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August 17, 2006

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Dear Jim:

Enclosed please find our report "Development of Comparative Cross-Tie Unit Costs and Values".

If you have any questions or comments please give me a call.

Respectfully yours,

Allan M. Zarembski, Ph.D., P.E.
President

Development of
Comparative Cross-Tie Unit Costs and Values

August 2006

Prepared for:

Railway Tie Association

by:

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Development of Comparative Cross-Tie Unit Costs and Values

Introduction

This report presents the results of an analysis of Comparative cross-tie 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
- Plastic

These values were obtained for tangent and curved tracks, separately, as well as for an overall average track determined using an aggregated mix of tangent and curved track, with a distribution reflective of the US national average.

In addition, separate values were obtained for high, medium and low density trackage.

The results presented here-in also reflect the upgrade of the RTA SelecTie model using recently obtained costs and performance based on input from selected US Class 1 railroads. The updated SelecTie model has been submitted under separate cover.

Three distinct approaches were used in this analysis is as follows:

1. Simplified Analysis of Unit Costs

   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.

2. Tie Replacement Life Cycle Costs

   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. In this analysis, wood, steel and plastic ties were replaced using conventional tie gangs, based on 25% replacement of ties per cycle. Note, this analysis is not appropriate for concrete ties because of the significant difference in 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 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. 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.

It should be noted that because of the difference in time horizons, the actual costs per unit of traffic ($/mile/MGT) differ significantly between the three methods. However the relative ranking and ratio can be used for comparison of wood against the other tie materials.

Tie Lives and Costs

Based on a survey of selected US railroads and suppliers, the following costs have been defined for wood, concrete, steel and 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

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 US 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 19 ½ inches
- Steel 2 is based on a tie spacing of 22 inches which is reported as being used in applications for steel ties
- Material costs include both tie and fastener costs.

*Also note; steel ties are very sensitive to the cost of steel, which has been rising recently. This cost may be significantly low in terms of future steel tie costs.

Tie Lives are calculated based on the revised SelecTie model which has been calibrated to reported tie lives from major US Class 1 railroads.

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

Tie lives are defined for the following curvature classes:

- Tangent
- Moderate: defined here as 4 degree

A composite curvature value is also calculated based on track that is 80% tangent and 20% curved (to reflect a distribution identified on selected US railway routes)

Finally, wood tie lives are also reported as a function of climatic condition as follows:

- "Dry" Climate Track Representative of Western US
- Moderate Climate Track: Representative of Northern US
- "Wet" Climate Track: Representative of Southeastern US

These lives are defined as follows:

Wood Tie Life

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

Moderate Climate Track	Curve (deg)		
MGT	0	4	Aggregate
10	45	36	43.5
25	38	30	36.2
50	33	26	31.5

"Wet" Climate Track	Curve (deg)		
MGT	0	4	Aggregate
10	34	27	32.8
25	29	22	27.3
50	25	19	24

Concrete

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

In the case of plastic or composite ties; the tie life was assumed to be comparable to dry climate track wood tie life. However, this performance has not yet been confirmed by field experience.

Plastic Tie Life

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

In the case of steel ties; the tie life was assumed to be an average of concrete and dry climate track wood tie life. However, 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

Simplified Analysis of Unit Costs

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. The updated SelecTie tie life model was used to calculate the life of the tie, in years, as a function of traffic density, as noted in the previous section. Using the tie life in years and the annual MGT, a tie life in MGT was calculated. Using the costs defined in the previous section, the unit cost, defined here $/mile/MGT was calculated for five of the six cases defined previously (the Steel 2 case, with a 22 inch tie spacing was not considered a realistic case for main line track and was not included.).

Using these unit costs ($/mile/MGT), the ratio of wood tie to alternate tie cost was also calculated. 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.

The calculated costs are as follows:

For Wood Ties

"Dry" Climate Track (Western US)							
Life Wood Ties		Tangent		Mod Curve		Aggregated Track	
	MGT	Years	MGT	Years	MGT	Years	MGT
Low Tonnage	10	50	500	39	390	47.8	478
Med Tonnage	25	40	1000	33	825	38.6	965
High Tonnage	50	36	1800	28	1400	34.4	1720
Cost Wood Ties		Tangent		Mod Curve		Aggregated Track	
$/Mile/MGT	MGT						
Low Tonnage	10	**$618**		**$792**		**$646**	
Med Tonnage	25	**$309**		**$374**		**$320**	
High Tonnage	50	**$172**		**$221**		**$180**	

Moderate Climate Track (Northern US)							
Life Wood Ties		Tangent		Mod Curve		Aggregated Track	
	MGT	Years	MGT	Years	MGT	Years	MGT
Low Tonnage	10	45	455	36	356	43.5	435
Med Tonnage	25	38	947	30	742	36.2	906
High Tonnage	50	33	1649	26	1292	31.5	1577
Cost Wood Ties		Tangent		Mod Curve		Aggregated Track	
$/Mile/MGT	MGT						
Low Tonnage	10	**$679**		**$866**		**$709**	
Med Tonnage	25	**$326**		**$416**		**$341**	
High Tonnage	50	**$187**		**$239**		**$196**	

"Wet" Climate Track (Southeast US)							
Life Wood Ties		Tangent		Mod Curve		Aggregated Track	
	MGT	Years	MGT	Years	MGT	Years	MGT
Low Tonnage	10	34	343	27	269	32.8	328
Med Tonnage	25	29	714	22	560	27.3	684
High Tonnage	50	25	1244	19	975	23.8	1190
Cost Wood Ties		Tangent		Mod Curve		Aggregated Track	
$/Mile/MGT	MGT						
Low Tonnage	10	**$899**		**$1,148**		**$940**	
Med Tonnage	25	**$432**		**$552**		**$452**	
High Tonnage	50	**$248**		**$317**		**$259**	

