TECHNOLOGY DIGEST

Timely Technology Transfer

GUIDELINES FOR THE SELECTION OF BALLAST MATERIAL AND MAINTENANCE TECHNIQUE

by

S. M. Chrismer

TD95-001

Summary

Recent research conducted by the AAR suggests:

- that it is often cost effective to use more durable ballast, even when a somewhat higher purchase price is considered.
- that there are economic limits of ballast hauling and an economically optimum ballast depth which are determined primarily by material quality.
- that ballast renewal by plowing is often more economical than by undercutting/cleaning when the ballast recovery rates are below about 30%.

These and other findings from a study using the BALLAST2 model allow the engineer to compare the predicted outcome with a particular situation and to determine if changes in current purchasing and maintenance practices are warranted.

The BALLAST2 model was used to develop ballast selection and maintenance guidelines which provide the lowest life cycle cost. By first assuming industry standard track conditions for the model inputs, the nominal ballast life cycle cost was established to be about $4800/mile/year. Then, certain track input values were varied over their typical range and the change in this annual, per track-mile cost was determined. From these analyses, certain practices were shown to be more cost effective than others for the conditions assumed.

A copy of the BALLAST2 model may be obtained so that the user may change the default values provided to reflect a particular situation, and perform the same sort of analyses as shown in this digest. This more customized approach would provide solutions and cost cutting practices more tailored to the user.

Suggested Distribution:

Operating/Engineering Department —

- ❑ **Maintenance of Way**
- ❑ **Maintenance Planning**

Association of American Railroads
Research and Test Department

February 1995

INTRODUCTION AND CONCLUSIONS

The BALLAST2 model provides a tool for considering life cycle cost when selecting ballast material and maintenance technique. With this model, a series of analyses were performed to develop general guidelines which can provide a lower cost ballast maintenance solution.

Comparisons of ballast life cycle costs can be made considering wood versus concrete ties, FRA track Class, ballast material quality and depth, and other issues. Some of the guidelines provided from the analyses include the economic hauling limit of a ballast from the quarry, an economically optimum ballast depth, and the maintenance technique which provides the lowest life cycle cost for the given track conditions.

A decision flow chart is also provided to help determine if ballast maintenance is the appropriate remedy. The user is urged to go through the flow chart before using BALLAST2.

With these techniques the maintenance engineer may arrive at a better economic solution to track maintenance problems. The BALLAST2 model can provide an economic rationale for changing maintenance practices so as to lower maintenance life cycle costs.

In this study, BALLAST2 was used to determine the effects of ballast quality, hauling distance, and depth, FRA track class, etc. on the equivalent annual life cycle cost. It was found that these items often have the largest influence on this cost.

Results Of Study

Ballast Quality - More durable ballast materials will have a longer life in track. If all other factors are constant, longer lasting ballast will have a lower life cycle cost (equivalent annual cost, or EAC). Using the BALLAST2 model, which predicts ballast life, the effect of material quality (Abrasion Number) on the EAC can be seen in Exhibit 1. Note that even though a higher purchase price for the stronger material was considered in the analysis, a cost savings associated with using better ballast is still predicted.

Also considered in Exhibit 1 is the effect of tonnage levels with the different material qualities of ballast. As seen, the cost of ballast material and maintenance decisions are more sensitive on heavier tonnage track.

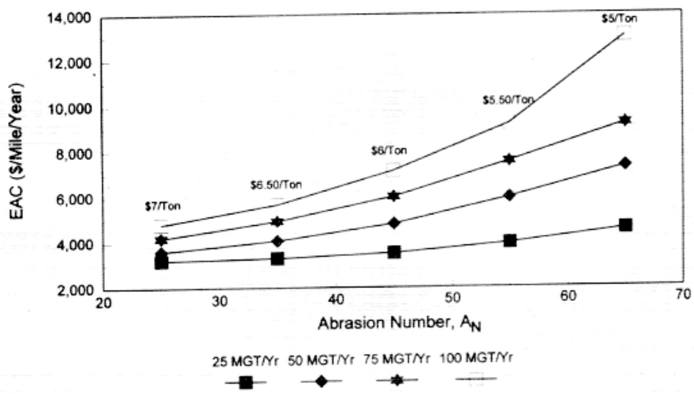

Exhibit 1. Ballast Life Cycle Cost with Abrasion Number and Traffic Tonnage.

