HYSTERETIC LIVE LOAD EFFECT IN SOIL-STEEL STRUCTURES

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1. Introduction

Soil-steel structures stands for relatively inexpensive and reliable method for constructing engineering structures such as culverts, bridges or shallow tunnels. Mechanical behaviour of this type of structures results from the complexity of the interaction between soil backfill and flexible shell. As a consequence, the behaviour of entire structure is derived from the characteristics of both – the steel shell as well as the soil backfill and, thus, it is significantly non-linear. This is manifested, *inter alia*, by the hysteretic live load effect which has been identified experimentally by in situ tests, conducted on a few structures [1] [2] [3]. The aforementioned effect consists in the fact that the mechanical response of the structure to live loads is affected not only by the location and intensity of the load, but also by the direction of its movement. The paper presents description of in situ tests and numerical modelling is undertaken. Finally the results are commented and the conclusions are drawn.

2. In situ identification of the hysteretic live load effect

The hysteretic live load effect was identified in the tests in which the truck or locomotive was passing the bridge one way and then back without turning back. The test has been conducted independently on a few engineering structures located on roads [1] [2] and railways [3].

In the particular analysis, presented in the paper, the soil-steel bridge structure along the railway line in Świdnica is considered [3]. The longitudinal cross-section of the shell is referred to as arc type SC-19NA. The shell was made of corrugated metal sheets SuperCor SC 380×140×7 reinforced with a cover plate of the same profile. A span of the structure is L=15.0 m, height of the clearance h=5.232 m, the upper radius of curvature equals R=9.930 m. A width of the shell changes with the height and equals B_b=26.3 m in the bottom B_t=13.0 m in the top. The total structural height of the railway viaduct h_k=1.60 m includes the height of the steel shell, the backfill and the typical track structure.

The loading test was conducted with the use of ST43-type locomotive. For static test scheme, denoted as S2 in the original research [3], the reference points of measuring base were distributed along a circumferential line of the lower surface of the shell in a vertical plane under the axis of the track. In particular, the measurements of the shell vertical displacement in the key point of the shell were carried out using the inductive sensor characterized by the reading accuracy of 0.01 mm and measurement range 0-50 mm. The plots of the displacement versus load location corresponding to subsequent passages form hysteresis (see Fig. 1). The plots are shifted in the direction of the load movement. Furthermore, the local maxima are of the different values in the subsequent passages. Such observation indicates the presence of some dissipative processes that are not common in other bridge types.

3. Numerical modelling

The test, described above, was simulated with the use of Itasca Flac 7.0 software, based on finite volume method. The modelling procedure is similar to the one proposed in [4]. Constitutive model for soil medium is elastic-plastic one with Coulomb-Mohr plasticity function and unassociated flow rule. The material parameters correspond to the parameters of coarse sand in dense state of compaction. The steel shell and track are modelled with the use of beam linear elastic elements. The shell and the soil medium contact through one-sided frictional interface. The simulation was realized in a following manner: first the problem was solved for the initial position of the locomotive, next the load was slightly shifted in the direction of the passage and the problem was solved again, etc.

The comparison of the in situ test results (left) and numerical simulation are presented in Figure 1.

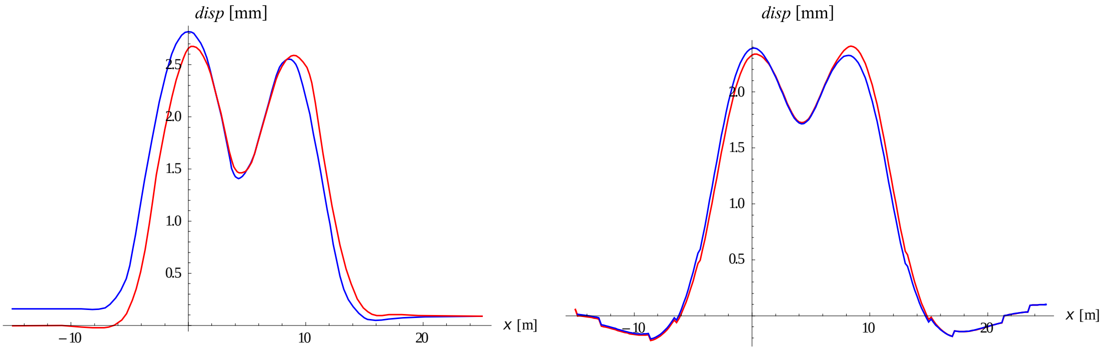

Figure 1. Vertical displacement of the shell key point during two passages of the locomotive – comparison of the in situ test results (left) and numerical simulation (right)

4. Summary and conclusions

The hysteretic live load effect was identified by in situ tests. The measurements clearly show that the deformation of the shell depends not only on the location of the load but also on the direction of the load movement. The presented results of the numerical simulation are in fair agreement with the experimental evidence. Based on the performed analysis it can be stated that the considered effect results inter alia from friction in the contact zone between steel shell and the soil and from nonlinear behavior of the soil backfill.

5. References

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