Ed Burkhart, Wisconsin Central president, answers questions during the World Congress on Railway Research.

Federal Railroad Administration and Amtrak, RTA is sponsoring research on high speed passenger rail vehicles with a significant wood tie installation in the Railroad Test Track (RTT) in Pueblo.

Additionally, in 1998, RTA will participate in the initial economic analysis to determine how to best upgrade in-revenue service track structure to accommodate higher speed passenger traffic. This initial phase of an anticipated demonstration project will lead to what industry officials expect to become an economic and practical template that local governments and railroads can use to upgrade existing wood track for improved passenger service.

RTA's education efforts complement these R&D activities by removing perception barriers. Since wood tie performance can be demonstrated, the communication of sound practice and science is critical to U.S. and global railway engineers considering high speed passenger corridor construction and maintenance.

Gauntt and Zarembski also viewed wood tie track in use currently in Italian railroads and traveled on Eurostar, Italy's high speed passenger train. "The trip was an exceptional opportunity for SelecTie™ and RTA members to be showcased to a global audience," Gauntt said. "The fact that we were able to dispel some commonly held misconceptions about our industry and wood tie performance is a bonus."

Crossties magazine and numerous copies of the RTA membership directory were supplied to fill the high number of requests for more information. "The educational effort was more effective than I expected," Zarembski said. "And that can only mean better understanding of RTA and its membership in all markets." ◆

As presented at the World Congress on Railway Research in Florence, Italy...

Evaluation Of Life Cycle Costs Of Alternate Tie (Sleeper)/Fastener Systems And Their Use In Defining Maintenance Policy And Practice

By Dr. Allan M. Zarembski & James Gauntt

Summary

The selection of the optimum track system configuration is very much dependent on the performance requirements and economic characteristics of the rail operation that is being configured. One of the key decisions in selecting an appropriate track system is the selection of the proper crosstie (sleeper)/fastener system. The range of available systems include a wide selection of crosstie (sleeper) and fastener types and materials and their associated purchase price, installation cost and maintenance activities. As a result, the selection of the economically "optimum" system will vary greatly based on purchase prices, material and labor costs, and requirements of the rail operation itself.

In order to help in this decision making process, economic analyses models have been developed and implemented. These models are life cycle costing models that take into account not only initial costs but

Calendar of Events

March 3, 1998
RTA Engineering Seminar
Atlanta Airport Marriott
Atlanta, GA
Contact: Debbie Holden,
(770) 460-5553

April 26-28, 1998
ASLRA Southwest/West Meeting
Sheraton Fiesta South Padre
South Padre Island, TX
Contact: Kathy Cassidy,
(202) 628-4500

April 28-May 2, 1998
HSGTA's 15th Annual Conference on High Speed Ground Transportation
Chicago, Ill.
(202) 789-8107

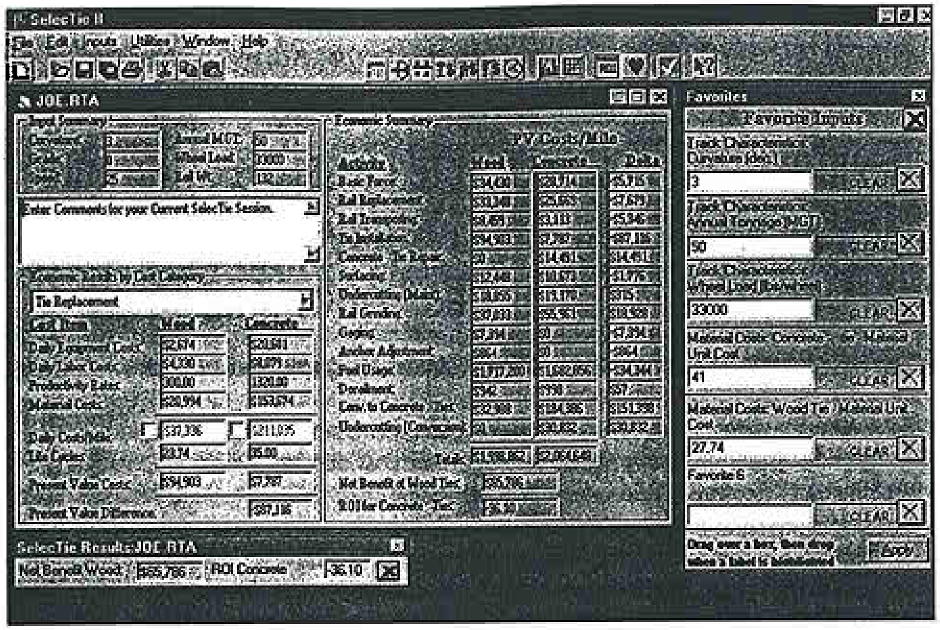
May 3-5, 1998
ASLRA Southern Region Meeting
Kingston Plantation
Myrtle Beach, S.C.
Contact: Kathy Cassidy,
(202) 628-4500

