# Clinker silo optimisation

State-of-the-art clinker silos have one or more discharge openings in the floor for emptying the clinker through a gravity discharge device to the conveyor in the discharge tunnel. However, in some cases bridge formation of the clinker results in considerable vibrations during clinker extraction, which over time slowly damage civil structures.

■ *by* ***Martin Wuerth,*** *Wuerth Consulting Engineers, Switzerland*

To reduce vibrations during clinker discharge as well as bridge formation and channel flow in a flat-bottomed silo (see Figure 1), László Bíró, a Hungarian engineer working in Switzerland, developed a silo table in around 1980. The idea behind this silo insert is to bring the flat-bottom clinker discharge to a mass flow and eliminate channel flow and bridging like in a cone silo (see Figure 2). While such inserts were included in some clinker silo projects, they were never seen as 'state-of-the-art'.

The silo table in a clinker silo

## Optimising clinker silos

Some time ago one client of Wuerth Consulting Engineers decided to build such an insert for its clinker silos and contacted the engineering firm to optimise this system. The target was to minimise vibrations and optimise clinker discharge. Wuerth advised the client to check the different possibilities using an experiment model scale of 1:100.

## Description of the experiment

The aim is to discharge the bulk material from the silo in a slow and continuous manner, without excessive mixing of the material. As a pan conveyor starts and stops many times, the flow inside a silo also repeatedly starts and stops. Therefore, a fast discharge flow is not desired because of the impact when it has to be stopped. Moreover, a flat surface of the product in the silo shows that there is no channel flow occurring.

When a silo table is inserted into the silo, a reduced flow speed of the bulk material and a very flat surface can be observed. These effects can also be measured using a model to test differently-shaped inserts.

In the experiment, set up by Wuerth, the company tested the following shapes of inserts:

1. no inserts (see Figure 3)
2. round table with four side openings and an opening in the table roof
3. round table with three side openings (one side closed)
4. round table with four side openings
5. star-shaped table with four side openings
6. round table with four openings and a cone on the table.

The first test was carried out without inserts, representing 95 per cent of all clinker silos.

The second test was made with a

Figure 1: silo flow and flow issues encountered

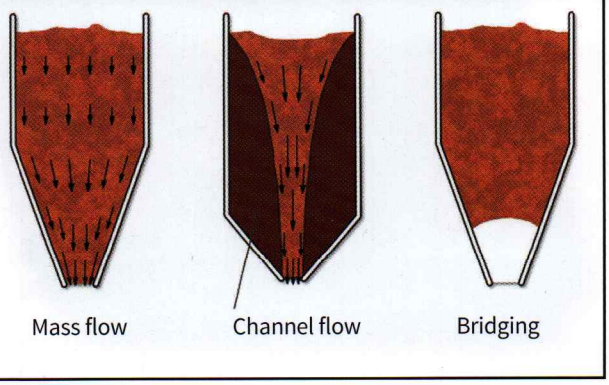


Figure 2: clinker discharge without (left) and with (right) silo table

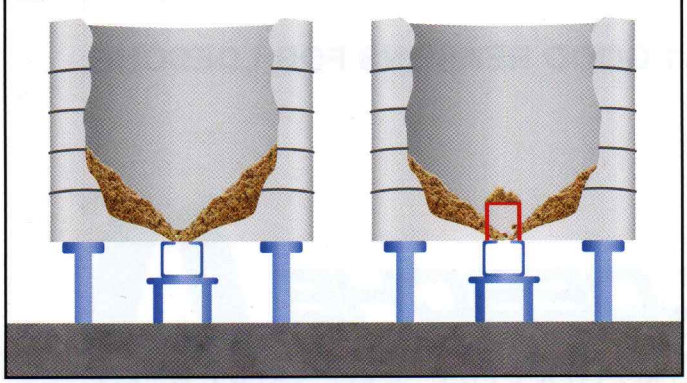

Figure 3: silo with one floor extraction (left) and the dead load after extraction (right)

