Design Project #1

Replacement of Vehicle Bridge over Spring Creek

Centre County, PA

Introduction to Engineering Design

EDGSN 100 Section 001

Big Huge Bridges

Design Team Number: 2

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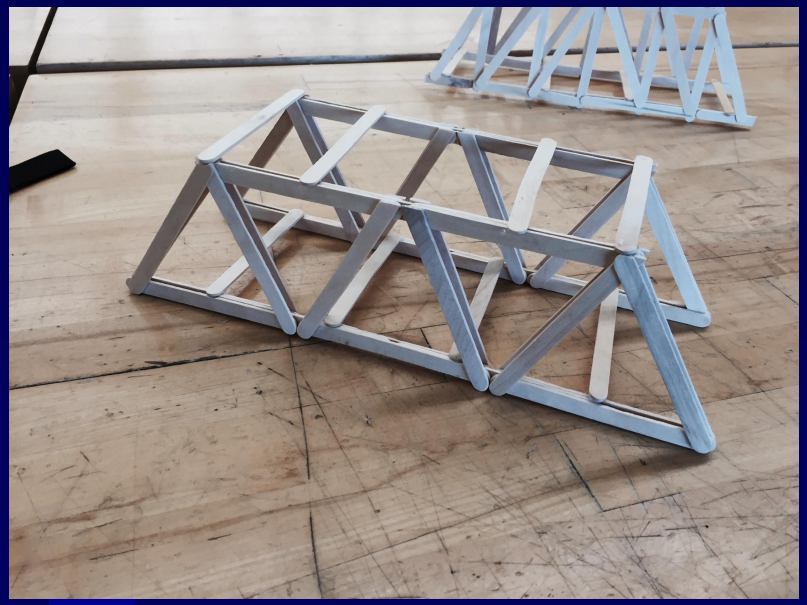

Presented to:

Prof. Berezniak

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Statement of Problem

Recent flooding events have destroyed a bridge located over Spring Creek along Puddintown Road in College Township, Centre County, PA. The biggest concern with the destruction of this bridge is any type of vehicle access to the local hospital.

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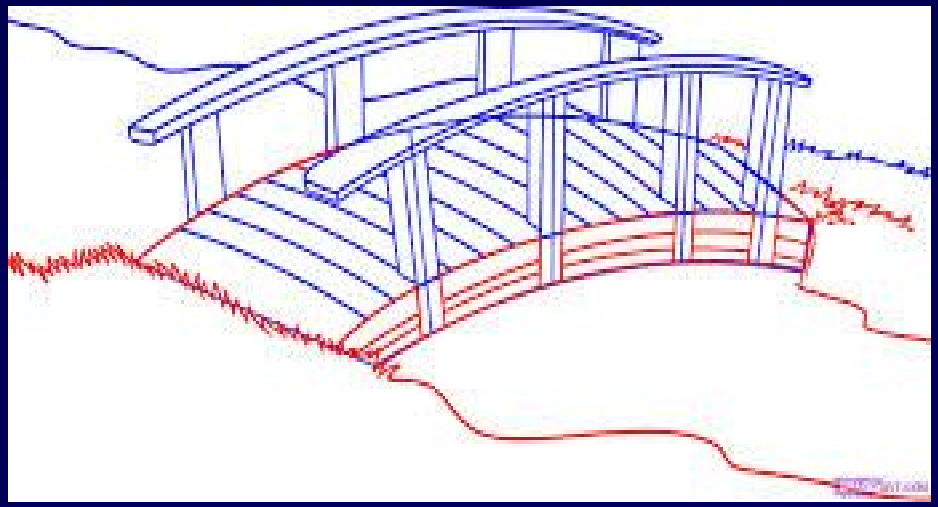
Objective

Design a new vehicle bridge to replace the destroyed one so everyone can go back to their normal ways.



