Alternatives to wooden sleepers in tracks with an unfavourable substructure

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Track conversion by changing the sleeper type
In some places during a track conversion from wooden sleepers to concrete sleepers without a renewal of the substructure, problems concerning a rapid change of track geometry occur. The reason for this is for example the massive change of the longitudinal level of the track related to a mud pumping of the ballast. The operational experience of the railway companies shows that wooden sleepers work well on tracks with substructure in an unfavourable condition. The useful life of the railway superstructure is approximately 40 years. The lifetime of the substructure is roughly twice this time approximately 80 to 100 years. Figure 1 shows the ideal case, in which every second renewal of the superstructure coincides with the renewal of the substructure. After 40 years a new superstructure has to be built over a substructure, which has already reached half of its service life. In this case, problems with wooden sleepers are relatively rare compared to concrete sleepers. The exact reason for this has not been examined extensive yet. Due to the coming end of the installation of new wooden sleepers because of the problematic creosote impregnation, an alternative sleeper type is needed for unfavourable substructure.

![Fig. 1: Schematic depiction of the life-time of superstructure and substructure [Source: Own graphic, with guidance of SBB]](image-url)
Laboratory test on wooden and concrete sleepers
To specify the parameters of an alternative sleeper to the wooden sleeper in case of unfavourable substructure, the behaviour of wooden and concrete sleepers must be investigated. One important topic is the vibrational characteristics of the two sleeper types. Figure 2 shows the result of the modal analysis of a B70 concrete sleeper.

![Modal analysis of a B70 sleeper](image)

Fig. 2: Vibration characteristics of a single B70 sleeper, modified from [1]

To examine the interaction of wooden and concrete sleepers with the substructure, test on a short track with five sleepers will be performed in the laboratory. The test setup consists of a 1:1 model of the track with a length of 3 m including ballast and substructure (see Figure 3). For the substructure a soil with a high percentage of fine particles is chosen. By moistening the substructure and introducing a cyclic loading (to simulate a passing axle), mud pumping is provoked in the laboratory. The laboratory tests will be setup with wooden sleepers and concrete sleepers in the same way. The test setups were monitored by a wide range of different measurement techniques in the superstructure and substructure. The settlements of the track will be measured as well as the acceleration of sleepers, ballast stones and substructure. Pressures and pore water pressures of the soil will be monitored.

![Laboratory test setup](image)

Fig. 3: Cause of mud-pumping and the laboratory test setup for provoking mud pumping with different sleeper types

Definition of the specifications of an alternative sleeper
The collected data of the laboratory test will be evaluated and interpreted. The first topic investigated will be the reason for the different behaviour of wooden and concrete sleepers to the formation of mud pumping in the ballast bed. The second point is the specification of the parameters of an alternative sleeper. This alternative should combine the advantages of the wooden sleeper, concerning the behaviour in case of unfavourable substructure and the persistence of the concrete sleeper.

References: