Concrete vs. Wood Ties: Making the Economic Choice

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Track components must satisfy two basic criteria for acceptance. The first criterion is a performance criterion, which addresses whether the component has sufficient "strength" to function and survive in the railway environment. The second criterion in the economic one, whether the cost of the component is economic with respect to other similar components or products.

This second criterion comes into play only if the first is satisfied, i.e., the component or system must have adequate performance, before its relative economics is even considered. Only when that performance criterion is met, the economic criterion comes into play.

One clear application of this approach is that of the cross- ties and fastener systems, specifically that of the concrete cross-tie as compared to the traditional wood cross-tie that has been used by railroads for over two hundred years. While concrete tie designs have been around for many years, it has only been in the last two decades that their performance has been deemed to be adequate to withstand the severe loading environment of North American freight operations.

Once this performance criterion has been satisfied, i.e., once it has been established that the concrete cross-ties can function and survive in the heavy haul environment, then the economics of this alternate tie system enters into the consideration of railway engineers. Specifically, the relative economics or the concrete tie system must be compared with the existing conventional systems, wood ties with cut spikes. In addition, the relative economic of these systems would have to be compared with several other technically proven systems, such as wood ties with alternate (elastic) fastening systems.

This economic comparison, however, is not a simple matter. Because different tie/fastener systems exhibit different lives, require different maintenance activities, and affect other maintenance activities differently, simple comparison of the initial or "first" cost is not adequate. Rather, a comprehensive comparison of the costs and benefits of the alternate systems over their entire service lives is required, i.e., a "life cycle" cost analysis.

This is further complicated by the fact that component lives and behavior vary significantly as a function of track and traffic characteristics, as well as individual railroad practices.

Thus, the relative economics of these alternate cross-tie systems is not fixed, but vary with many of the operating and maintenance parameters.

One approach that has been effectively used to address these significant differences is the development of life cycle costing computer models that can be run on personal computers. This approach led to several such models, such as the SelecTie model developed by ZETA-TECH Associates, Inc. for the Railway Tie Association. Such a model is capable of incorporating a comprehensive analytical methodology and allow for the ready (and rapid) changing of key parameters and the "instantaneous" recalculation of the results. This approach has been found to be an effective means of carrying out economic benefit comparisons, particularly ~such life cycle benefit analyses.

The basic analytical approach used in this methodology (and in the model itself) is a present worth analysis approach, in which all the costs associated with the two alternative systems are examined and compared in terms of a "present worth". Thus, any future costs or savings associated with the two systems are brought to the present, and the "worth" of these future costs calculated using an appropriate interest rate. (Thus, taking into account the time value of money.)

Thus, for each of the alternative tie/fastener systems the following are compared:

1. Initial Costs.

These are costs that are incurred at year 0, i.e., the present time. These costs include such items as the initial component costs for the replacement components (the new system being installed), the cost of their installation, the cost of any accompanying work (such as the addition of ballast), and any salvage value due to components removed from the track.

2. Life Cycle Costs.

These are costs that are incurred in the future, rather than at the present. These include such costs as different maintenance costs, different operating costs (i.e., fuel), derailment risk, etc. As noted previously, these future costs must be converted into their "present" cost to allow for final summation and comparison.

By combining the different costs, in terms of today's dollar (i.e., their present value), the existence, if any, of a net benefit for either tie/fastener system is determined.

In examining these life cycle component and maintenance costs, it appears that component lives and maintenance cycles are dependent on specific track, traffic, and operating characteristics which are specific to a given location and/or railroad.

Therefore, any such analysis must be sensitive to those characteristics that influence lives and corresponding costs. These characteristics include:

A. Track Characteristics

Track characteristics, such as presented in Table 1, have a strong influence on the lives of the key track components such as the rail, the ties themselves, and the ballast. In addition, maintenance cycles such as surfacing and grinding are determined by these characteristics. Since these differences in component lives directly affect the relative maintenance costs of the two tie/fastener systems, any effective analysis must include sensitivity to these track characteristics.