May 17-19, 1998
ASLRA Eastern Region Meeting
Radisson Lackawanna Station
Hampton Inn at Montage Mountain
Scranton, PA
Contact: Kathy Cassidy,
(202) 628-4500

May 17-20, 1998
AWPA 94th Annual Meeting
Marriott's Camelback Hotel
Scottsdale, AZ
Contact: John Nall,
(817) 326-6300

August 9-12, 1998
Annual RTA Crosstie Grading Seminar
Seaman Timber Company
Montevallo, AL
Contact: Debbie Holden,
(770) 460-5553

October 7-10, 1998
Railway Tie Association Annual Convention
Callaway Gardens
Pine Mountain, GA
Contact: Debbie Holden,
(770) 460-5553



Enter Comments for your Current SelecTie Session.

Track Characteristics: Curvature (deg): 3

Track Characteristics: Annual Tonnage (MGT): 50

Track Characteristics: Wheel Load (lbs): 33000

Material Costs: Concrete Tie Material Unit Cost: 41

Material Costs: Wood Tie Material Unit Cost: 27.74

SelecTie Results:JOE.RTA

Net Benefit Wood: $65,786 ROI Concrete: -36.10

Figure 1: SelecTie II life cycle model for comparison of alternate crosstie systems.

also maintenance activities which occur over the life of the track system. By accurately accounting for these costs, and their associated timing, it is possible to evaluate alternate design configurations and cost structures in order to help select the system that is "best" for a given operation and geographic location. One such model, the Railway Tie Association's SelecTie™ Model, has been used by various railways in making decisions as to where to use different tie/fastener configurations and systems. The SelecTie Model has been widely used in North America by railroads representing over 200,000 miles (300,000 kilometers) of track under a broad range of operating conditions including heavy axle load freight and lighter axle load passenger operations. Its focus is to assist in the decision as to the most cost effective (on a life cycle basis) crosstie material. The model, with its easy-to-use format and structure, has been the basis for decisions as to what ties to use (wood vs. concrete) and the definition of the usage "boundaries" (in terms of curvature and tonnage categories).

Introduction

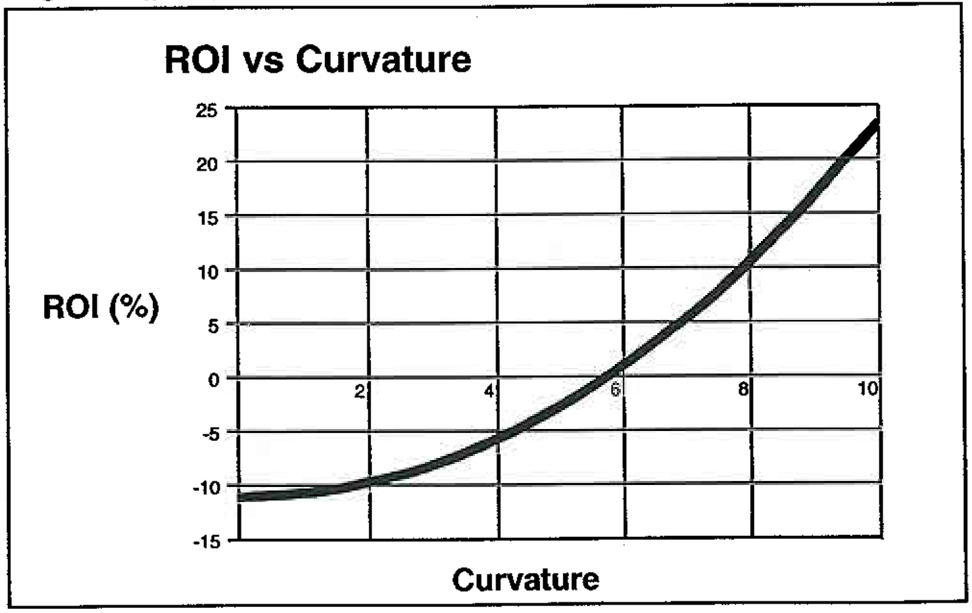
As railroads continue to experience financial constraints and associated budgetary restrictions, the selection of track components that provide the lowest overall cost throughout their life cycles becomes of increased importance. The selection of the optimum track system configuration is very much dependent on the performance requirements and economic characteristics of the railway operation that is being configured, as well as its operating and maintenance practices.

