RTA TieReport #2

Cost Comparison of Alternate Crosstie Materials

While wood cross-ties continue to represent the dominant tie material installed in the United States and Canada with a 95% share of all ties purchased in 2005 [1], other cross-tie materials in active use include:

Concrete | Steel | Composite/Plastic

In order to examine the economics of these alternate materials as compared to wood cross-ties, several detailed studies have been undertaken and computer models developed. The original focus of these analyses was on the comparison of wood vs. concrete cross-ties, where a new generation life cycle cost model, the "SelecTie" model, was developed to examine the full spectrum of purchase, installation and maintenance costs associated with these different tie types [2,3]. Table 1 illustrates the range of parameters used in such a detailed life cycle cost analysis.

Table 1: SelecTie Analysis Factors

Costs • Component (material) Costs - Tie - Fasteners and Fastener Components • Labor Costs
Tie Life as a Function of Track and Traffic Characteristics • Track Characteristics - Curvature - Grade - Climatic Condition - Track Design - Track Components • Traffic Characteristics - Operating Speed - Axle Load - Traffic Density (annual tonnage)
Economic Characteristics • Interest Rate
Maintenance Activities • Rail Replacement Costs • Tie Replacement Costs • Concrete Tie Repair Costs • Surfacing Costs • Other Maintenance Costs

The results of these life cycle cost analyses showed that for the vast majority of track, wood is the economic choice. However, there are locations and conditions where concrete is an economically attractive alternative [2,3]. Thus, these analyses must be updated as a function of the respective costs and life cycles of the alternate materials.

Such an updated analysis was recently performed which analyzed the costs and associated "values" of several of these alternate tie materials as a function of traffic and service [4]. Specifically, the study calculated the "value" of wood ties on a cost per ton mile basis as compared to these alternate tie materials, looking at respective costs, service life and performance.

Noting that the service lives vary as a function of traffic density, climatic conditions, curvature, etc., a set of comparisons was performed using current costs for tie materials (to include fasteners and installation, as presented in Table 2), wood tie service lives (as presented in the previous Tech Note number I), and service lives for the alternate tie materials (as presented in Table 3).

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Table 2: Tie Costs to Include Fasteners and Installation [4]

	Wood	Concrete 1	Concrete 2	Composite/Plastic	Steel 1*
Unit Cost	$95.00	$250.00	$200.00	$135.00	$140.00
Ties/Mile	3,250	2,640	2,640	3,250	3,250
Cost/Mile	$308,750	$660,000	$528,000	$438,750	$455,000

Notes:

- 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 2/3 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 19½ inches.

**Steel ties are sensitive to the cost of steel, which varies with demand.*

Table 3: Service Lives of Alternate Tie Materials [4]

Concrete

	Curve (deg)		
MGT	0	4	Aggregate*
10	60	53	58.6
25	51	45	49.8
50	46	41	45

*Aggregate life is for a composite curvature (80% tangent and 20% curves) which reflects a distribution identified on selected U.S. railway routes.

Composite/Plastic Tie Life**

	Curve (deg)		
MGT	0	4	Aggregate
10	50	39	47.8
25	40	33	38.6
50	36	28	34.4

**Composite/plastic tie life assumed to be comparable to dry climate track wood tie life. This performance has not yet been confirmed by field experience.

Steel Tie Life***

	Curve (deg)		
MGT	0	4	Aggregate
10	55	46	53.2
25	45.5	39	44.2
50	41	34.5	39.7

***Steel tie life assumed to be an average of concrete and dry climate track wood tie life. This performance has not yet been confirmed by field experience.

Three distinct cost/benefit analysis approaches were used to examine the respective values of the different tie materials,

1. **Simplified Analysis of Unit Costs** (all materials)
   Tie material and replacement (labor and equipment) costs used to calculate a cost/mile/MGT based on a full, one-time replacement of all of the cross-ties.

2. **Tie Replacement Life Cycle Costs** (Steel and Composite/Plastic vs. Wood)
   Tie material and replacement (labor and equipment) costs used to calculate a cost/mile/MGT, based on a 100-year life cycle using conventional cyclic tie gangs[1].

