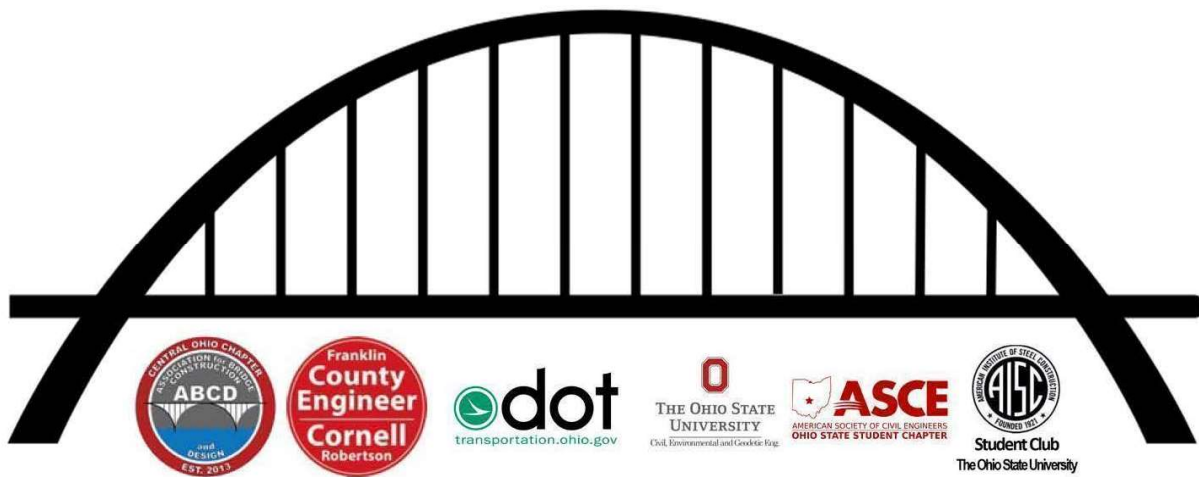


CENTRAL OHIO



MINIATURE BRIDGE BUILDING COMPETITION

Central Ohio Miniature Bridge Building Competition- Specifications 2024

Description:

The objective of this event is to design and build a structure with the highest load-to-weight capacity ratio (Failure Load / Self-Weight), over a predetermined span using supplied materials. The bridge must have an unobstructed flat roadbed capable of allowing a wheeled car to pass over its entire length. Each team may consist of 2 to 3 students and one chaperone (teacher or other non-student adult). The bridge is to be built on site the day of the competition. Each school may enter as many teams as they wish. This is an engineering event; therefore, failure to adhere to the rules and regulations herein will result in disqualification, however, the bridge may still be tested but will not be eligible for any awards.

The bridge is to be a single-span structure constructed of balsa wood. All wood materials will be provided by the Central Ohio Miniature Bridge Building Competition committee. The design team must allow for a Matchbox or Hot Wheels type car to roll along the bridge deck prior to testing. A car will be provided at the competition. Any type of bridge may be constructed if it meets the following specifications. Construction of a practice prototype bridge prior to competition is strongly encouraged and additional materials for a single prototype will also be provided by the committee.

Materials:

1. One set of practice building materials to construct a practice bridge will be provided for each participating team. This set will include the same materials that shall be included in

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the bridge kit provided for the submitted bridge. The bridge kit contains the following:

- a. 20 balsa wood sticks, 3 feet long and 1/8-inch square
 - b. 1 balsa wood plank, 18 inches long by 3 inches wide by 1/8 inch thick. This plank **MUST** be used for the bridge roadway, any leftover may be used as each team desires.
 - c. 1 copy of the Specifications, Rules & Guidelines (to be downloaded from the competition website).
 - d. Glue
2. Bridges shall be bonded using a cyanoacrylate medium density super glue that will be provided by the committee. This is a fast-setting, gap-filling, 5-15 second curing glue.
 3. All tools used for construction should be provided by the building team. If your school / team is unable to provide the necessary tools, please reach out to the committee for assistance in acquiring these tools. Some suggested tools are as follows:
 - a. Exacto Knife Kit / Razor
 - b. Jig or Form for the Bridge
 - c. Ruler / Scale
 - d. Cutting Board
 - e. Clamps
 - f. Latex / rubber gloves
 - g. Protective eyewear for participating students must be worn during testing (provided by the building team).

Construction:

1. Time for construction is limited to 3 hours.
2. Team chaperones may not in any way participate during actual building of the structure. Any questions related to construction will be directed to the Rules Committee.
3. Do not coat the bridge with any material (i.e., paint, stain, marker or glue). The materials must remain in their natural wood state. **Using any material not included in your bridge kit will result in disqualification.**
4. All excess glue should be removed from surfaces that are not bonded together.
5. A bridge must have a minimum of 3 structural members. Bridges not having a minimum of 3 structural members will be disqualified and not tested unless testing is requested by the team. Laminating to create one thick bridge deck is not permitted (i.e., no slab-type bridges are permitted, see Figure 4). For the purposes of this competition, lamination means the gluing together of pieces of balsa wood parallel along the length of the piece to form thicker, stronger members.

While you may not glue all of your wood together to form a slab-type bridge, you may glue up to six pieces together, in order to help strengthen your deck and the rest of the bridge. Be creative! (See Figures 4 and 5.) The laminated member cannot exceed 3 parallel pieces in height or width to form larger members. Having more than 6 pieces laminated, or more than 3 parallel pieces laminated together in any direction will result in disqualification (see sample scoring sheet, Figure 6). Also, a laminated member

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cannot be spaced closer than $\frac{1}{4}$ inch perpendicular to another parallel laminated member. Having a spacing less than $\frac{1}{4}$ inch will result in a disqualification, (see Figure 6.) The balsa wood plank used for the roadbed will not be counted as a laminated piece. It will be as if the wood plank is not there creating a space of $\frac{1}{8}$ inch.

The determination of whether a bridge has been laminated incorrectly is up to the discretion of the judges. If you feel that your design may be questionable, please contact a member of the Rules Committee as early as possible.

