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Summary

For warehouse buildings, a steel fibre-reinforced concrete floor is often used as floor construction. Where pile foundations are required for this type of floor, the piles must be placed relatively close together, depending on the limited bending moment capacity of the floor. Close spacing of piles implies that the pile load is relatively low in most cases, e.g. in comparison with heavily loaded piles under columns and facades.
This article describes a recent project where, for the foundations of a 12,000 m² fibre-reinforced concrete floor, a type of pile was used that is new to Sweden: the Dutch Voton HSP pile (HSP = High Speed Pile).

Figure 1 *Voton HSP installation.*

High Speed Piles for foundations of steel fibre-reinforced concrete floors

Central warehouse FMCL

The Swedish government wanted to change the basic structure of the Swedish defence into a modern operations-oriented force. This implies tougher requirements concerning controls of storage, handling and distribution of the equipment. One stage of this transformation was to build a new central warehouse (FMCL) for the Swedish Armed Forces in Arboga.

Project / Site supervision	AB Consila
Design	Structor AB
Geotechnical engineering	Bredenberg Teknik
Foundation works Voton HSP	Voorbij Funderingstechniek (The Netherlands)
Earthworks	Skanska Sverige AB
Steel structure	Ruukki OY (Finland)
Building costs	Appr. SEK 500 million
Construction period	2007 - 2009

Soilconditions – design with Voton HSP

The subsoil consists of:

- upper layer 1 m – 1.5 m of dry crust clay.
- 3 – 14 m uncompacted clay (shear resistance 10 – 20 kPa), resting on friction material (gravel, sand), or moraine on rock.
- average ground water level: 1 m below existing grade, varying appr. 0.5 m up or down depending on the season and rainfall conditions.

After various comparisons, the decision was made to establish the lower loaded section of the fibre-reinforced floor on HSP piles. This solution had never before been used in Sweden, but there were good references from the domestic market, the Netherlands. In order to ensure the intended quality and bearing capacity, a test programme was conducted at the Arboga works site. The programme involved static test-loading as well as excavation of a number of piles after the test.

The total floor space of the FMCL is 40,000 m². The floor is made of 200 mm fibre-reinforced concrete. The floor foundation for the cold storage area (12,000 m²) was designed with HSP piles:

- diameter 180 mm
- pile length 7 – 14 m
- pile distance 1,20 m square grid
- altogether appr. 8,000 piles
- dimensioned load effect in the flexural strength state 150 kN
- concrete grade C20/25.

High Speed Piles

The piles can be characterised as *cast in situ* concrete piles. The manufacturing process is shown in *figure 3*. Pile production is very quick – a 10 m pile produced using the above method takes some 2 minutes. Capacity for the project in question amounted to 350 to 400 piles per 12-hour shift, compared to about 20 – 30 for

conventional pile driving. Available pile diameters: 180 mm - 220 mm and 273. Last two types in combination with reinforcing cages (upto 10 m in length). The equipment used can produce piles 25 m in length.

Verification and inspection

Pump pressure, flow and other relevant production data were recorded in the computerised documentation and presentation system in the cab of the pile crane. All data were stored locally and also transmitted in real-time to the database server in the Netherlands.
If there is any disruption the driver intervenes, but in normal production the processes are largely automated.

Once the piles had hardened for about 2 weeks, they are inspected by means of integrity testing, to make sure no cracks or the like have occurred. Test percentage of 10% is a standard value for this type of test. At Arboga 800 HSP piles were tested without any defective piles being found. Two piles were exposed down to a depth of some 4 m. It was noted that the surface of the piles was very smooth and appr. 20 cm in diameter (nominal 180 mm).

Test-loading

As referred to above, static test loading was carried out on several HSP piles. An excavator was driven up onto a 25 mm steel plate so that the centre of gravity was directly above the jack on top of the pile. The testing up to 285 kN was carried out without any significant tendency to crumpling. Loads were applied in increments of 50 kN.
Each load increment was maintained for 16 minutes, with movements recorded after 1, 4, 9 and 16 minutes. The load was removed incrementally. The greatest remaining movement measured was appr. 5 mm (total station, accuracy +/- 1 mm).

Conclusion

Altogether the use of Voton HSP piles can be seen as successful in this project. Besides the use as pile foundations for concrete warehouse floors, HSP piles are also used in road and railway embankments (LTP constructions) and piled raft foundations. It is therefore considered that HSP piles could be a useful method of restricting settlement and increasing the subsoil bearing capacity.