One of the key decisions in selecting an appropriate track system is the selection of the proper crosstie (sleeper)/fastener system. The range of available systems include a wide selection of crosstie (sleeper) materials [e.g. timber, concrete, steel, plastic] and a similar wide range of fastener types [cut spikes, elastic fasteners, threaded fasteners, etc.]. Concurrent with this wide range of materials and configurations is a corresponding range in purchase price, installation cost, and maintenance activities (and corresponding costs). As a result, the selection of the economically "optimum" such system will vary greatly based on purchase prices, material and labor costs, and requirements of the rail operation itself (to include such factors as traffic density, speed, axle load, type of traffic, etc.).

However, even before an economic decision can be made, it is first necessary to ensure that the performance of the different components under consideration is adequate to meet the needs of the intended service. This is the first step in the selection of a suitable track configuration, in general, and a suitable tie (sleeper)/fastener configuration in particular (Zarembski, 1988). Thus, it is necessary to identify suitable component candidates that have sufficient "strength" to function and survive in the railway environment being considered. This is generally accomplished through the use of performance specifications, which define the range of performance deemed acceptable by the railway for each class of operating conditions. Such performance standards have been developed for both timber and concrete sleepers (American Railway Engineering Association, 1996) and their respective fastening systems (Zarembski, 1984, 1987) and have been used by both industry associations and individual railways in determining the adequacy of the tie system. These specifications, when used in combination with laboratory tests and field trials, provide the level of confidence needed by the railway in order to consider the component(s) to be safe and adequate for installation in track.

It is only when the tie/fastener component or system has been shown to provide adequate performance that its relative economics can be considered. At that point, the question becomes whether the cost of an alternate component is economically viable with the

Figure 2: Effect of curvature of the relative economics.



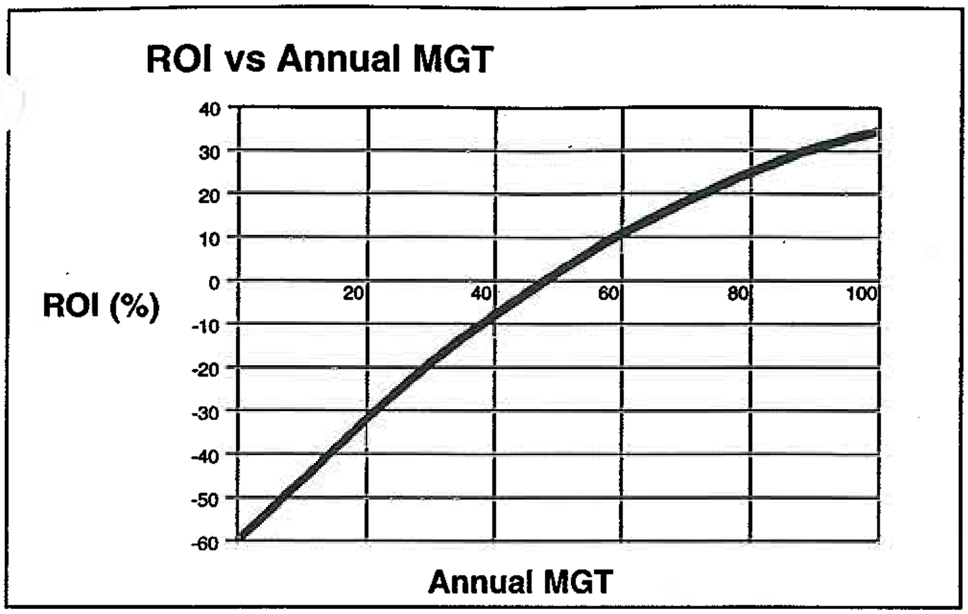


***Figure 3:** Effect of MGT on the relative economics.*

more traditionally used component. The history of the concrete crosstie in North America is a good example of this two-step process. While concrete tie designs had been introduced as early as 1893 (Hay, 1982), 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. With the introduction of an American Railway Engineering Association specification and the successful installation of several large scale test sites in severe loading environments, the issue of "adequate" performance of concrete ties was finally met in the 1980s.