For Concrete Ties

Life Concrete 1		Tangent		Mod Curve		Aggregated Track	
	MGT	Years	MGT	Years	MGT	Years	MGT
Low Tonnage	10	60	600	53	530	58.6	586
Med Tonnage	25	51	1275	45	1125	49.8	1245
High Tonnage	50	46	2300	41	2050	45	2250
Cost Concrete Ties		Tangent		Mod Curve		Aggregated Track	
$/Mile/MGT	MGT						
Low Tonnage	10	**$1,100**		**$1,245**		**$1,126**	
Med Tonnage	25	**$518**		**$587**		**$530**	
High Tonnage	50	**$287**		**$322**		**$293**	

Life Concrete 2		Tangent		Mod Curve		Aggregated Track	
	MGT	Years	MGT	Years	MGT	Years	MGT
Low Tonnage	10	60	600	53	530	58.6	586
Med Tonnage	25	51	1275	45	1125	49.8	1245
High Tonnage	50	46	2300	41	2050	45	2250
Cost Concrete Ties 2		Tangent		Mod Curve		Aggregated Track	
$/Mile/MGT	MGT						
Low Tonnage	10	**$880**		**$996**		**$901**	
Med Tonnage	25	**$414**		**$469**		**$424**	
High Tonnage	50	**$230**		**$258**		**$235**	

For Plastic (Composite Ties)

Life Plastic		Tangent		Mod Curve		Aggregated Track	
	MGT	Years	MGT	Years	MGT	Years	MGT
Low Tonnage	10	50	500	39	390	47.8	478
Med Tonnage	25	40	1000	33	825	38.6	965
High Tonnage	50	36	1800	28	1400	34.4	1720
Cost Plastic Ties		Tangent		Mod Curve		Aggregated Track	
$/Mile/MGT	MGT						
Low Tonnage	10	**$878**		**$1,125**		**$918**	
Med Tonnage	25	**$439**		**$532**		**$455**	
High Tonnage	50	**$244**		**$313**		**$255**	

For Steel Ties

Life Steel 1		Tangent		Mod Curve		Aggregated Track	
	MGT	Years	MGT	Years	MGT	Years	MGT
Low Tonnage	10	55	550	46	460	53.20	532
Med Tonnage	25	45.5	1137.5	39	975	44.20	1105
High Tonnage	50	41	2050	34.5	1725	39.70	1985
Cost Steel Ties		Tangent		Mod Curve		Aggregated Track	
$/Mile/MGT	MGT						
Low Tonnage	10	**$827**		**$989**		**$855**	
Med Tonnage	25	**$400**		**$467**		**$412**	
High Tonnage	50	**$222**		**$264**		**$229**	

Based on the above unit costs, the following wood/alternate tie unit cost ratios were calculated:

For "Dry" Climate Track (Western US)

Wood/Concrete 1	Tangent		Mod Curve	Aggregated Track
$/Mile/MGT	MGT			
Low Tonnage	10	0.56	0.64	0.57
Med Tonnage	25	0.60	0.64	0.60
High Tonnage	50	0.60	0.68	0.61

Wood/Concrete 2	Tangent		Mod Curve	Aggregated Track
$/Mile/MGT	MGT			
Low Tonnage	10	0.70	0.79	0.72
Med Tonnage	25	0.75	0.80	0.75
High Tonnage	50	0.75	0.86	0.76

Wood/Plastic	Tangent		Mod Curve	Aggregated Track
$/Mile/MGT	MGT			
Low Tonnage	10	0.70	0.70	0.70
Med Tonnage	50	0.70	0.70	0.70
High Tonnage	50	0.70	0.70	0.70

Wood/Steel 1	Tangent		Mod Curve	Aggregated Track
$/Mile/MGT	MGT			
Low Tonnage	10	0.75	0.80	0.76
Med Tonnage	25	0.77	0.80	0.78
High Tonnage	50	0.77	0.84	0.79

For Moderate Climate Track

Wood/Concrete 1	Tangent		Mod Curve	Aggregated Track
$/Mile/MGT	MGT			
Low Tonnage	10	0.62	0.70	0.63
Med Tonnage	25	0.63	0.71	0.64
High Tonnage	50	0.65	0.74	0.67

Wood/Concrete 2	Tangent		Mod Curve	Aggregated Track
$/Mile/MGT	MGT			
Low Tonnage	10	0.77	0.87	0.79
Med Tonnage	50	0.79	0.89	0.80
High Tonnage	50	0.82	0.93	0.83

Wood/Plastic	Tangent		Mod Curve	Aggregated Track
$/Mile/MGT	MGT			
Low Tonnage	10	0.77	0.77	0.77
Med Tonnage	25	0.74	0.78	0.75
High Tonnage	50	0.77	0.76	0.77

Wood/Steel 1	Tangent		Mod Curve	Aggregated Track
$/Mile/MGT	MGT			
Low Tonnage	10	0.82	0.88	0.83
Med Tonnage	25	0.82	0.89	0.83
High Tonnage	50	0.84	0.91	0.86

For "Wet" Climate Track (representative of Southeastern US)

Wood/Concrete 1	Tangent		Mod Curve	Aggregated Track
$/Mile/MGT	MGT			
Low Tonnage	10	0.82	0.92	0.83
Med Tonnage	25	0.83	0.94	0.85
High Tonnage	50	0.86	0.98	0.88

Wood/Concrete 2	Tangent		Mod Curve	Aggregated Track
$/Mile/MGT	MGT			
Low Tonnage	10	1.02	1.15	1.04
Med Tonnage	25	1.04	1.18	1.07
High Tonnage	50	1.08	1.23	1.11