B. Traffic Characteristics

In a similar manner, traffic characteristics, such as presented in Table 2, directly influence the component lives, maintenance cycles, and corresponding costs.

C. Economic Characteristics

Economic characteristics include such factors as the acceptable rate of interest, rate of inflation, and the railroads required rate of return for new investments, which directly influence the time value of money. This, in turn, directly relates to the present worth of the future maintenance and component replacement costs.

D. Maintenance Activities

A key area of cost differential is that associated with life cycle maintenance costs. These costs are associated with a large group of maintenance activities, such as presented in Table 3. As can be seen in that table, these maintenance activities include activities specific to either wood or concrete ties or to both. In all cases, these are differences in maintenance procedures, maintenance cycles and maintenance costs between the two systems being examined. The proper structuring of these maintenance costs and their inclusion into the comparison between the two systems represents a key part of this model and will be discussed in detail later on in this paper.

E. Costs

The final major area of variability required for definition of the characteristics of the different tie/fastener systems is that of costs themselves. These include material costs, labor costs, equipment costs, and operating costs, both directly as in the case of fastener components or indirectly such as with operating costs.

Each of these sets of characteristics must be properly accounted for in any effective economic analysis.

One such overall analysis approach (used by the SelecTie model) examines the economics of replacing an existing wood tie track system (with either cut spikes or elastic fasteners) with concrete ties and elastic fasteners. This approach first examines the cost of conversion to concrete, including all material, labor, and equipment costs together with appropriate rates of production. Any salvageable materials, to include wood ties in various conditions, and conventional OTM (plates, anchors, spikes, etc.) must be properly credited against the cost of conversion. Any disposal costs, such as for old ties that are not reusable, must be added to the cost of the conversion.

Once the conversion costs are established, the individual maintenance costs must be developed for each of the tie/fastener systems. For each of these maintenance activities, which are listed in Table 3, it is necessary to calculate the life cycle costs associated with each tie/fastener system. These maintenance costs, such as rail relay, etc., are ongoing, and occur at a calculated cycle. These cycles are directly dependent on the life of the component under the specified traffic and track conditions. Thus, rail relay takes place at the end of the life of the rail.

Two parallel maintenance activity streams can thus be calculated for the two tie/fastener systems, using different gang composition and equipment, different materials, and exhibiting different maintenance cycles. By bringing these future maintenance costs to a present worth, they can be compared directly, and a cost difference (benefit) calculated.

Since this type of economic analysis is sensitive to a large number of variables, the relative benefits of wood vs. concrete cross-ties are dependent on the specific assumptions and values for each case. As a result, it is not possible to present the entire range of possible results in this paper. In fact, it can be clearly stated that neither wood nor concrete is always the best, i.e., the most economical system. Rather, each has conditions and situations where it will be economically attractive.

However, in order to provide an indication of possible results and key sensitivities, a series of illustrative examples will be presented here. It must be carefully noted that these examples are based on a specifically defined "base case" analysis, which includes defined costs, component lives, and maintenance practices. As variables are changed in this base case, the results of the analysis and of the sensitivity studies will also change.

Figure 1 presents the relationship between the Return on Investment (ROI) for concrete tie track as a function of the track curvature' (all other variables being held constant to the base case values). As used here, ROI represents the attractive- ness of using concrete ties, with a large positive ROI representing a condition where the use of concrete ties is economically justified and a negative ROI representing conditions where the use of concrete ties is not economically justified, i.e., wood would represent the more economically attractive choice.

As can be seen in this figure, there is a negative ROI for concrete tie track for curvatures up until 5 1/2 degrees. Beyond that value, the ROI for concrete becomes positive. This indicates that for this base case, wood tie track is more economic until approximately 5 1/2 degrees after which concrete tie track be- comes economically viable.