At that point, the economics of the alternate tie and fastener systems entered into the consideration of railway engineers. With adequate performance, the relative economics of these alternate systems must be compared with the existing conventional systems, wood ties with cut spikes. In addition, the relative economics of these systems would have to be compared with several other technically proven systems, such as wood ties with alternate (elastic) fastening systems.

Such an 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. This entails a "life cycle" cost analysis of the alternate systems.

Life Cycle Models

The performance of life cycle analyses is complex, in that a large number of factors must be properly accounted for. These factors are often strongly interdependent; thus, changing one affects many of the others. Thus, the relative economics of a major track component such as the crosstie are not constant for all conditions, but vary as relative costs and operating conditions vary.

In order to keep track of and properly account for these interdependent factors, economic analyses models have been developed and implemented. These models are life cycle costing models that take into account not only initial costs but maintenance activities (and costs) which occur over the life of the track system. By accurately accounting for these costs, and their associated timing, it is possible to evaluate alternate design configurations and cost structures in order to help select the system that is "best" for a given operation and location.

Such a life cycle cost model combines the life and cost (both capital and maintenance) of the product, the crosstie or sleeper, into a quantitative economic measure of overall product "performance." Thus, these models represent a tool for use by railroad personnel in making optimum economic decisions concerning material selection that are specific to both the actual operating conditions and the maintenance practices of a given line, route, or territory.

SelecTie™

One of the most successful of these life-cycle economic models is the SelecTie™ model developed for and distributed by the Railway Tie Association, the association of crosstie producers in North America.

SelecTie™ was first introduced in 1989 as a spreadsheet model for comparing the relative (life cycle) costs of concrete and wood crossties with varying fastener types (Zarembski, 1989). SelecTie™ was obtained by virtually all of the major U.S. and Canadian railroads for their own internal use in evaluating these comparative economics. As the first user-friendly, personal computer based crosstie model, it quickly became the standard for life cycle modeling of alternate crosstie configurations. With over 2,500 line items of user changeable data, immediate access to the results of analyses, and research-based life cycle equations, the user was quickly and easily provided with a look at the crosstie's costs over its active service fe. Economic comparison of alternate materials and maintenance practices could thus be performed, with immediate results. By providing the user with the present value costs for each component option, wood vs. concrete, together with the corresponding return on investment, the user had the ability to determine which alternative was the best economical choice.

SelecTie™ II (See Figure 1) was recently introduced as an upgrade to SelecTie™ and represents a new generation of a comprehensive engineering economics model designed for use on a personal computer running Microsoft Windows 3.1 or higher. This model combines the easy to use Windows operating environment and a sophisticated analytical approach that provides railroad users with a user-friendly decision support tool. SelecTie™ II contains standard features common to Windows that will make most users familiar with the Windows environment comfortable in accessing and changing data in the SelecTie™ II program. These features include pull-down menus, an icon-based toolbar, common file selection and print dialog windows, online help, etc. (Palese 1997).

Analysis Approach

The analytical approach used in this model is the 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." In this approach, all future costs or savings associated with the two systems, such as future replacement or maintenance costs, are brought to the present, and the "worth" of these future costs calculated using an ppropriate interest rate (thus taking into account the time value of money).

This approach is taken for each of the major cost categories for the alternative tie/fastener systems:

Initial costs are costs that are incurred at year 0 and include initial component costs, initial installation costs, cost of additional ballast (at installation), undercutting cost (at installation) and salvage value due to components removed from the track.

Life cycle costs are cost streams (i.e. cycle of costs) that are incurred in the future, rather than at the present. These include maintenance costs, operating costs, derailment risk, etc. As noted previously, these future costs must be converted into their "present" cost. The specific cost areas addressed by the model include: rail replacement costs, rail transposition costs, tie replacement costs, basic track force costs, concrete tie repair costs, surfacing costs, undercutting (maintenance) costs, rail grinding costs, gaging costs, anchor adjustment costs, fuel costs, derailment costs.

Note, not all costs are applicable to each of the component systems (i.e. concrete ties with elastic fasteners do not require gaging or anchor adjustment). These different costs are then combined, in terms of "current" dollars, to determine if there is a net benefit for either tie/fastener system.

