

Bridge Economy & Life Cycle Costs of Steel & Concrete Bridges

Missouri TEAM March 14, 2019



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Today's Presentation

Initial Cost Case Studies & Life Cycle Cost Study of Typical Steel and Concrete Bridges



Problem Statement – Why This Presentation?

Preconception that Concrete is Less Expensive than Steel for Typical Bridges

Many Times Steel is Not Even Considered

Owners Paying More Than They Could for Bridges

Unwarranted Lack of Competition Not Good



Problem Statement – Why This Presentation?

Preconception that Concrete is Less Expensive than Steel for Typical Bridges

Today's Presentation Initial Costs – A Summary of Case Studies Life Cycle Costs – A Look at Capital Costs

To Break That Preconception



First Costs: Steel & Concrete Bridges

Case Studies





Missouri County Bridges – Where the SSSBA Began Steel Concrete



Audrain County, MO Bridge 411 Built 2012 Steel 4 Girders 47.5 ft. Span 24 ft. Roadway Width 2 ft. Structural Depth No Skew

Audrain County, MO Bridge 336 Built 2012 Precast 6 Hollowcore Slab Girders 50.5 ft. Span 24 ft. Roadway Width 2 ft. Structural Depth 20° Skew





Concrete

Case Study Bridges: Side-by-Side Comparison Total Cost of Structure

Steel



19.3% Total Bridge Cost Savings with Steel



<u>Total</u>	Bridg	e Costs	
			•

TOTAL	= \$111,853 (\$97.48 / sq. ft.)
Engineering	= \$ 8,246
Rock	= \$ 8,302
Guard Rail	= \$ 7,895
Equipment	= \$21,521
Labor	= \$24,125
Material	= \$41,764

TOTAL	= \$154,035 (\$12
Engineering	= \$21,335
Rock	= \$ 7,571
Guard Rail	=\$ 6,603
Equipment	= \$24,966
Labor	= \$26,110
Material	= \$67,450
Total Bridge Co	SIS

Total Pridge Costs

\$154,035 (\$120.83 / sq. ft.)





Case Study Bridges: Superstructure Only Comparison

(Remove Site Prep, Abutment, Grading & Finishing, Guardrail, Engineering, Rock, Etc)

Steel							
Superstucture C	<u>osts</u>						
Material							
Girders	= \$2	21,463					
Deck Panels	=\$	7,999					
Reinf Steel	=\$	3,135					
Concrete	=\$	4,180					
Labor	=\$	5,522					
Equipment*	=\$	500					
SUPER TOTAL	= \$4	2,799					

Concrete

Superstructure Costs

Material

SUPER TOTAL	= \$6	51,338
Equipment*	=\$	4,000
Labor	=\$	4,884
Concrete	= \$	965
Reinf Steel	= \$	724
Deck Panels	= \$	0
Slab Girders	= \$5	50,765

SUPER TOTAL = 37.54 / sq. ft.

SUPER TOTAL = \$50.61 / sq. ft.

*Added cost to use galvanized steel = \$5,453.80 or \$0.22 / lb. (includes est. 10% fabrication fee) ** Cost to use weathering steel is approximately \$0.04 / lb. (already included in cost in example)

*County Crane (30 Ton) used for Steel, Larger Rented Crane (100 Ton) Required for Concrete (Equivalent County Crane Cost is \$1520, would result in Steel Cost of \$38.88 / sq. ft.)



Case Study Bridges: Audrain County, MO

Steel: Superstructure \$37.54 per sq. ft.

Concrete: Superstructure Cost \$50.61 per sq. ft.



