PVC Pipe Bridge
Event Specifications
MESA Day 2020

Sponsored by

LEVEL:	Middle School/High School
NUMBER OF TEAMS:	One (1) team per school can participate at the MESA Day. Three (3) teams can participate at MESA Regional Events
TEAM MEMBERS:	Two (2) to Six (6) students
OBJECTIVE:	Students will build a PVC pipe bridge that meets the criteria outlined in the design parameters and is designed to safely support a vertical load.

MISSION AND SUMMARY

Civil Engineering is challenged with various aspects of infrastructure every day. The MESA PVC Pipe Bridge Competition increases awareness of real-world engineering issues such as spatial constraints, material properties, strength, serviceability, fabrication and building processes, safety, esthetics, project management, and cost. Success in competition requires application of engineering principles and theory, and effective teamwork. Future engineers are stimulated to innovate, practice professionalism, and use materials efficiently. Students design and build a PVC pipe bridge by themselves but may consult with faculty and other advisors. Students gain maximum benefit if they fabricate the entire bridge themselves. Safety is paramount. ASCE requests that competitors, advisors, hosts, and judges take all necessary precautions to prevent injury to competitors, judges, host personnel, and spectators. Risky procedures are prohibited. The Competition provides design and management experience, opportunity to learn fabrication processes, and the excitement of networking with and competing against teams from other schools.

The rules simulate a request for proposal with realistic challenges encountered in bridge design and construction. Competition judges and the Rules Committee take the role of the "*owner*" and have authority to accept and reject entries.

The rules accommodate a variety of designs and encourage innovation. Students 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 intended to be prescriptive but may require some interpretation. The procedure for requesting clarification is on the MESA website.

Members of the Student Steel Bridge Rules Committee are:

Jose A. Aguilar, P.E., WSP, ASCE Southern Arizona Branch Younger Member Forum

PROBLEM STATEMENT

The MESA-DOT (Department of Transportation) provides funds to repave the state's highways and replace numerous bridges rendered deficient by age, increased traffic demand, overloading, and inadequate maintenance. MESA-DOT determined that design costs can be minimized for most bridges by using a generic superstructure needing only minor adaptations for each site. This strategy is viable only if the design accommodates the more challenging site conditions. Therefore, there are restrictions on transportation, site layout, and access over water. Serviceability, construction cost and duration, material cost, and esthetics are critical considerations. PVC is specified for ease of prefabrication, rapid construction, high strength to weight ratio, and high level of recycled content. Each competing firm (team) is requested to submit a bridge model to demonstrate its concept. Models will be constructed under simulated field conditions and will be tested for stability, strength, and serviceability using standardized vertical loads. MESA-DOT engineers will judge the models by multiple criteria including durability, constructability, usability, stiffness, construction speed, efficiency, economy, and aesthetics. The contract will be awarded to the firm whose model satisfies specified requirements and best achieves project objectives.

GLOSSARY

- *Bridge* - a structure constructed only of members and loose connections.
- *Member* - a rigid component comprised of parts. A member shall retain its shape, dimensions, and rigidity during timed construction and load testing
- *Assembly* - two members that are joined together in a staging yard during timed construction with a connection.
- *Footing* - member of bridge that makes contact with the ground. *See layout for "footing area"*
- *Builder* - student members of a team who are within the construction site at the start of timed construction.
- *Tool* - device that is used to construct the bridge but is not part of the completed bridge. A competing team provides its own tools.
- *Deflection* - the distance a bridge moves under a load from original state.

DESIGN PARAMETERS

1. Bridge must be made of ½ inch Schedule 40 PVC
2. All bridge members shall not exceed overall dimensions of 2 ft x 6 in x 6 in. That is, it shall fit into a right rectangular prism (i.e., box) of those dimensions.
3. Connections must be loose and can be made of PVC pipe connectors or other solid materials. The use of suspension cables is not allowed.
4. Dimensions of bridge (See *Diagrams* in the Appendix for more info)
    a. The bridge's height shall not extend more than 5 ft above the ground or river.
    b. The bridge shall not be wider than 4 ft at any location along the span.
    c. The bridge shall not touch the river or the ground outside the footings. The river is 3 ft wide and the footings are 2 ft from the river banks. (*Note:* This has changed from the 2019 rules. See *Diagram* in the Appendix for overview)
    d. Vertical clearance of 1 ft - 6 in shall be provided under the bridge at all points directly over the ground and river.
    e. The bridge shall provide exactly two decking support surfaces that are continuous along the full length of the bridge and a straight rectangular vehicle passageway such that the template illustrated by the Vehicle Clearance Template detail on the

Site and Bridge Diagram will pass without obstruction along the decking support surfaces for the full length of the bridge.

f. The height of the bridge's loading surface shall be no more than 2 ft – 7 in above the surface of the river or ground at any point.