Wood/Plastic	Tangent		Mod Curve	Aggregated Track
$/Mile/MGT	MGT			
Low Tonnage	10	1.02	1.02	1.02
Med Tonnage	25	0.98	1.04	1.00
High Tonnage	50	1.02	1.01	1.02

Wood/Steel 1	Tangent		Mod Curve	Aggregated Track
$/Mile/MGT	MGT			
Low Tonnage	10	1.09	1.16	1.10
Med Tonnage	25	1.08	1.18	1.10
High Tonnage	50	1.12	1.20	1.13

Tie Replacement Life Cycle Costs

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. In this analysis, wood, steel and plastic ties were replaced using conventional tie gangs, based on 25% replacement of ties per cycle. Note, this analysis is not appropriate for concrete ties because of the significant difference in cycles, due to the fact that concrete ties are replaced out of face (100% replacement) and thus are not included here. (see SelecTie analysis in next section).

Value of Money	8%
Time Horizon	100 years
Medium Tonnage	MGT = 25 MGT/yr
Tangent Track	

Using the above-defined cost of money and life cycle parameters, the following life cycle costs were calculated for the six types of ties analyzed.

Moderate Tonnage Tangent Track

Wood life cycle "dry" climate track Based on 812.5 ties per mile per cycle cycle = 0.25 life Cost per cycle $73,125 Tie Life = 40years cycle = 10 years			
Cycle	Years	Factor	Cost
0	0	1.00000	$77,188
1	10	0.46319	$35,753
2	20	0.21455	$16,560
3	30	0.09938	$7,671
4	40	0.04603	$3,553
5	50	0.02132	$1,646
6	60	0.00988	$762
7	70	0.00457	$353
8	80	0.00212	$164
9	90	0.00098	$76
10	100	0.00045	$35
Totals		1.86248	$143,760
Total MGT=		2500	
$/mile/MGT		$58	

Wood life cycle moderate climate track Based on 812.5 ties per mile per cycle cycle=0.25life Cost per cycle $73,125 Tie Life= 38years cycle= 9.47 years			
Cycle	Years	Factor	Cost
0	0	1.00000	$77,188
1	9	0.48253	$37,246
2	19	0.23284	$17,972
3	28	0.11235	$8,672
4	38	0.05421	$4,185
5	47	0.02616	$2,019
6	57	0.01262	$974
7	66	0.00609	$470
8	76	0.00294	$227
9	85	0.00142	$109
10	95	0.00068	$53
	Totals	1.93186	$149,115
	Total MGT=	2367	
	$/mile/MGT	$63	

Wood life cycle "wet" climate track Based on 812.5 ties per mile per cycle cycle = 0.25 life Cost per cycle $73,125 Tie Life = 29 years cycle = 7.14 years			
Cycle	Years	Factor	Cost
0	0	1.00000	$77,188
1	7	0.57702	$44,539
2	14	0.33295	$25,700
3	21	0.19212	$14,829
4	29	0.11086	$8,557
5	36	0.06397	$4,937
6	43	0.03691	$2,849
7	50	0.02130	$1,644
8	57	0.01229	$949
9	64	0.00709	$547
10	71	0.00409	$316
11	79	0.00236	$182
12	86	0.00136	$105
13	93	0.00079	$61
14	100	0.00045	$35
	Totals	2.36355	$182,437
	Total MGT=	2501	
	$/mile/MGT	$73	

Plastic life cycle Based on 812.5 ties per mile per cycle cycle = 0.25life Cost per cycle $105,625 Tie Life = 40 years cycle = 10years			
Cycle	Years	Factor	Cost
0	0	1.00000	$109,688
1	10	0.46319	$50,807
2	20	0.21455	$23,533
3	30	0.09938	$10,900
4	40	0.04603	$5,049
5	50	0.02132	$2,339
6	60	0.00988	$1,083
7	70	0.00457	$502
8	80	0.00212	$232
9	90	0.00098	$108
10	100	0.00045	$50
	Totals	1.86248	$204,290
	Total MGT=	2500	
	$/mile/MGT	$82	

Steel 1 life cycle Based on 812.5 ties per mile per cycle cycle = 0.25 life Cost per cycle $109,688 Tie Life = 45.5 years cycle = 11.375 years			
Cycle	Years	Factor	Cost
0	0	1.00000	$113,750
1	11	0.41668	$47,398
2	23	0.17362	$19,750
3	34	0.07235	$8,229
4	46	0.03015	$3,429
5	57	0.01256	$1,429
6	68	0.00523	$595
7	80	0.00218	$248
8	91	0.00091	$103
9	102	0.00038	$43
	Totals	1.71406	$194,974
	Total MGT=	2559	
	$/mile/MGT	$76	

Based on the above unit costs, the following wood/alternate tie unit cost ratios were calculated:

For Moderate tonnage (25 MGT) tangent track

For "Dry" Climate Track (Western US)

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 US)

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

For Moderate tonnage (25 MGT) curved track

Wood life cycle dry climate track Based on 812.5 ties per mile per cycle cycle = 0.25 life Cost per cycle $73,125 Tie Life = 33 years cycle = 8.25 years			
Cycle	Years	Factor	Cost
0	0	1.00000	$77,188
1	8.25	0.52997	$40,907
2	16.5	0.28087	$21,680
3	24.75	0.14885	$11,490
4	33	0.07889	$6,089
5	41.25	0.04181	$3,227
6	49.5	0.02216	$1,710
7	57.75	0.01174	$906
8	66	0.00622	$480
9	74.25	0.00330	$255
10	82.5	0.00175	$135
11	90.75	0.00093	$72
12	99	0.00049	$38
	Totals	2.12699	$164,177
	Total MGT=	2475	
	$/mile/MGT	$66	