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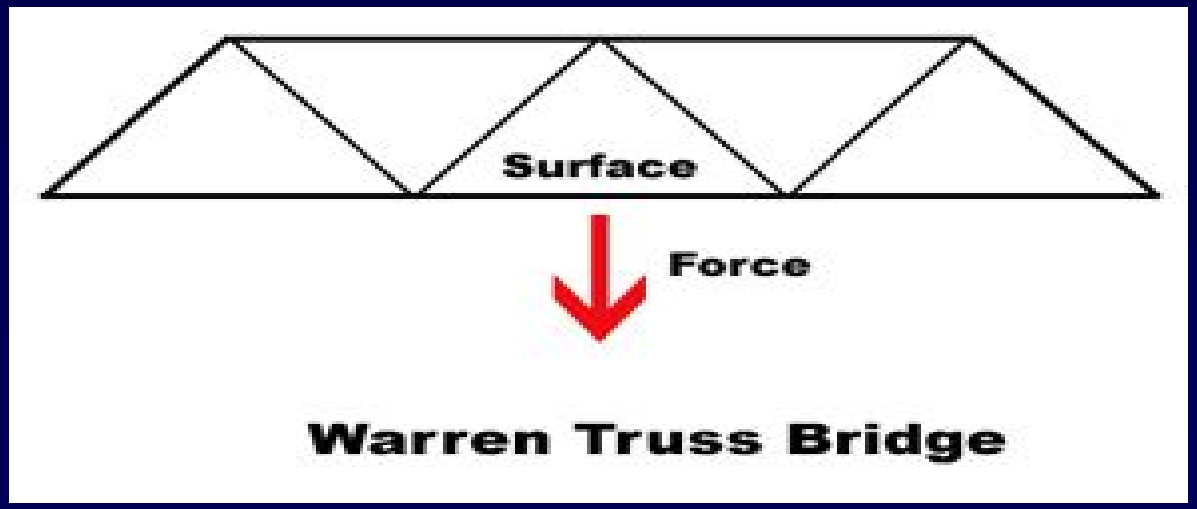
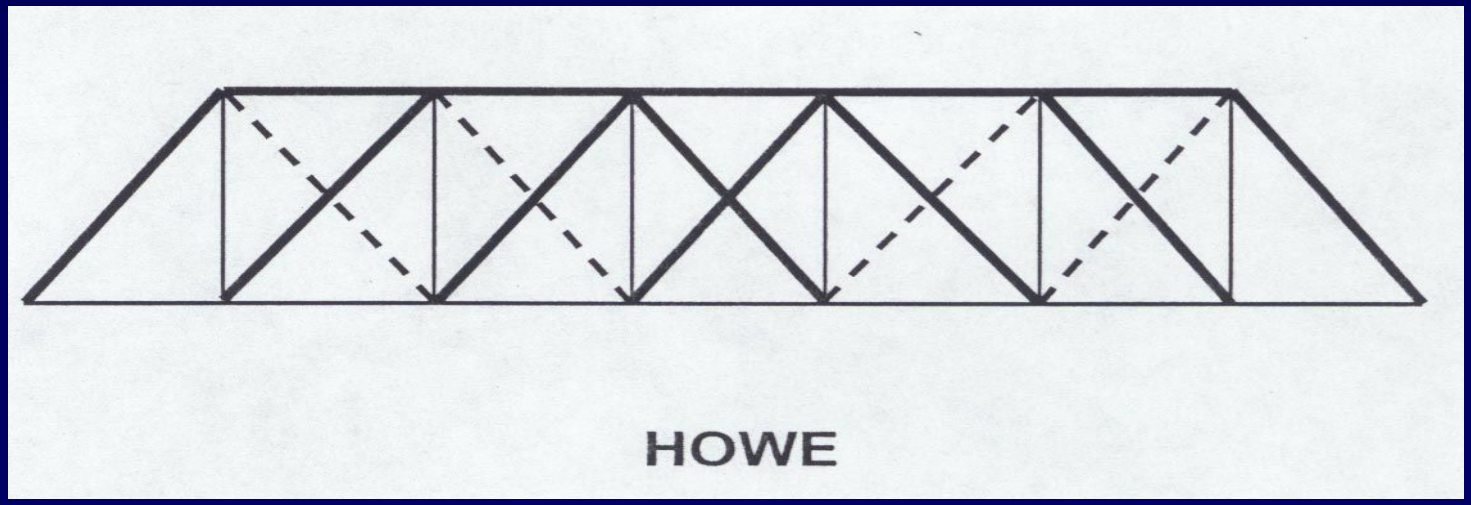
Design Criteria

Both a Warren & Howe bridge should be designed, steel types and size both being chosen by each individual design teams. For specific requirements refer back to the full SOW.