Same bridge conditions:

- Structural Depth = 2 ft. (No Difference in Approaches)
- Roadway Width = 24 ft.
- Same Abutments for Both Can be Used (Steel Could Use Lighter)
- Same Guard Rail System
- Same Work Crew

SHORT SPAN STEEL

🐐 University of Wyoming

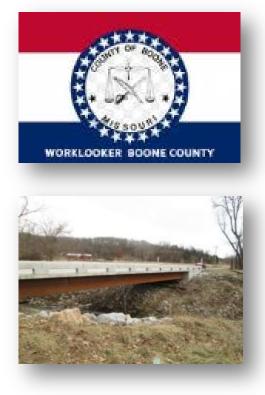
Case Study Bridges: Other Bridges in Audrain County

Superstructure			S	teel				Concrete			
Bridge Number	061	140	149	152	710	AVG	028	057	069	520	AVG
Year Built	2008	2008	2008	2009	2010	AVG	2009	2010	2011	2006	AVG
Span Length	50	50	40	62	64	53.2	36	36	38	40	37.5
Skew	0	0	0	30	35	13	0	15	20	30	16.25
Cost Summary											
- Labor	\$14,568	\$21,705	\$15,853	\$24,765	\$31,949	\$21,768	\$12,065	\$15,379	\$14,674	\$19,044	\$15,291
- Material	\$56,676	\$53,593	\$46,282	\$92,821	\$69,357	\$63,746	\$51,589	\$54,450	\$50,576	\$46,850	\$50,866
- Rock	\$6,170	\$6,216	\$3,694	\$8,235	\$6,501	\$6,163	\$5,135	\$7,549	\$5,378	\$3,621	\$5,421
- Equipment	\$7,487	\$12,026	\$7,017	\$19,579	\$15,266	\$12,275	\$5,568	\$10,952	\$11,093	\$14,742	\$10,589
- Guardrail	\$4,715	\$7,146	\$3,961	\$7,003	\$7,003	\$5,966	\$4,737	\$4,663	\$5,356	\$3,323	\$4,520
Construction Cost	\$89,616	\$100,686	\$76,807	\$152,403	\$130,076	\$109,918	\$79,094	\$92,993	\$87,077	\$87,580	\$86,686
CONST. COST PER FT ²	\$74.68	\$83.91	\$80.01	\$102.42	\$84.68	\$86.09	\$91.54	\$107.63	\$95.48	\$91.23	<mark>\$96.32</mark>



County Bridge (Designed by eSPAN140)

- Boone County, Missouri (Local)
 - High Point Lane Bridge
 - 102 feet (2 lane rural road plate girder bridge)
 - 44" weathering steel plate girders (4 lines)
 - Constructed in summer 2013







State Bridge (Designed by eSPAN140)

Kansas Department of Transportation

- Shawnee County
- 112 feet (5 plate girder bridge)
- Competitive bid process (steel vs. concrete)
- DOT used eSPAN140 for preliminary design
- Constructed in summer 2014
- 1 Steel Bridge Bid
- 3 Concrete Bridge Bids

Concrete = \$ 1.243 - \$ 1.425 mil





Two MoDOT State Bridges Crossing US 63 in Boone County

Concrete P/S: 92 ft – 92 ft Route H (Columbia Airport) Built 2011 Steel Plate Girder: 98 ft – 98 ft Discovery Parkway (Columbia) Built 2007



SHORT SPAN STEEL

🐐 University of Wyoming

Concrete P/S: 92 ft – 92 ft Route H (Columbia Airport) Built 2011

Letting Date	5/27/2011						
1800	206-10.00	Class 1 Excavation	85	CUYD	\$1,700.00		
1810	702-10.12	Structural Steel Piles (12 in.)	737	LF	\$33,533.50		
1820	702-60.00	Pre-Bore for Piling	240	LF	\$9,600.00		
1830	702-70.00	Pile Point Reinforcement	22	EA	\$2,420.00		
1840	703-20.03	Class B Concrete (Substructure)	76.2	CUYD	\$45,339.00		
1850	703-42.13	Slab on Concrete I-Girder	630	SQYD	\$160,650.00		
1860	703-42.15	Safety Barrier Curb	438	LF	\$27,156.00		
1870	705-60.03	Type 6 (54in.), Prestressed Concrete I-Gir	731	LF	\$120,615.00		
1880	706-10.60	Reinforcing Steel (Bridges)	7860	LB	\$9,039.00		
1890 -	707-10.00	Conduit System on Structure		L.S.	\$ 5,500.00 -		
1900	712-33.01	Steel Intermediate Diaphragm for P/S Cou		EA	\$3,900.00		
1910	715-10.01	Vertical Drain at End Bents	2	EA	\$3,000.00		
1920	716-10.02	Laminated Neoprene Bearing Pad	8	EA	\$1,200.00		
1930	716-10.03	Laminated Neoprene Bearing Pad (Tapere	8	EA	\$2,480.00		
1940	725-10.00	Corrugated Metal Pipe Pile Spacers	10	EA	\$20,000.00		
		•					
Total Bridge Cost = \$440,632.50							
		Tota	ai Brid	age cost =	\$440,632.50		
				Cost/ <mark>t</mark> ² =	\$77.71		

