Developement Of Comparative Crosstie Unit Costs & Values

By Allan M. Zarembski, Ph.D., P.E. & Sunil Kondapalli,
ZETA-TECH Associates Inc.

In order to examine crosstie life cycle economic costs, ZETA-TECH Associates Inc. along with the Railway Tie Association developed an analysis of comparative crosstie unit costs and values as a function of traffic and service. Specifically, this activity calculated the "value" of wood ties on a cost-per-ton-mile basis as compared to competing tie types to include concrete, steel and plastic crossties.

These values were obtained for tangent and curved tracks, separately, as well as for an overall U.S. "average" track determined using an aggregated mix of tangent and curved track, with a distribution reflective of the U.S. national average. In addition, separate values were obtained for high-density (50 MGT annually), medium-density (25 MGT), and low-density (10 MGT) trackage.

Three distinct approaches were used in this unit cost analysis:

1. Simplified Analysis of Unit Costs
Tie material and replacement (labor and equipment) costs calculated on a cost-per-mile of track, based on full, one-time replacement of all crossties.

2. Tie Replacement Life Cycle Costs
Tie material and replacement (labor and equipment) costs calculated on a cost per mile of track, based on 100-year life cycle cost analysis. Used for wood, steel and plastic ties replaced using conventional tie gangs, based on 25 percent replacement of ties per cycle. Note, this analysis is not appropriate for concrete ties because of the significant difference in cycles and because concrete ties are replaced out of face (100 percent replacement).

3. Full SelecTie Life Cycle Cost Analysis
Concrete vs. wood tie analysis was performed using the RTA SelecTie model[1], where all major maintenance activities are included to calculate a cost-per-mile of track, based on a full life cycle cost analysis. Note, this analysis was limited to the wood vs. concrete tie analysis.

Note, because of the difference in time horizons, the actual costs per unit of traffic ($/mile/MGT) differ between the three methods. However, the relative ranking and ratio are appropriate and can be used for comparison of costs.

Tie Life Assumptions & Costs

Table 1 shows the costs defined for wood, concrete, steel and plastic (composite) ties.

Tie lives are calculated based on the revised *SelecTie* model, which has been calibrated to reported tie lives from major U.S. Class 1 railroads. *See Table 2 for all tie lives.*

Note: Tie lives are defined for three classes of annual tonnage:

- Low: 10 MGT per year
- Moderate: 25 MGT per year
- High: 50 MGT per year ▶

Table 1 — Costs For Wood, Concrete, Steel, & Plastic (composite) Ties

	WOOD	CONCRETE 1	CONCRETE 2	PLASTIC	STEEL 1	STEEL 2
Unit cost	$95.00	$250.00	$200.00	$135.00	$140.00	$140.00
Ties/mile	3,250	2,640	2,640	3,250	3,250	2,880
Cost/mile	$308,750	$660,000	$528,000	$438,750	$455,000	$403,200

Concrete 1 represents costs of complete out-of-phase installation of concrete track as part of new construction, based on the costs of a major U.S. Class 1 railroad.

Concrete 2 represents two-thirds of the labor and equipment costs reported for concrete 1 and is considered a "lower bound" cost for cases with very high rates of tie installation productivity.

Steel 1 is based on a standard tie spacing of 19 1/2 inches.

Steel 2 is based on spacing of 22 inches, which is used in some applications of steel ties but is not commonly used in main line track.

Note: Material costs include both tie and fastener costs.

Table 2 — Tie Lives

	WOOD									CONCRETE			PLASTIC			STEEL		
	"Dry" Climate Track			"Moderate" Climate Track			"Wet" Climate Track											
	Curve (deg); AGG=Aggregate																	
MGT	0	4	AGG	0	4	AGG	0	4	AGG	0	4	AGG	0	4	AGG	0	4	AGG
10	50	39	47.8	45	36	43.5	34	27	32.8	60	53	58.6	50	39	47.8	55	46	53.2
25	40	33	38.6	38	30	36.2	29	22	27.3	51	45	49.8	40	33	38.6	45.5	39	44.2
50	36	28	34.4	33	26	31.5	25	19	24	46	41	45	36	28	34.4	41	34.5	39.7

Table 3 — For "Dry" Climate Track (Western U.S.)

	WOOD/ CONCRETE 1			WOOD/CONCRETE 2			WOOD/PLASTIC			WOOD/STEEL 1		
	MGT	Tangent	Mod Curve	MGT	Tangent	Mod Curve	MGT	Tangent	Mod Curve	MGT	Tangent	Mod Curve
Low Tonage	10	0.56	0.64	10	0.70	0.79	10	0.70	0.70	10	0.75	0.80
Med Tonage	25	0.60	0.64	25	0.75	0.80	50	0.70	0.70	25	0.77	0.80
High Tonage	50	0.60	0.68	50	0.75	0.86	50	0.70	0.70	50	0.77	0.84

Table 4 — For Moderate Climate Track

	WOOD/ CONCRETE 1			WOOD/CONCRETE 2			WOOD/PLASTIC			WOOD/STEEL 1		
	MGT	Tangent	Mod Curve	MGT	Tangent	Mod Curve	MGT	Tangent	Mod Curve	MGT	Tangent	Mod Curve
Low Tonage	10	0.62	0.70	10	0.77	0.87	10	0.77	0.77	10	0.82	0.88
Med Tonage	25	0.63	0.71	50	0.79	0.89	25	0.74	0.78	25	0.82	0.89
High Tonage	50	0.65	0.74	50	0.82	0.93	50	0.77	0.76	50	0.84	0.91

Table 5 — For "Wet" Climate Track (representative of Southeastern U.S.)

