

## SAMPE's 20-year History of Its Bridge Building Contest

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The SAMPE Bridge Building contest marked its 20<sup>th</sup> year at the Seattle conference in May 2017. We thought it worthwhile to present the contest history, identify contest organizers and schools, document the contest growth both in North America and other regions, and provide some anecdotal stories of interest. Most SAMPE members attending the spring meeting saw the excitement of a hundred students crowding around a tensile test machine on the exhibition floor as the bridges were loaded to failure. Here's how it all began...

The original SAMPE Bridge Building contest started in 1991 when the NJ SAMPE Chapter partnered with the NJ Science Supervisors Association to offer a composite materials bridge building contest to high school students throughout the state of NJ. Over the course of six years, from 1991 through 1996, the contest evolved and ultimately provided a foundation for the North American contest which started in 1998 (Table 1).

Table 1. New Jersey Initial Bridge Building Contests

New Jersey Bridge Building Contest			
Year	Bridge Geometry	Participants Students/Schools	General Rules or Requirements
1991	22x3 inch bridge	95 / 20	Lightest bridge to support 100 pounds for 1 minute
1992	40x3 inch bridge	Unknown / 40	Lightest bridge to support 100 pounds for 1 minute
1993	24x24 inch platform	75 / 25	Lightest structure to support student standing on it
1994	48x12 inch bridge	60 / 14	Bridge must support student walking over bridge
1995	22x3 inch drawbridge	Unknown / 25	Solar powered drawbridge, must also support 75 pounds
1996	22x3 inch bridge	40 / 15	Survive 1 kg top and side impacts, then support 75 pounds

The New Jersey contest included both carbon and glass fabrics and epoxy resin. Since the contest objective was to introduce the students to composite materials, we did not try to differentiate between glass and carbon property levels, and so bridge construction seemed to take on the student mindset of "let's use everything in the kit."

Material kits were supplied to each school. The kits contained carbon and glass fabrics; 2-part polyamine RT cure epoxy resin; end grain balsa and PVC honeycomb cores; adhesive paste; and glass and carbon braids. Also included in the kit was a 45-minute video tape (VCR tape – remember, it was 1991), produced in a local high school lab and featuring the author showing the students what composite materials were and how to fabricate something simple.

Each year the NJ contest did something different. In the first year, the 22-inch long bridge had to support 100 pounds for 1 minute. The loading consisted of 45 one kg cylinders borrowed from a high school physics lab (Figure 1). In the second year, the bridge length was increased to 40

inches. We switched to a 24x24 inch platform in the third year, with the criteria being the greatest student weight the platform could support. One school recruited the heaviest student in the school as part of their team. In 1994, the bridge was 48x12 inches and the requirement was for 3 students to stand on it at the same time – without failing. That year we also had a 5<sup>th</sup> grade elementary school class participating. It turned out that the teacher of that class had a daughter who was a SAMPE member and was also an M&P engineer working at Boeing Vertol division near Philadelphia. Their bridge was a work of art, and it was the only one ever fabricated using a vacuum bag and a very large autoclave. In 1995, we combined technologies. The contest objective was to build a solar powered composite drawbridge that could support 75 pounds and go up and down. The local power company, PSE&G, donated 200 solar panels and each school got 4 of them for their power source. We also supplied small motors and gears.



Figure 1. High School Bridge Contest (Early Version)

The importance of partnering with the NJ Science Supervisors Association (NJSSA) was critical to the contest's success. The NJSSA provided all the advertisement of the contest to the state high schools. Its members were the school team advisors. NJSSA also had contacts with the power company for the solar panels and with the NJ Liberty Science Center for holding the contest.

By 1996, the contest had run its course. NJSSA was on to other activities. Our national SAMPE contest was conceived in a bar in the Anaheim Hilton at the 1997 Exhibition. Ben Rasmussen, Malcolm Rosenow and the author sat around a table thinking about what we could do for the 1998 conference when NJ SAMPE would be the major sponsor. Consequently, the contest was born.