6. The bridge must be constructed to meet the following specifications:
 - a. The bridge will span a clear opening of 12 inches on the load table. Note that the bridge will need to be longer than 12 inches to allow for bearing on the table. The bridge shall be between 12.5 - 14 inches long to provide adequate bearing. The building kit will provide a sufficient amount of materials. Please plan accordingly.
 - b. Bridge will only be allowed to rest on the loading table, provided by the COhMBBC. No glue or physical attachments may be made to the top or sides of the loading table. (see Figure 3)
 - c. Bridge width:
 - i. Minimum = 2 inches from face to face of "rail" to accommodate travel way width. **Note the loading apparatus is 1.75 inches wide.**
 - ii. Maximum = None
 - d. Bridge height:
 - i. Minimum = None: check that overhead members are high enough to accommodate loading block & bolt (see Figure 1)
 - ii. Maximum = None
 - e. The bridge must contain an attached roadbed (See Note 7 under Testing) with a minimum width of two (2) inches and a length greater than twelve (12) inches.
 - f. Roadbed height is not to exceed half-inch (0.5") above the top surface of the loading table (base of bridge) at the supports.
 - g. The overall weight of the bridge cannot exceed 100 grams.
7. A roadbed is defined as a surface that allows free passage of a rolling Matchbox or Hot Wheels car. The car must be provided with a roadbed width that will accommodate the car axle width and allow for successful travel from one end of the bridge to the other. **The maximum car dimensions used at the competition will be 1.5" wide x 1" high x 3" long.**
8. The roadbed must be able to accommodate the load plate and bolt at application point (see Note 7 under Testing and Figures 1 & 2). The loading block application point is at the midway point in the bridge (See Figure 2). It is the teams' responsibility to mark the location of the hole required for loading. Event staff will drill the hole.

TESTING:

1. Testing will commence following completion of construction and judging.
2. In the order of completion, all bridges will go to the Check Station where they will be

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weighed, and a determination made as to whether or not each individual bridge is in compliance with the construction requirements (See Figure 5). Questions regarding specifications may be made while the bridge is at the build table, however once the bridge has been submitted for judging (taken to the judging table), no changes are permitted. Bridges that are completed but do not meet the construction requirements will be disqualified. Bridges that are not in compliance can be tested but will not be eligible for any awards.

3. Also, at the Check Station, the bridge will be checked for "drivability." One end of the bridge will be placed on a wooden block approximately 2-1/4 inches in height to incline the bridge. A model car (Matchbox or Hot wheels) will be placed on the elevated end of the bridge and allowed to roll the length of the roadbed (minimum of 12 inches). If the car fails to roll the whole length, the student may restart the roll from the point it stopped. Students will be allowed one (1) restart. If, on the restart, the model car cannot freely roll along the surface of the roadbed from beginning to end, the bridge will be disqualified. Bridges that are disqualified can be tested but will not be eligible for any awards.
4. Students must wear protective eyewear during construction, loading and testing. No exceptions.
5. The event sponsor will provide the loading block and testing apparatus.
6. During the testing phase, the bridge will be placed in the center of the testing apparatus containing a span of twelve (12) inches.
7. The load will be applied to a 2"L x 1-3/4"W x 1/4"H loading plate resting at the midpoint of the span on the deck. Structural members must be clear of the eyebolt. A standard five-gallon plastic bucket will be attached to the loading block by a three-eighths (0.375) inch diameter eye bolt, which will pass up through the bridge from below. The roadbed must be constructed to accommodate the 1-3/4"-wide loading plate and the three-eighths (0.375) inch eye bolt at the midpoint of the span.
8. At this point, the bridge will be pre-loaded with ten (10) pounds, placed into the loading bucket. The judges will then add loading material to the five-gallon bucket until the structure fails. For this contest, structural failure is defined as obvious structural collapse (loading bucket no longer supported).
9. The total load incorporates the total mass of the loading apparatus, bucket and loading material.

Scoring (see Appendix B):

1. Overall ranking will be based on the structural efficiency scores.
2. The structural efficiency will be determined by the equation:
[Maximum load supported (grams) / mass of bridge (grams)]
3. When a bridge has passed through the Check Station, it will remain at the Waiting Station until the time of load testing.
4. Event sponsors may take pictures of all bridges that are entered in the tournament for future assessment and instructional purposes.
5. Engineering ethics are an important factor in today's engineering design. If it is

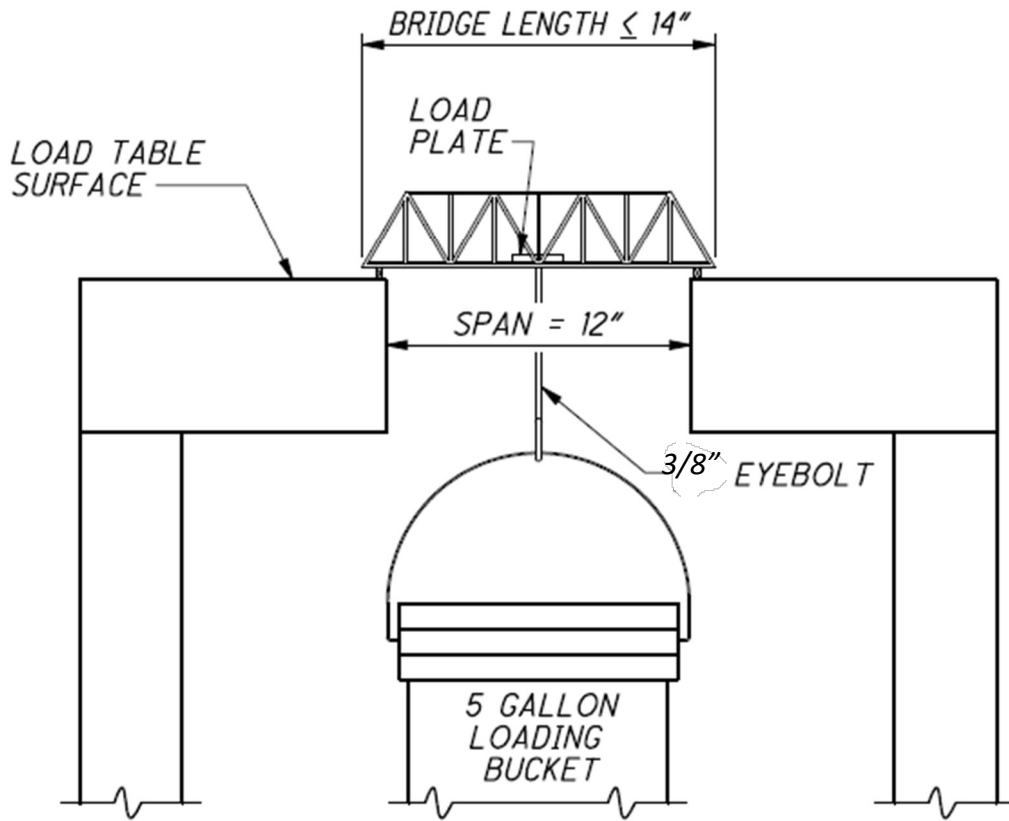
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determined by the judging committee that a deliberate violation of the competition rules has occurred, it may result in the disqualification of the offending team.

