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HEAVY AXLE LOAD REVENUE SERVICE MUD-FOULED BALLAST INVESTIGATION

SUMMARY

Transportation Technology Center, Inc., investigated the track substructure at three Norfolk Southern mainline sites to determine the root causes of localized mud-fouled ballast deterioration and associated track roughness, as Figure 1 shows.

Mud clogs the ballast that supports the roadbed, which prevents effective drainage of water. Track roughness occurs over time as a track's geometry is degraded by the dynamic forces of train wheels on the rail. The inspections were performed as part of Task Order 215 – Federal Railroad Administration Heavy Axle Load Revenue Service Tests and were cofunded with the Association of American Railroads Strategic Research Initiatives Program.

The inspections were carried out by digging cross trenches in the tie cribs to a depth of 3–4 feet below the ties. The trenches revealed that water trapped in the fouled ballast layer was the main cause of the geometry deterioration at all sites. Although well-defined ditches were located next to and below the elevation of the ballast layer, the very low permeability of the fouled ballast shoulder and clay subgrade effectively blocked lateral drainage from the ballast section to the ditch. As a result, the top ballast layer was fouled with mud slurry that, in some cases, was being pumped up around the sides and ends of the ties.

At the inspection sites, at least one trench was dug where mud was being pumped to the surface and one was also dug where mud was not visible at the surface (i.e., surface looks clean). The underlying fouling conditions at the mud and non-mud spots were found to be similar. The similarity in underlying conditions indicated that mud spots can rapidly develop on tracks that visually appear to have a clean and well functioning ballast section.

Maintenance activities such as cribbing to remove fouled ballast between ties, surfacing, and ballast undercutting/cleaning to depths of 12 inches (in) or less are commonly used to deal with muddy ballast conditions. However, these methods do not necessarily restore adequate permeability of the ballast layer. Installing cross drains or ballast renewals that are deeper than 12 in below the ties may be required to restore the lateral drainage path.

Figure 1. Muddy Ballast Site with Degraded Track Geometry

BACKGROUND

The Federal Railroad Administration and the Association of American Railroads are cosponsoring research into track substructure performance being carried out by Transportation Technology Center, Inc. (TTCI). One issue being addressed is the problem of muddy ballast and localized mud spots. Ballast that is highly fouled with mud suffers significant loss of strength and is prone to rapid deformation. Track behavior at mud spots reflect the weak support condition with excessive rail deflection and accelerated tie, fastener, and track geometry degradation.

OBJECTIVES

Dealing with mud spots is an industry-wide problem. Defining the root cause of the condition is an immediate goal of the research and was the objective of this investigation.

METHODS

Preliminary inspections were performed at Norfolk Southern mainline locations in Alabama, Kentucky, West Virginia, and Ohio, where muddy ballast had been identified as an ongoing problem by local maintenance forces. The purpose of these Phase 1 cursory inspections was to get a general idea of conditions and to select two or three sites for more thorough investigation as the second phase of the project. Site selection criteria included (1) local conditions considered to be fairly representative of other North American sites, (2) favorable site access, and (3) minimum annual tonnage of 30 million gross tons (MGT). As a result of Phase 1, three sites were selected for the Phase 2 investigation:

- Site 1 — PC line milepost (MP) 59.1, Track 1 near Columbiana, OH, 55 MGT annually. Double track with reoccurring mud spots of moderate severity in shallow cut area on Track 1. There is a well-defined ditch about 12 feet from the south rail ballast shoulder.
- Site 2 — RD line MP 83.0, Track 1 near Ravenna, OH, 46 MGT annually. Double track with a number of severe and reoccurring mud spots creating rough track geometry on Track 1. A well-defined ditch is located approximately 20 feet from Track 1. The adjacent Track 2 shows no sign of mud or rough track.
- Site 3 — CNO&TP line MP 75.7 near Georgetown, KY, 73 MGT annually. Single track with numerous mud spots over several miles.

The Phase 2 inspections were carried out by digging cross trenches across the track to a depth of 3–4 feet below the ties. The substructure layers were measured and sketched, and the layer material was identified in general accordance with the ASTM Visual-Manual soil identification procedure D2488. Samples of material from the layers were collected for further laboratory tests. At each location, at least one trench was dug where mud was visible on the surface of the ballast, and one was dug where mud was not visible.

RESULTS

Three cross trenches were dug at the PC 59.1 site. One trench was dug at the mud spot and labeled XT-1, and two others were dug at nearby locations where mud was not visible on

the surface and labeled XT-2 and XT-3. The substructure layer conditions at all three trenches were similar, including the following:

- A top granular layer consisting of loose to medium-dense aggregate that was wet and fouled primarily with mud slurry.
- A second granular layer, denser than the top layer, very wet and fouled, but without the mud slurry.
- Subgrade of moist plastic clay, gray in appearance and moderately stiff at the surface, becoming increasingly stiff a few inches below the subgrade surface.