Figure 2 presents the effect of varying annual tonnage (in MGT) for the base case analysis. As can be seen in this figure, the ROI for concrete tie track becomes positive (indicating a benefit in changing to concrete) at an annual tonnage level of approximately 32 MGT. For track with less than 32 MGT of traffic, the concrete tie track ROI is negative for this base case.

The effect of varying wood tie life for the base case is presented in Figure 3. In this example, the ROI for concrete tie track becomes positive when wood tie life is less than 24 years. If the wood tie life is greater than 24 years, the Concrete ROI is negative.

Figures 4 and 5 present the effects of varying the tie costs, for concrete and wood ties respectively. As can be seen in these figures, the ROI for concrete tie track becomes positive as the concrete tie price decreases or when the wood tie price increases. Thus, for concrete tie price levels below $42 per tie, the base case shows a positive ROI for concrete. Alternately if the wood tie price increases above $ 35 per tie, the ROI becomes positive for the conversion to concrete tie track.

Once again, it must be noted, that as individual variables are changed, to include track, traffic, maintenance, or cost characteristics, the specific "break even" points for the two sets of analysis will change.

Thus, it can be seen through these examples that the economic analysis of alternate cross-tie systems is a complex one, with sensitivity to a large number of key parameters. Thus, it is not possible to simply state when concrete is economically viable or when wood is the economically attractive alternative. These decisions must be made on a case by case basis. Detailed analysis, however, shows that there are locations and conditions under which each, wood and concrete, is economically viable. That is, there are locations in track, where wood is the economically attractive alternative and there are locations in track where concrete is an economically attractive alternative. However, specific analysis must be carried out to define the respective boundaries.

In order to effectively perform such a detailed analysis, economic analysis models can be used. These models have the ability to perform sensitivity analyses to key operating, maintenance, and cost parameters. By examining the impact of changing these key variables, the long term ramifications of these decisions can be examined. This also allows for the establishment of economic "boundaries" to define those locations where either track alternative is more economically attractive.

Finally, by allowing for variation in track maintenance practices, to include gang size, make-up, and productivity, it is possible to examine the effects of different maintenance practices. This can be performed not only within the context of the wood vs. concrete tie studies, but individually for specific individual cases. This allows for the ultimate broadening of this type of economic analysis model to investigate the sensitivity of track costs to a wide range of variables both within and outside the control of railroad engineering departments. As such, this type of life cycle cost analysis offers the potential for being an extremely powerful economic analysis tool for railroad officers.

TRACK CHARACTERISTICS

- CURVATURE
- GRADE
- RAIL SECTION
- WHEEL LOAD
- LUBRICATION
- BALLAST DEPTH
- TIE SPACING
- OTHER

TABLE 1

TRAFFIC CHARACTERISTICS

- SPEED
- ANNUAL TONNAGE
- AXLE LOAD

TABLE 2

MAINTENANCE ACTIVITIES

- RAIL REPLACEMENT
- RAIL TRANSPOSITION
- GAGING
- TIE REPLACEMENT
- ANCHOR ADJUSTMENT
- SURFACING
- GRINDING
- FUEL CONSUMPTION
- BASIC FORCES

