Optimum Cross Sleeper Length and Ballast Tamping Area for Narrow Gauge Tracks

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Ballasted tracks are subject to differential settlement under repeated load during train operation. This differential settlement causes track irregularity. To correct track irregularity, ballast tamping, in which ballast is pushed underneath the sleepers, is performed (Fig. 1). Normally, however, the ballast under the central part of the sleeper is not tamped. Therefore, the density of the ballast there becomes lower than that of the ballast at either side. As train load is applied to ballast areas that differ in density, they are either compressed vertically or flowed laterally, resulting in further ballast settlement (initial settling process). In the subsequent process, in which the uneven density distribution is corrected to a certain degree and the settlement continues (gradual settling process), in the case where a conventional sleeper (length: 2 m) is used, a void occurs between the sleeper and the ballast near each end of the sleeper, due to the dependence of ballast strength on its confining pressure. As this void widens, the settlement of the ballast increases.

This paper describes the results of a cyclic loading test carried out on a full-scale track model to study the effects of sleeper length and ballast tamping area on ballast settlement properties (Fig. 2).

The amplitude of sleeper displacement after a repeated load was applied once and 10^6 cycles, respectively, is shown in Fig. 3. The changes in average amount of sleeper settlement and in degree of sleeper differential settlement are shown in Fig. 4. In the area of ballast tamping, "ordinary" means that the ballast in the area up to about 400 mm on each side from the rail center was tamped, and "entire length" means that the ballast along the entire length of the sleeper was tamped. From Fig. 3(a), it can be seen that when repeated load is applied once, the longer the sleeper length, the smaller the sleeper displacement tends to become at each end, and that with a given sleeper length, the sleeper displacement at each end is smaller when the ballast is tamped along the entire length of the sleeper. In "ordinary" ballast tamping with sleeper length l = 2.0 m and l = 2.3 m, respectively, the sleeper displacement at each end is greater than that at the center. In the other cases, the sleeper displacement at each end is smaller than that at the center. From Fig. 3(b), it can be seen that after the repeated load is applied 10^6 cycles, the change in sleeper deformation in "entire length" ballast tamping with sleeper length l = 2.3 m and in "ordinary" ballast tamping with sleeper length l = 2.6 m, respectively, is smaller than the change in sleeper deformation after the repeated load is applied once. The implication is that "l = 2.0 m, ordinary" and "l = 2.3 m, entire length" increase the sleeper support at the center, whereas "l = 2.6 m, entire length" increases the sleeper support at each end. Fig. 4 indicates that both the average amount of differential settlement and the degree of differential settlement are small when the sleeper displacement at the center is slightly larger than that at each end after the initial application of the repeated load, since the sleeper deformation does not change under repeated load.

From the above facts, in order to reduce the ballast settlement effectively when the area of ballast tamping is "ordinary," it is necessary to increase the sleeper length to 2.6 m. The reason for this is that even when the sleeper length is extended, the ballast under the extended portion is not tamped sufficiently. However, by adopting "l = 2.3m, entire length," it should be possible to obtain a ballast settlement reducing effect comparable to that obtained by "l = 2.6 m, ordinary."

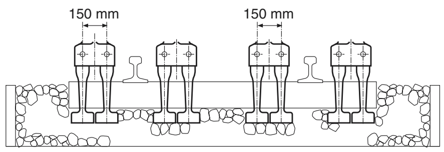

Figure 1. Ballast tamping area for narrow gauge track with cross sleepers (length: 2.0 m) when multiple tie tamper is used.

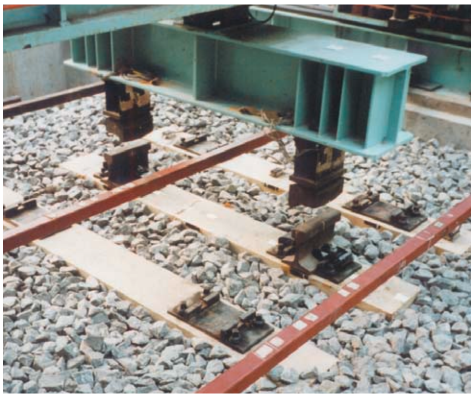

Figure 2. Cyclic loading test on full-scale track model.

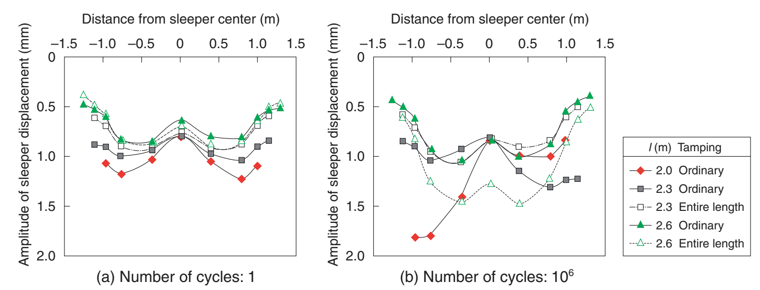

Figure 3. Amplitude of sleeper displacement.

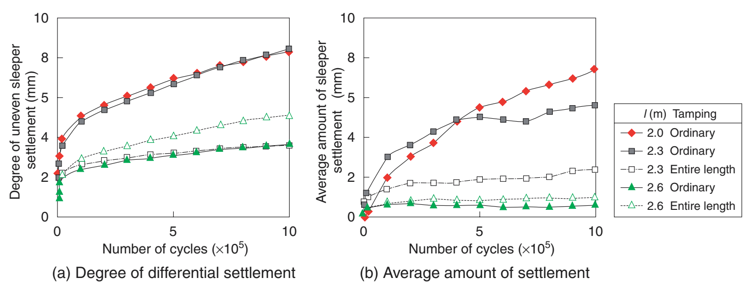

Figure 4. Transition in amount of sleeper settlement.