In 1998, the rules were very simple. Just build a 24x4 inch bridge and the one with the highest P (applied center load) to bridge weight ratio wins. Kits contained carbon and glass fabric and fiber, epoxy resin and balsa wood and PVC foam cores. There were only 2 categories: (1) use kit materials and out-of-autoclave curing and (2) anything else, including any materials in your shop, and even the use of an autoclave. And there were 2 entry levels, student and professional. We had about 30 entries, including 12 professionals and 9 University teams. Some of the professional bridges were highly sophisticated using Textron Hy-Bor boron/epoxy prepreg and Toray M46J carbon fiber. Universities competing included University of Washington, Cerritos Community College, University of Maryland, West Virginia University, University of Nevada/Reno, California State San Luis Obispo and Weber State University. Of the 12 professionals, two are still active SAMPE members – Todd Dugan and Lou Dorworth. Also, Brian Flinn was faculty advisor of the University of Washington teams in 1998 and is still doing that in 2017. As prizes, we gave away \$450 plus 6 tennis racquets and a graphite golf shaft driver.

The next few years continued with the same bridge geometry. Prize money increased as did the variety of composite sporting goods given away as prizes. We were now giving away tennis racquets, fishing rods, hockey sticks and baseball bats. And we still had both student and professional categories. In 2000, we had 64 entries, including professionals from Japan and New Zealand. In 2001 and 2002, the contest tried a platform geometry, where 3 support posts were equally spaced around a 22-inch circle. The criteria were the same maximum load P divided by platform weight (W). One professional contestant, Stan Stawski, brought in a 6-gram balsa platform with a helium balloon attached underneath. Since the weight was zero, his P/W was infinite. We had to rewrite the rules for the next year. In 2003, the bridge geometry returned permanently. Also, 2003 was the first year for the poster session. That was an instant success because we wisely required teams to submit a poster to be eligible for the cash prizes in the bridge contest.

In 2005, we finally banned the use of Boron fiber in the bridges. There were continuing safety concerns about Boron splinters, particularly for those handling the failed bridges on display. Also, 2005 was the first year for the SAMPE wing contest that ran in parallel to the bridge contest. NASA LaRC was largely responsible for that contest. Earlier, we approached Langley and asked for some financial support. Their response was “sorry, but bridges don’t fly”. So, we initiated the wing contest and NASA LaRC became a willing and generous sponsor. In Table 2, note that the prize money took a healthy jump in 2006. The wing contest ran from 2005 to 2010. This was a dihedral wing geometry that had to support 100 pounds over 34 inches. We used a slight modification of the basic bridge test fixture to test the wings. Also, 2006 was the first year that we had a natural fiber category and the last year that we had any professional engineers in the competition.

Table 2. Bridge Building Contests Year-to-Year

Bridge Building Contest Year by Year						
Year	Entry Types				Cash	Notes
	Bridge	Wing	Student	Prof	Prizes	
1998	30		X	X	450	24x4 inch bridge, highest P/W
1999	53		X	X	1250	24x4 inch bridge, vertical drop impact then vertical load, highest P/W
2000	64		X	X	1000	24x4 inch bridge, first entries from Japan and New Zealand (prof)
2001	45		X	X	1000	22-inch triangular platform, vertical load, highest P/W
2002	45		X	X	1800	22-inch triangular platform, vertical load, highest P/W and highest stiffness, 2 Jr H.S entries
2003	55		X	X	2800	24x4 inch bridge, highest P/W, entries from Brazil (prof) and New Zealand, first poster session
2004	64	Trial	X	X	3000	24x4 inch bridge using glass pultrusion inserts, last year for Prof entries, also trial wing contest
2005	45	20	X		4000	24x4 inch bridge using glass pultrusion inserts, dihedral wing supports 100 lbs over 34 inches
2006	52	18	X		7000	24x4 inch double deck bridge, first year for natural fiber category
2007	34	21	X		5500	24x4 inch bridge, highest P/W
2008	41	12	X		6000	24x4 inch bridge, highest P for max bridge weight of 750 grams
2009	56	13	X		6000	24x4 inch bridge, highest P for max bridge weight of 650 grams
2010	69	18	X		8000	24x4 inch bridge, highest P for max bridge weight of 600 grams, no closed box beams
2011	57		X		4600	First entry from China
2012	62		X		7300	
2013	61		X		7600	
2014	70		X		8800	First entry from Mexico
2015	64		X		8000	First entry from Japan
2016	90		X		3900	First entry from Brazil, 24x4 inch bridge, introduced recycled carbon fiber category
2017	74		X		7200	24x4 inch bridge, introduced poster video category, T- shirts for all participants