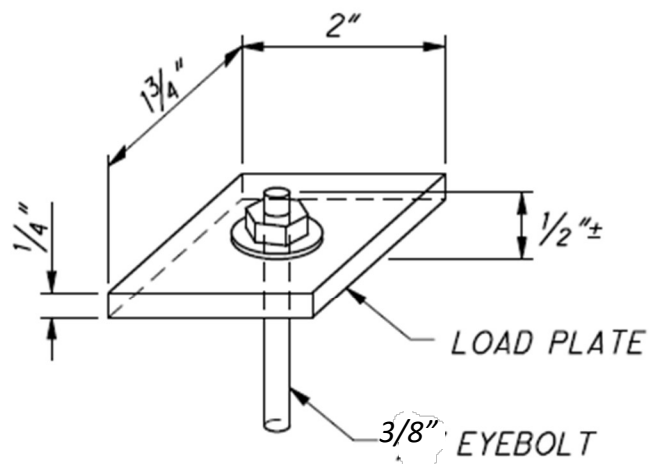
6. Bridges will be judged on aesthetics. Aesthetics by definition means “a pleasing appearance or effect.” Bridge aesthetics will be judged prior to bridge loading. Bridges for this competition will be qualitatively judged on aesthetics based on their form, proportion, order, balance, scale and quality of construction. Definitions and further discussion of bridge aesthetics is included in Appendix A of this document.

Competition Viewing, Results & Award Presentation:

Participants in attendance at the onsite building event can view the loading live at the event. The event will not be broadcast for livestream viewing. Each bridge loading will be videoed and the videos will be posted to the event YouTube site after the event. The winners will be notified through email and the overall results will be posted on the event website. The winners will be invited to receive their awards at the Engineers Week Luncheon and to attend the luncheon.



LOADING TABLE SETUP



LOAD PLATE DETAIL

FIGURE 1
(NOT TO SCALE)

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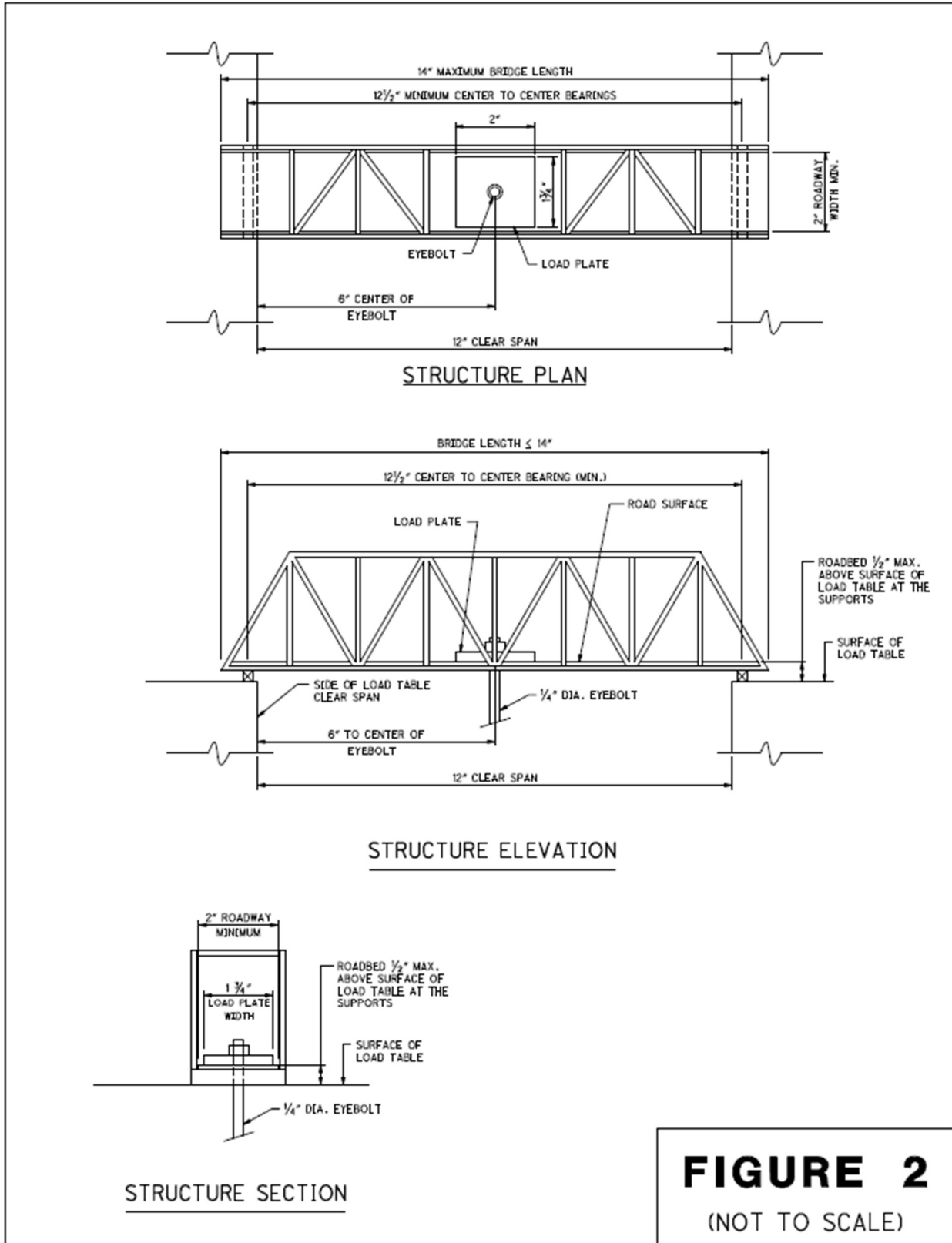