Wood life cycle moderate climate track Based on 812.5 ties per mile per cycle cycle = 0.25 life Cost per cycle $73,125 Tie Life = 30 years cycle = 7.50 years			
Cycle	Years	Factor	Cost
0	0	1.00000	$77,188
1	8	0.56146	$43,338
2	15	0.31524	$24,333
3	23	0.17700	$13,662
4	30	0.09938	$7,671
5	38	0.05580	$4,307
6	45	0.03133	$2,418
7	53	0.01759	$1,358
8	60	0.00988	$762
9	68	0.00554	$428
10	75	0.00311	$240
11	83	0.00175	$135
12	90	0.00098	$76
13	98	0.00055	$43
	Totals	2.27961	$175,957
	Total MGT=	2438	
	$/mile/MGT	$72	

Wood life cycle "wet" climate track Based on 812.5 ties per mile per cycle cycle = 0.25 life Cost per cycle $73,125 Tie Life = 22 years cycle = 5.50 years			
Cycle	Years	factor	Cost
0	0	1.00000	$77,188
1	6	0.65489	$50,549
2	11	0.42888	$33,104
3	17	0.28087	$21,680
4	22	0.18394	$14,198
5	28	0.12046	$9,298
6	33	0.07889	$6,089
7	39	0.05166	$3,988
8	44	0.03383	$2,612
9	50	0.02216	$1,710
10	55	0.01451	$1,120
11	61	0.00950	$734
12	66	0.00622	$480
13	72	0.00408	$315
14	77	0.00267	$206
15	83	0.00175	$135
16	88	0.00114	$88
17	94	0.00075	$58
18	99	0.00049	$38
	Totals	2.89671	$223,590
	Total MGT=	2475	
	$/mile/MGT	$90	

Plastic life cycle Based on 812.5 ties per mile per cycle cycle = 0.25 life Cost per cycle $105,625 Tie Life = 33 years cycle = 8.25 years			
Cycle	Years	factor	Cost
0	0	1.00000	$109,688
1	8.25	0.52997	$58,131
2	16.5	0.28087	$30,808
3	24.75	0.14885	$16,327
4	33	0.07889	$8,653
5	41.25	0.04181	$4,586
6	49.5	0.02216	$2,430
7	57.75	0.01174	$1,288
8	66	0.00622	$683
9	74.25	0.00330	$362
10	82.5	0.00175	$192
11	90.75	0.00093	$102
12	99	0.00049	$54
	Totals	2.12699	$233,304
	Total MGT=	2475	
	$/mile/MGT	$94	

Steel 1 life cycle Based on 812.5 ties per mile per cycle cycle = 0.25 life Cost per cycle $109,688 Tie Life = 39 years cycle = 9.75 years			
Cycle	Years	factor	Cost
0	0	1.00000	$113,750
1	10	0.47219	$53,712
2	20	0.22297	$25,362
3	29	0.10528	$11,976
4	39	0.04971	$5,655
5	49	0.02347	$2,670
6	59	0.01108	$1,261
7	68	0.00523	$595
8	78	0.00247	$281
9	88	0.00117	$133
10	98	0.00055	$63
	Totals	1.89413	$215,458
	Total MGT=	2438	
	$/mile/MGT	$88	

Based on the above unit costs, the following wood/alternate tie unit cost ratios were calculated:

For Moderate tonnage (25 MGT) curved track

For “Dry” Climate Track (Western US)

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 US)

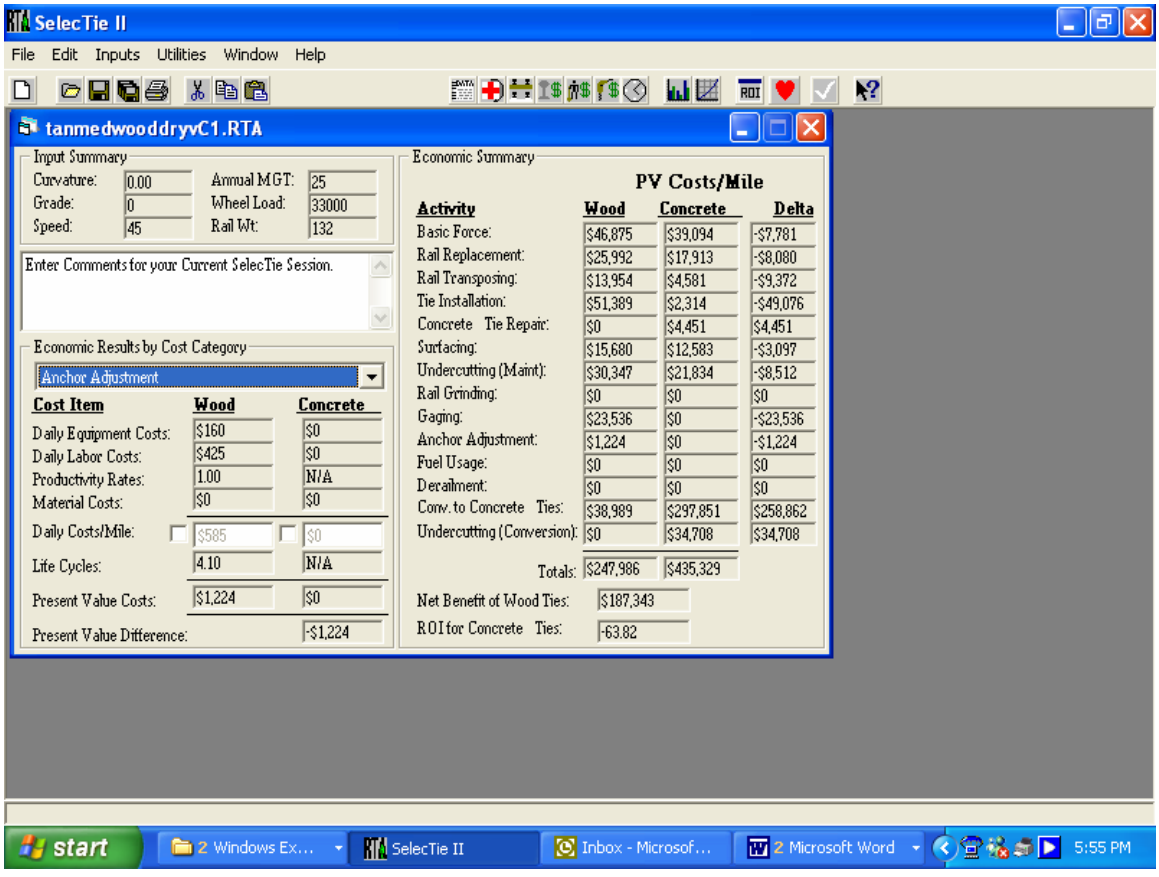
wood-”wet”/Plastic	0.96
wood-”wet”/Steel 1	1.02

