieces, steel pieces in which the hinge pin has been inserted, or steel units field-bolted together.

It is recommended to the judging panel to penalize accordingly the situations where unit sizes are exceeded. (See Safety and Material Handling Violations.)

Temporary Shoring

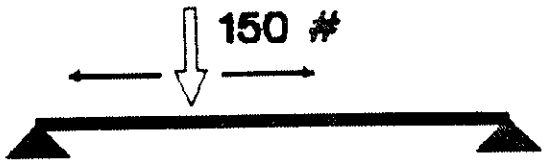
The size and weight of temporary shoring units is not limited. They should be pre-assembled and placed in position prior to the start of competition.

LOAD TESTS

The Safety Support must be in place 3 to 4 inches below the primary bridge steel prior to the start of load testing.

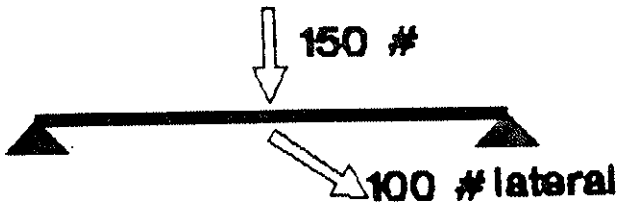
Test 1

Place a single 150# cart or other loading device (representing the 75 ton truck) anywhere on the bridge. Check vertical deflection limits and sidesway limits.



Test 2

With the 150# load still applied from Load Test 1, located at the center of the bridge, tie a rope to a primary structural element near the center of the span. The member shall be designated by the design team. Apply approximately 100# tension to the rope (representing 100,000# lateral force on the bridge.) The 100# tension is roughly equal to a person pulling on the rope horizontally with full effort. Check lateral sidesway limits.

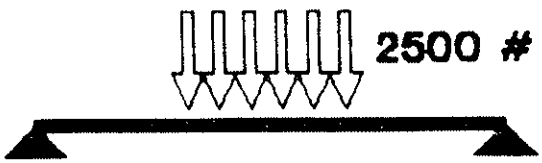


Test 3

Remove the lateral loading from Load Test 2. Add 350# of concentrated load, for a total of 500# (representing the 250 tons), to the center of the bridge. Spread the load over an area not to exceed 3 feet long and 3 feet wide. Check for vertical deflection limits and sidesway.

Test 4

Gradually increase the load, starting at the 500# from Load Test 3, up to 2,500# maximum. Apply this load over an area not to exceed 6 feet long and 3.5 feet wide. Make periodic checks of vertical deflection and sidesway.



TEST DEFLECTION AND SIDESWAY LIMITS

Load Tests 1 through 3 are for the minimum requirements and are conducted first. Deflections are measured at mid-span from the initial as-built position of the bridge, following the placement of the grating or other roadway surface. The vertical deflection under Tests 1, 2 and 3 must not exceed 2 inches. The horizontal sway must not exceed 1 inch.

Load Test 4 is also measured at mid-span from the initial as-built position of the bridge, following placement of the grating. The bridge does not have to pass Load Test 4 to qualify in the competition. The loading is applied until the 2,500# load limit, the maximum permitted vertical deflection of 3 inches, or the maximum permitted sidesway of 2 inches is reached. At 3 inches of vertical deflection, the bridge should be close to resting on its Safety Support.

CONSTRUCTION TOLERANCE

Vertical Alignment

Vertical alignment is measured along the top of the roadway. Establish a theoretical straight line at the top of grating at each abutment. From this line, the actual position of the roadway may be 3 inches higher or 2 inches lower.

Horizontal Alignment

There is no limit to how far the bridge may be out of alignment horizontally. However, bridges out of alignment generally will encounter stability problems.

Grating Placement

The grating (or other roadway surface) must be sufficiently even and smooth to allow for a rolling cart to pass from one end of the bridge to the other. Grating may not be lapped upon itself. Uneven conditions caused by grating placed on bolt heads and nuts will be considered acceptable.