5. All connections and members shall be visible in the completed bridge so that compliance with specifications can be verified.
6. Bridge must withstand 100 pounds loaded vertically.
7. All bridge members must be solid in nature. The use of materials such as bungee cord is prohibited.
8. Vertical *deflection* (See definition in glossary) of the bridge must not exceed 4 in.

Engineering Notebook & Aesthetics

Aesthetics is judged by the following criteria:

- ❑ Appearance of bridge, including balance, proportion, elegance, and finish.
- ❑ Quality of fabrication.
- ❑ Permanent identification of the bridge consisting of the name of the school. The name shall be applied to PVC with paint or decals, and should be easily legible (lettering at least 1 inch high is recommended). A bridge that lacks appropriate identification will receive a very low aesthetics rating.

Engineering Notebook is judged by the following criteria:

- ❑ Identification of the school, 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 and top view of the bridge
- ❑ Provisions for Accelerated Bridge Construction (ABC), such as design features, construction sequencing, and procedures intended to minimize construction time
- ❑ Acknowledgement of school technicians, faculty, teachers and others who helped fabricate the bridge or provided advice

Additional information may be included such as names/logos of financial sponsors. The Engineering Notebook is not a part of the bridge but must be turned in at specifications check.

CONSTRUCTION

Only builders and judges are permitted within the construction site boundary during timed construction. Team members who are not builders, coaches, faculty, advisers, other associates of the team, 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.

There shall be no more than six (6) and a minimum of two (2) builders.
A tool shall not weigh more than fifteen pounds. Tools requiring external power connections, batteries, or other internal energy supplies **shall not** be used during timed construction.
The clock is stopped when the team captain informs the judge that construction is complete. After construction is finished the bridge shall not be modified except for correction of connections that may become loose.

SAFETY PRACTICES

If any rule in this subsection is violated during timed construction, the judge will explain the violation. The clock will continue to run during the explanation. Builders will continue 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 approved for load testing and will not be eligible for awards.

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.

At all times during timed construction every builder shall wear protective glasses; if a hard hat is provided it must be worn at all times.

Throwing anything is prohibited.

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

If construction time exceeds 45 minutes, the team may finish building the bridge. Consequently, the bridge will receive a time of 80 minutes for the time score, but will still be load tested.

A bridge with damage that would reduce its strength or stability (such as a missing or broken member) will not be approved for load testing and is not eligible for awards. Repair and modifications are not permitted after timed construction.

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

An activity shall be halted if the judge considers it to be hazardous. If competitors cannot load their bridge safely, loading will cease and the bridge.
Competitors who are not participating in loading, faculty, advisers, and other spectators shall observe from a safe area designated by the judges.

Damaged bridges (e.g., missing or broken member) shall not be tested.

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

The number of people near the bridge shall be minimized during vertical load tests. No more than one (1) competitor shall participate in the vertical load test.

Safety supports shall be provided by MESA, and shall be of adequate strength, height, and number to arrest falling load if a bridge collapses. Safety supports shall be in place under the decking units before load is placed on the bridge. Safety supports shall be adjusted individually for each bridge so that load cannot drop more than 5 inches.

No one shall reach, crawl, or step under 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.

Judges shall 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.

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

EQUIPMENT PROVIDED BY MESA

The dimensions of 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 5 inches if the bridge collapses. Safety supports will be plastic buckets.

A total load of **100 pounds** should be supplied in pieces of uniform size and weight that can be handled safely. The recommended load consists of books, sacks of material, steel beams, concrete blocks, or jacking systems could be used. Decking is not included as part of the 100 pound load and will be a 2 ft x 2 ft x ½ in piece of plywood.

Vehicle template will be supplied to assure the bridge meets the usability requirements, which dimensions are provided in the Diagrams.

