Construction of the first railroad widening in the Netherlands on a Load Transfer Platform (LTP)

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ABSTRACT: This paper describes the construction and some general aspects of the design of a 70m long Load Transfer Platform (LTP) or Piled Embankment (PE). The LTP was constructed underneath a railway track in Houten. Because this was the first LTP constructed under a railway in the Netherlands, some specific challenges were encountered during construction. The paper deals with the general aspects of construction.

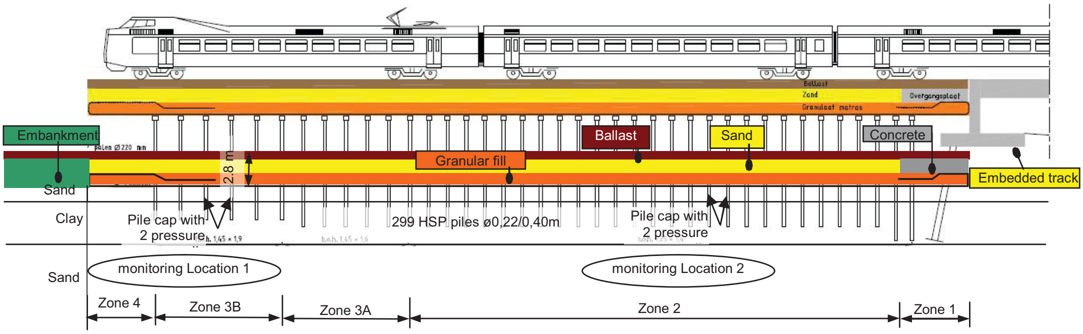

Figure 1 Longitudinal cross section of the LTP Houten

1 INTRODUCTION

Because of an emphasis on reducing construction time, lateral movements near buildings and reducing the disturbance to the surrounding area during the construction of embankments, several Load Transfer Platforms (LTPs) or Piled Embankments (PEs) have been constructed in the Netherlands in the past 10 years. The first LTP for a light rail system is described by Van der Stoel et al (2006). This paper describes the first LTP for a main railway system in Houten.

Recently a 70m long LTP was constructed underneath a railway track in Houten, the railway between Utrecht and Maastricht (average frequency of eight passenger trains and one cargo train every hour). The reason why a LTP was chosen in Houten is that not only did the soil consist of soft compressible soils and construction time and space were limited, but more importantly a smooth transition zone had to be formed between a stiff construction (new 200m long viaduct with embedded railway track) and an embankments constructed the conventional way (long construction time, residual settlements). The piled embankments was also a good solution to reduce maintenance costs.

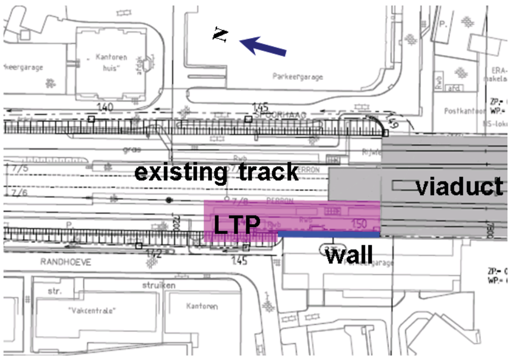

Figure 2 Situation Houten LTP

The situation is shown in Figure 2 (note the limited space because of the wall, the existing track and the buildings). Figure 1 shows a longitudinal section of the LTP and Figure 3 shows a schematic cross section.

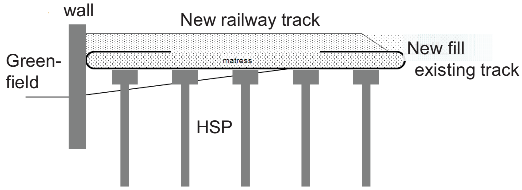

Figure 3 Schematic cross section of LTP

Generally the construction consist of HSP foundation piles, geogrids and a mattress consisting of 0.8m of ballast, 1.0m of sand and 1.0m of granular fill.