[1]This analysis is not appropriate for concrete ties because of the significant difference in tie gang cycles, due to the fact that concrete ties are replaced out of face (100% replacement).

3. **Full SelecTie Life Cycle Cost Analysis** (Concrete vs. Wood)
   Full life cycle analysis performed using the RTA SelecTie model, including all of the major maintenance activities (to include tie replacement, rail replacement, surfacing, grinding, etc.). Cost/mile/MGT calculated based on life cycle cost analysis.

Because of the difference in time horizons, the actual costs per unit of traffic ($/mile/MGT) differ significantly among the three methods. However, the relative rankings and ratio are appropriate for comparison of wood against the other tie materials.

In all cases, the cost/mile/MGT for each analysis pair; wood vs. alternate tie material, was converted to a value ratio, the ratio of wood tie to alternate tie cost/mile/MGT. Note: When this ratio is less than 1, it means that 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, based on tie installation costs and total tie life in MGT (not accounting for the time value of money), the results are presented in Table 4. In this 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 cross-ties. Using the tie life in years, annual MGT, the defined replacement unit cost defined here, $/mile/MGT was calculated together with the ratio of wood tie to alternate tie cost.

Table 4: Simplified Unit Cost Analysis (All Materials)

For "Dry" Climate Track
(Western U.S.)

Wood/Concrete 1		Tangent	Mod Curve
Low Tonnage	10	0.56	0.64
Med Tonnage	25	0.60	0.64
High Tonnage	50	0.60	0.68

Wood/Concrete 2		Tangent	Mod Curve
$/Mile/MGT	MGT		
Low Tonnage	10	0.70	0.79
Med Tonnage	25	0.75	0.80
High Tonnage	50	0.75	0.86

Wood/Plastic		Tangent	Mod Curve
Low Tonnage	10	0.70	0.70
Med Tonnage	25	0.70	0.70
High Tonnage	50	0.70	0.70

Wood/Steel 1		Tangent	Mod Curve
Low Tonnage	10	0.75	0.80
Med Tonnage	25	0.77	0.80
High Tonnage	50	0.77	0.84

For Moderate Climate Track

Wood/Concrete 1		Tangent	Mod Curve
Low Tonnage	10	0.62	0.70
Med Tonnage	25	0.63	0.71
High Tonnage	50	0.65	0.74

Wood/Concrete 2		Tangent	Mod Curve
Low Tonnage	10	0.77	0.87
Med Tonnage	50	0.79	0.89
High Tonnage	50	0.82	0.93

Wood/Plastic		Tangent	Mod Curve
Low Tonnage	10	0.77	0.77
Med Tonnage	25	0.74	0.78
High Tonnage	50	0.77	0.76

Wood/Steel 1		Tangent	Mod Curve
Low Tonnage	10	0.82	0.88
Med Tonnage	25	0.82	0.89
High Tonnage	50	0.84	0.91

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

Wood/Concrete 1		Tangent	Mod Curve
Low Tonnage	10	0.82	0.92
Med Tonnage	25	0.83	0.94
High Tonnage	50	0.86	0.98

Wood/Plastic		Tangent	Mod Curve
Low Tonnage	10	1.02	1.02
Med Tonnage	25	.98	1.04
High Tonnage	50	1.02	1.01

Wood/Concrete 2		Tangent	Mod Curve
Low Tonnage	10	1.02	1.15
Med Tonnage	25	1.04	1.18
High Tonnage	50	1.08	1.23

Wood/Steel 1		Tangent	Mod Curve
Low Tonnage	10	1.09	1.16
Med Tonnage	25	1.08	1.18
High Tonnage	50	1.12	1.20

For the life cycle cost analysis based on tie material and installation costs and total tie life, the results for the moderate tonnage case are presented in Table 5. In this 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 cost analysis. The wood, steel and plastic ties were replaced using conventional tie gangs, based on 25% replacement of ties per cycle and a cost of money of 8%.