Technical Approach Phase 1: Economic Efficiency

A stable replacement bridge with the lowest possible cost that can support it's own weight and that of the specified load is the optimal design.

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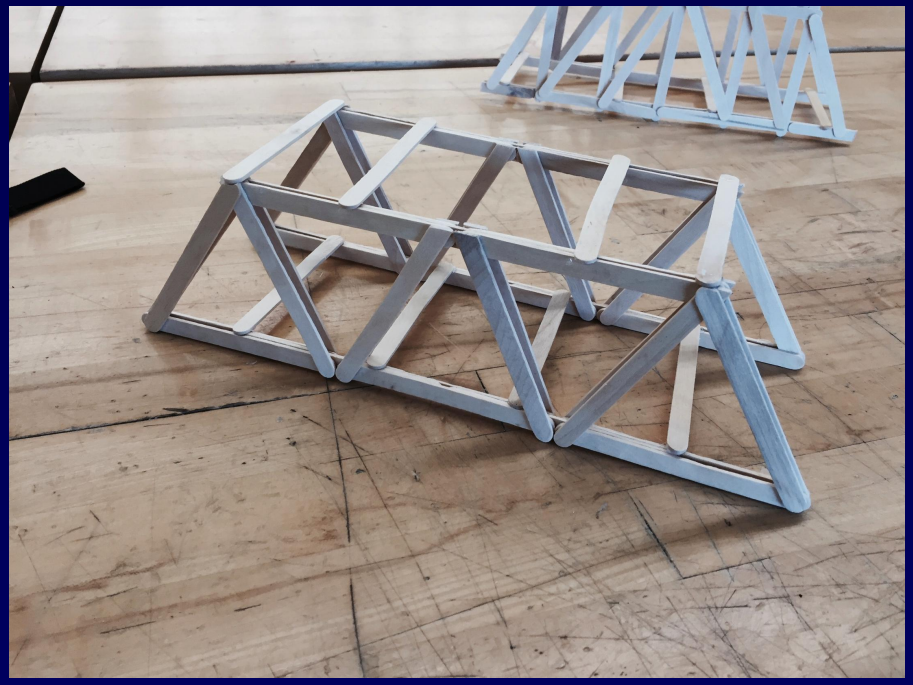
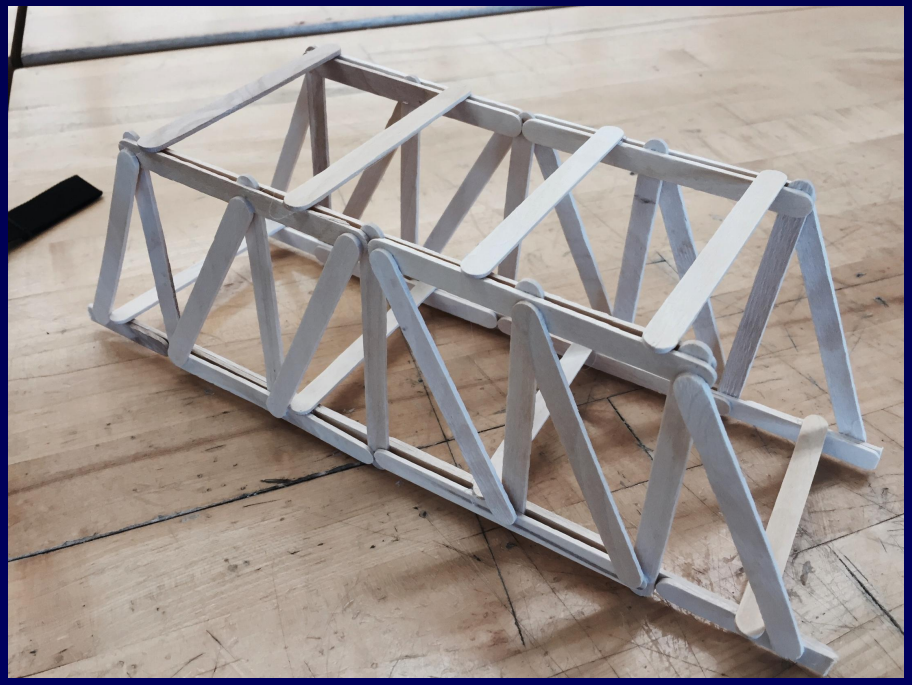
Technical Approach Phase 2: Structural Efficiency

Prototypes of both the Howe Truss and Warren Truss bridges were built and tested to find the total amount of weight the bridges could hold.