The behaviour of the LTP has been and is still intensively monitored, see Van Duijnen et al (2010).

2 SITE INFORMATION

The main function of the LTP is to form a transition zone between a viaduct with an embedded railway track and the embankment with an track in ballast. Figure 1 presents a longitudinal cross section of the LTP. Figure 4 shows an overview of the works. The soil profile consists of 1m of sand, 3m of soft clay under which 20m of sand is found.

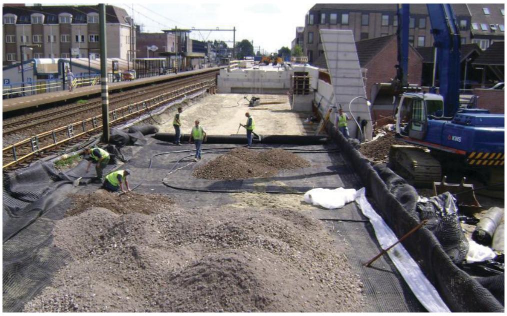

Figure 4 Overview of the works

3 PILES

To minimize installation and maintenance cost, a foundation system was designed consisting of Voton® High Speed Piles (HSP piles) with a maximum design load of about 250 kN overlain by a geogrid reinforced mattress. The principle of the vibro/installation of the HSP is shown in Figure 5. HSP piles with a diameter of 0.22 m and an average length of ca 8m were installed in a varying square grid. The pile cap was enlarged with reinforced concrete to ø0.4 m.

An advantage of the pile system is the control of and adaptability to the soil conditions during installation. Pile length can immediately be adjusted on the spot whenever insufficient bearing capacity is encountered during installation. For the same purpose pile diameter can be adapted quite easily. Production has been up to 100 piles/day.

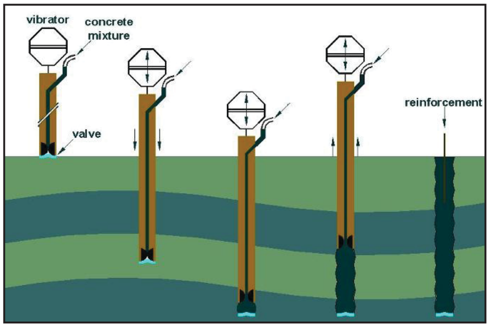

Figure 5 Principle of Voton-HSP installation

Because the LTP had to function as a smooth transition zone from the bridge to the "natural" rail-road embankment the piles were put further from each other divided in 3 sections. A fourth section is the mattress over a length of 5 m without piles underneath.

4 GEOGRIDS

The embankment was not allowed to exercise a horizontal pressure on the existing wall and is temporary higher to the existing rail-road which is still in function during construction of the LTP. That meant that not only the LTP but also the embankment on top of that had to be build using geogrids. The cross-section in Figure 6 shows an impression of this construction.

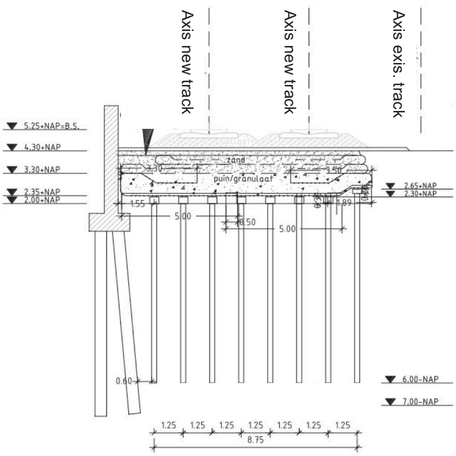

Figure 6 Cross section next to wall

A comparable construction was used during the construction of an integrated LTP and gabions system in Almere, the Netherlands (Van der Stoel et al, 2007).

Because the piles of the LTP were divided in 3 sections with different piles distance in both directions. The geogrids are positioned in cross and longitudinal direction, see Figure 7.