TABLE 3

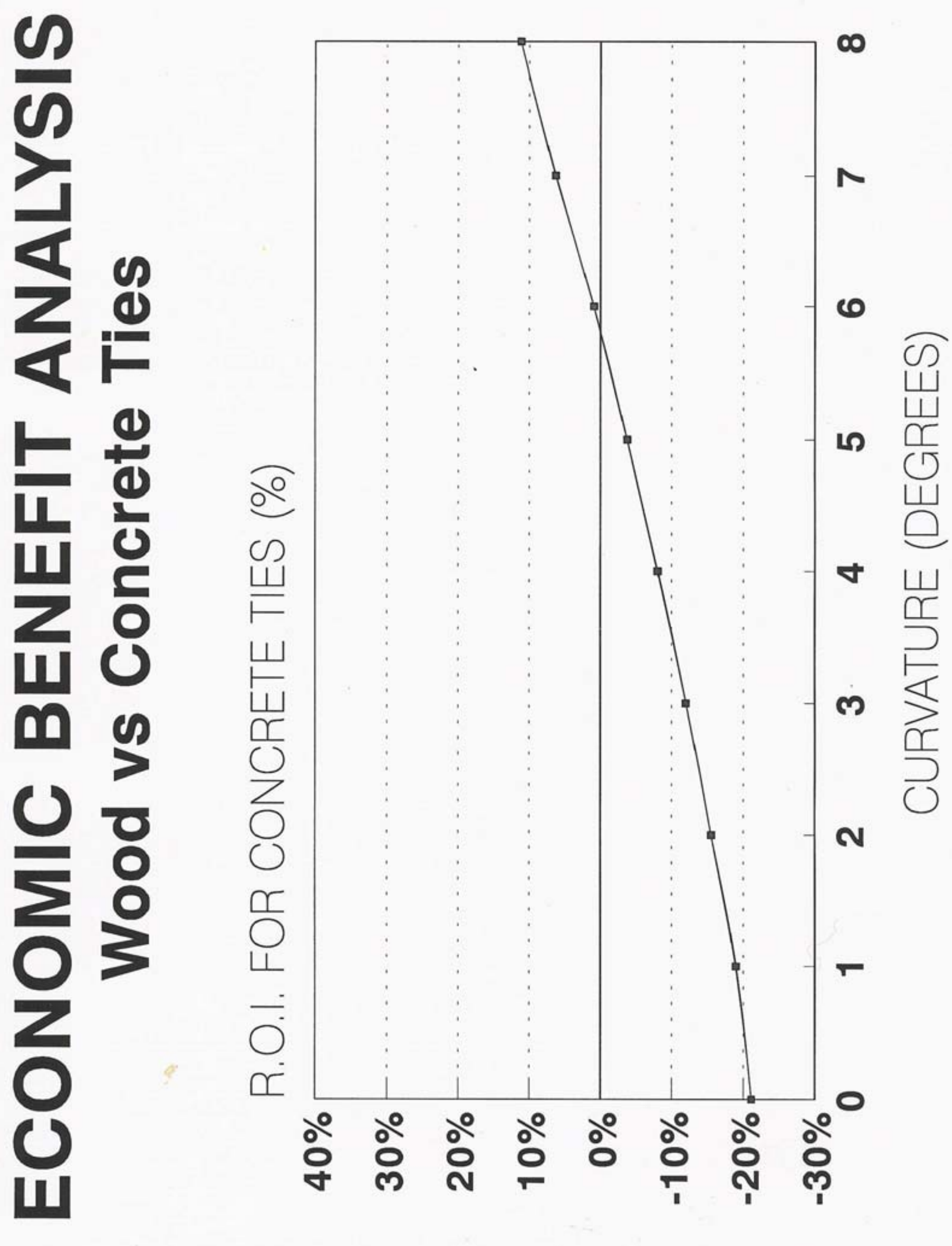
ECONOMIC BENEFIT ANALYSIS
Wood vs Concrete Ties
R.O.I. FOR CONCRETE TIES (%)
40%
30%
20%
10%
0%
-10%
-20%
-30%
0
1
2
3
4
5
6
7
8
CURVATURE (DEGREES)

