TTCI TECHNOLOGY DIGEST

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Effectiveness of Spot Tamping in Fine-filled Ballast

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The research described was performed by Transportation Technology Center, Inc., a wholly owned subsidiary of the Association of American Railroads.

Key Findings:

- Higher tamping lifts resulted in longer maintenance cycles because the remaining lift after the initial settlement was greater.
- An overlift in the center of the previous dip can further extend maintenance cycles by allowing for even higher tamping lift, thus greater remaining lift, after the initial settlement.
- All four spot tamping events resulted in initial settlement of about 0.4 inch at the middle of the dip in the first 2 million gross tons (MGT) regardless of lift height, added material, or ballast wetness. Further testing is needed to verify this value under a wider range of conditions. This suggests the initial settlement magnitude, while possibly site-specific, may be able to be predicted.
- The ballast consolidation phase appears to end at about 0.1 MGT in dry ballast conditions, agreeing with previous research. This suggests that the ballast vertical, lateral, and longitudinal resistance will near pre-tamping levels at 0.1 MGT. Using a ballast stabilizer after tamping may speed up this process.
- Tamping in wet fine-filled conditions does not appear to be effective because of the difficulty to tamp and maintain the lift during the tamping process. More studies will be performed in this condition to verity.

Transportation Technology Center, Inc. (TTCI) has been studying the effectiveness of spot tamping in fine-filled ballast using the Rainy Section of the High Tonnage Loop (HTL) at the Facility for Accelerated Service Testing (FAST) Pueblo, CO. Key findings show that higher lifts and the implentation of an overlift can increase the maintenance cycle in fine-filled ballast.

Spot tamping in fine-filled ballast often is difficult and not extremely effective. In addition, there is a lack of best practices in the industry, and railroads will often tamp the problematic section until the track holds surface and repeat the process as often as required. A second benefit from this study was the opportunity to take a deeper look into the ballast consolidation phase and help determine an appropriate MGT to release slow orders after surfacing.

This *Technology Digest* is part of an ongoing study investigating the behavior of fine-filled ballast when exposed to moisture. The project was conducted by TTCI under the Association of American Railroads (AAR) Strategic Research Initiatives Program, with joint funding from the Federal Railroad Administration.

BACKGROUND

Spot tamping is a common maintenance method used in the railroad industry to realign track surface after track settlement has occurred at a specific location. The method involves raising the track to desired elevation and then using vibrating tamping tines to push and compact the ballast underneath the crossties.[1]

In general, there are no associated best practices for tamping and its effectiveness can vary considerably based on the ballast condition, method used, and tamper operator. Railroad practices vary, but usually the practice involves adding ballast and tamping until the desired elevation is obtained. However, initial ballast settlement may cause the track to lose the majority of its surface in the first few MGT; thereby reducing the effectiveness of the maintenance practice.

As part of a larger project at the FAST Rainy Section studying the effect of moisture and maintenance in fine-filled ballast,[2] the effectiveness of spot tamping in fine-filled ballast was explored. The Rainy Section consists of fine-filled ballast from natural fine degradation with a fine percentage of about 40 percent (FI = 40), which fills the majority of voids within the ballast and can inhibit drainage. This condition is a reoccurring maintenance challenge for railroads to maintain surface.

A second benefit from the study was to further determine an appropriate MGT in which slow orders can be released after surfacing. Immediately after tamping, the ballast tends to lose lateral and longitudinal translational resistance from the lower ballast mass density[3] and thus slow orders are issued until the ballast can regain its resistance.

BALLAST CONSOLIDATION

The study was initiated after the first time the Rainy Section was spot tamped and resulted in significant settlement after the first night of operations.

In Figure 1, the top-of-rail (TOR) elevations pre-tamping, post-tamping, and after the first 2 MGT is shown.

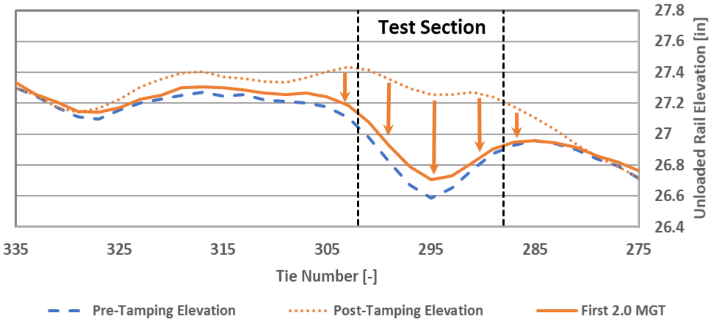

Figure 1. Rail settlement after tamping

The TOR elevations are an unloaded method of measuring rail elevation — it will not account for track deflection under train operations, but it will give relevant insight into track lift heights and settlement. The results show that the initial 2-MGT settlement profile almost reverts back to the pre-tamping elevation profile, suggesting the majority of the lift height was lost.

