Playing it smart

by Martin Wuerth, Wuerth Consulting Engineers, Switzerland

In today's investment-constrained world, global cement companies are looking to reduce their investment costs in terms of cost per tonne of new cement capacity and are keen to streamline the procurement process. Part of this review includes assessing the cost of civil design.

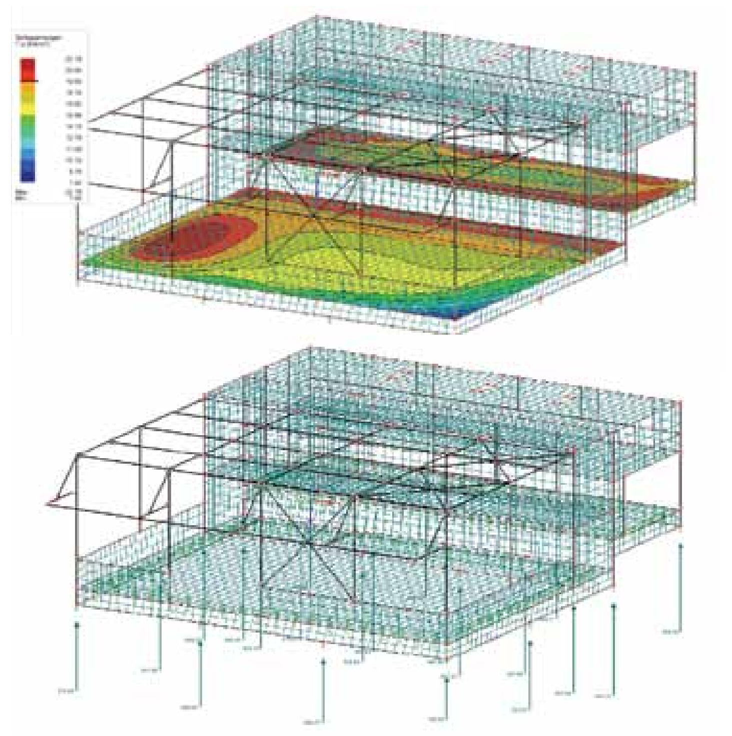

Figure 1: interaction of pile and flat foundation: soil pressure under the floor slab (top) and pile forces (bottom)

Civil engineering contributes a significant part of the costs relating to new cement plant projects. However, it has been argued that producers sometimes pay too much for the civil design of a cement plant. The reasons for behind this issue and the solutions for it generate many interesting questions, but the answers are far from simple.

One of the main reasons is the industry's preference for simple and easy civil solutions rather than innovative and economical designs. This bias can come at a 10-20 per cent civil cost premium to the plant owner.

To reduce investment costs in civil design, a project needs engineers and peer reviewers who are capable of thinking outside the box in terms of standards and codes. It requires engineers who not only know the standard issues but also understand how civil structures work in detail.

Two examples follow – both of which involve an economic design that were not accepted by the checking engineer and cost the owner more than 20 per cent of the required civil costs.

Example 1: interaction of pile and flat foundation

Bad soil conditions are expected to underlie a new building. A good, thick layer of heavily-compacted gravel is 5m below the surface. This layer is covered by a soft band of clay. The soil report gives the elastic (E) modulus for the gravel layer as 50-70MN/m^2 and 5-10MN/m^2 for the clay layer.

The calculation of pile and flat foundation interaction shows that only 50 per cent of the building load has to be taken by the piles – the other share of the load will be shouldered by the soft soil.

How is that possible?

The building's footprint is quite large. An area of such size multiplied with a very low soil pressure still gives a force which had not be founded on piles. In this example there is a maximum soil pressure of 22KN/m^2 that ultimately leads to a 50 per cent reduction of the number of piles.

Avoiding overloading the pile

Consider in the spring calculation for the piles the higher E-modulus from the soil report and the lower E-modulus for the slab. Hence, model the piles a bit harder and the soil below the slab a bit softer to reflect reality.

Why did the checking engineer not accept this solution?

According to the engineer's statement, the pile must carry the entire building load.

The settlement calculation is too difficult and too rough. The physics behind the calculation state that to carry a load, every pile must settle ($\sigma = E \times \varepsilon$). However, this settlement also generates soil pressure under the floor slab. Therefore, the discussion between the engineer and the peer reviewers should focus on the relation surrounding this mechanism rather than if this mechanism can be considered. If the engineer does not understand this relation, he will generate excessive building costs for the investor.

Example 2: buckling resistance of bulk steel silos

A turnkey contractor who had won a tender for supply and erection of a large steel coal silo contacted Wuerth

Engineering to ask for support. The project's tender document stated that the buckling resistance had to be designed according to an American standard for liquid-filled steel tanks. Fortunately, the contractor quickly realised that it is uneconomical to design a bulk silo in line with a liquids tank code. Using a proper bulk silo design according to EC standards enabled the contractor to save 30 per cent in steel weight.

Wuerth explained to the consultant the differences between liquid and bulk materials in terms of the buckling resistance of a steel shell by using a simple test with cans. Because of the internal friction of the bulk material, the internal pressure of a silo can be considered for the buckling resistance calculation (according EC 3: 1993-1-6 strength and stability of shell structures)

In this test three cans are used: the first remains closed, but the other two are opened. After the drinks are enjoyed one of the opened cans is filled with sand and the other with water. Each can is then subjected to a 100kg load. Figure 2 shows that the following happens:

- under CO_2 gas pressure, the closed can (right) does not move
- the can filled with water (left) buckles on the entire wall height
- the sand-filled can (middle) only buckles a little at the top

Again, the explanation is due to physics: the internal friction of bulk material increases the buckling resistance of the walls.

Why did the checking engineer not accept this solution?

For reasons unknown to Wuerth, the consultant had not allowed the use of the right code for this application, stating that the safety factor with a liquid design is larger than that of a bulk design.


A positive example of economic, smart design and good designer-peer reviewer collaboration: an elevated water storage tank for a water treatment plant in Iraq, supplied by a specialised company

However, the owner was very interested in the explanation and resultant design, which remained unsupported by the consultant.

Conclusion

The reduction of investment costs for new cement plants is not an utopian goal and can realistically be achieved.

To reduce investment costs, a change in attitude is required, discarding the "safety on safety" mindset of civil engineers and peer reviewers. The "keep it simple and easy" objective focusses the designer on tasks and risks rather than on economic solutions.

By creating a process that is based on competitive solutions rather than competitive fees, one can effectively reach lower civil work costs for the client.

Futhermore, by not mixing engineering and peer reviewing teams and allowing the designer to choose the peer reviewer and vice versa, one can avoid "safety on safety" mentality. The designer and checker have to speak the same language and think along the same lines. In addition, the project requires only one peer reviewer who understands the design of your detail engineer. After this, the quality check is complete and safety guaranteed.

The collaboration between 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, it is important to conserve as many resources as possible and allow for their properties in a well-considered manner, moves which often take courage and assertiveness.

Figure 2: (l to r) can filled with water, can filled with sand, empty can