Full SelecTie Life Cycle Cost Analysis

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. 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.

Using SelecTie to compare wood vs Concrete tie track over the total life cycle of the analysis results in the costs shown in the Figure 1 below for wood tie track in a dry environment, moderate tonnage and no curvature.

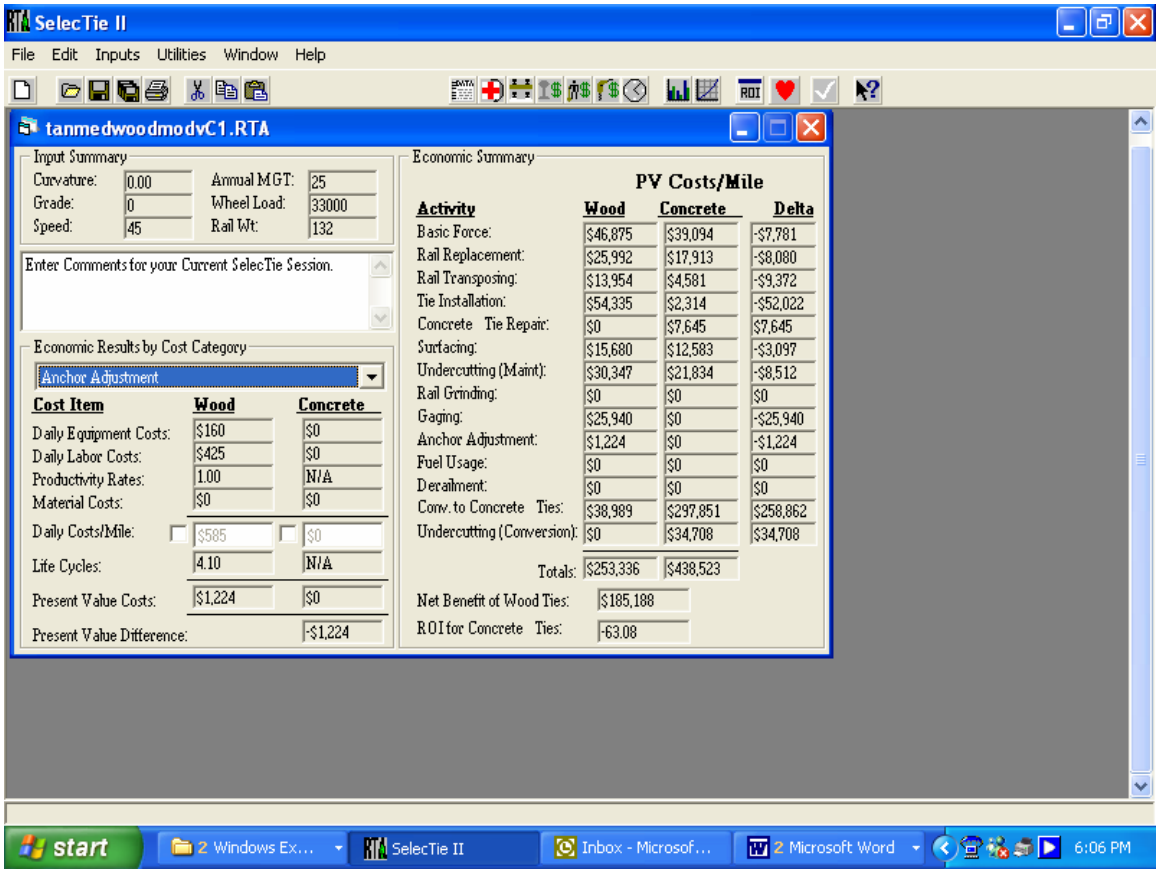
Figure 1: SelecTie Analysis Wood ("dry" climate track) vs. Concrete; Moderate Density; Tangent Track



As can be seen from Figure 1, the Present Value of the Wood Tie track costs is $247,986. The corresponding Present Value of the Concrete Tie track costs is $435,329.The resulting ratio of Wood ("dry" climate track) to concrete is 0.57

Figure 2 presents the comparison of wood vs. concrete tie track for wood tie track in a moderate environment, moderate tonnage and no curvature.