From 2007 to 2010, there were only slight modifications to the contest rules. The four bridge categories were carbon kit, carbon non-kit, glass kit and natural fiber. The limit on bridge weight was progressively lowered. By 2010, the maximum bridge weight was 600 grams and the criteria became the greatest load that a 600-gram bridge could support (as opposed to maximum P/W). In 2009, Boeing became another strong sponsor and by 2010, the contest was awarding \$8000 in prize money, almost all of it going to participating student SAMPE Chapters.

2011 marked a change in leadership for the contest. From 1998 to 2010, the author was the contest chairman, with help from John Osterndorf who handled all finances, Stan Stawski, who

ran the wing contest from 2005 to 2010, and Narendra Taly, who co-chaired the 2010 contest. In 2011, Karin Anderson assumed control of the contest and ran it through 2014. LaNetra Tate ran the contest in 2015 and 2016 and Sarah Cox was the chair in 2017. Table 3 shows the committee members responsible for coordinating the contest over the years. Not listed but always helpful were SAMPE staff members Michelle Tubb and Rosemary Loggia.

Table 3. Contest Chairs

<b>Contest Chairs – North America SAMPE Contests</b>	
1998-2006	Howard Kliger
2006-2009	Howard Kliger, Stan Stawski
2010	Howard Kliger, Narendra Taly, Stan Stawski
2011-2014	Karin Anderson, Brian Flinn, T.J. Zimmerson, Richard Lort
2015-2016	LaNetra Tate, TJ Zimmerman, Sarah Cox
2017	Sarah Cox, TJ Zimmerman, Ashley Tracey, Alison Lake

The changing leadership also brought about an expansion of the contest categories as well as the number of participating schools. In 2010, there were only 5 categories (carbon kit and non-kit, glass kit and non-kit and natural fiber) and about 20-25 schools competing, bringing about 50 bridges and 10 wings. By 2017, there were about 75 bridges from 5 countries (the wing contest ceased after 2010) and the number of categories had increased to 8. Beam geometries were separated into I-beam, square beam and sandwich beam and also a new recycled carbon fiber category was added. The poster session was also expanded to include a video option. With all the additions, the grading system became more complex as well. In a different perspective, the rules grew from 1-page in 1998 to 3-pages in 2010 to 14-pages by 2017. There were more than 60 participating schools in the North American contest throughout its history (Table 4).

### **Derivative Bridge Building Contests Expanded**

Starting in 2011, bridge building contests began in China, Japan, Brazil and also in the Utah area under the sponsorship of the Utah SAMPE Chapter.

The Chinese contests started in 2011 and were chaired by Prof. Zhen Shen and Jason Cui. Each year, students from Harbin Engineering University, Chengdu Aeronautic Polytechnic University and Tongji University submitted about 15 bridges for their competition. The rules were the same as the North American contest. Winning teams were invited to compete in the North American contest and starting in 2014, records indicate that the Chinese schools placed very high in the competitions, often taking first place in multiple categories.