Ballast Hauling - The economic hauling limit of a ballast material depends on its predicted life in track and purchase cost, versus that of any other potential ballast sources. An economic comparison of ballast sources can be made using BALLAST2. Exhibit 2 shows an example comparison between two quarries of dissimilar material quality, purchase price, and distance to the work site.

As shown, there is a breakeven point (hauling distance where the life cycle costs are equal) for the two materials at a considerable distance away from Quarry A. For track to the left of the breakeven point, Quarry A ballast is less costly, while to the right, Quarry B ballast is preferred. Southern Pacific Railroad performed this type of analysis with the model to determine which quarries to use on their system. An estimated $7 million per year was projected to be saved by changing ballast purchasing and maintenance practices accordingly.

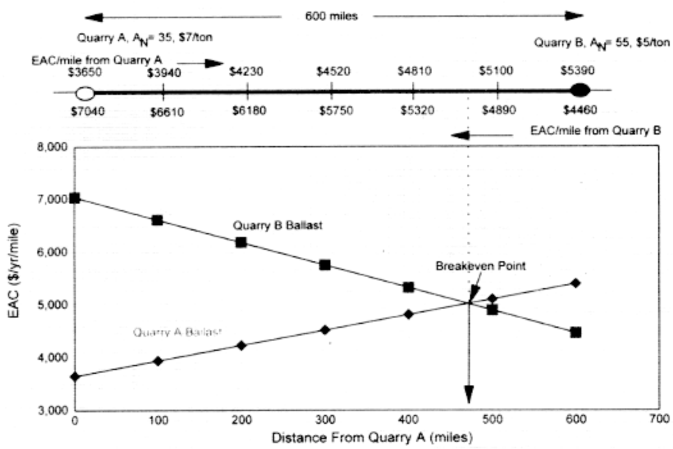

Exhibit 2. Cost Comparison of Hauling Ballast from Two Quarries.

Ballast Depth - A practical lower limit of ballast depth under tie is about six inches (the depth of tamper tine insertion) while an upper limit might be about 18 inches due to potential shear instability in a ballast section which is too deep. Within this wide range the depth of ballast could be determined based on a life cycle cost analysis. Exhibit 3 shows that the least life cycle cost depth is dependant on the material quality (ballast life). For stronger materials, the required depth is less since the breakdown rate is slower. For weaker materials, more depth is required to provide more interparticle void space to hold the more abundant fines from breakdown.

The total depth of ballast plus subballast should be sufficient to limit stresses on the subgrade. However since subballast is usually less expensive on a per track foot basis, the difference between the least cost ballast depth and the granular depth required for the subgrade should be made up with subballast.

FRA Track Class - The cost of maintaining track to certain quality standards (FRA classes 3, 4, 5, and 6) was also analyzed. As shown in Exhibit 4, the required tamping frequency increases exponentially with more restrictive standards. The charts are output from the BALLAST2 model which predicts the rate of track roughness increase (standard deviation of rail profile) with time, tonnage, and maintenance applications for the ballast life in track. Not surprisingly, the life cycle costs increase exponentially with track class as well. This is due to the increased tamping required over the ballast life.

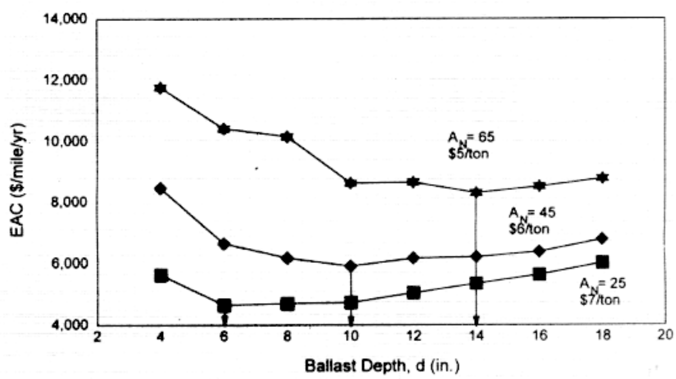

Exhibit 3. Ballast Life Cycle Costs with Ballast Depth and Material Quality.