FIGURE 2

(NOT TO SCALE)

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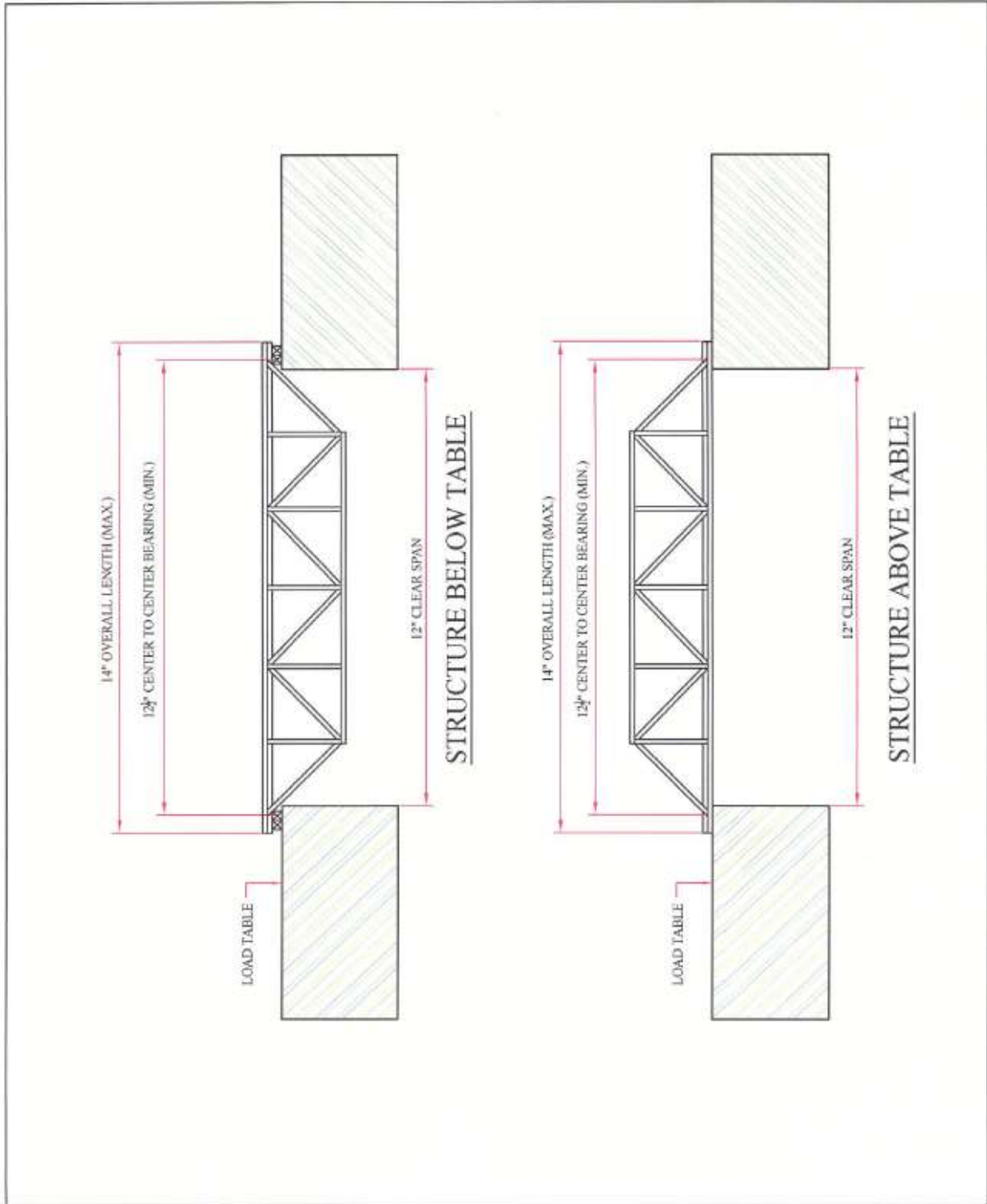


FIGURE 3
(NOT TO SCALE)