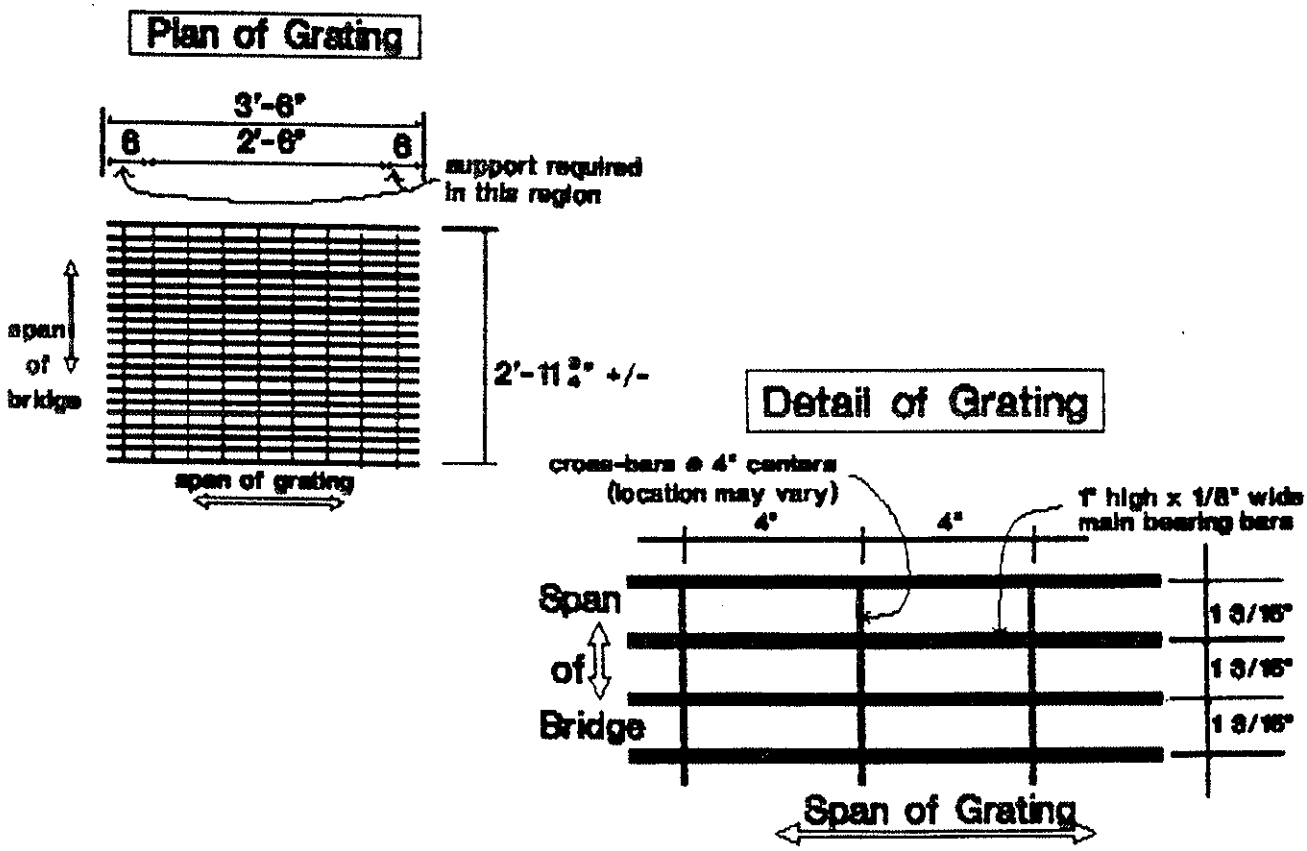
MODULAR DECK UNIT (GRATING)

This item will be supplied by the Host Chapter. If another form of roadway unit is supplied, the Host Chapter will notify entrants.

The grating is generically identified as "W-19-4 (1 x 1/8) steel." Steel bar grating has strength in one direction only, the direction in which the main bearing bars span. Grating will be 3'-6" long, the width of the roadway, spanning this direction. In other words, the grating must span perpendicular to the length of the bridge. Support must be provided under each end of the grating per the sketch on the next page. It is not necessary to support the grating along the sides of the grating. The grating cannot be attached or anchored to the bridge in any way. Each section of grating will be approximately 2'-11-3/4" wide. The grating weighs 4.9 pounds per square foot, so the total weight of each piece of grating will be close to 52 pounds.

For the Load Tests, do not exceed 400 psf uniform load or a 500 pound concentrated point load. Do not load in any cantilever region of the grating.

The maximum clear span for the grating is 3'-6", the entire width of the roadway. The maximum clear cantilever beyond a support is 6 inches.



GENERAL RULES

1. Beginning of Competition

To begin the competition, all bridge materials should be placed in the staging yards. Bridge pieces should be unassembled except within individual piece size and weight limits. For example, gusset plates could be attached to the main member as long as the total individual limits are not exceeded. Structural steel should be sorted and may be pre-arranged in assembly order. Bolts should be sorted according to size and stored in containers or "nail aprons", but not pre-arranged in the steel sections. Grating sections, if included in final construction, should be stacked. Cable should be coiled. Cable may not be pre-attached to the structural steel elements. Cable connecting items such as clamps and sockets may be pre-attached to the cable.

Tools should be in the staging yard. All team members are to start in a staging yard. Shoring, if used, and the Safety Support should be pre-assembled and placed in their final positions on the river banks and river prior to the start of the timed competition.