These and other factors are considered in the full "guidelines" report (R-876). It is hoped that the resulting guidelines provide the user with useful information to obtain lower cost ballast usage and maintenance decisions. Copies of Report R-876 and the BALLAST2 model can be obtained by contacting the individual listed at the end of this digest.

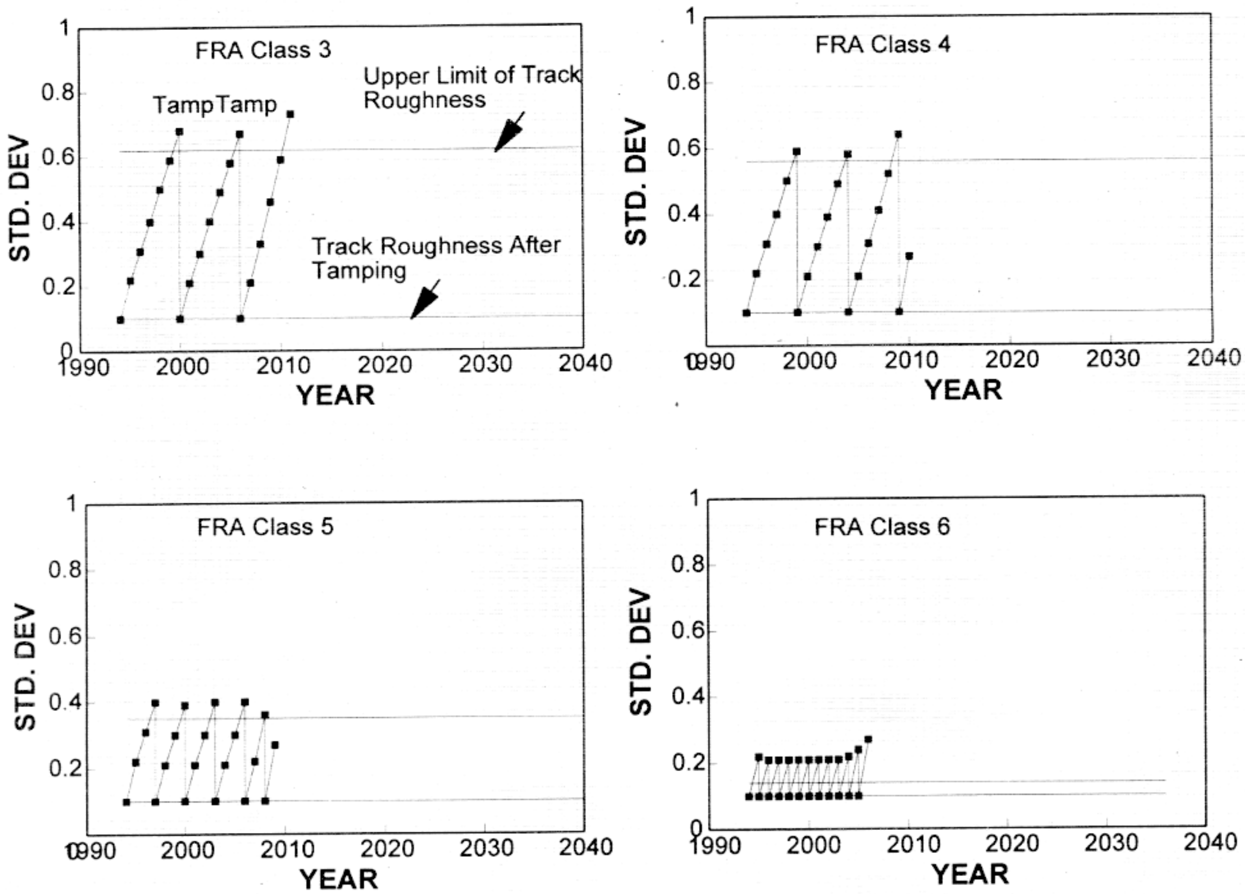

Exhibit 4. Increasing Frequency of Surfacing Required to Maintain FRA Track Class.

Note: Contact S. M. Chrismer at (312) 808-5848 with questions or comments about this document.

A more detailed report, which may contain revised information, will be available at a later date through the Document Distribution Center, Chicago Technical Center, 3140 South Federal Street, Chicago, Illinois 60616. A report list is available upon request.