Steel Plate Girder: 98 ft – 98 ft Discovery Parkway (Columbia) Built 2007

etting Date	etting Date 9/28/2007							
1560	206100	Class 1 Excavation	130	CUYD	\$4,420.00			
1580	7021012	Structural Steel Piles (12 in.)	1850	LF	\$64,750.00			
1570	6071066 -	Pedestrian Fence	470	LF	\$33,840.00-			
1590	7027000	Pile Point Reinforcement	60	EA	\$5,700.00			
1600	7032003	Class B Concrete (Substructure)	171.7	CUYD	\$60,095.00			
1610	7034212	Slab on Steel	1835	SQYD	\$308,280.00			
1620	7034215	Safety Barrier Curb	387	LF	\$17,415.00			
1650	7121121	Fabricated Structural Low Alloy Steel (Plate G	439610	LB	\$518,739.80			
1630	7061060	Reinforcing Steel (Bridges)	15820	LB	\$15,029.00			
1640	7071000 -	Conduit System on Structure		L.S.	\$7,000.00 -			
1660	7123610	Slab Drains	12	EA	\$2,400.00			
1700	7151001	Vertical Drain at End Bents	2	EA	\$4,000.00			
1720	7162000	Laminated Neoprene Bearing Pad	9	EA	\$10,800.00			
1710	7161003	Laminated Neoprene Bearing Pad (Tapered)	18	EA	\$6,750.00			
1730	7251000	Corrugated Metal Pipe Pile Spacers	20	EA	\$5,000.00			
1670	7125365A	Intermediate Field Coat (System G)	22100	SQFT	\$30,940.00			
1680	7125370A	Finish Field Coat (System G)	2800	SQFT	\$3,220.00			
1690	7129911	Misc. Fab. Struc. Low Alloy Steel (Aesthethics	24330	LB	\$54,742.50			
	Total Bridge Cost = \$1.057 538.8							
Cost/ft ² =								
	Cost/ft ² with ENR CCI Adjustment of 1.139 = \$72.94							



Concrete P/S: 92 ft – 92 ft Route H (Columbia Airport)

Built 2011

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1870	705-60.03	Type 6 (54in.), Prestressed C	1.0	aro?	ase or	2.1		1ft2				3 <mark>0</mark>
1880	706-10.60	Rainf	IU	CIEC		Ċ	a1 18	5/11-)
1200	= NR(U)											
	1840 703-20.03 Class B Concrete (Substructure) 76.2 CUVD \$45,339.00 160 500 00 1850 703-42.13 Slab on Concrete I-Girder 630 SQVD \$160,650.00 00 1860 703-42.15 Safety Barrier Curb 438 438 0 00 1870 705-60.03 Type 6 (54in.), Prestressed C 00 00 00 1880 706-10.60 Rainford 438 00 00 00 1880 706-10.60 Rainford 00 00 00 00 1880 706-10.60 Rainford 00 00 00 00 19 For 2017 Steel 5 91.18/ft2 00 00 19 For 2017 Steel 5 85.58/ft2 00 00 19 Corruged Metal Pipe Pile Spacers 20 EA \$10,800.00 19 Corrugated Metal Pipe Pile Spacers 20 EA \$5,000.00 19 Corrugated Metal Pipe Pile Spacers 20 EA \$5,000.00 190											
	011.0	47		1		=	00.0			<u> </u>	EA	\$4,000.00
	or 20)^\ /	St	eel					Samig Pad	9	EA	\$10,800.00
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-							-					