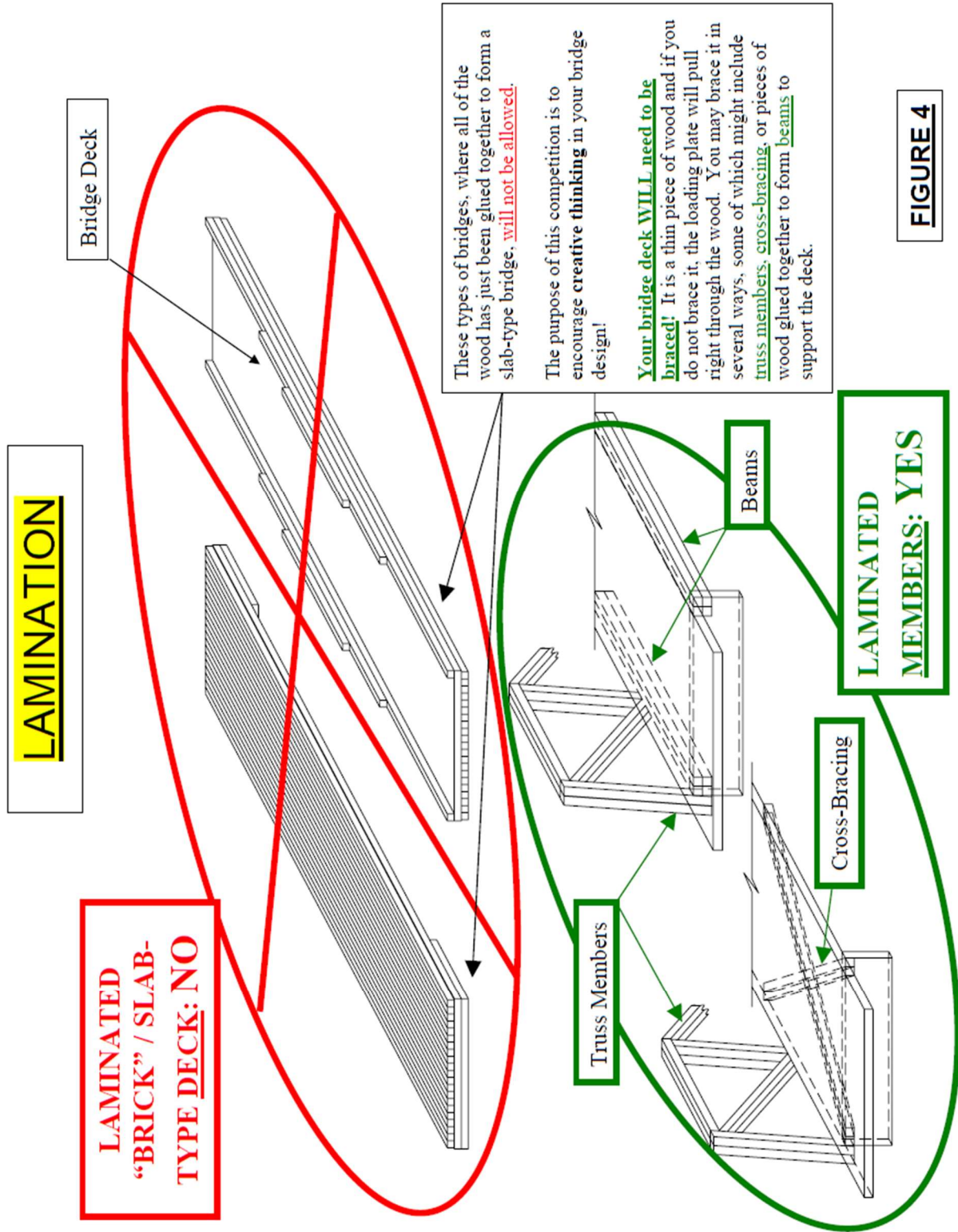
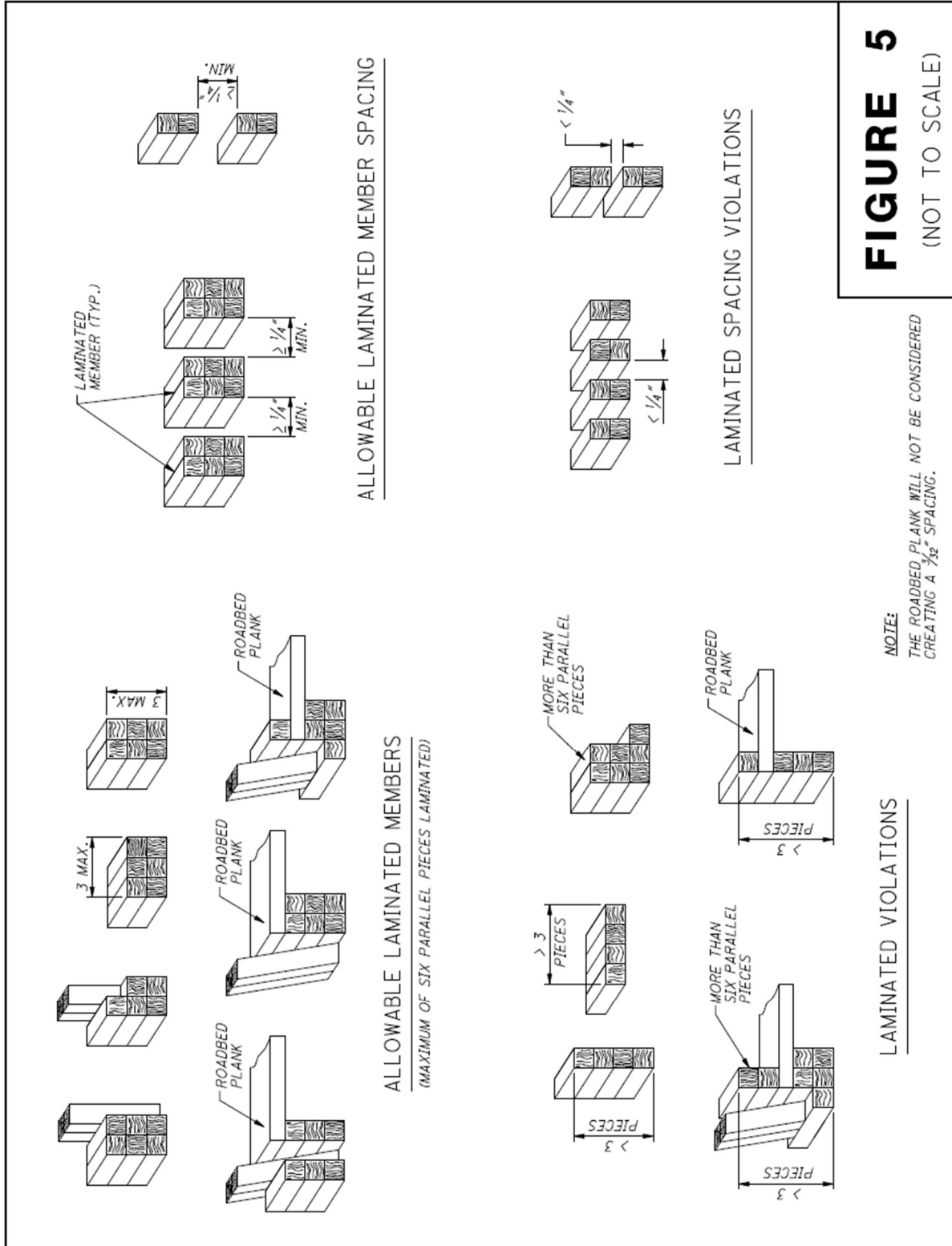