Dutch contractor Voorbij Funderingstechniek, which undertook the work, has four sets of equipment for the installation of HSP piles besides some 30 conventional pile cranes. ■

**Peter Oscarsson has moved earlier this year to company C&M Projekt AB.*

Figure 2 *Test loading and over 4 m exposed HSP pile.*

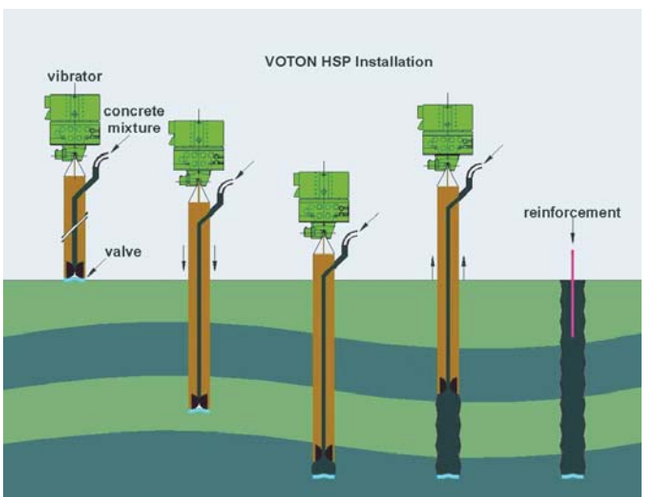

Figure 3 *Schematic view of the installation of HSP piles (www.voton-hsp.com).*

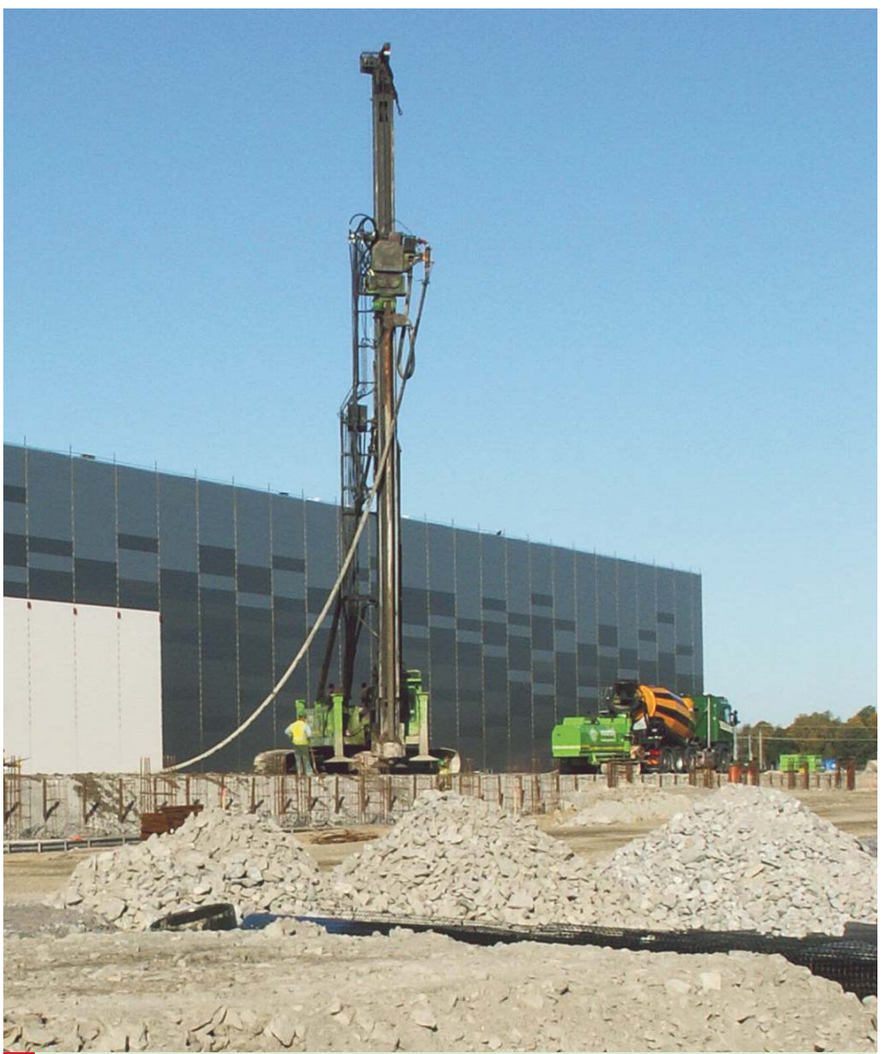

Figure 4 *The machinery used consisted of a pile crane and concrete pump. Both items are on caterpillar tracks, with relatively low ground pressure. The crane weighs some 60 tonnes.* *Photo: Andre de Lange, Voorbij Funderingstechniek.*