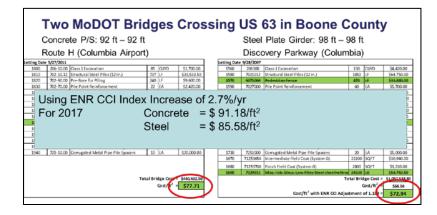
Summary on Initial Costs

Case Studies of County Bridges

Competitive Bids

Bridges over US 63

Others Not Shown Here



Case Study Bridges: Audrain County, MO Steel: Superstructure \$37.54 per sq. ft. Concrete: Superstructure Cost \$50.61 per sq. ft. 25.8% superstructure cost savin Same bridge conditions Structural Depth = 2 ft. (No Difference in Approaches)

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Steel Bridges Compete and Win!





What About Life Cycle Costs?

Historical Life Cycle Costs of Steel & Concrete Girder Bridges

Report on ShortSpanSteelBridges.org

Thank You to PennDOT professionals for their participation. Thanks to SMDI, NSBA and AGA for supporting the work.





Why the Study?

As owners replace their bridge infrastructure, the question of Life Service and Life Cycle Costs routinely comes up between concrete and steel bridge options.

This is especially true for typical and short span bridge replacement projects.

The bridge industry does not have a good answer: Both steel and concrete bridge advocates claim an advantage. Anecdotal information is not convincing.



Study Objective

Examine Historical Life Service (Performance and Maintenance) and Agency Life Cycle Costs (True Agency Costs for a Bridge) of Steel and Concrete Bridges in Pennsylvania

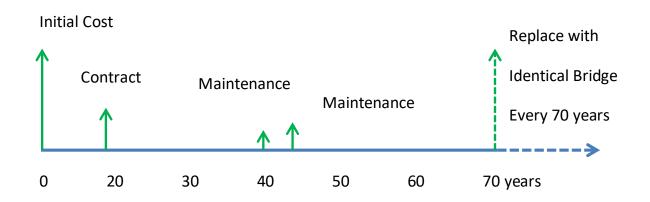




Life Cycle Cost Data Collection

Start with a Comprehensive Inventory of Bridges

Initial Costs & Date Built Maintenance Costs and Date Performed End of Service Date – End of Life Model







Life Cycle Cost Data Collection

Start with a Comprehensive Inventory of Bridges

Initial Costs & Date Built Maintenance Costs and Date Performed End of Service Date – End of Life Model

Issues: Availability of Historical Data

Large Amount of Time & Resources to Collect Data

PennDOT Stepped Up to Participate





PennDOT Database Development

Criteria to Develop LCC Bridge Database

Modern typical bridge structures Precast I-Beam, Box Adjacent, and Box Spread bridges Steel Rolled Shape and Welded Plate Girder bridges

Bridges built between 1960 and 2010

Bridges with complete and accurate department maintenance records Consider any maintenance cost that is equal to or greater than \$0.25/ft²

Bridges with known initial costs

Bridges with complete and accurate external contractor maintenance and rehabilitation

Initial cost limitation to bridges with initial cost less than \$500/ft² and greater than \$100/ft²

Note: Total Recorded Initial and Maintenance Costs Used





PennDOT Database Development

All Bridges in PennDOT Inventory	= 25,403
Number of Type Bridges in Inventory	= 8,466
Number of Types Built 1960-2010	= 6,587

Bridges that Meet All Criteria

Table 8: Final LCC Database that Meets All Criteria

Bridge Type	Number of Bridges that Meet All criteria	Percentage of 1960 – 2010 database
Steel I Beam	82	14.9%
Steel I Girder	230	22.6%
P/S Box - Adjacent	400	27.8%
P/S Box - Spread	581	26.5%
P/S I Beam	412	29.8%
Total	1705	25.9%



NEEDED Notes on Limitations

Database Contains Only 25.9% of Eligible 1960 - 2010 Bridges

Large Percentage of Bridges Not Included Bridges Removed Due To:

> Unknown Dates and/or Costs of Department Maintenance Unknown Dates and/or Costs of Contractor Maintenance

Therefore,

Database is "Skewed" Towards Bridges with Lower Amounts of Maintenance



NEEDED Notes on Limitations

The Systematic Nature of the Study Used

Total 1960-2010 PennDOT Database Average Deterioration Rates Based on Condition Ratings

The Study Does Not Predict Any Future Maintenance

Therefore,

Results, Comparisons & Conclusions Must Be Taken In Context to the Database and the Database Limitations



PennDOT Database Bridge Life Model

Bridge Life Model uses Average Deterioration Rates of Total PennDOT Inventory

Assume Bridge Replacement at Condition Rating = 3 Super Structure Condition Rating Used

Table 9: Average Deterioration Rates

 $Deterioration Rate = \frac{(2014 \ Condition \ Rating) - 9}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(2014 \ Condition \ Rating)} = \frac{(2014 \ Condition \ Rating)}{(201$ 2014 – (Year Built)

3 - (2014 Condition Rating)Remaining Life = (Average Deterioration Rate)

Bridge Life = 2014 - (Year Built) + Remaining Life

Bridge Type	Number of Bridges	Deterioration Rate
	1960 - 2010	(Condition Rating
		Loss/Year)
Steel I Beam	550	-0.07114
Steel I Girder	1017	-0.08144
P/S Box - Adjacent	1440	-0.08125
P/S Box - Spread	2196	-0.07988
P/S I Beam	1384	-0.08383



PennDOT Database Bridge Life Model

Bridge Life Model uses Average Deterioration Rates of Total PennDOT Inventory $Deterioration Rate = \frac{(2014 Condition)}{2014 Condition}$

Assume Bridge Replacement at Condition Rating = 3 Super Structure Condition Rating Used

Table 9: Average Deterioration Rates

 $Deterioration Rate = \frac{(2014 \ Condition \ Rating) - 9}{2014 - (Year \ Built)}$

 $Remaining \ Life = \frac{3 - (2014 \ Condition \ Rating)}{(Average \ Deterioration \ Rate)}$

Bridge Life = 2014 - (Year Built) + Remaining Life

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P/S I Beam	1384	-0.08383

All are "similar" with None "Way Out" of Balance

Steel Rolled

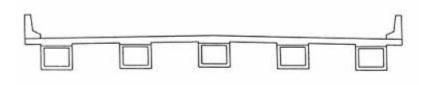
Precast Box Spread



Agency Life Cycle Costs – An Example

Precast Spread Box-Beam Bridge

30570
P/S, Box Beam (Spread)
Shuylkill
0.75 mi. N of Exit 107(33)
1969
3
176 ft
7621 ft ²
5



Average Precast Box Beam – Spread bridge deterioration rate = -0.07988

Remaining Life = $\frac{(3-5)}{-0.07988}$ = 25 years

Bridge Life = 2014 + 25 - 1969 = 70 *years*

+ BRIDGE ALLIANCE

🐐 University of Wyoming

Life Cycle Costs

Example Bridge Costs

Initial Cost:	Year = 1969	Cost = \$141475 (\$18.56/ft ²)	Work: Bridge Construction
External Contract:	Year = 1988	Cost = \$58401 (\$7.66/ft ²)	Work: Latex Overlay
Maintenance 1:	Year = 2009	Cost = \$1891 (\$0.25/ft ²)	Work: Repair Concrete Deck
Maintenance 2:	Year = 2013	Cost = \$2510 (\$0.33/ft ²)	Work: Repair Concrete Deck

ENR Construction Cost Indices

 $2014 \ Dollars = \frac{CCI \ 2014}{CCI \ 19XX} 19XX \ Dollars$

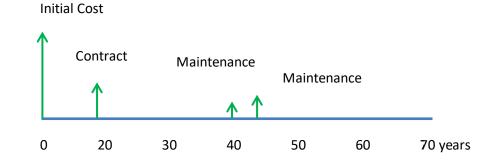
Transform the costs to constant 2014 dollars using Construction Cost