Table 4. Participating Schools in North America SAMPE Contests

<b>Participating schools (In North America Contests)</b>	
Bellingham Tech College	South Dakota (SDSMT)
Brigham Young Univ.	Stanford Univ.
BYU-Idaho	Texas State Univ. -San Marcos
Cal State LA	Tongji Univ.
Cal State Long Beach	Union College
Cal Poly San Luis Obispo	Univ. Autonoma De Baja Cal
Centro Univ. DA FEI Brazil	Univ. Cal Los Angeles
Cerritos College	Weber State
Chengdu Aeronautic Polytech China	Winona State
Cuesta College	UC Santa Barbara
Davis Applied Tech College	U. Arizona
Drexel Univ.	U. Auckland NZ
Edmonds Community College	U. British Columbia
Federal Univ. of Rio de Janeiro	U. Cincinnati
Florida Inst of Tech	U. Dayton
Florida State Univ.	U. Delaware
Florida A&M Univ.	U. Maryland
Gonzaga Univ.	U. Wisconsin Milwaukee
Harbin Engineering Univ. China	U. Nevada Reno
McGill Univ.	U. Nevada Las Vegas
Montana Tech	U. North Texas
NC State Univ.	U. Texas Austin
Nihon Univ. Japan	U. Tokyo
New York Univ.	U. Washington
Penn State Univ.	U. West Virginia
Peninsula College	U. Wisconsin Milwaukee
Philadelphia Univ.	US Naval Academy
Rutgers Univ.	Utah State Univ.
Salt Lake Comm. College	Virginia Tech
San Diego State Univ.	Washington State Univ.
	Western Washington Univ.

The contest in Brazil is chaired by Jorge Nasseh. They also have copied the North American rules with some simplifications (fewer categories). The Brazilian contest has been operating since 2015 with as many as 38 bridges from 13 universities (Table 5). They plan to limit the 2018 contest to 25 bridges so the contest can run in one day. They also provide about \$10,000 (USD equivalent)

in prizes each year, which includes airfare and hotel for 2 students of the winning bridge to compete in the North American contest the following year.

Table 5. Participating Schools (Derivative Contests Within North America and Global Chapters)

<p><b>SAMPE China</b></p> <p>Harbin Engineering University Chengdu Aeronautic Polytechnic Tongji University</p> <p><b>SAMPE Brazil</b></p> <p>Universidade Federal do Rio de Janeiro Universidade Federal do Para Instituto de Engenharia Maua Universidade Federal de Campinas Universidade Federal de Minas Gerais Centro Universitario FEI Universidade do Vale do Itajai Universidade de Sao Francisco Universidade Santa Cecilia Universidade Federal do Rio Grande do Sul Universidade de Sao Paulo Universidade Federal de Itajuba Universidade de Mogi das Cruzes</p> <p><b>Utah Chapter (North America)</b></p> <p>Brigham Young University - Provo University of Utah Utah State University Montana Tech Salt Lake Community College Davis Applied Technical College Southern Utah University Brigham Young University - Idaho</p>
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The Utah contest involves students from schools in the Utah/Montana/Idaho area (Table 5). Brigham Young University had an internal student competition dating back to 2008, but the Utah SAMPE Chapter assumed control of the contest in 2012. It now involves about 7-8 schools with about 20 bridges each year. And the Utah SAMPE Chapter sends the winning bridge teams to the North American contest each year. Prof. David Fullwood, Prof. Dan Adams and Alan Done are the contest co-chairs.

## Looking Back

Throughout the contest, the basic bridge geometry remained the same, although the designs were creative, innovative and often mystifying. There was the natural fiber entry whose reinforcing fiber was an ostrich feather. And then there was the carbon fiber reinforced concrete bridge that couldn't be broken in the test machine. It was also the heaviest bridge ever entered in any contest. The basic bridge geometry and some bridge examples are shown in Figures 2, 3 and 4.