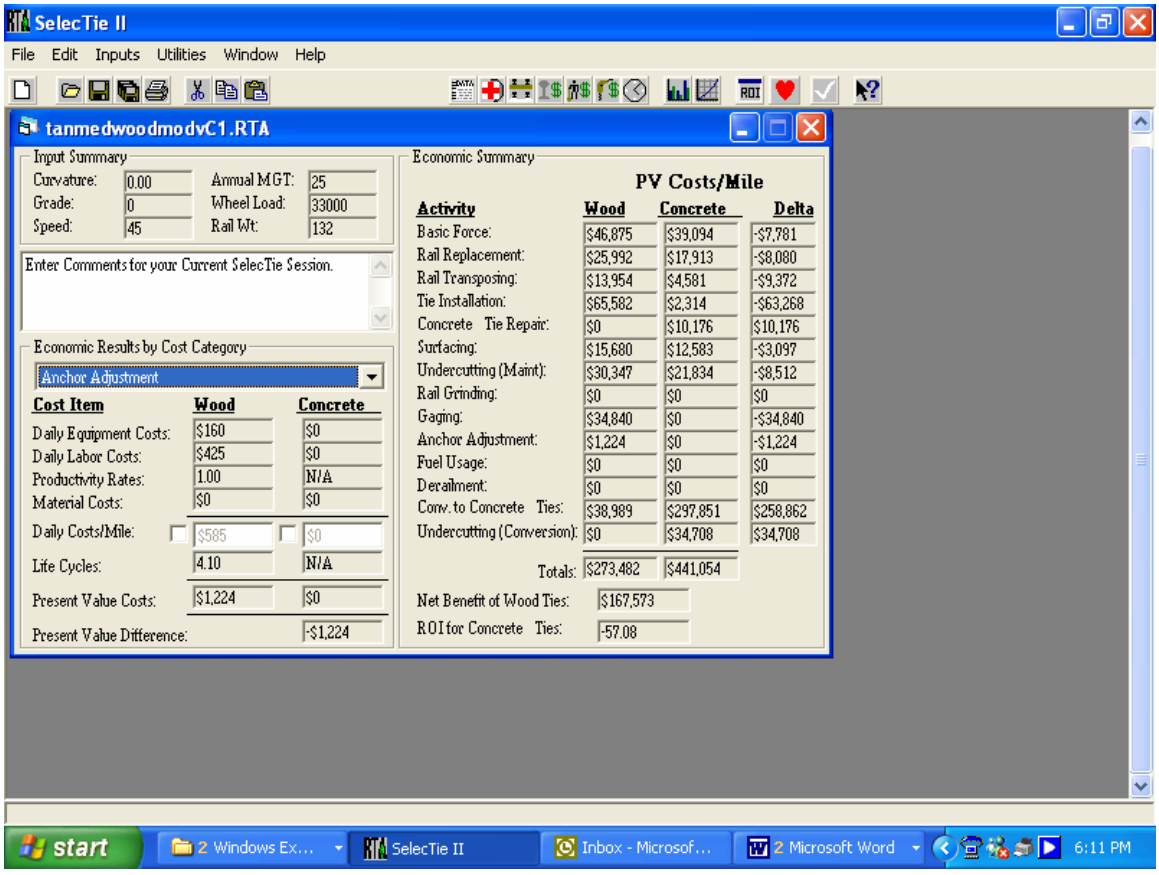
Figure 2: SelecTie Analysis Wood (moderate climate track) vs. Concrete; Moderate Density; Tangent Track



As can be seen from Figure 2, the Present Value of the Wood Tie track costs is $253,336 the corresponding Present Value of the Concrete Tie track costs is $438,523. The resulting ratio of Wood (moderate climate track) to Concrete is 0.58

Figure 3 presents the comparison of wood vs. concrete tie track for wood tie track in a wet environment, moderate tonnage and no curvature.

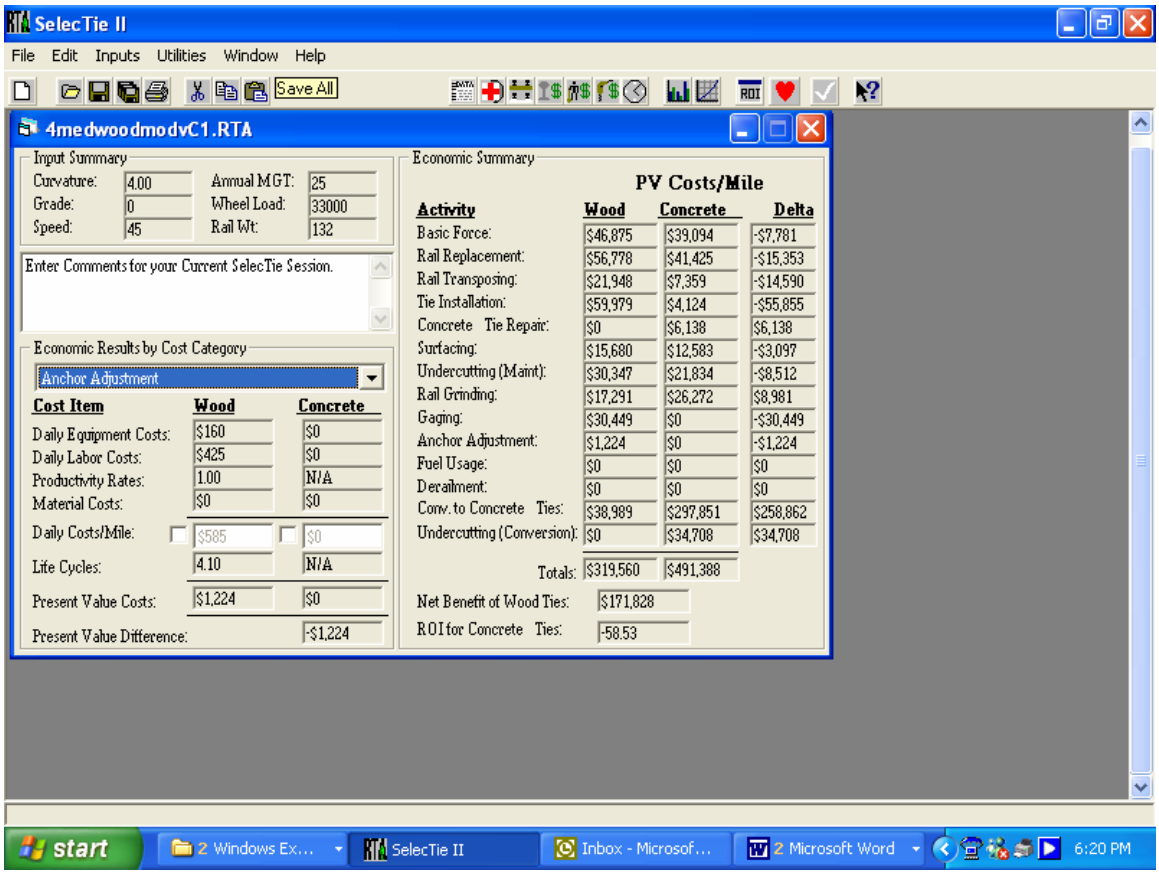
Figure 3: SelecTie Analysis Wood ("wet" climate track) vs. Concrete; Moderate Density; Tangent Track