Structural Efficiency: load at failure/actual bridge weight in grams



Warren Truss Bridge



Howe Truss Bridge

Results Phase 1: Economic Efficiency

Both bridge designs are quite efficient, however the Warren Truss bride design comes out to be over $10,000 cheaper versus the Howe.

Table 4: Warren Truss Bridge EEBD 2015 Cost Calculations Report

Type of Cost	Item	Cost Calculation	Cost
Material Cost (M)	Quenched & Tempered Steel Hollow Tube	(6786.2 kg) x ($7.70 per kg) x (2 Trusses) =	$104,508.23
Connection Cost (C)		(21 Joints) x (500.0 per joint) x (2 Trusses) =	$21,000.00
Product Cost (P)	2 - 90x90x4 mm	(%s per Product) =	$1,000.00
	4 - 100x100x5 mm	(%s per Product) =	$1,000.00
	1 - 110x110x5 mm	(%s per Product) =	$1,000.00
	3 - 120x120x6 mm	(%s per Product) =	$1,000.00
	2 - 130x130x6 mm	(%s per Product) =	$1,000.00
	4 - 140x140x7 mm	(%s per Product) =	$1,000.00
	1 - 150x150x7 mm	(%s per Product) =	$1,000.00
	3 - 160x160x8 mm	(%s per Product) =	$1,000.00
	4 - 170x170x8 mm	(%s per Product) =	$1,000.00
	2 - 180x180x9 mm	(%s per Product) =	$1,000.00
	2 - 190x190x9 mm	(%s per Product) =	$1,000.00
	4 - 200x200x10 mm	(%s per Product) =	$1,000.00
	3 - 220x220x11 mm	(%s per Product) =	$1,000.00
	4 - 240x240x12 mm	(%s per Product) =	$1,000.00
Site Cost ($)	Deck Cost	(10 4-meter panels) x ($4,700.00 per panel) =	$47,000.00
	Excavation Cost	(19,900 cubic meters) x ($1.00 per cubic meter) =	$19,900.00
	Abutment Cost	(2 standard abutments) x ($5,250.00 per abutment) =	$10,500.00
	Pier Cost	No pier =	$0.00
	Cable Anchorage Cost	No anchorages =	$0.00
Total Cost	M + C + P + S	$104,508.23 + $21,000.00 + $14,000.00 + $77,400.00 =	$216,908.23

Total Cost Warren: $216,908.23

Total Cost Howe: $227,579.90

Table 1: Howe Truss Bridge EEBD 2015 Cost Calculations Report

Type of Cost	Item	Cost Calculation	Cost
Material Cost (M)	Quenched & Tempered Steel Hollow Tube	(7803.9 kg) x ($7.70 per kg) x (2 Trusses) =	$120,179.90
Connection Cost (C)		(20 Joints) x (500.0 per joint) x (2 Trusses) =	$20,000.00
Product Cost (P)	4 - 110x110x5 mm	(%s per Product) =	$1,000.00
	3 - 120x120x6 mm	(%s per Product) =	$1,000.00
	2 - 130x130x6 mm	(%s per Product) =	$1,000.00
	4 - 140x140x7 mm	(%s per Product) =	$1,000.00
	3 - 160x160x8 mm	(%s per Product) =	$1,000.00
	1 - 170x170x8 mm	(%s per Product) =	$1,000.00
	4 - 180x180x9 mm	(%s per Product) =	$1,000.00
	7 - 200x200x10 mm	(%s per Product) =	$1,000.00
	6 - 220x220x11 mm	(%s per Product) =	$1,000.00
	3 - 240x240x12 mm	(%s per Product) =	$1,000.00
Site Cost ($)	Deck Cost	(10 4-meter panels) x ($4,700.00 per panel) =	$47,000.00
	Excavation Cost	(19,900 cubic meters) x ($1.00 per cubic meter) =	$19,900.00
	Abutment Cost	(2 standard abutments) x ($5,250.00 per abutment) =	$10,500.00
	Pier Cost	No pier =	$0.00
	Cable Anchorage Cost	No anchorages =	$0.00
Total Cost	M + C + P + S	$120,179.90 + $20,000.00 + $10,000.00 + $77,400.00 =	$227,579.90

Results Phase 2: Structural Efficiency

Overall for the 8 design teams, the Howe proved to be more structurally efficient than the Warren design.