FIGURE 1

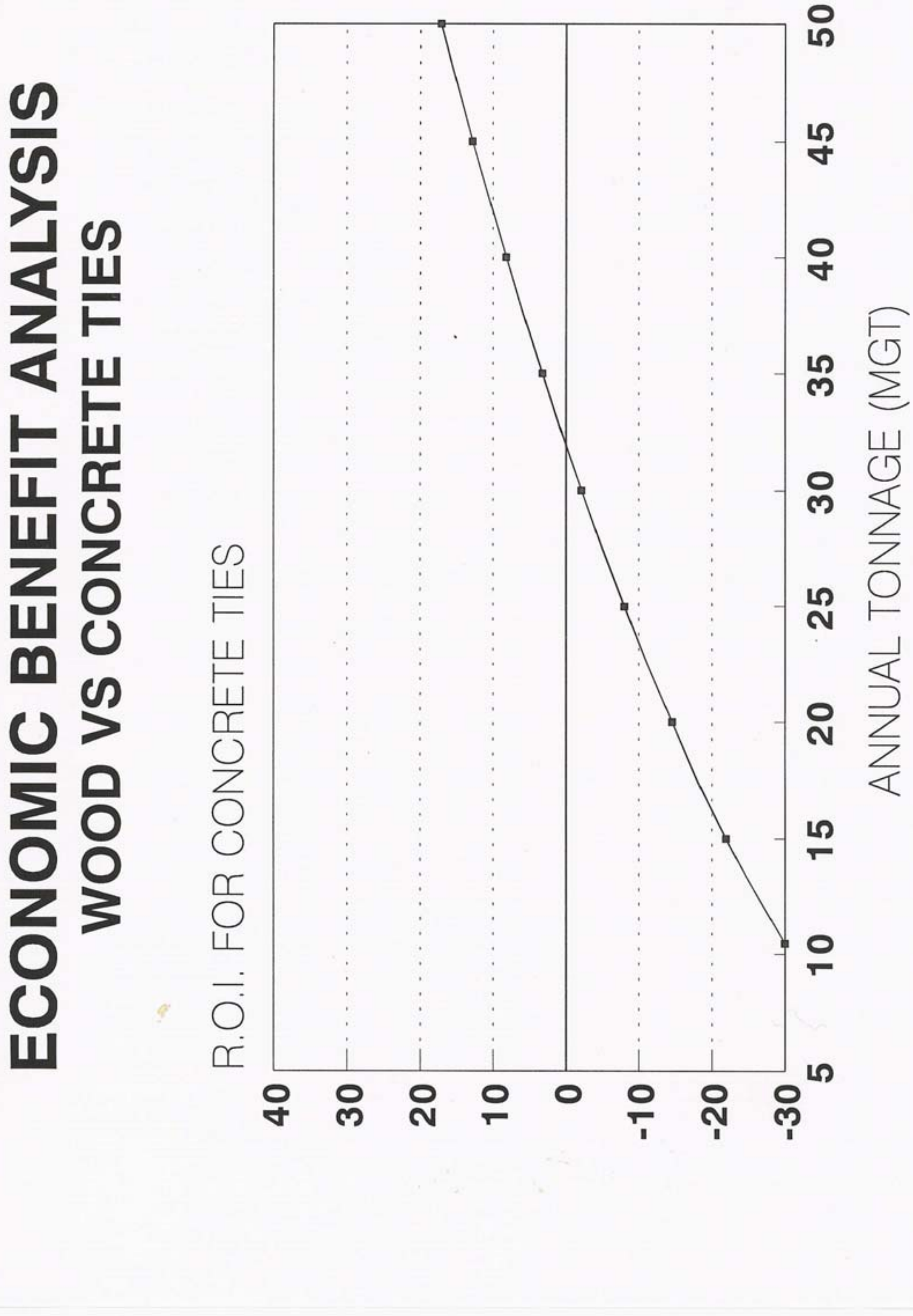
ECONOMIC BENEFIT ANALYSIS
WOOD VS CONCRETE TIES
R.O.I. FOR CONCRETE TIES
40
30
20
10
0
-10
-20
-30
5
10
15
20
25
30
35
40
45
50
ANNUAL TONNAGE (MGT)