SCORING

The overall performance rating of a bridge is as follows:
(Builders x Minutes to build x Weight of Bridge) / Load

The team with the lowest score wins. In case of a tie, the Engineering Notebook will be the tiebreaker.

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School:_____

Student Names:_____

_____

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Specification Check Pre-Build (circle one):	**Pass**	**Fail**
Bridge only uses ½" Schedule 40 PVC for structural members?	Yes	No
Members are within the allowed dimensions (2'0" x 6" x 6")	Yes	No
Connections are loose	Yes	No
A Notebook has been submitted	Yes	No

Specification Check Post-Build (circle one):	**Pass**	**Fail**
Bridge does not touch the ground or water, except for footings?	Yes	No
Footings are at least 2' from river bank?	Yes	No
Bridge does not extend more than 5'0" above the ground/river?	Yes	No
Bridge is not wider than 4'0" anywhere along the span?	Yes	No
Bridge has a Vertical clearance under the bridge of at least 1'6"?	Yes	No
Has two decking support surfaces & a straight rectangular passageway that allows the Vehicle Clearance Template to pass unobstructed?	Yes	No
Decking support surfaces that are no more than 2'7" above the ground/river	Yes	No
All connections and members are visible	Yes	No
Bridge has permanent identification (name of school)	Yes	No

Design Testing:

Builders:_____(people)

Construction Speed:_____(minutes)

Weight of Bridge:_____(pounds)

Load:_____(pounds)

Overall Performance = (Builders x Construction Speed x Weight of Bridge)/Load:_____

Lead Judge Signature:_____ Student Signature:_____

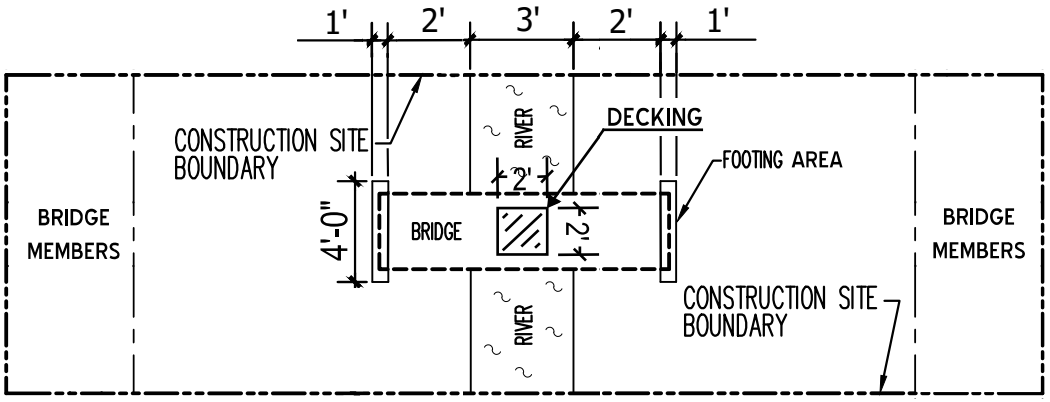
Comments/Suggestions:

Rubric for Engineering Design Notebooks (EDN).

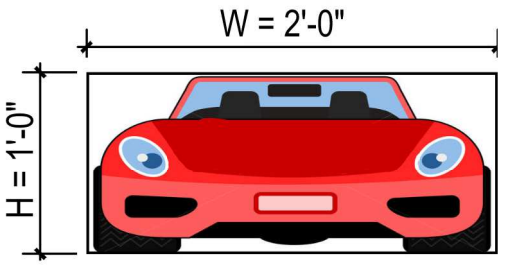
EDN Goals	3	2	1	0
1. Explore				
□ Described Design Objective □ Described Success Criteria □ Described Constraints □ Described Variables and Constants	All	Most	Some	None
□ Described Prior Knowledge □ Described Brainstorming □ Described Exploration (testing materials, modelling, etc.)	All	Most	Some	None
□ Has Research documented with at least 5 sources (website, book, video, article, interviews, etc.) □ Research is reliable (i.e. experts, researched websites, etc.)	All	Most	Some	None
2. Design				
□ Describes materials used □ Documents data from previous trials □ Documents modifications	All	Most	Some	None
□ Includes sketch/photo of initial prototype □ Includes sketch/photo of final prototype	All	Most	Some	None
3. Test				
□ Has data in graphical form □ Has written description of data □ Multiple iterations	All	Most	Some	None
□ Describes pros and cons of data results □ Discusses next steps □ Tests are well designed	All	Most	Some	None
4. EDN Organization				
□ Has Table of Contents or clearly labelled sections □ Notebook is organized	All	Most	Some	None
4.2 Labeled. □ Clearly labeled with School and Team Members names.			Yes	No
Column Totals (for selected categories)				
			Total (out of 25)	