Table 5: *Tie Replacement Life Cycle Costs Analysis*

(Steel and Composite/Plastic vs. Wood)

Moderate Tonnage (25 MGT) Tangent Track

For "Dry" Climate Track (Western U.S.)

wood-"dry"/Plastic	0.70
wood-"dry"/Steel 1	0.75

For Moderate Climate Track

wood-mod/Plastic	0.77
wood-mod/Steel 1	0.83

For "Wet" Climate Track (e.g., Southeastern U.S.)

wood-"wet"/Plastic	0.89
wood-"wet"/Steel 1	0.96

Moderate Tonnage (25 MGT) Curved Track

For "Dry" Climate Track (Western U.S.)

wood-"dry"/Plastic	0.70
wood-"dry"/Steel 1	0.75

For Moderate Climate Track

wood-mod/Plastic	0.77
wood-mod/Steel 1	0.82

For "Wet" Climate Track (e.g., Southeastern U.S.)

wood-"wet"/Plastic	0.96
wood-"wet"/Steel 1	1..02

The analysis of Concrete vs. Wood ties was performed using the RTA SelecTie model [2,3], 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. Maintenance cycles were activity-specific based on internal SelecTie life models. Most recent updated costs were used in SelecTie.

**Note: This analysis was limited to the Wood vs. Concrete tie analysis.*

Figure 1: SelecTie Analysis Wood ("dry" climate track) vs. Concrete, Moderate Density, Curved Track

Figure 1

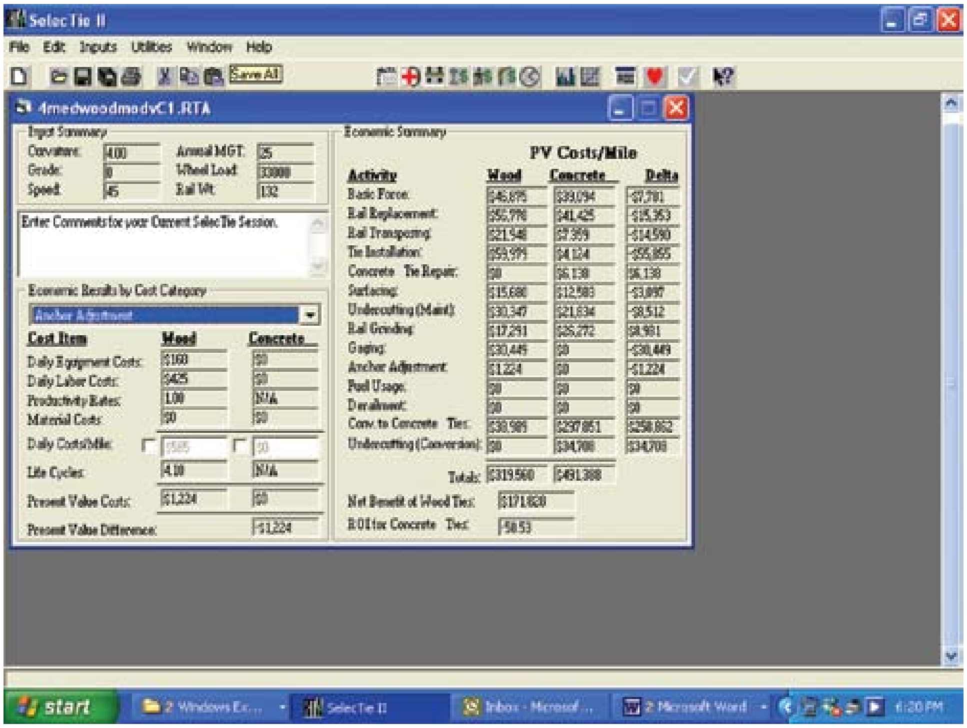

Figure 1 illustrates a sample SelecTie analysis comparing wood vs. concrete tie track in a dry environment, moderate tonnage and moderate curvature.

The results of the SelecTie analysis for moderate tonnage (25 MGT) tangent and curved track are presented in Table 6.