FIGURE 4



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Figure 6 – Sample Scoring Card

Central Ohio Miniature Bridge Building Competition

Saturday, February 12, 2021

Bridge Score for: _____

(enter school name & team number)

Construction Requirements			
Item	Enter Y or N	Qualifier	Notes
Structure Weight, Grams		900	Enter Actual Structure Weight
Is the Structure Length less than 12.5" or over 14"?	N	0	If does not meet design specifications, bridge is disqualified
Is the Roadbed Length less than 12" or greater than 14"?	N	0	If does not meet design specifications, bridge is disqualified
Is the Roadbed height more than 0.5" above the testing table?	N	0	If does not meet design specifications, bridge is disqualified
Is the clear Roadbed Width less than 2"?	N	0	If does not meet design specifications, bridge is disqualified
Has the car rolled freely along the entire roadbed after at the most 2 attempts?	N	0	If does not meet design specifications, bridge is disqualified
Does the bridge have less than 3 structural members?	N	0	If does not meet design specifications, bridge is disqualified
Are more than 6 pieces glued together to form a member?	N	0	If does not meet design specifications, bridge is disqualified
Is the bridge coated / painted?	N	0	If does not meet design specifications, bridge is disqualified
Are members spaced closer than ¼" apart?	N	0	If does not meet design specifications, bridge is disqualified
Weight Total =		--	All bridge can be loaded even if disqualified, disqualified bridges are not eligible to win an award
Qualifies to compete for an award =		Yes	

Structural Stability		
Item	Weight	
Failure Load, Pounds	--	
Failure Load, Grams	---	
Efficiency (Failure Load / Revised Structural Weight) =	--	

Structure Ranking	0
Total number of Entries	50

APPENDIX A

Aesthetic Definitions and Discussion

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The following Aesthetic guidelines are excerpts from the Minnesota Department of Transportation's "Aesthetic Guidelines for Bridge Design" March 1995

Bridge design is a process requiring the use of science, technology, and artistic judgment for its finest design solution. Each of these three abilities brings a separate

and distinct quality to the design process. Artistic judgment tempers science and technology to blend the design into an appealing work of beauty. These three abilities, applied in equal parts, produce a synergistic design effect - design excellence. Throughout the design process there are many aesthetic opportunities presented. Because aesthetics are innate emotions rather than calculated values, science and technology offer little or no help regarding these artistic judgements.

The fundamentals of aesthetic design involve basic visual ideas that summon innate emotional responses. These emotional responses are often subtle, but never-the-less, as real as any other emotion. The study of aesthetic design fundamentals includes the consideration of the visual relationship of a bridge and its site, as well as the mass, shape, and form of the structure.

Aesthetic Visual Design Elements:

Line - A line may be thought of as a direct link between two points, either real or implied. Lines within the context of a bridge are seen in the profiles of railings, spans, piers, abutments, and wingwalls. Line has a psychological influence on the viewer as the eye and mind seek out the basic building blocks in identifying objects. Temperament and motion are often attributed to the orientation and shape of line. Vertical and horizontal lines are considered formal and stable, while oblique lines are considered dynamic, and curved lines can be considered dynamic or tranquil.

Shape - When a line closes, it forms a two-dimensional surface with spatial directions of height and width. This two-dimensional surface can be called shape. While shape delineates horizontal and vertical dimensions, it excludes depth and volume. Sought by the eye, shape quickly identifies many objects. The purest of shapes is a back-lit elevation view, or a silhouette. Depending on one's position and the time of day, bridges may appear as a silhouette.

Form - Form reveals objects in three dimensions, adding depth to the height and width of shape. The visual experience of moving under or over a bridge is primarily influenced by the form of the bridge, its geometry, span arrangement, horizontal alignment, vertical profile, and relation to adjacent structures. The form of a bridge is seen in the context of space or sets of spaces that create its environment. Although the eye gathers stereoscopic cues, form is primarily revealed as volumes modeled in light and shadow.

Color – Color plays both a practical role and an aesthetic role in the design of bridges. The perception of color conjures an immediate and rudimentary emotional response and is a means of conveying visual information. Color is not simply cosmetic; when used with understanding, color can be applied to define, clarify, modify, accentuate, or subdue the visual effects of structural elements. **However, for this competition, the bridges cannot not be painted or sealed or colored in any way.**

Texture - Texture is found on the surface of all objects and is closely related to form. Texture helps define form through subtle surface variations and shadings. It can be used to soften or reduce imposing scale, add visual interest, and introduce human scale to large objects such as piers, abutments, and tall retaining walls. Distance alters our perception of texture. When viewed from a distance, fine textures blend into a single tone and appear flat. As a rule, the greater the distance or the larger the object, the coarser or larger the texture should be.