Comments/Suggestions:

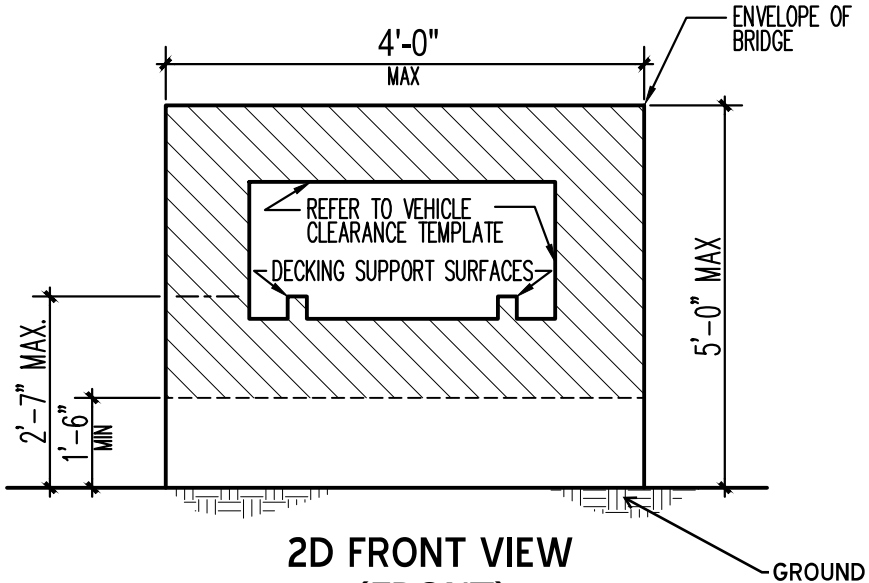
SITE PLAN



2D PLAN VIEW (TOP)



VEHICLE CLEARANCE TEMPLATE (CAR)



2D FRONT VIEW (FRONT)