2. Measurement of Time

Total team time, the numer of team members times the elapsed time, is used. Timing starts when the Team Captain declares the team ready and the Timing Official declares the start. Time stops when the Team Captain declares the bridge construction complete and all team members, tools, and shoring have been returned to a staging yard. The Safety Support is not to be removed. If an unsafe condition arises, the time should be stopped to allow the team to rectify the unsafe condition. If adjustment to the Safety Support is needed, all work shall stop, the clock stopped, and the adjustment made.

3. Measurement of Weight

The total weight of bridge, materials, exclusive of grating or other bridge decking materials, shall be used. Weigh-in of individual pieces may be made prior to assembly, or a weight taken as the bridge sits on the abutments. Cable weight measurement, including cable fittings, clamps, etc., shall be made separately for use in the "cost" category.

4. Materials

All bridge materials must be steel, including framing members, bolts and cable. Cable is defined as a flexible strand material that is easily coiled.

5. Shoring

Each school is responsible for providing its own temporary shoring. Temporary shoring may be of wood or steel, and should be strong enough to support the weight of the bridge. Its weight is not considered a part of the final bridge weight, nor is the time to assemble and place the shoring in advance of the timed competition counted.

Shoring should be made vertically adjustable to compensate for variations in the height of abutments and uneven conditions in the river bank. Particular care should be exercised when making minor adjustments to shoring in order to maintain safe conditions. The use of solid wood blocking and/or steel shims is suggested for minor adjustments.

Shoring must be the final item removed from the erection site to the storage yard, following completion of the bridge erection. Final bolting and adjustments may be made following the removal of shoring, but once the shoring is removed, climbing or sitting on the bridge is not permitted.

6. Safety Support

The Host Chapter will make final design and provide a Safety Support for use in erection and load testing of the bridges. The purpose of this Safety Support is to provide a "fail-safe" support to the bridge and students should the bridge or shoring collapse during construction or during load testing. The Safety Support should have a capacity of at least 6,000 pounds. This is the estimated total of bridge weight, grating weight, load test limit weight, multiplied by a factor of safety of 1.7. The width of the Safety Support should be enough to prevent collapse to the ground, considering possible lateral sidesway of the bridge. The height of the Safety Support should be adjustable, just as shoring is adjustable.

The support is to be placed in the river at mid-span of the bridge, but may be offset as required to miss any bridge elements. The Safety Support is not to be used as a temporary construction shore (see Material Handling Violations.)

The Safety Support should be placed prior to the start of the timed competition, if at all possible. Prior calculation of the required Support elevation, and adjustment to that level, should be made. If the bridge design is such that the Safety Support must be placed after partial assembly of the bridge (say between chords of a truss), the Support must be in place prior to any students sitting or climbing on the bridge. In this situation, the bridge-building team shall stop all work and the clock shall be stopped. The team shall place the Safety Support in position, with material handling rules suspended for this purpose. Following placement, the clock will restart and work may be resumed by the full crew.

7. Tools

Each school is responsible for providing its own tools. Tools must start in the staging yard, but may be stored on the river banks and access roads after the competition begins. Tools may not be tossed or handed across the river except when carried by an individual across the substantially complete bridge. Only hand tools are permitted. Field welding, electric and pneumatic tools are not permitted. Ginpoles, jacks, winches, come-alongs, counterweights and other hoisting devices are not permitted. Simple ropes are permitted as hand tools.

8. Material Handling

Pieces may not be carried by an individual over an abutment. Pieces may be carried by an individual around the wingwall to the river bank. Pieces may also be handed over the abutment from one individual to another.

Materials may not be stored or laid down on the river bank or access roads. The exception to this rule is for bolts, nuts, washers and tools. Materials may be rested on abutments.

9. Movement by Individuals

Individuals must stay within the access road, staging yard and river bank limits. Stepping over the abutment is not permitted, except to climb onto the bridge. If climbing onto the bridge, no materials may be carried with the individual.

Crossing the river at any time is not permitted, except after the bridge is substantially complete. This is defined as when the bridge superstructure will support the full weight of the individual. Temporary scaffolding may not be used across the river, nor can an individual jump across the river.

10. Safety and Material Handling Violations

Violations of material handling and individual movement rules are listed below. Should a team accumulate more than 50 penalty points, the team is eliminated from the "fastest bridge" category. Also, $40.00 will be added to the "cost" of the bridge in the "lowest cost" category. For each additional increment of 50 penalty points, add another $40.00.

A. If an individual drops a tool, bolt, washer or nut into the river, 2 points are assessed, representing the lost time to get a replacement.

B. If a piece or unit, including cable, drops or touches the river, or touches the Safety Support, 5 points are assessed, representing the lost time to repair or replace the item.

C. For other material handling violations, or individual movement violations, 5 points are assessed, representing crane overloads or other safety hazards.

D. If an individual steps into the river, 20 points are assessed, representing a loss of life.

E. If the team exceeds the piece and unit size and lifting limits criteria, 15 points should be assessed.