Flexible cement storage

by Martin Wuerth, Wuerth Consulting Engineers, Switzerland

With its new cement silo, CRH-owned Jura Cement in Switzerland wanted to combine additional cement storage capacity with the flexibility to offer clients a wider range of blended cements. To achieve this, the cement producer contacted Wuerth Consulting Engineers.

Slip-forming work of the 10 chambers, which will offer Jura Cement the required flexibility in product range

The 10-chamber silo, with a diameter of 25m and height of 60m, has a total cement capacity of 15,000t, providing the extended storage capacity and product flexibility required. In addition, the design of the new silo also considered the need to operate the facility with low energy consumption. Hence, short material handling routes, mechanical instead of pneumatic charging and gravity discharging were key design parameters.

As Jura Cement looked for a designer to deliver the best design, the company realised quickly that every consultant has their own way of dealing with the project's special requirements. Consequently, a checking engineer was contracted to keep an eye on the selected designer. While the structural analysis of the silo was made by RFEM, Peter Jäger, the checking engineer, verified this through his own calculation with Axis and Autodesk Robot, and by comparing the results of the three finite element software solutions, an economic design without compromising safety and quality, was offered to the client.

Ultimately, the basis for the design was the silo loading standard DIN 1055/6 (2005) which deals with eccentric discharge loads more carefully than the earlier version.

Fortunately, the silo was to be built on gravel heavily compacted during the last Ice Age, making for very good soil conditions. Nevertheless, the small footprint necessitated the building of a pile foundation, which has the advantage of an improved settlement process and ensures that the neighbouring buildings (some of which have been at the site for over 100 years) will not be affected by the settlement curve.

Laying the foundations

However, to build a silo across three existing railway lines, including one in continuous operation, surrounded by existing buildings, presented a number of challenges.

The opening for the three railway tracks is 12m wide, giving the additional benefit of a limited footprint for the silo, but without supporting columns the structure required a supporting horizontal beam at the top of the railway track opening. Fortunately, the silo was to be built on gravel heavily compacted during the last Ice Age, making for very good soil conditions. Nevertheless, the small footprint necessitated the building of a pile foundation, which has the advantage of an improved settlement process and ensures that the neighbouring buildings (some of which have been at the site for over 100 years) will not be affected by the settlement curve.

Building upward

The execution of the project was expected to take nine months, but the harsh winter of 2011-12 and additional steel rebars quality tests lengthened this schedule to nearly 12 months.

The silo was slip-formed in three stages:

- start of the inverted cone – from 0-10.3m height
- end of the inverted cone – up to 23m
- up to the top – 58.5m.

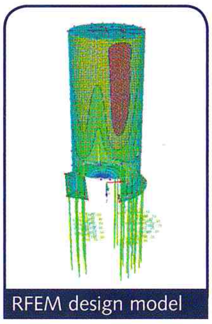
The cone and the roof slabs were made of composite structures, while for the formwork, prefabricated concrete elements were poured on-site with a second layer of concrete.

A testing time

During the execution of the concrete work, quality assurance mainly focussed on the material properties of the concrete and steel rebars used. The correct concrete recipe that satisfied the requirements of the owner, the designer and the slip-forming company turned out to be quite hard to find. The key issue surfaced in the third stage of the slip-forming process when during the 10 days required to carry out this step, the daily temperature varied considerably from 35˚C to 10˚C. In terms of the rebars used, the designer ordered registered steel in the contract but this allowed for only single samplings for yield stress and fatigue strength because the regulator had already carried out the entire test series. However, the tests carried out did not meet the requirements for single samplings so the

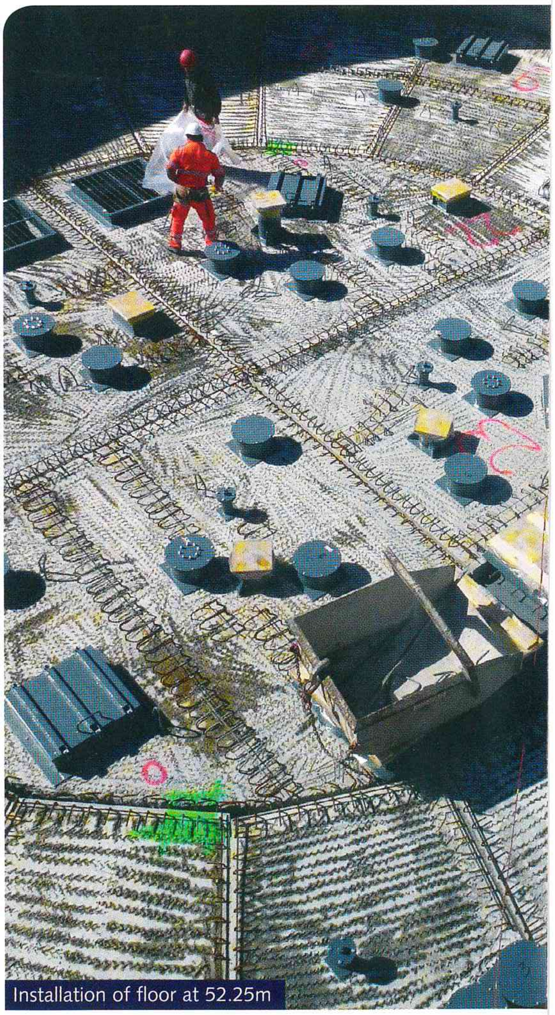
Table 1: silo facts

Piles ϕ1.2m	1120m
Concrete consumption	5500m³
Reinforcement	1050t
Equipment supplier	Ibau Hamburg, Germany
Civil contractor	Strabag, Switzerland
Designer	Wuerth Consulting Engineers, Switzerland
Site supervisor	UHAG, Switzerland
Checking engineers	P Jäger AG, Switzerland


RFEM design model


Erection during railway operation

Foundation work during winter


Installation of floor at 52.25m

entire test series had to be carried out according to the code requirements. For example, in the fatigue strength test seven samples of each diameter have to be tested and five must pass muster. While the supplied steel rebars met all code requirements, the execution of an entire verification process clearly needed more time and incurred extra expense than just the taking of single samplings.

While the contractor selected for the task only had limited experience with slip form silos, the subcontracting of excellent subsuppliers, such as Bitschnau from Austria for the slip formwork and rebar assembler Josef Christen AG, ensured the successful completion of these tasks.

Thanks to Wuerth's economic and quality design, Jura Cement now benefits from a larger storage facility as well as increased flexibility in terms of the product range it is able to offer customers. The new silo also operates with a low energy consumption, which impacts positively on the unit's running costs, and offers a safe working environment to its users. ■

The silo's cone under erection

The nearly-finished silo