FIGURE 2

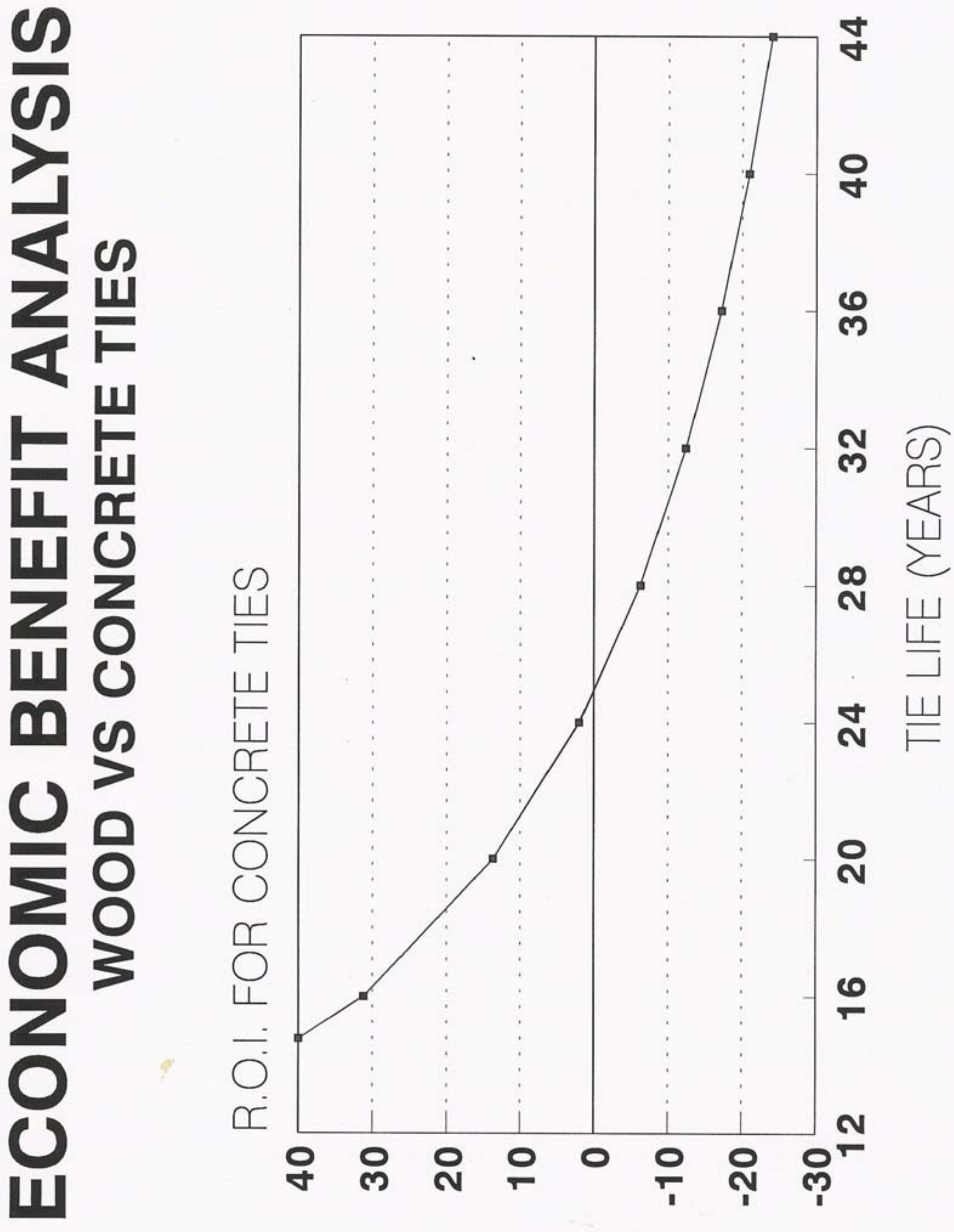
ECONOMIC BENEFIT ANALYSIS
WOOD VS CONCRETE TIES
R.O.I. FOR CONCRETE TIES
40
30
20
10
0
-10
-20
-30
12
16
20
24
28
32
36
40
44
TIE LIFE (YEARS)