As can be seen from Figure 3, the Present Value of the Wood Tie track costs is $273,482 the corresponding Present Value of the Concrete Tie track costs is $441,054. The resulting ratio of Wood ("wet" climate track) to Concrete is 0.62

In the case of curved track, Figure 4 presents the comparison of wood vs. concrete tie track for wood tie track in a dry environment, moderate tonnage and moderate curvature.

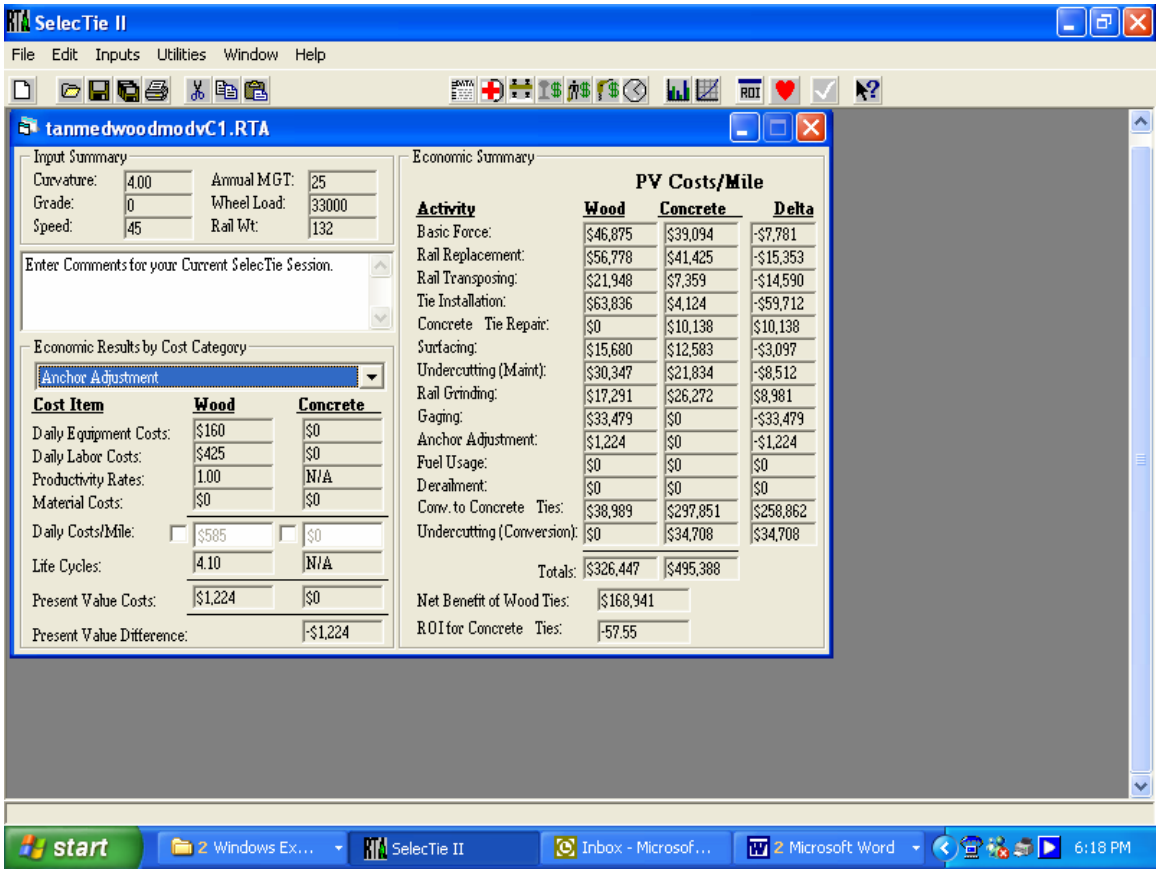
Figure 4: SelecTie Analysis Wood ("dry" climate track) vs. Concrete; Moderate Density; Curved Track



As can be seen from Figure 4, the Present Value of the Wood Tie track costs is $319,560. The corresponding Present Value of the Concrete Tie track costs is $491,388.The resulting ratio of Wood ("dry" climate track) to concrete is 0.65

Figure 5 presents the comparison of wood vs. concrete tie track for wood tie track in a moderate environment, moderate tonnage and moderate curvature.