Figure 7 Geogrids positioned in cross and longitudinal direction

The lateral direction geogrid was positioned first and the longitudinal grid directly on top of that. Essential is that the forces can only be transferred from one geogrid to the other on top off the pile caps when using overlap. Because the geogrids are 5m wide and there are different piles distances a special layout plan was made for the overlap. Due to the differential pile distances this overlap was bigger than usually applied. A difficulty in the execution was that at the moment of geogrid installation all piles were covered with 0,05m of sand, so they had to be recovered to guarantee a correct position.

The geogrids that were positioned in lateral section are a Fortrac R450/50-30 MP and in longitudinal direction a Fortrac R450/50-30 MP. In zone 3A and 3B Fortrac R600/50-30T was applied. Due to lack of space on the site (see Figure 8) the geogrids for the lateral sections were prepared on the neaded length in the Huesker factory and could be placed and rolled out directly without extra handling.

For the monitoring program on 2 locations 8 displacement measurement devices were connected to the geogrids. The devices were partly connected underneath the geogrids (see detail in Figure 7).

Both sides of the mattress and the embankment on top were build with a steel mesh as a temporary formwork (see Figure 9). The mattress consists of crushed granular materials and the embankment above is constructed using sand (see right side Figure 9). The compaction was measured for each layer of fill.

Figure 8 Working right next to railroad track

Figure 9 Border construction

The connection between the ridged railway bridge/the connecting concrete transition plate and the LTP is shown in Figure 10.

Figure 10 Connection to railway bridge transition plate

5 DESIGN

The design of piled embankment was performed using the EBGEO (2004, geogrids) and the Dutch code for pile foundations was used to calculate the bearing capacity of the piles (NEN6740). Lateral loading of the piles, either caused by the internal forces in the piled embankment or by external forces due to for instance vehicle loads or asymmetry of the embankment, however, can cause relatively large bending moments in the foundation piles of the embankment. The displacements, lateral forces and bending moments were determined using Plaxis FEM calculations. An example of a lateral section is shown in Figure 11 and Figure 12.

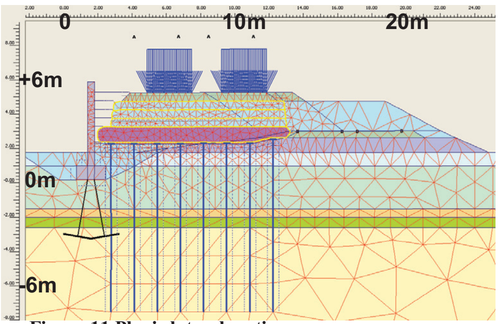

Figure 11 Plaxis lateral section

In the longitudinal direction acceleration and deceleration forces are analysed. This analyses included the horizontal stiffness of the track itself, to reduced local maximum deceleration forces.

Note that the piles and steel reinforcement in the piles significantly contribute to the costs of the piled embankment! For this case, also a comparison has been made between a 3D and 2D FEM model, which can be found in Van Eekelen et al (2010).

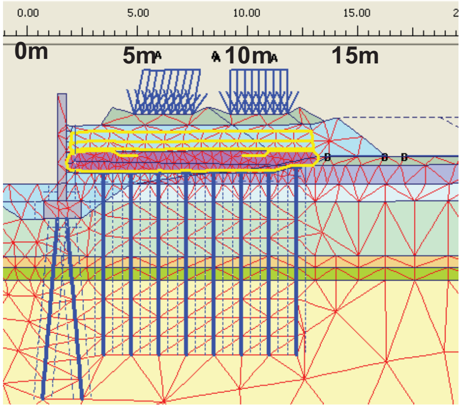

Figure 12 Plaxis lateral section (horizontal loading)

6 CONCLUSIONS

The LTP in Houten was designed and constructed in a relative short time period. Based on the monitoring results up to now, the LTP is considered to be a successful transition construction between a rigid (foundation) construction and a embankment that is subject to residual settlements.

7 ACKNOWLEDGEMENTS

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