FIGURE 3

ECONOMIC BENEFIT ANALYSIS
WOOD VS CONCRETE TIES

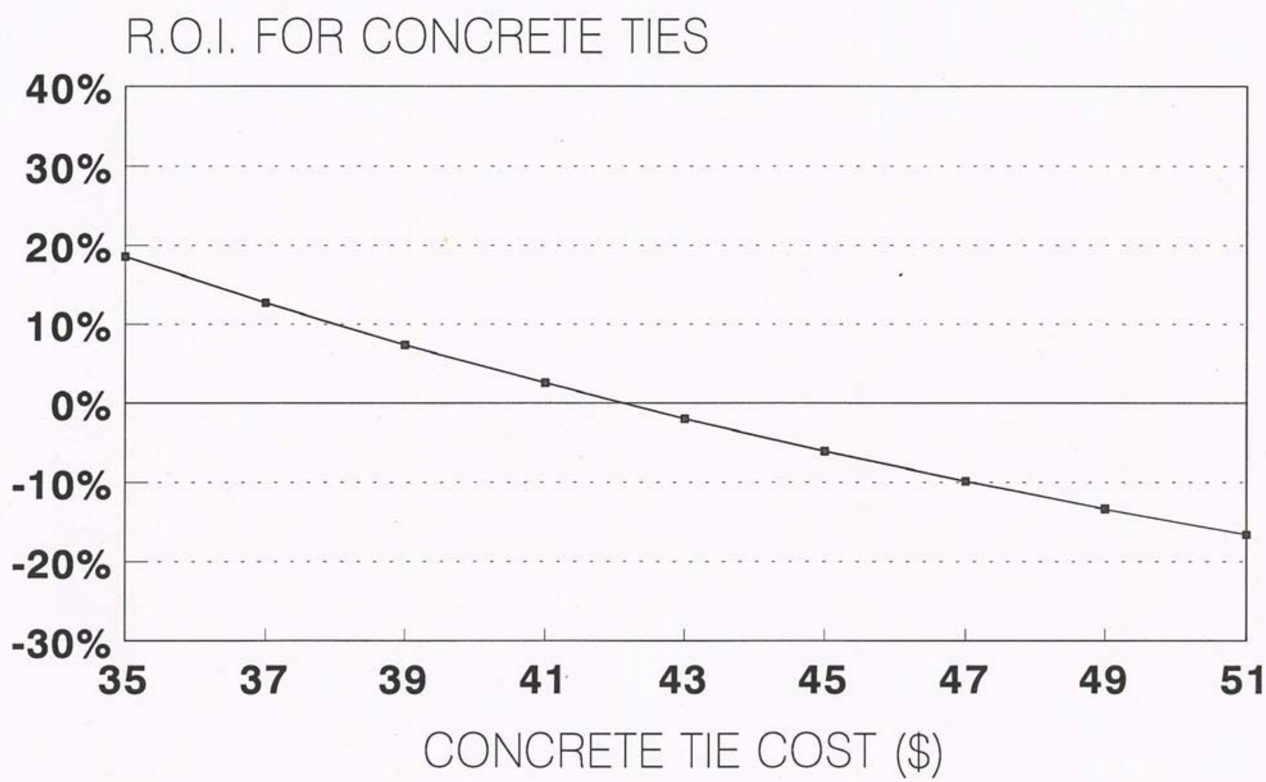

FIGURE 4

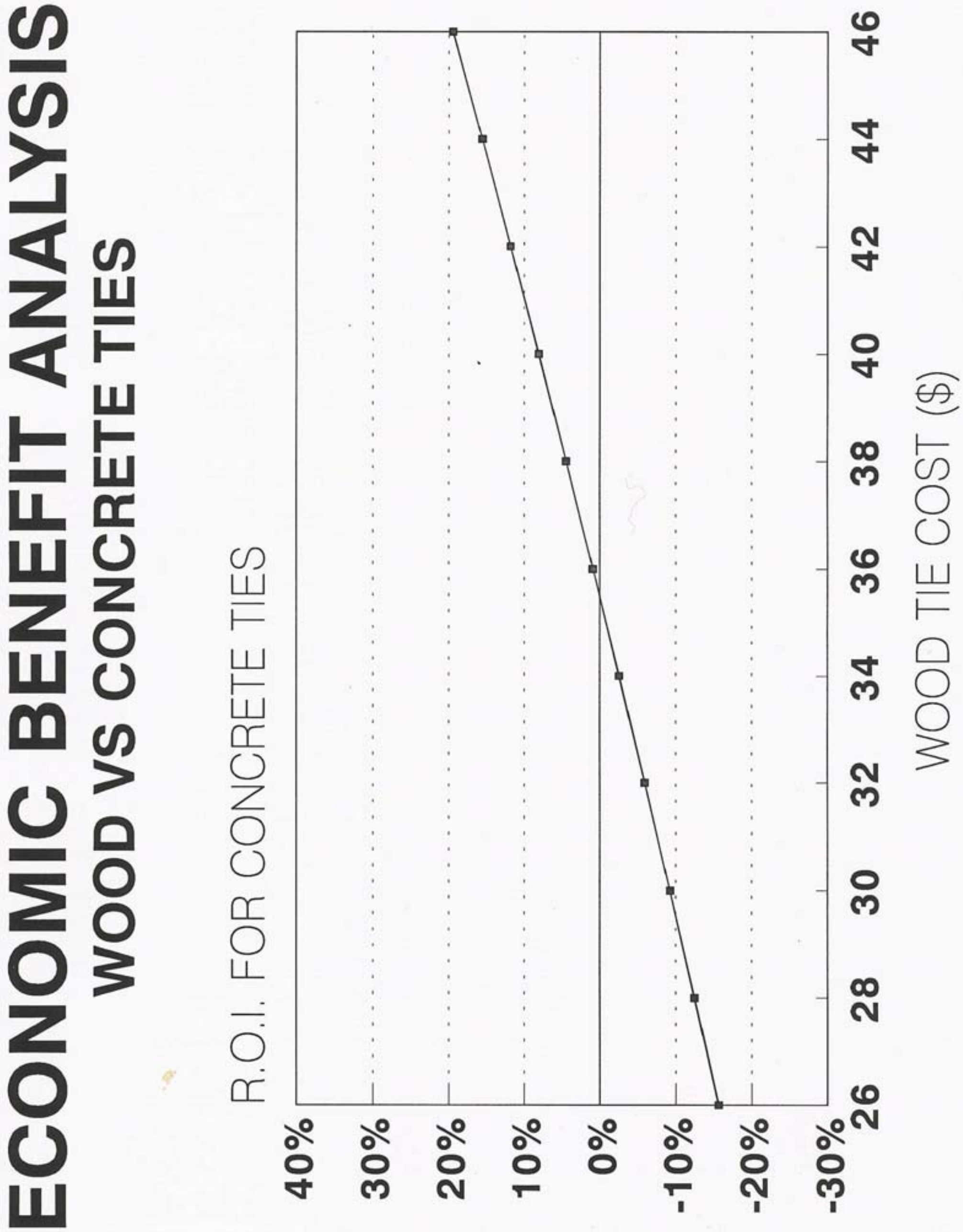
ECONOMIC BENEFIT ANALYSIS
WOOD VS CONCRETE TIES
R.O.I. FOR CONCRETE TIES
40%
30%
20%
10%
0%
-10%
-20%
-30%
26
28
30
32
34
36
38
40
42
44
46
WOOD TIE COST ($)

FIGURE 5