	WOOD/ CONCRETE 1			WOOD/CONCRETE 2			WOOD/PLASTIC			WOOD/STEEL 1		
	MGT	Tangent	Mod Curve	MGT	Tangent	Mod Curve	MGT	Tangent	Mod Curve	MGT	Tangent	Mod Curve
Low Tonage	10	0.82	0.92	10	1.02	1.15	10	1.02	1.02	10	1.09	1.16
Med Tonage	25	0.83	0.94	25	1.04	1.18	25	0.98	1.04	25	1.08	1.18
High Tonage	50	0.86	0.98	50	1.08	1.23	50	1.02	1.01	50	1.12	1.20

Tie lives are also defined for the following curvature classes:

- Tangent
- Moderate: defined here as 4 degree
- Composite or "Aggregate" curvature: 80 percent tangent and 20 percent curved (distribution identified on selected U.S. railway routes)

Wood tie lives also reported as a function of climatic condition as follows:

- "Dry" Climate Track Representative of Western U.S.
- Moderate Climate Track: Representative of Northern U.S.
- "Wet" Climate Track: Representative of Southeastern U.S.

For plastic or composite ties, tie life was assumed to be comparable to dry climate track wood tie life. Note, this performance has not been confirmed by field experience.

For steel ties, tie life was assumed to be an average of concrete and dry climate track wood tie life. Note, this performance has not been confirmed by field experience.

Results

Results for the three analyses performed are presented as a ratio between wood and alternate tie costs on a $/Mile/MGT basis. Note, when this ratio is less than 1, the unit cost of the wood ties is less than the alternate ties. If it is greater than 1, it means the cost of the alternate ties is less.

For the *simplified analysis*, tie material and replacement (labor and equipment) costs were used to calculate a cost per mile of track, based on a full, one-time replacement of all of the crossties[2]. Using the defined tie installation costs and tie lives (in MGT), *Tables 3, 4 & 5* on page 17 show the cost ratios that were generated.

For the *life cycle cost analysis*, tie material and replacement (labor and equipment) costs were used to calculate a cost per mile of track, based on a 100-year life cycle. In this analysis, wood, steel and plastic ties were replaced using conventional tie gangs, based on 25 percent replacement of ties per cycle. Note, this analysis is not appropriate for concrete ties because of the significant difference in cycles and because concrete ties are replaced out of face (100 percent replacement) (see SelecTie comparison). For the life cycle cost analysis, *Table 6* shows the assumptions that were made.

Using the defined cost of money and life cycle parameters shown in *Table 6*, the life cycle costs ratios shown in *Table 7* were calculated.

Concrete vs. wood tie analysis was performed using the RTA SelecTie model, where all of the major maintenance activities addressed by the SelecTie model (to include tie replacement, rail replacement, surfacing, grinding, etc.) costs were used to calculate a cost per mile of track, based on a life cycle cost analysis. Using SelecTie to compare wood vs. concrete tie track over the total life cycle of the analysis results in the cost ratios that are shown in *Table 8*.

Conclusions

Based on the tie costs and calculated lives presented above, wood crossties have a lower cost per mile per MGT than any of the alternate tie configurations, except for applications in wet climates where the tie life is significantly reduced or for severe curvature high density applications.

In general, for moderate density tangent track of the order of 25 MGT per year located in a moderate climate zone of the US, wood tie costs ($/mile/MGT) are of the order of 60 to 80 percent of concrete tie track; 70 to 75 percent of plastic (composite) ties, and 80 to 85 percent of steel tie track costs.

For moderate density moderate curvature track (25 MGT per year) located in a moderate climate zone of the U.S., wood tie costs ($/mile/MGT) are of the order of 65 to 85% of concrete tie track; 70 to 80 percent of plastic (composite) ties, and 80 to 90 percent of steel tie track costs.

For dry climates, the wood tie costs represent a corresponding smaller percentage of the costs of alternate tie types; for wet climates, they represent a correspondingly higher percentage of the costs of alternate tie types. §

Footnotes

1 The *RTA SelecTie II* model was recently upgraded using costs and performance data from selected U.S. Class 1 railroads.

2 This analysis was not a life cycle analysis and did not account for time value of money.

Table 6 — Cost of Money & Life Cycle Parameters

Value of Money	8%
Time Horizon	100 years
Medium Tonage	MGT=25 MGT/yr.

Table 7 — Wood Tie Life Cycle Costs Ratio

		MODERATE TONNAGE (25 MGT) TANGENT TRACK	MODERATE TONNAGE (25 MGT CURVED TRACK)
"Dry" Climate Track (Western U.S.)	Wood-"dry"/Plastic	0.70	0.70
	Wood-"dry"/Steel 1	0.75	0.75
Moderate Climate Track	Wood-mod/Plastic	0.77	0.77
	Wood-mod/Steel 1	0.83	0.82
"Wet" Climate Track (Southeastern U.S.)	Wood-"wet"/Plastic	0.89	0.96
	Wood-"wet"/Steel 1	0.96	1.02

Table 8 — Concrete Tie Life Cycle Costs Ratio

		MODERATE TONNAGE (25 MGT) TANGENT TRACK
"Dry" Climate Track (Western U.S.)	Wood-"dry"/Concrete Tangent Track	0.57
	Wood-"dry"/Concrete Curved Track	0.65
Moderate Climate Track	Wood-mod/Concrete Tangent Track	0.58
	Wood-mod/Concrete Curved Track	0.66
"Wet" Climate Track (Southeastern U.S.)	Wood-"wet"/Concrete Tangent Track	0.62
	Wood-"wet"/Concrete Curved Track	0.71