*NOT DRAWN TO SCALE

REV.	BY	DATE	APP	REC NO.	EXPIRES	SEAL HOLDER	DESCRIPTION
							2017 PVC BRIDGE RULES

DESIGNED BY	J. AGUILAR
DRAWN BY	J. AGUILAR
CHECKED BY	B. PIKE
IN CHARGE	M. LEON
DATE	09/16

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SUBMITTED

APPROVED

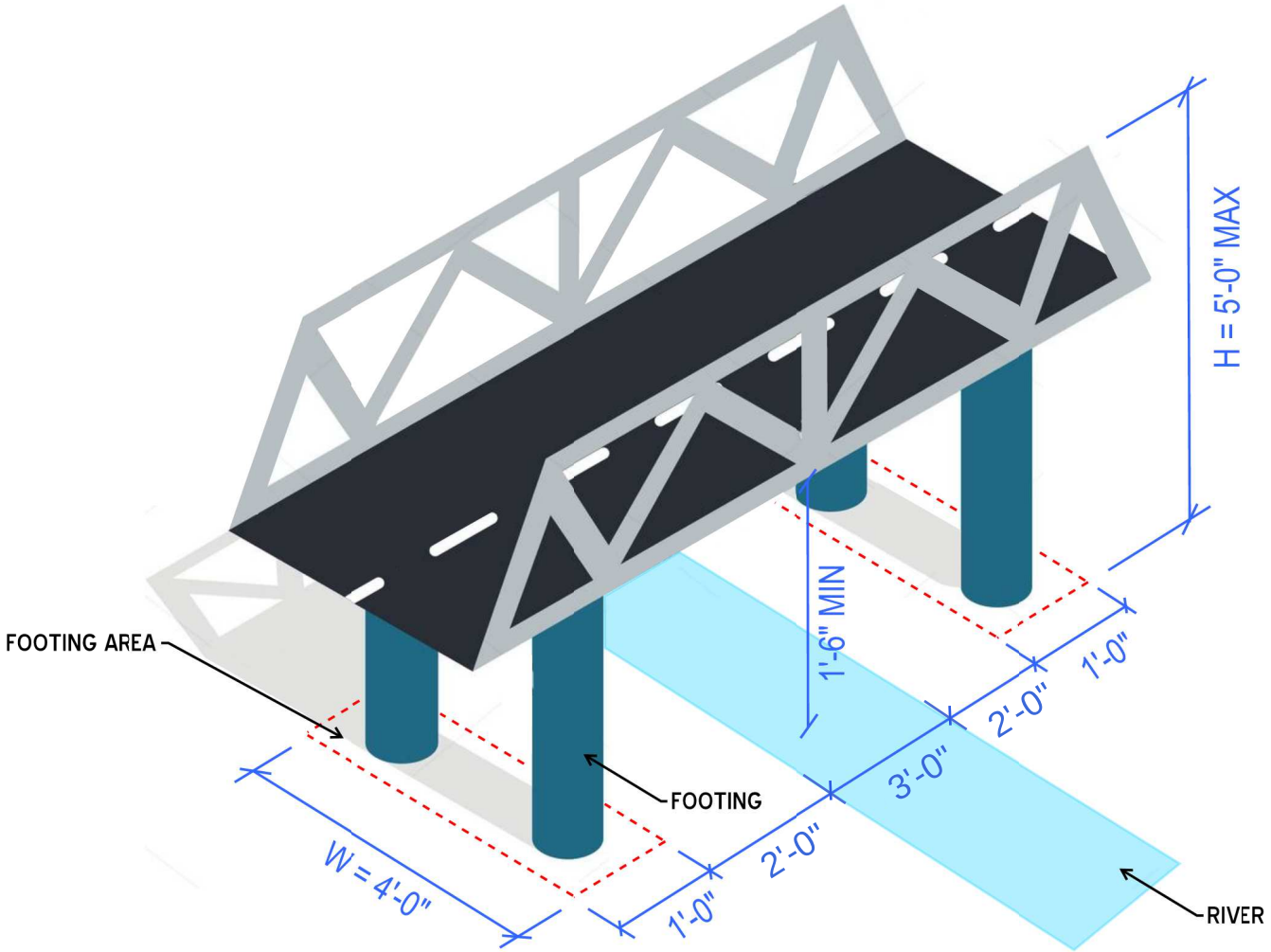
SITE AND BRIDGE DIAGRAM

CONTACT NUMBER

DRAWING NO. DWG 1

SCALE NTS

SHEET NO.



3D BRIDGE VIEW (SIDE)

REV.	BY	DATE	APP	REC NO.	EXPIRES	SEAL HOLDER	DESCRIPTION
							2017 PVC BRIDGE RULES

DESIGNED BY	J. AGUILAR
DRAWN BY	J. AGUILAR
CHECKED BY	B. PIKE
IN CHARGE	M. LEON
DATE	09/16

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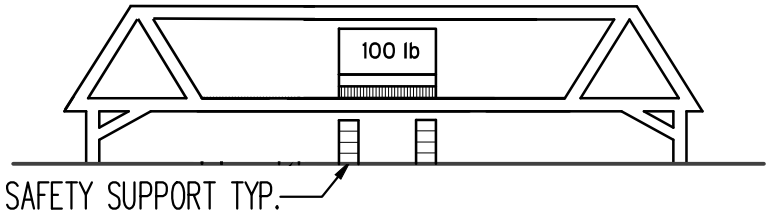
3D VIEW

CONTACT NUMBER

DRAWING NO. DWG 2

SCALE NTS

SHEET NO.



VERTICAL LOAD TEST

NOTES:

1. SAFETY SUPPORTS TO BE IN PLACE UNDER THE LOAD AND TO REMAIN AT ALL TIMES DURING LOADING.
2. ALL LOADING SAFETY PROCEDURES TO BE FOLLOWED.

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APPROVED

LOADING DIAGRAMS

CONTACT NUMBER	
DRAWING NO.	DWG 2
SCALE	NTS
SHEET NO.	