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Aesthetic Qualities of design are intangible, perceived qualities arising from the relationship of design elements. The properties of Aesthetic Qualities are:

Proportion - Proportion exists in geometry and in musical frequencies, or tones. The correlation between harmonic proportions in music, geometry, and color evolved in antiquity from a philosophical basis. This correlation between harmonic proportions in music and architecture is strongly suggested in classical architecture. Balanced and harmonious geometric proportions are fundamental characteristics in the development of graceful buildings and bridges alike. Proportion helps to successfully define the relationship among structural elements and implies the order of significance of the elements. Proportion suggests the role played by elements in a structure - their relative size classifying some as performing principal functions and others as attending to secondary functions. The concept of proportion may be thought of as a mathematical relationship. A graphical example of such a relationship is the Golden Rectangle. The Golden Rectangle is a logarithmic spiral constructed from the convergence of a mathematical series of proportions referred to as the Fibonacci series. This series is based on the proportion of $a:b$, $b:(a+b)$, etc. In design, the most obvious proportional relationships are based on relative size and shape of the elements. Appropriate proportion must exist between the various parts of a structure: between its height, width, and depth; between solids and voids; between surfaces and openings; and between areas of sunlight and shadow.

Rhythm - Rhythm is the regular recurrence of any like elements in, on, or around a structure. It requires that the elements have some similarity of visual characteristics in addition to a modulated placement. In bridges, for example, major rhythms are created by the repetition of similar pier shapes. Minor rhythms may be created by the spacing of light poles, post spacing within a railing, or even the horizontal rustication on a pier. Modulating the placement of these elements can create visual flow or movement across the scene. A good example of this is when pier spacing gradually increases near the main span when a bridge crosses a wide river or lake.

Harmony - Harmony is the relationship of the elements of a design based on similarity of their visual characteristics. The relationship must be complementary. If the planes or lines in a design have more dissimilar characteristics than they have similar characteristics, they are not likely to be perceived as harmonious. This is most readily achieved by using the Law of the Same or the Law of the Similar.

Law of the Same: Harmony may be perceived or created in a structure or composition of structures that attains order through the repetition of the *same* elements, forms, or spaces.

Law of the Similar: Harmony may be perceived or created in a composition that attains order through the repetition of *similar* elements, forms, or spaces.

Order - Order refers to arrangement. It is the arrangement of design elements so that they work together as a unit without visual confusion. The whole arrangement works as a unit with each element having a proper place and function. The selection of a constant girder depth throughout the structure is an element of good order. Order is also achieved by limiting the lines and edges of a structure to only a few directions. Under the rule of order, the regular recurrence of similar elements in a composition creates a natural flow, known as rhythm, that is satisfying to the eye.

Balance - Visual balance is the perceived equilibrium of design elements around an axis or focal point. Rather than a physical balance, it may also refer to equilibrium of abstract elements of the design such as masses, visual weight, texture, etc. Visual balance is fundamental to all successful compositions.

Contrast - One principle of contrast is the dynamic relationship among parts of a design based on complementary opposition of visual characteristics. Contrast relieves the monotony of simple harmony by complementing the harmonious characteristics of some design elements with their opposites, thus adding a heightened awareness of each other. A second principle of contrast is that of dominance. This concept

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relates to one of two contrasting elements commanding the visual attention over the other. One becomes the feature and the other becomes the supporting background. In terms of design, a dominant theme is essential in organizing the design into a pleasing aesthetic experience.

Scale – Scale refers to the size relationship among various features of the structure and between the total structure and its surroundings. Since design concerns itself with things that are to be used by people, a connection exists between the human body and designed objects. We often refer to structures that respond to the size of the human form as having human scale. This would be particularly true for a pedestrian bridge or any bridge with high pedestrian usage. When a bridge becomes exceptionally large, many of the component elements lose their human scale. Elements such as piers, pylons, or superstructure members may take on monumental scale. Here it becomes more important that the structure be in scale with the surrounding environment.

Unity - Unity is presented last because it encompasses the perfect application of all the other qualities. It refers to the combined effects of all other aesthetic qualities applied simultaneously. Unity is the condition, or state, of full resolution of the site and project functions. Unity implies harmony where all of the elements are in accord, producing an undivided total effect. Unity provides the observer with a sense of wholeness, generated by some central or dominating perception in the composition.

Aesthetic Design Objectives, Throughout the design process, designers should have aesthetic goals or objectives for the bridges they design, just as we have engineering objectives for safety, economy, serviceability, etc. As with engineering objectives, aesthetic design objectives should be established prior to the start of the design process so they can serve as an aesthetic compass, of sorts. Ideally, aesthetic objectives would be quantitative and therefore easily measured. But, given the subjective nature of aesthetics, visual design goals will necessarily have to be qualitative. Only through subjective evaluation can the success of the visual design objective application can be measured. When evaluating a bridge, designers should evaluate each part of the structure in terms of the whole, and the whole structure in terms of the setting and highway corridor.

Several aesthetic design objectives are offered in the following paragraphs to aid designers in visualizing, evaluating, and articulating their designs. These objectives should be considered as a fundamental framework that designers can use to initiate the application of aesthetic design. The aesthetic quality concepts discussed previously can be applied to this framework to refine the appearance of the structure.

Functional Clarity - Need defines the purpose of a bridge. Therefore, a fundamental requirement is that the bridge design must fulfill its purpose. The structure must do so in an obvious manner. The structural design must provide an honest structural response to the load-carrying task at hand. The bridge should reveal itself in a pure and clear form.

The structure must also serve the physical circumstances of its particular location. Geometry of the roadway, the topography, and the presence or absence of other structures or buildings are all design considerations in the selection and development of bridge types and configurations. When evaluating functional clarity, designers should ask: Does the bridge serve its function in both deed and appearance? Is the form of the structure appropriate to the function of the structure?

Scale & Proportion - The structure should be in scale with its surroundings as well as with other parts of the structure. The primary structural elements, e.g., span lengths, girder depth, abutment height, should have good proportional relationships to each other and their structural chore. Generally, no single element should dominate the visual composition. The collective design of the structure should be in scale with the site and environmental considerations. The structure form should have an appearance of lightness.

When evaluating the scale and proportion of a structure, designers should ask: Are the substructure elements proportional to the superstructure? Is the size of each bridge element consistent with its

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respective structural assignment? Is the structure size suitable for its setting and purpose? Does the superstructure seem slender without appearing delicate, or is it ponderous?