The only difference in the appearance of the three trenches was that the mud slurry in the top layer had pumped through the shoulder ballast at XT-1 to form a mud spot (Figure 2).

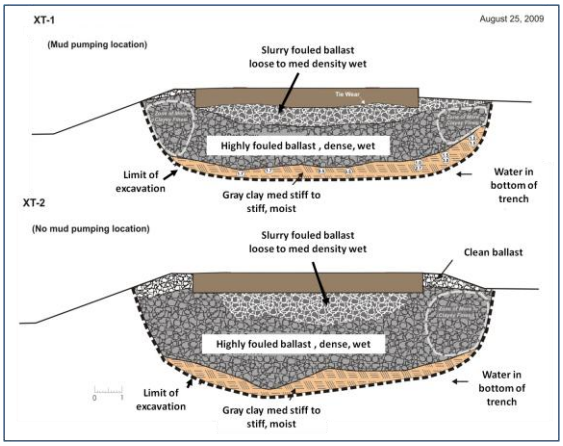

Figure 2. Similarity of XT-1 and XT-2 Cross Sections

Two cross trenches were dug at the RD 83.0 site: one at a mud spot labeled XT-5 and the other at a non-mud spot labeled XT-4. The conditions at these trenches were somewhat similar to PC 59.1, as Figure 3 shows, and are described as follows:

- The mud spot had a top layer less than 12 inches deep that was wet and fouled with mud slurry material.
- It had a second layer, denser than the top layer, also wet and fouled, but without the slurry. Water also collected at the bottom of the trench as at PC 59.1.
- The hardpan layer, consisting of cemented limestone and slag, was located between the second granular layer and the subgrade. The subgrade that was visible at the edge of the hardpan was moist clay.

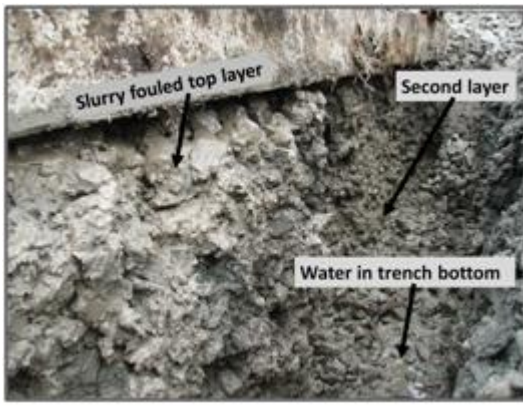

Figure 3. Ballast Condition at XT-5 Cross Trench

Two cross trenches were dug at the CNO&TP 75.5 site labeled XT-6 and XT-7. As with the other sites, the granular layers were very wet with water collecting in the bottom of the trench, along with slurry-fouled top layer and a denser, highly fouled second layer. However, there was a third layer of medium-dense granular limestone gravel subballast sitting on a hardpan layer (Figure 4). This site was slightly different from the other two in that there was more water present, and the slurry tended to pump through the ballast

shoulder near the toe, rather than pumping up around the ties.

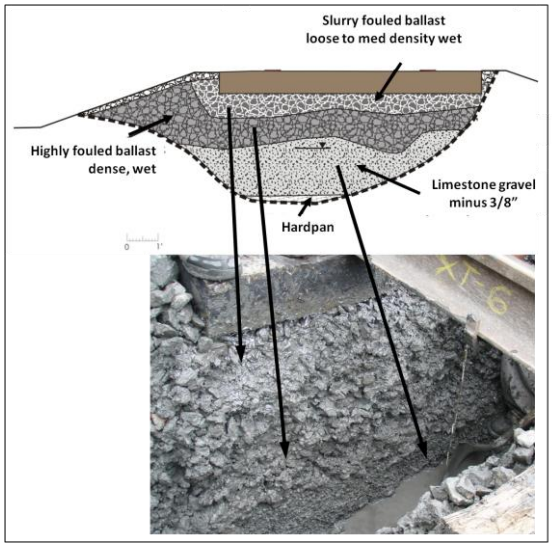

Figure 4. Ballast Layers at the CNO&TP 75.5 Site

CONCLUSIONS

The root cause of ballast deterioration and mud pumping was found to be water trapped in the highly fouled ballast layers. External drainage at the sites, i.e., longitudinal ditches and drains, appeared to be adequate to remove water from the right-of-way; however, the internal drainage of the ballast section was inadequate to drain water laterally to the ditches.

FUTURE ACTION

Plans are in place to install a mud spot remediation test at the site near Ravenna, OH. The approach will be to install an impermeable layer between the top and bottom ballast layers to facilitate drainage and isolate the fouled bottom ballast from the clean top ballast.

ACKNOWLEDGMENTS

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KEYWORDS

Track substructure, ballast fouling, muddy ballast, mud spots, track drainage, ballast cross trench inspections