Table 6: SelecTie Life Cycle Costs Analysis (Concrete vs. Wood)

Moderate tonnage (25 MGT) **tangent track**

For "Dry" Climate Track (Western U.S.)

wood-"dry"/Concrete Tangent Track	0.57
wood-"dry"/Concrete Curved Track	0.65

For Moderate Climate Track (Western U.S.)

wood-moderate/Concrete Tangent Track	0.58
wood-moderate/Concrete Curved Track	0.66

For "Wet" Climate Track (e.g., Southeastern U.S.)

wood-"wet/Concrete Tangent Track	0.62
wood-"wet"/Concrete Curved Track	0.71

However, as noted in earlier analyses, as the annual tonnage increases, the relative benefit of the wood cross-ties changes, with the benefit (defined in terms of Return on Investment or ROI) decreasing, in some cases, at higher annual tonnage levels as illustrated in Figure 2.

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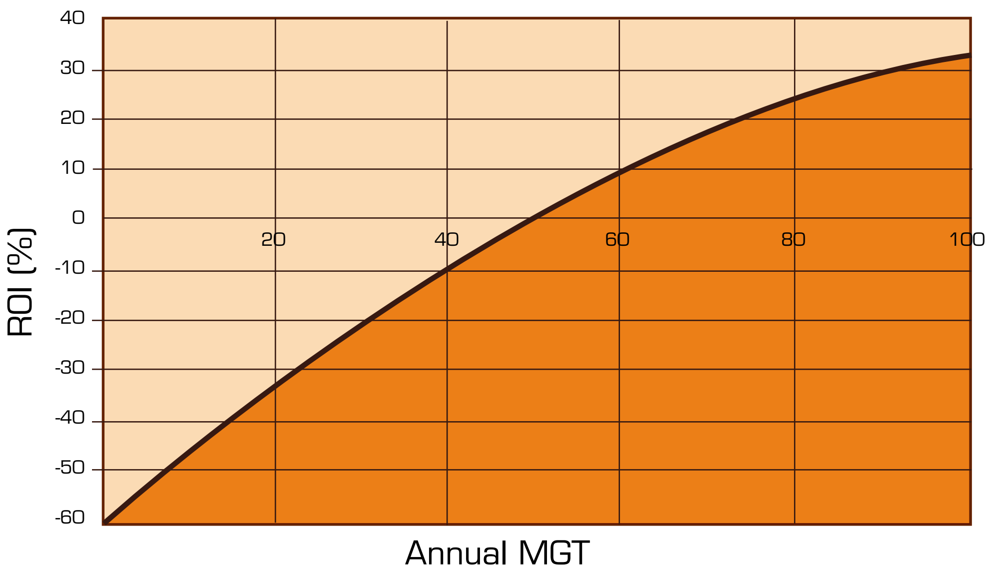
Figure 2: SelecTie Sensitivity Analysis for ROI of Concrete (vs. Wood) Track [3]

Figure 2



Based on these analyses, it can be seen that in general, wood ties 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 high-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 U.S., wood tie costs ($/mile/MGT) are of the order of 60 to 80% of concrete tie track; 70 to 75% of plastic (composite) ties, and 80 to 85% 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% of plastic (composite) ties, and 80 to 90% 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.

**Note: Analysis shows Return on Investment (ROI) of concrete tie track as compared to wood tie track. Negative or low ROI indicates wood tie is more advantageous.*

REFERENCES

1. Gauntt, J.C., "Wood Ties Dominate 2005 Installs," *Crossties Magazine*, September-October 2006.

2. Zarembski, A. M., and Masih, J.T.A., "On the Development of Computer Model for the Economic Analysis of Alternate Tie/Fastener Configuration," American Railway Engineering Association (presented at the March 1989 Annual Conference, Chicago).

3. Zarembski, A. M., and Gauntt, J.C., "Evaluation of Life Cycle Costs of Alternate Tie (Sleeper)/Fastener Systems and Their Use in Defining Maintenance Policy and Practice," WCRR Conference, Florence, Italy, November 1997.

4. Zarembski, A. M., "Development of Comparative Cross-Tie Unit Costs and Values," Report to the Railway Tie Association, August 2006.