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Numerical modeling of the deformation in railway foundation – A case study

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ABSTRACT: For modeling the development of railway track deformation, a quasi-static model describing the stress - permanent strain - cycle number - relationship of granular soils has been developed in terms of the cyclic triaxial test results from literature. The in-situ measurement carried out in the section Wittenberge-Dergenthin of the extending railway line Hamburg-Berlin is analyzed by using the developed model and the procedure. The research indicates that the essential parameters included may be assessed by using the results of the vibration table tests on soils. The comparison of the predicted settlement with the measured values shows satisfactory agreement.

1 INTRODUCTION

The increasing application of the slab tracks, which are more difficult to adjust geometrically, requires that the total settlement as well as the differential settlement of the railway foundation must be limited within a much smaller value compared to those for ballasted tracks.

In this paper, a case study is presented for the section Wittenberge-Dergenthin of the extending railway line Hamburg-Berlin, where the slab superstructure was applied. For monitoring the stability and deformation of the track, extensive in-situ measurement was carried out during and after the construction. In the analysis, a quasi-static model developed by the authors was used, see (Kempfert & Hu 1999). The essential parameters included were determined from the back-analysis of the vibration table tests.

2 QUASI-STATIC MODEL

The real dynamic loading from railway traffic and the physical mechanism of soil deformation under such condition are very complicated. The consideration of all aspects with one mechanical model seems to be not realistic, at least in the present stage. Simplification must be made for practical purpose.

A simplified procedure called quasi-static model has been proposed and numerically implemented by the authors for describing the permanent deformation of granular soils under cyclic loading, see Fig. 1. The basic assumptions are as follows:

-The maximum of the cyclic dynamic loading is seen as input parameter "quasi-static stress σ".

-In-situ measurement indicates that during train passing the resulted excess pore water pressure in granular soils is usually very low and decreases within very short time down to zero after train passing. Upon this, the factor of pore water pressure may be excluded.

-The cyclic strain part ε^{qe} is generally much smaller than the permanent strain ε^{cp}. The quasi-elastic modul E can be assumed to be independent of the cycle number.

-The viscous dashpot η_1 is introduced to simulate the permanent strain ε^{cp} for the cyclic stable case and is dependent on the cyclic number N. This dependency can be described using the empiric relationships from cyclic triaxial tests, see Table 1.

-For the failure case, the conventional viscoplastic formulation can be used.

3 THE RAILWAY LINE SECTION WITTENBERGE-DERGENTHIN

3.1 *Project*

In 1993/94 the railway line Hamburg-Berlin was extended by using the slab superstructure (type Züblin) on the section Wittenberge-Dergenthin (6 km long). The old track was the ballasted superstructure and showed a bad state. The design train speed is 160 km/h, optionally up to 200 km/h.

As illustrated in Fig. 2, the slab superstructure of the Züblin type consists of an upper bearing concrete plate with a thickness of 28 cm and a 30-cm thick