Table 8: Graph of Warren Truss Bridge Structural Efficiency for all Teams

	Actual Bridge Weight (grams)	Actual Bridge Weight (lbs) (grams* 0.00220462)	Load at Failure (lbs)	Structural Efficiency (strength: weight) (load at failure / actual bridge weight in grams)
Group 8	81.9	0.180558378	68.4	378.8248474
Group 7	75.5	0.16644881	55.6	334.0366326
Group 6	83.8	0.184747156	70.4	381.0613464
Group 5	85.3	0.188054086	60.8	323.3112414
Group 4	73.2	0.161378184	32.7	202.6296194
Group 3	83.4	0.183865308	90.8	493.8397623
Group 2	80.3	0.177030986	55.1	311.2449478
Group 1	85.2	0.187833624	39	207.6305571

Table 7: Graph of Howe Truss Bridge Structural Efficiency for all Teams

	Actual Bridge Weight (grams)	Actual Bridge Weight (lbs) (grams* 0.00220462)	Load at Failure (lbs)	Structural Efficiency (strength: weight) (load at failure / actual bridge weight in grams)
Group 8	80	0.1763696	70	396.8937958
Group 7	79.7	0.175708214	34.3	195.2099974
Group 6	85.2	0.187833624	72.1	383.8503377
Group 5	81.4	0.179456068	58.3	324.8705973
Group 4	78.1	0.172180822	77.9	452.4313399
Group 3	81.8	0.180337916	108.8	603.3118404
Group 2	75.3	0.166007886	34	204.8095474
Group 1	84.5	0.18629039	49.4	265.1773932

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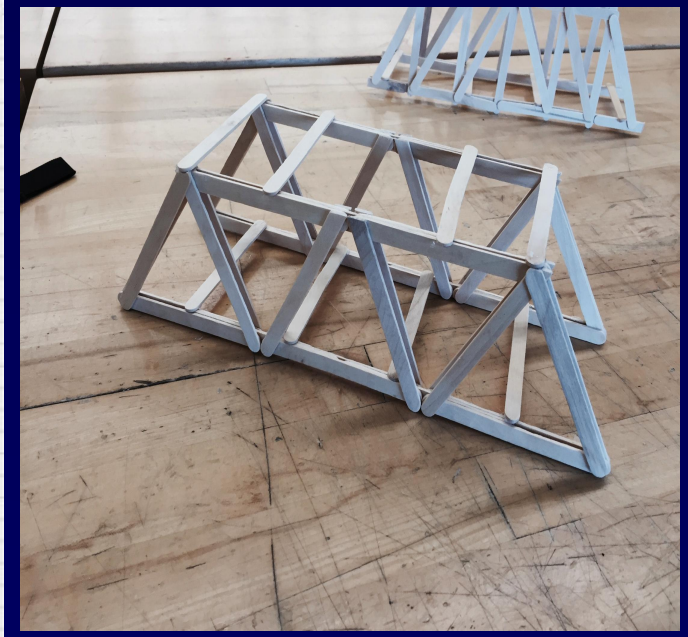
Best Solution

The objective of this design project was to find the most economically efficient bridge that could still handle the necessary loads. Looking at both of these intentions the Warren Truss bridge meets the load requirement and is much more inexpensive.