Initial Cost:	Year = 0	Cost = \$18.56/ft ² (9806/1269)	= \$143.45/ft ²
External Contract:	Year = 19	Cost = \$7.66/ft ² (9806/4519)	=\$ 16.63/ft ²
Maintenance 1:	Year = 40	Cost = \$0.25/ft ² (9806/8570)	= \$ 0.28/ft ²
Maintenance 2:	Year = 44	Cost = \$0.33/ft ² (9806/9547)	= \$ 0.34/ft ²



Life Cycle Costs Example Bridge Life Cycle

OMB Circular A-94 2011 30 yr Discount Rate = 2.3%



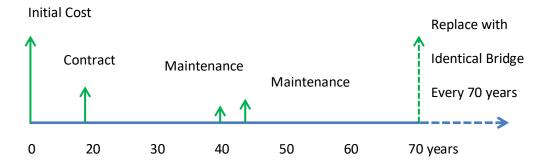
Present Value Cost for 1 Cycle

 $PVC = \$143.45 + \$16.63(1.023)^{-19} + \$0.28(1.023)^{-40} + \$0.34(1.023)^{-44} = \$154.49/ft^2$



Life Cycle Costs Example Bridge Life Cycle

OMB Circular A-94 2011 30 yr Discount Rate = 2.3%



Present Value Cost for 1 Cycle

 $PVC = \$143.45 + \$16.63(1.023)^{-19} + \$0.28(1.023)^{-40} + \$0.34(1.023)^{-44} = \$154.49/ft^2$

Perpetual Present Value Cost = Capitalized Cost

$$PPVC = \$154.49 \left[\frac{(1+0.023)^{70}}{(1+0.023)^{70}-1} \right] = 1.256(\$154.49) = \$193.97/ft^{2}$$

With PPVC, Can Compare Bridges Directly



Life Cycle Cost Analyses

The Steel Plate Girder Bridge Data Base

General Information

Steel I Welded Girder - General In

Maintenance & Contract Work

Initial & LCC

	Steel I Welded Girder - Gener	al Information	Steel I Welded Girder Initial Cost, Maintenance and External Contra		
Briting County		Robert Downstry Material	law law	lus lus	Steel I Welded Girder - Life Cycle Cost Results
Bold Allegitary 813 Allegitary 814 Allegitary 815 Allegitary 816 Allegitary 817 Allegitary 818 Allegitary 813 Allegitary 814 Ballegitary 815 Ballegitary 816 Ballegitary 817 Ballegitary 818 Ballegitary 819 Ballegitary 810 Ballegitary 811 Ballegitary 812 Ballegitary 813 Ballegitary 814 Ballegitary	Lockfordination Manual Alex Charling and a main fragment and Charling and an annual and charl Charlos and an annual and charl Charles and an annual and and an annual and an annual and and an annual and an annual and and annual and annual and annual and annual and annual and annual	Term Term (bit is types) Legistry (bit is types) Legistrypes) Legistr	NUT Dist Data Data Data Data 100 1000 1000 1000 Data	Units Units Units Units English 1011 1012	Mark Table Total Store Store Total Store Total Total <tht< th=""></tht<>
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30588 Dauphin 30588 Dauphin 30584 Dauphin	LOWER CRITCH COMPANY 3.0ML NEL OF HIGH SPEEL 3.5ML NEL OF HIGH SPEEL	Initial, perpetual present va	lua and futura maintanan	oo oosta	14592 5212.79 5202.79 5203 1948 528 118 5 14503 5241.57 5203 1220 1220 1221 52 14594 5364.53 5246.57 5208 1231 122 526 5
34760 Dauphin 34767 Dauphin 34777 Daushin	INTER OF M3.5 US22 INTER OF M3.5 US22 DAME OF MC4520M	initial, perpetual present va	liue, and future maintenan		14098 200-70 \$210.0 \$0.0 \$77.7 \$8 385 4 14097 \$211.25 \$19655 \$14.0 \$77.7 72 158 5 14777 \$2755 \$106.5 \$200 \$76 \$76 \$80 \$77
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Life Cycle Cost Analyses