Order & Balance - The bridge should exhibit a natural progression of assemblage. Order is achieved by limiting the direction of lines to a minimum. Repetition of visual elements should be used sparingly to develop rhythm; if used to excess it can create monotony. The orientation and interaction of the design elements should suggest balance between the elements. The layout and alignment of the elements should promote harmony rather than confusion.

When evaluating the order and balance of a structure, designers should ask: Does the arrangement of components work together as a unit or promote visual confusion? Are the lines of the bridge limited to a few directions? Does the visual weight, texture, and mass of the members promote visual balance?

Simplicity & Continuity – The bridge form should appear straightforward and uncomplicated. Simplicity of form and clean lines are considered attributes of attractive structures. The architectural features should enhance the overall appearance. The design should express an overall continuity in appearance. Shapes used to form elements should be from the same family. For instance, beveled piers should be used with a beveled barrier rail design; rounded pier designs with a rounded railing. The number of materials, colors, and textures should be kept to a minimum. Details should appear consistent.

When evaluating the simplicity and continuity of a structure, designers should ask: Does the visual composition present a consistent design theme? Can a viewer comprehend the bridge in a glance, or does it require concentration of the viewer?

Site/Environment Integration - Bridges must be integrated with their environment, landscape, cityscape, or surroundings. This is particularly true where dimensional relationships and scale are concerned, as pedestrians are uneasy and uncomfortable with heavy, brutal forms. The dimensions of the structure must relate to human scale when pedestrians are involved. Bridges should make a positive contribution to the immediate environment in which they are placed.

When evaluating environment integration, designers should ask: Does the structure type, color, and color scheme complement its surroundings? Does the bridge visually conflict with its adjacent buildings or landscape? Are the materials, and finishes of the bridge native or foreign to the setting?

Principle Aesthetic Design Factors

As one might expect, there is no single design parameter that controls the general physical characteristics of a bridge. An attractive bridge is the orchestration of design parameters employed simultaneously to complement each other. Designers can interpret these design parameters to constitute principal aesthetic design factors.

The principal aesthetic design factors fashion the visual basis upon which the balance of the appearance is built. Designers should concentrate on developing the best design solutions for these design parameters prior to considering other visual treatments. To find the best design solution, designers must consider the aesthetic objectives outlined previously when making decisions regarding these design parameters.

Principal Aesthetic Design Factors:

- Superstructure type and shape
- Vertical and horizontal geometry and their relationship to the surrounding environment
- Pier placement and shape
- Abutment placement and shape

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Interaction between the bridge and its surroundings/environment

Single-span Structures

Single-span bridges are the simplest of highway structures. The appearance of single-span bridges is sensitive to the appropriate proportions between bridge elements. Fitting proportions should exist between the (suspended) superstructure and the height and width of the openings; and between the beam depth and span length. For most single-span bridges, the general location of the abutments will be determined by horizontal clearance requirements, structural constraints, and economy. However, once the general layout has been developed, it should be refined based on aesthetic analysis.

The slenderness ratio for single-span structures may vary between $l:d = 5$ to 30. Depending on the slenderness and proportions, the structure may appear heavy and clumsy. Conversely, it may appear light and elegant. For a single-span bridge, the designer should consider the relations among the opening beneath the bridge, the mass of the abutments, and the slenderness of the structure depth. These relations can be idealized in two visual compositions. At one end of the spectrum is a bridge with deep abutments and a short span length. The opening beneath this bridge will approximate a square, i.e., the total bridge length (L) approximately equals the vertical clearance (c). In this instance, the abutments provide a large mass, and the proportions play a more important role than does slenderness. A lower slenderness ratio of, perhaps 10, is appropriate for this idealized situation. At the other end of the spectrum is a bridge with shallow abutments and a long span length. The opening beneath this bridge will form a flat rectangle. As the span length begins to exceed the height, the slenderness begins to play a more important role. Abutment depths should be proportional to girder depth with shallower abutments used for shallower depth girders. In this instance, a slenderness ratio of 20 is more appropriate for harmonious proportions.

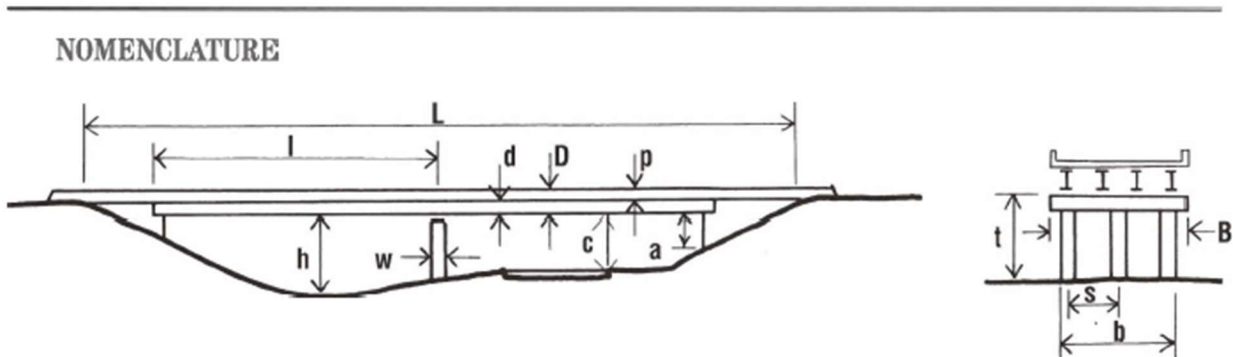


Fig. Guideline nomenclature

Guideline Element Abbreviations:

a – dist. bottom of girder to bottom of abut. face	t – pier height
B – pier length at cap or top	b – pier length at base
c – vertical clearance at pavement edge	d – girder depth
D – total superstructure depth	l – span length
h – vertical clearance to the ground	s – spacing of columns
L – total bridge length	w – pier width
p – rail ht., top rail/bot. of deck	

Throughout this section and the balance of these guidelines, specific letters will be used to denote phys-

ical aspects of bridge elements. These aspects and their representative letters are shown above.