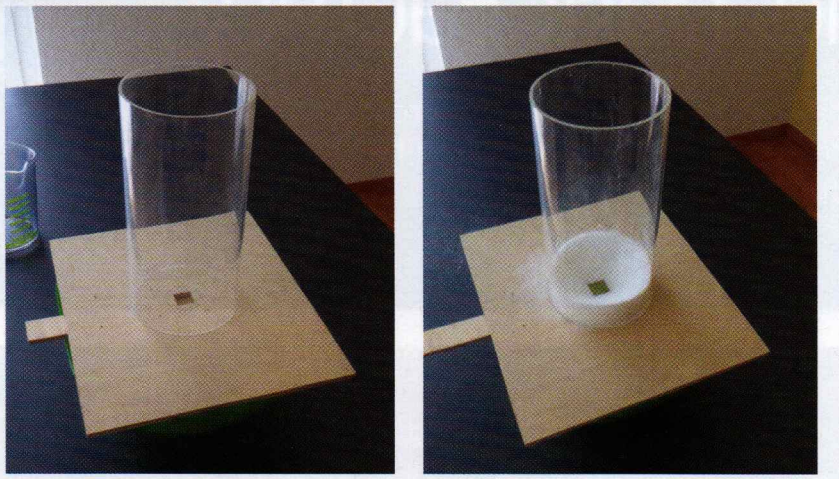

Figure 4: different shapes of silo tables were tested (L-R: round, cone, star shape) but were found to have little impact on the ease of discharge

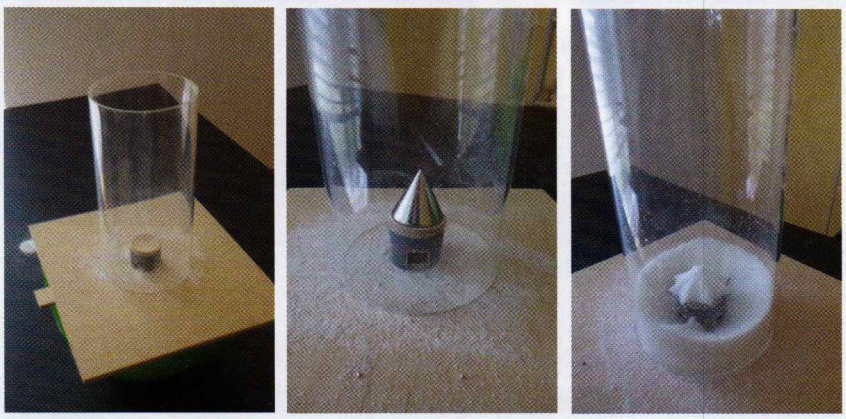

table and a table opening. The additional opening minimises the dead load part of a silo.

The third test included a table with one closed side opening. If you retrofit such an insert, there must be access from the discharge tunnel.

The fourth test included a table and four openings. This can only be built in cases where the insert has been taken into account at the beginning of a silo project.

The fifth test used a star-shaped table roof, while the sixth used a metal cone.

As clinker has a large variety of shapes and sizes, the experiment used rice and sugar. The length-width ratio of rice is ~3, while that of a sugar crystal is around 1. However, the test results showed only marginal differences in these two very different bulk materials.

In addition, the impact of the roughness of the silo wall was tested (sandpaper on wall and smooth plexiglass) and the results showed no significant impact.

However, during discharge, test measurements showed that the insertion of a silo table had a significant effect on the ease of discharge. The shape of the table itself had little effect and while a more sophisticated silo table lead to better results, the difference was marginal (see Figures 4 and 5). Therefore, the additional investment in a more sophisticated model did not result in much added efficiency.

## Conclusion

Silo tables have been used in clinker silos for more than 30 years and with consistently-positive outcomes. This experiment showed that even simple inserts (silo table) improved discharge efficiency to 90 per cent and additional investment in more sophisticated solutions is often not good value for money.

Including a silo table in the original design is the much-preferred approach as subsequent retrofits generate multiple costs.

In addition, investment costs can be further reduced by avoiding excessive safety concerns. Engineers and peer reviewers must be 'forced' into finding economic solutions. The aim of the competitive tender should be to identify the best solution, rather than the lowest cost for the assignment, and this solution-based approach may well result in lower civil works costs for the clients.

Furthermore, it is not recommended to mix engineer and peer reviewer teams. Letting the designer choose the peer reviewer ensures they speak the same language and think along the same lines, a requirement that is underestimated.

A project only needs one peer reviewer. Once the quality check has been completed satisfactorily, safety issues should have been addressed. The collaboration between the designer and peer reviewer is generally underestimated and it is important that both parties carry out the job as a team.

To reduce civil costs, they must also conserve resources as much as possible to meet their targets. ■

Figure 5: results of the experiment with different inserts and shapes of silo tables