Additional Bridges Removed Based on PPVC

To Consider "Typical" Bridges, Keep Bridges with PPVC within +/- 1 Standard Deviation of Overall Average

Bridges in the Life Cycle Cost Analyses

Table 13: Final Life Cycle Cost Database

Bridge Type	Number	Number
	of Bridges in	of Bridges in LCC
	Table 11 Database	Study Database
Steel I Beam	82	54
Steel I Girder	230	144
P/S Box - Adjacent	400	282
P/S Box - Spread	581	397
P/S I Beam	412	309
	1705	1186





LCC Report

Analysis and Variables Examined in Report

Bridge Life PPVC

> Number of Spans Bridge Length

PVC Future Costs Department Maintenance External Contracts For the entire report: <u>www.ShortSpanSteelBridges.org</u>

Additional LCC report on Galvanizing: <u>www.ShortSpanSteelBridges.org</u>

For Steel Bridges

Curved vs. Straight Fracture-Critical Protection (Painted, Weathering, Galvanized)

SHORT SPAN STEEL

🐐 University of Wyoming

Bridge Life

Table 10: Final LCC Database that Meets All Criteria

Bridge Type	Number of Bridges in Final LCC Database	Average Year Built	Average Bridge Life (years)
Steel I Beam	82	1981	81.3
Steel I Girder	230	1977	79.2
P/S Box - Adjacent	400	1985	74.0
P/S Box - Spread	581	1984	79.9
P/S I Beam	412	1984	74.5

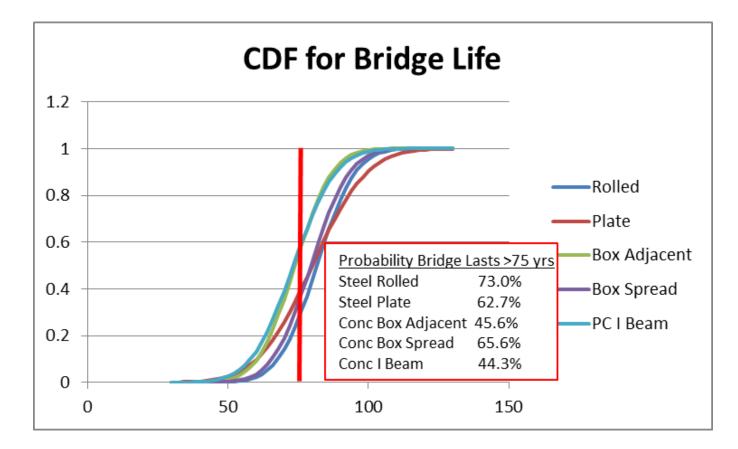
Steel Rolled Precast Box - Spread

All are "similar" with None "Way Out" of Balance





Bridge Life





Perpetual Present Value Cost – All Bridges

Table 14: Life Cycle Cost Results Using Total Database

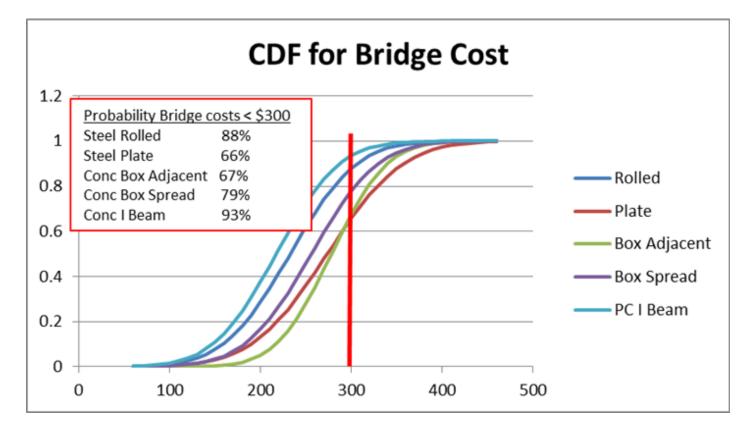
	# Bridges	PPVC	Initial Cost	Future Cost	Avg Length	Avg # Spans	Avg Year Built	Avg Life
Steel I Beam	54	\$232.78	\$194.78	\$0.42	166	2.19	1980	82
Steel I Girder	144	\$273.71	\$226.10	\$0.21	406	4.07	1976	80
P/S Box - Adjacent	282	\$278.30	\$223.74	\$0.96	89	1.31	1987	74
P/S Box - Spread	397	\$256.11	\$210.65	\$2.06	89	1.56	1986	79
P/S I Beam	309	\$217.50	\$174.10	\$0.20	212	2.43	1985	73