In examining the life cycle component and maintenance costs, it became apparent 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, in order to llow for such a model to be used in determining the relative economics of the different systems, it was necessary to make the model itself sensitive to these characteristics that influence lives and corresponding costs. Track characteristics include curvature, grade, rail weight, tie

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spacing, ballast depth, superelevation, premium rail and lubrication. Traffic characteristics are operating speed, axle load and traffic density (annual tonnage).

The economic characteristic is interest rate. The different costs are component (material) costs, labor costs and operating costs. For maintenance activities, see listing under life cycle costs.

By providing the user the ability to vary each of these areas, the desired level of flexibility and sensitivity is achievable in this cost benefit model.

Sensitivities

A life cycle model, such as SelecTie™, is capable of analyzing a large range of conditions, with the final results, the relative benefits of wood vs. concrete crossties, dependent on the specific assumptions and input values. Since there are hundreds of variables, the model has a built-in capability of performing sensitivity analysis that allows for the evaluation of the sensitivity to key variables which affect the relative costs. Such a sensitivity analysis is illustrated in Figures 2 and 3, which show the effect of changing curvature and MGT respectively (note the "base" values for this sensitivity include annual tonnage of 50 MGT, a timber tie cost of $27.74 and a concrete tie cost of $41).

Figure 2 presents the Return on Investment (ROI) for concrete tie track as a function of the track curvature (all other variables being held constant). As can be seen in this figure, there is a negative benefit (ROI) for concrete tie track for curvatures up to 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 economical until approximately 6 degrees after which concrete tie track becomes economically viable.

In a similar manner, Figure 3 presents the effect of varying the annual MGT for the base case with a curvature of 5 1/2 degrees. As can be seen in this figure, the ROI for concrete tie track becomes positive as the annual tonnage increases above the MGT per year. Thus, for the base case shown (and all of the associated assumed values for the 5 1/2 degree curve), if the annual MGT increases above 50, the ROI becomes positive for the conversion to concrete tie track.

As can be seen from these two examples, 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.

Use of SelecTie™ By Railways

The SelecTie™ Model is the most widely used such economic model in North America, having been used by railroads representing over 200,000 miles of track (300,000 kilometers) under a broad range of operating conditions to include heavy axle load freight and lighter axle load passenger operations. This model has been used extensively by freight railroads, passenger railways and transit systems in both the United States and Canada to assist in the decision as to where and when to use alternate crosstie materials and has been the basis of major policy decisions on the use of these materials.

For example, CP Rail, one of the two major Canadian railways, used SelecTie™ in its evaluation process when it made the decision in 1989 to standardize on a premium wood tie for all of its heavy usage lines and conventional wood ties for its lighter usage lines. In the analysis, it found that the economics of concrete ties were not favorable in light of its own costs and operations.

Other railroads, such as CSX and Union Pacific in the United States, which made the decision to use concrete ties on select heavy usage (high curvature, high density) lines, made use of SelecTie™ to define the "boundaries" for this usage. This was done by performing sensitivity analyses such as shown in Figure 2. Experience led to a further refining of these boundaries, and more intense scrutiny of the interdependency of the variables (curvature, traffic density, speed, etc.). Norfolk Southern and Burlington Northern recently upgraded their models to include the newest life-cycle equations and forecasting tools as part of their ongoing economic decision making process.

Other rail systems, such as commuter railways (Los Angeles Metrolink) use SelecTie™ to decide between wood and concrete ties for rehabilitation and upgrade projects.

Summary

The issues associated with the overall costs and benefits of alternate track components, such as timber and concrete ties (sleepers), are complex and interwoven. As such, it is not possible to universally 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.

Because of the number and range of variables that affect such a decision, use of a sophisticated analysis model is often the best way to proceed. This was the case in North America with the SelecTie™ model.

Such detailed analyses show that there are locations and conditions under which either wood or concrete tie track 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. This was the process used by different railway systems in the United States and Canada to help decide if they should use concrete ties, where they should use them, and how best to install and maintain them. This latter area, which also allows for examination of alternate maintenance practices to include gang size, make-up, and productivity, makes it possible to examine the effects of different maintenance practice on overall (life cycle) costs. 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, it offers the potential for being an extremely powerful economic analysis tool, one which cost conscious railways must make use of in order to help them get the maximum benefit for each "dollar" of expenditure.

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