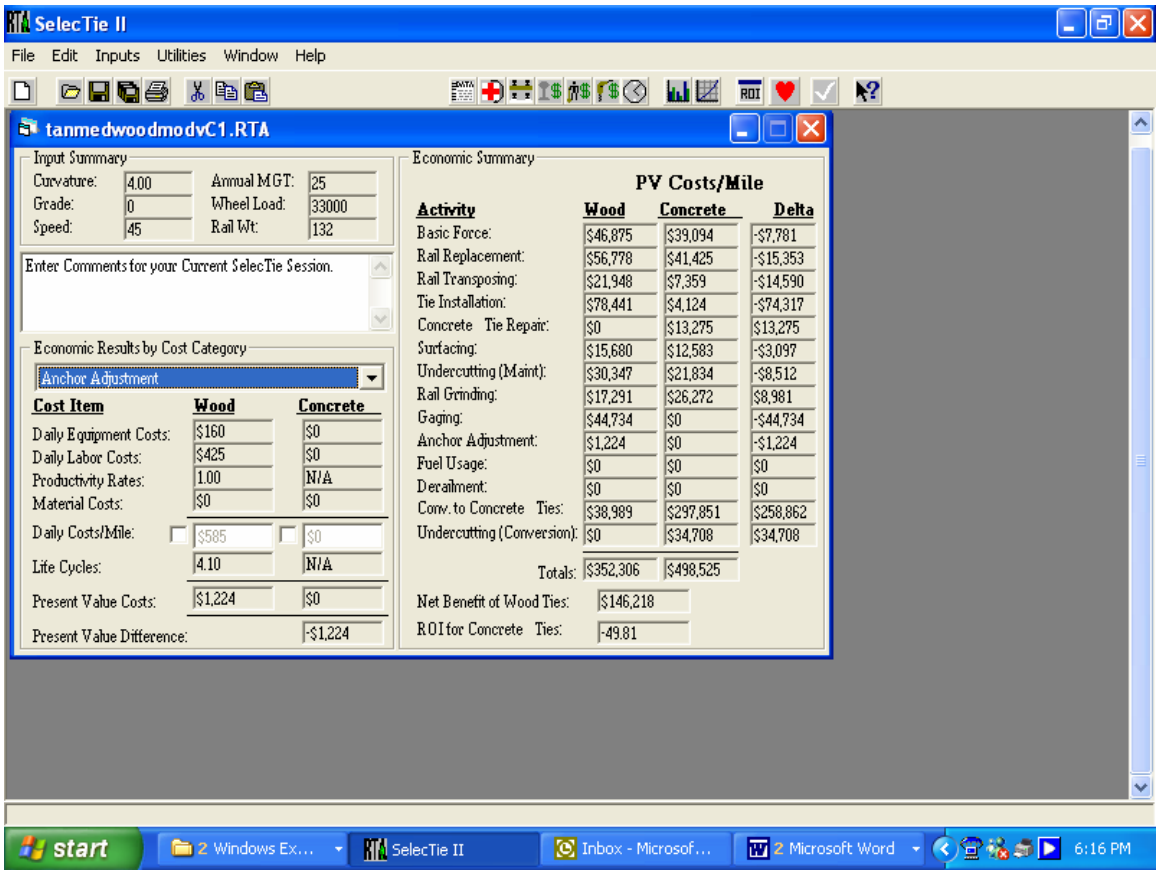
Figure 5: SelecTie Analysis Wood (moderate climate track) vs. Concrete; Moderate Density; Curved Track



As can be seen from Figure 5, the Present Value of the Wood Tie track costs is $326,447 the corresponding Present Value of the Concrete Tie track costs is $495,388. The resulting ratio of Wood (moderate climate track) to Concrete is 0.66

Figure 6 presents the comparison of wood vs. concrete tie track for wood tie track in a "wet" environment, moderate tonnage and moderate curvature..

Figure 6: SelecTie Analysis Wood ("wet" climate track) vs. Concrete; Moderate Density; Curved Track



As can be seen from Figure 6, the Present Value of the Wood Tie track costs is $352,306. The corresponding Present Value of the Concrete Tie track costs is $498,525. The resulting ratio of Wood ("wet" climate track) to Concrete is 0.71.

Based on the above unit costs, the following wood/alternate tie unit cost ratios were calculated:

For Moderate tonnage (25 MGT) tangent and curved track

For "Dry" Climate Track (Western US)

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

For Moderate Climate Track

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

For "Wet" Climate Track (e.g. Southeastern US)

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

Results and Conclusions

Summarizing the results of the analyses presented here gives the following ratios between wood and alternate tie costs on a $/Mile/MGT basis.

For the simplified analysis based on tie installation costs and total tie life (in MGT) (not accounting for the time value of money)

For "Dry" Climate Track (Western US)

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	50	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

For “Wet” Climate Track (representative of Southeastern US)

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/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/Plastic		Tangent	Mod Curve
Low Tonnage	10	1.02	1.02
Med Tonnage	25	0.98	1.04
High Tonnage	50	1.02	1.01

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

Life Cycle Analysis

For Moderate tonnage (25 MGT) tangent track

For “Dry” Climate Track (Western US)

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 US)

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

For Moderate tonnage (25 MGT) curved track

For “Dry” Climate Track (Western US)

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 US)

wood-”wet”/Plastic	0.96
wood-”wet”/Steel 1	1.02

SelecTie Model

For Moderate tonnage (25 MGT) tangent and curved track

For “Dry” Climate Track (Western US)

wood-“dry”/Concrete Tangent track	0.57
wood-“dry”/Concrete Curved track	0.65

For Moderate Climate Track

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

For “Wet” Climate Track (e.g. Southeastern US)

wood-”wet”/Concrete Tangent track	0.62
wood-”wet”/Concrete Curved track	0.71

Thus 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 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% 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 US, 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.