Figure 2 shows the results of a bending beam measurement installed at Tie 295 (the center of the Rainy Section), which experienced about 1 inch of tie settlement during the first 2 MGT. Top-of-rail and bending beams measure two different variables with the TOR measuring unloaded rail elevation along the track while bending beams can measure the tie settlement and deflection at individual ties during every train pass. Loose spikes and other slack within the fastening system explain the difference in settlement magnitudes, but both methods show the initial settlement.

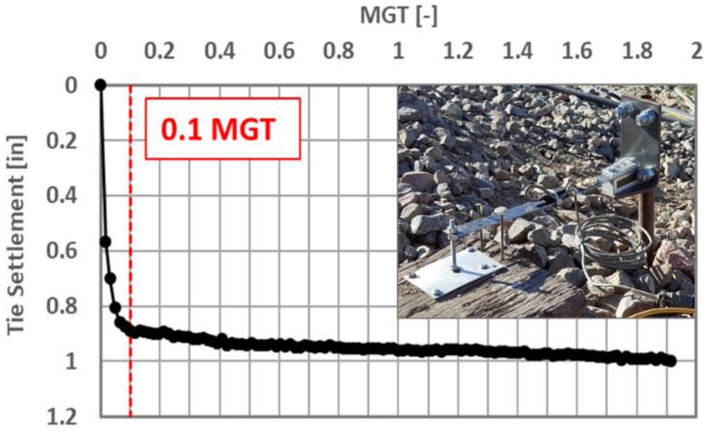

Figure 2. Bending beams measured tie settlement during initial 2 MGT

Figure 2 also shows that majority of that initial settlement occurred in the first 0.1 MGT under dry conditions, and then stabilized afterward. In the literature,[1] the initial settlement is called the “ballast consolidation phase” and is primarily settlement from the re-compaction of the ballast particles into a more compact state. After the ballast settlement stabilizes, the ballast experiences a post-consolidation phase in which the ballast settlement rate reduces. Further studies are required to determine if this 0.1 MGT value holds true under wet conditions.

These results agree with previous studies on lateral track stability showing that most of the lateral track resistance lost after tamping was regained after about about 0.1 MGT.[3] Once the ballast consolidates or settles to a more compact state, its vertical, lateral, and longitudinal resistance should approach pre-tamping levels.

SPOT TAMPING LIFT HEIGHTS

Since reoccurring spot tamping is required to maintain the surface of the Rainy Section, TTCI researchers were able to evaluate the effectiveness of lift height, the addition of extra ballast, and moisture. Table 1 lists the tamping tests that have been performed to date at the Rainy Section.

Table 1. Tamping variables

Test	Lift Height	Material Added?	Wet or Dry?
1	0.52 in.	No	Dry
2	0.51 in.	Yes	Dry
3	1.47 in.	Yes	Dry
4	0.07 in.	Yes	Wet

The lift height was calculated as the average rail elevation lift of both rails at Tie 295, as shown in Figure 1. Material added refers to whether additional material was used during the tamping process. While typical railroad maintenance would use clean ballast, additional FI = 40 fine-filled material was used in order to avoid compromising the other aspects of the Rainy Section test. The wet-versus-dry variable compares whether the fine-filled ballast was noticeably wet or dry. Typical railroad experience suggests tamping fine-filled ballast while wet is ineffective.

Figures 3 and 4 present the results of each of the tamping tests. In Figure 3, the x-axis represents the lift height and the y-axis represents the initial 2 MGT settlement from TOR measurements. In Figure 4, the x-axis represents the percentage lift height loss after 2 MGT. These values are calculated by dividing the y-axis value by the x-axis value in Figure 3.

The two figures emphasize different aspects of the results. Figure 3 suggests that the various variables have minimal impact on the magnitude of the initial 2 MGT settlement and the results show any tamping procedure produces about 0.4 inch of initial settlement. This result is surprising as the initial settlement is often dependent on the lift height.[4] More testing is required to validate and this result may be an artifact of the 20-foot testing zone or other variables.