Precast I Beam Steel Rolled

All are "similar" with None "Way Out" of Balance



Perpetual Present Value Cost – All Bridges





Perpetual Present Value Cost – Length<140 ft

Short Length Bridges

Table 20: Life Cycle Cost Results for Bridge Length Maximum = 140 ft

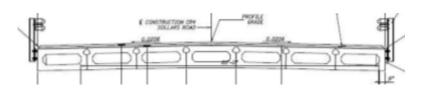
	# Bridges	PPVC	Initial Cost	Future Cost	Avg Length	Avg # Spans	Avg Year Built	Avg Life
Steel I Beam	27	\$266.24	\$222.08	\$0.16	84	1.26	1978	82
Steel I Girder	18	\$311.26	\$257.19	\$0.29	119	1.00	1977	81
P/S Box - Adjacent	240	\$292.38	\$235.03	\$0.95	69	1.09	1987	74
P/S Box - Spread	325	\$272.20	\$225.14	\$2.16	64	1.23	1986	81
P/S I Beam	98	\$281.64	\$231.20	\$0.05	104	1.08	1987	77

Steel Rolled Precast Box Spread

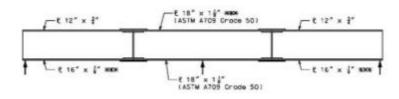
All are "similar" with None "Way Out" of Balance



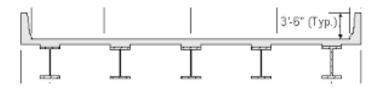
Which Type of Bridge is Best?







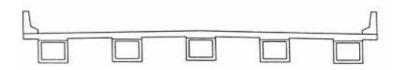
Steel Plate Girder



Steel Rolled Beam



Precast I Beam



Precast Box Spread





Which Type of Bridge is Best?

All are "similar" with None "Way Out" of Balance



Which Type of Bridge is Best?

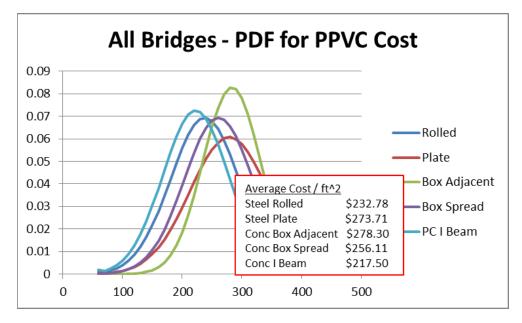
All are "similar" with None "Way Out" of Balance

Overall Weighted Average PPVC = $\frac{252.40}{ft^2}$ - Capitalized Costs

Bridge Types within 14% of Weighted Average

Standard Deviation Range \$48.02/ft² - \$65.60/ft² [COV ≈ 20% - 25%]

Any One Type of Bridge May Be Most Economical for a Given Bridge Project



There is No One Type of Bridge That Clearly Beats the Others



Conclusions

Typical Concrete and Steel Bridges are Competitive on Initial Cost, Future Costs, Life Cycle Costs and Bridge Life

For any Given Bridge Project, Concrete or Steel Bridge Types May Be the Most Economical

Preconception that Concrete is Always Less Expensive is a Misconception

Owners Should Consider Both Steel and Concrete Alternatives for Individual Bridge Projects



Need More Information?

Rich Tavoletti

Director, Short Span Steel Bridge Alliance Steel Market Development Institute <u>RTavoletti@steel.org</u>

412-458-5822



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