Not only has the contest exposed students to composite fabrication, materials, and test, but it also has provided a unifying project for student SAMPE Chapters to identify with and provide a platform for Chapter activity and thus grow the Chapter. More than 3000 students have participated in the contest in the past 20 years. That is a remarkable legacy.

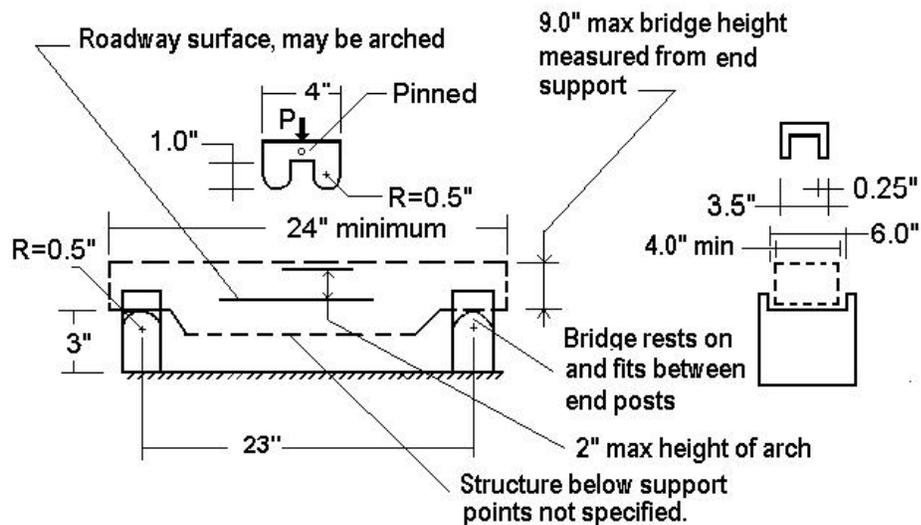


Figure 2. Bridge Test Fixture

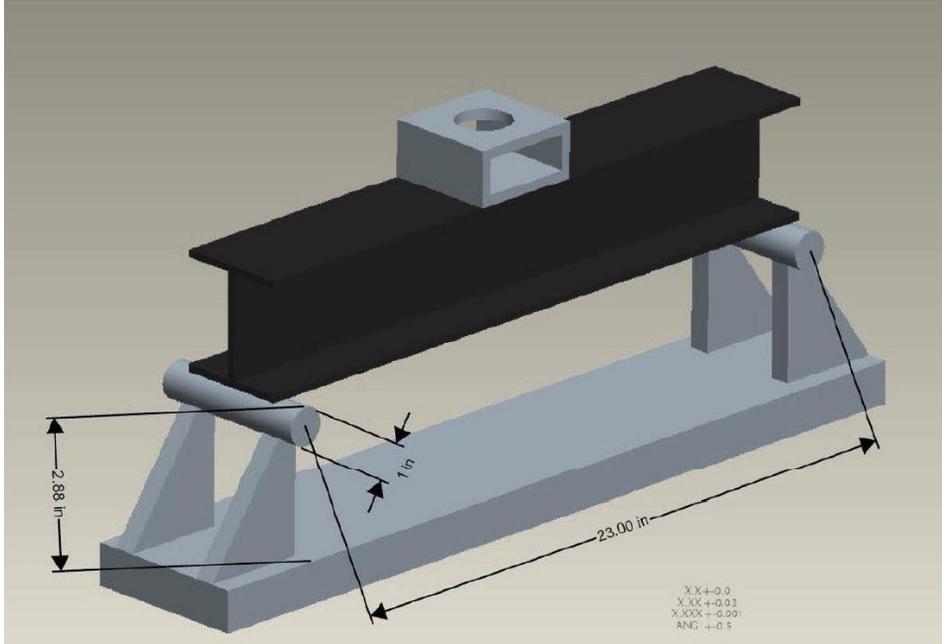


Figure 3. Bridge Test Configuration



Figure 4. Bridges on Display