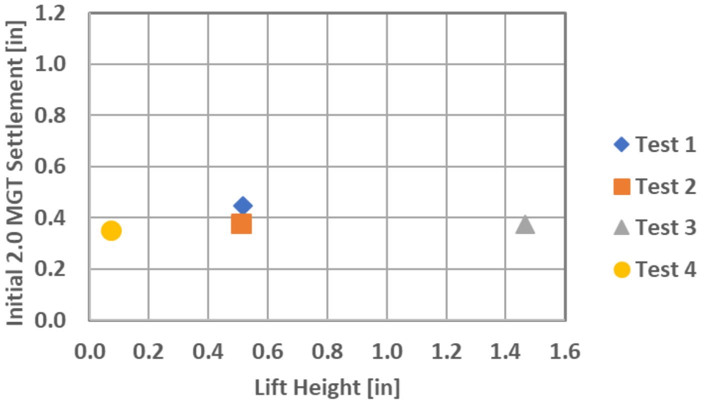

Figure 3. Lift height versus initial 2 MGT settlement

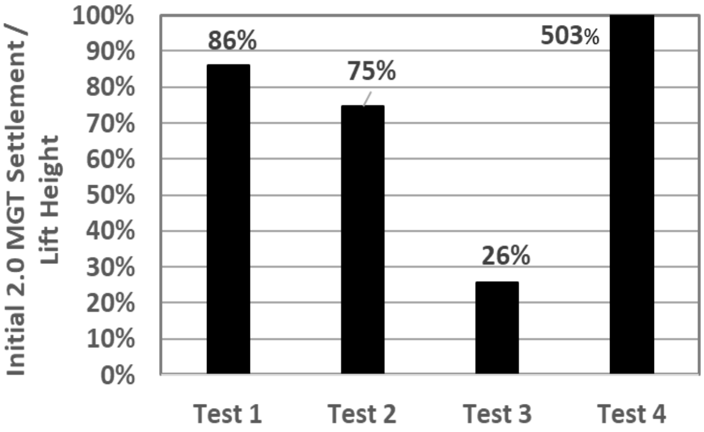

Figure 4. Percentage of lift height loss after Initial 2 MGT

Figure 4, however, shows dramatic differences in the percentage of lift height lost relative to the lift height. Comparing Test 1 and 2 show that adding material during a small lift (~0.5 inch) has a slight reduction in initial settlement, but Test 3 (also shown in Figure 5) suggests that a higher lift will result in more residual lift (the remaining lift after the initial settlement). This means that the benefit of spot tamping will increase as the lift height increases. Spot tamping lifts below 0.5 inch show little gain.

Test 4 also shows the difficulty of maintaining track geometry when the fine-filled ballast is wet. The small lift height of 0.07 inch was a result of difficulty experienced by the tamper in lifting the track to the desired elevation and maintaining that elevation during the tamping process. This suggests that tamping when fine-filled ballast is wet should be avoided unless absolutely necessary.

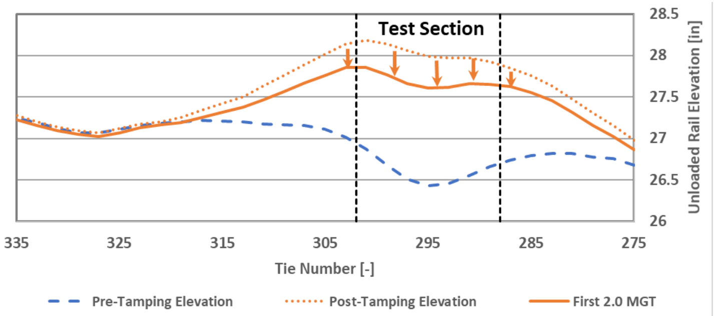

Figure 5. Rail settlement after tamping with an overlift

OVERLIFT

A second technique that can be used to increase track geometry life and therefore maintenance cycles is to surface with an overlift.[5] An overlift will result in a hump in the middle of the previous dip after surfacing with the goal of a flat geometry after the initial settlement has occurred.

On Test 3, the surfacing resulted in an initial hump of 0.8 inch using a 62-foot chord. After the first 2 MGT, this surface hump was reduced to 0.5 inch — a loss of 0.3 inch of profile. This hump placed during Test 3 may be too large for revenue service but it extended the maintenance cycle of the test section and resulted in smaller rail deflections, which can help extend the life of rail and ties.

CONCLUSION AND FUTURE WORK

Test results to date show that higher lifts and implementing an overlift can increase the maintenance cycle in fine-filled ballast. As testing on the Rainy Section continues, additional spot tamping, testing, and a wider variety of ballast conditions are anticipated

References

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