Table 5: Warren Truss Bridge EEBD 2015 Load Test Report

	Material Type	Size (mm)	Length (m)	Compression Force	Compression Strength	Compression Status	Tension Force	Tension Strength	Tension Status
1	QTS Hollow Tube	180x180x9	4.47	1547.41	1769.4	OK	0	2836.38	OK
2	QTS Hollow Tube	140x140x7	4.47	0	814.77	OK	1543.63	1715.83	OK
3	QTS Hollow Tube	170x170x8	4.47	1262.67	1420.38	OK	0	2388.53	OK
4	QTS Hollow Tube	130x130x6	4.47	0	586.66	OK	1257.58	1371.19	OK
5	QTS Hollow Tube	160x160x8	4.47	975.83	1251.19	OK	0	2241.09	OK
6	QTS Hollow Tube	120x120x6	4.47	0	464.52	OK	969.54	1260.61	OK
7	QTS Hollow Tube	140x140x7	4.47	687.51	814.77	OK	0	1715.83	OK
8	QTS Hollow Tube	100x100x5	4.47	0	224.01	OK	680.96	875.43	OK
9	QTS Hollow Tube	120x120x6	4.47	398.78	464.52	OK	69.62	1260.61	OK
10	QTS Hollow Tube	90x90x4	4.47	75.78	132.87	OK	392.62	633.99	OK
11	QTS Hollow Tube	90x90x4	4.47	110.56	132.87	OK	357.84	633.99	OK
12	QTS Hollow Tube	120x120x6	4.47	364	464.52	OK	104.4	1260.61	OK
13	QTS Hollow Tube	100x100x5	4.47	0	224.01	OK	646.18	875.43	OK
14	QTS Hollow Tube	140x140x7	4.47	652.32	814.77	OK	0	1715.83	OK
15	QTS Hollow Tube	110x110x5	4.47	0	302.31	OK	934.19	967.57	OK
16	QTS Hollow Tube	150x150x7	4.47	939.68	961.41	OK	0	1844.84	OK
17	QTS Hollow Tube	130x130x6	4.47	0	586.66	OK	1221.21	1371.19	OK
18	QTS Hollow Tube	170x170x8	4.47	1226.3	1420.38	OK	0	2388.53	OK
19	QTS Hollow Tube	140x140x7	4.47	0	814.77	OK	1507.26	1715.83	OK
20	QTS Hollow Tube	180x180x9	4.47	1511.04	1769.4	OK	0	2836.38	OK
21	QTS Hollow Tube	170x170x8	4	1382.35	1559.03	OK	0	2388.53	OK
22	QTS Hollow Tube	200x200x1	4	2457.08	2530.55	OK	0	3501.7	OK
23	QTS Hollow Tube	240x240x1	4	3222.34	3958.27	OK	0	5042.45	OK
24	QTS Hollow Tube	240x240x1	4	3677.23	3958.27	OK	0	5042.45	OK
25	QTS Hollow Tube	240x240x1	4	3821.68	3958.27	OK	0	5042.45	OK
26	QTS Hollow Tube	240x240x1	4	3655.97	3958.27	OK	0	5042.45	OK
27	QTS Hollow Tube	220x220x1	4	3180	3209.27	OK	0	4237.06	OK
28	QTS Hollow Tube	200x200x1	4	2394.35	2530.55	OK	0	3501.7	OK
29	QTS Hollow Tube	170x170x8	4	1349.82	1559.03	OK	0	2388.53	OK
30	QTS Hollow Tube	100x100x5	4	0	280.02	OK	675.76	875.43	OK
31	QTS Hollow Tube	160x160x8	4	0	1390.76	OK	1873.22	2241.09	OK
32	QTS Hollow Tube	190x190x9	4	0	2110.37	OK	2787.23	3002.25	OK
33	QTS Hollow Tube	200x200x1	4	0	2530.55	OK	3392.01	3501.7	OK
34	QTS Hollow Tube	220x220x1	4	0	3209.27	OK	3686.66	4237.06	OK
35	QTS Hollow Tube	220x220x1	4	0	3209.27	OK	3671.11	4237.06	OK
36	QTS Hollow Tube	200x200x1	4	0	2530.55	OK	3372.69	3501.7	OK
37	QTS Hollow Tube	190x190x9	4	0	2110.37	OK	2788.74	3002.25	OK
38	QTS Hollow Tube	160x160x8	4	0	1390.76	OK	1894.67	2241.09	OK
39	QTS Hollow Tube	100x100x5	4	0	280.02	OK	692.02	875.43	OK



Conclusions

Based on the results obtained from testing the bridges, the Warren Truss bridge proves to be the better choice based on a combination of the Structural Efficiency values we obtained and the overall cost difference between the two designs.

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Total Cost	M + C + P + S	$104,508.23 + $21,000.00 + $14,000.00 + $77,400.00 =	$216,908.23

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Recommendations

PennDot should select a Warren Truss bridge design to replace the damaged bridge.