The Many Faces of Ballast Fouling

When ballast degrades and fails, it loses its ability to carry out its primary functions of supporting and draining the track. In fact, one category of ballast failure was attributed to "a lack of ballast support allowing differential track settlement."[1]

A mechanism causing this loss of support and subsequent failure of the ballast is 'fouling' of the ballast. Fouling is the filling of voids or the open areas within the ballast by small particles known as 'fines.' Thus, fouling of the ballast will impede drainage, and reduce the strength and load-carrying capacity of the ballast layer. The mechanisms that contribute to fouling as well as the nature of the fines that do so have been the subject of recent research.[1,2]

From without and within

In general, fouling of the ballast can be from sources external to the ballast or can come from the ballast itself. Table 1 presents a comprehensive list of the different potential causes and sources of ballast fouling.[1] As can be seen from this table, these fall into three major categories:

1. *Fouling from the surface* — An external source of fouling might be fines dropped from trains, such as coal dust or grain from hopper cars; sand from locomotives, or wind-borne material.

2. *Fouling from below the ballast layer* — The external source can be subgrade particles that have penetrated up into the ballast.

3. *Fouling from a breakdown of the ballast particles themselves* — This can be by fines developed from the mechanical failure of the ballast under the influences of traffic loading, weathering, maintenance activities and the like.

Fines from all three of the sources mentioned are generally present in the ballast. But the relative amount of fines from these sources has been the subject of investigations into determining the best possible means of extending ballast life and controlling ballast degradation.

In two recent studies, it was found that ballast breakdown accounted for nearly 90 percent of the fines existing under North American heavy axle-load conditions. At the same time, only 50 percent of the fines under lighter axle-load conditions — in this case, British Rail — was traced back to the ballast.

While the range of ballast-generated fines was estimated to be between 25 and 90 percent, it was noted also that, based on field and laboratory data, ballast breakdown is assumed to be the main source of ballast fouling.[1] Thus, a better breakdown-resistant ballast can have longer life in track.

As noted earlier, as the ballast degrades, the voids in the ballast become filled. This cloggage results in reduced permeability, that is, a loss of the ballast's ability to permit

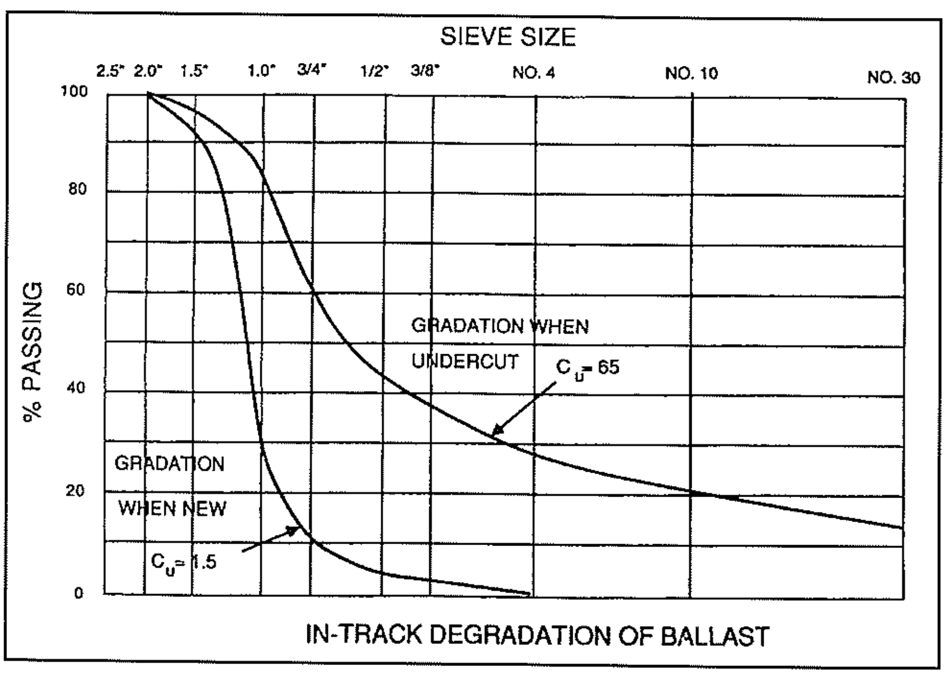

Figure 1 — Ballast gradation; new and after significant traffic

Table 1 — Ballast fouling sources and causes

1. FRONT THE SURFACE:
   a) delivered with ballast
   b) dropped from trains
   c) wind blown
   d) from tie wear
   e) splashings from adjacent wet spots
2. FROM THE SUBGRADE, BECAUSE OF:
   a) poor drainage
   b) lack of a filter/separator
3. BALLAST BREAKDOWN FROM:
   a) handling, for instance at the quarry, during transport and dumping
   b) thermal stressing from heating, for instance under desert conditions
   c) freezing of water in particles
   d) weathering, including the effects of acid rain
   e) tamping
   f) traffic's repeated loading, vibration, and the hydraulic action induced in slurry formed in track

passage of water. In turn, the amount of voids is dependent on particle size and 'gradation' of the ballast. Gradation is the distribution of particles by size.

Uniform gradation better for drainage

Studies comparing 'broad' gradations of ballast (large ranges of particle sizes) with 'narrow' gradations (with small ranges of particle sizes) have found that the narrow gradations offer larger void areas, and thus more empty space to accommodate fines. In fact, as is noted in Reference 2: for a broadly graded ballast, 10- to 15-percent fines were found to be required to impede drainage, while it took 20- to 25-percent fines in a uniformly graded ballast to achieve the same result. Moreover, the distribution of voids is not uniform in the broadly graded ballast.

As ballast degrades under traffic loading, its gradation broadens — a direct result of the breakdown of larger ballast particles into smaller ones. Such a change in gradation is illustrated in Figure 1. The figure presents the change from a narrow gradation of a new ballast to one that is broader after several hundred MGT.

Obviously, ballast wear and therefore life can be controlled by the use of materials less prone to breakdown, and with gradations having large void 'ratios,' or percentages of voids. However, caution is recommended when selecting ballast with a large particle size and narrow gradation. While the void ratio is large, this material may also settle quickly under load.[1]

At present, it is not clear if a narrower gradation ballast breaks down more rapidly than does one with broader gradation. Therefore, ballast having gradations broader than current AREA recommendations should be employed with caution.

References:

1. Chrismer, S.M.: "Ballast and Subgrade Maintenance: Working Group Progress Report"; Association of American Railroads Report WP-129, October 1987.
2. Klassen, M.J.; Clifton, A.W., and Watters, B.R.: "Track Evaluation and Ballast Performance Specifications"; Transportation Research Board, Washington, D.C., January 1987.