

New silo shell to upgrade your old silo for the next generation

Martin Wuerth (Wuerth Consulting Engineers) discusses a silo repair method which has after execution a lifetime of more than 30 years.

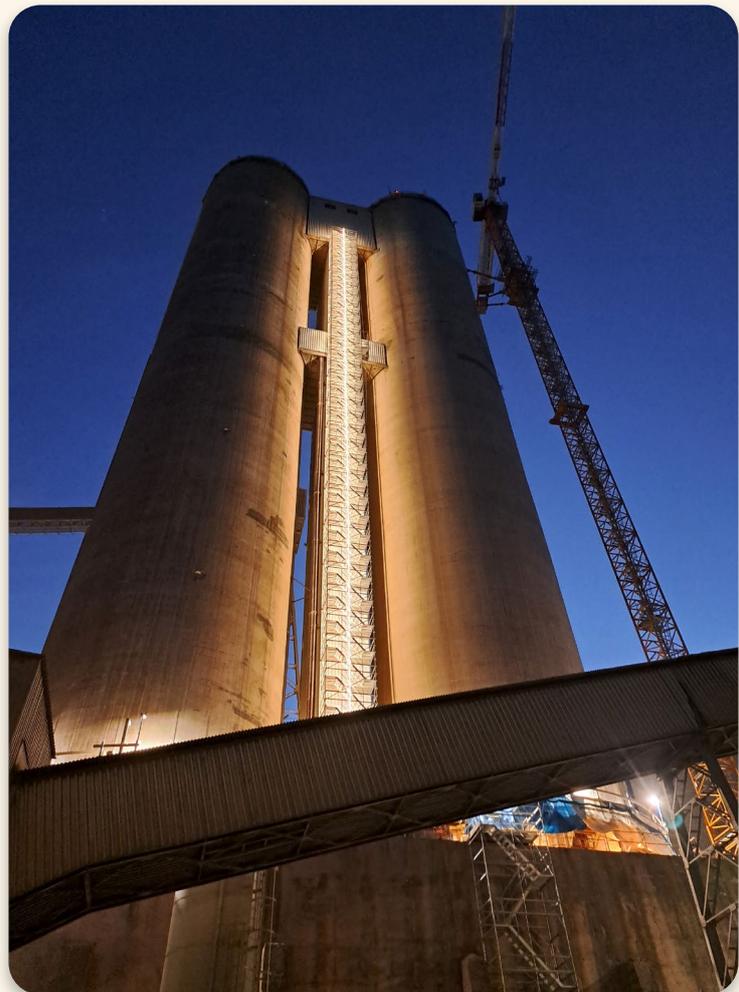
Introduction:

Every single building has a service lifetime. If you don't manage them, one day this time is running out and your structure will collapse. In percentage, silo structures collapse three times more often than bridges or all other civil structures and this phenomenon is to watch worldwide. Even very sophisticated structures like soccer stadiums, bridges and sky scrappers are safer buildings than silos!

There are two main reasons for that:

First: The live load of a silo is approx. 90 % of the total load, the live load of a bridge or building is less than 50 %. In other words, a silo structure is used much more at the service limit than other buildings.

Second: Maintenance is different. buildings & bridges are used by people. People often detect cracks and corrosion in an early stage. Public or private buildings are also observed by facility managers which take care on their buildings. Who is taking care of silos in a cement plant? Nobody, as long as your equipment is running, everything is all right. Maintenance budgets were shortened, and silos are not priority because they made no problems in the past decade.



Old silos before repair

Definition of service lifetime:

This is the time which the rebars & post tensioning can hold back the bulk material inside a silo.

Bad concrete quality, high and low temperature, acid rain, wrong design or corrosion will limit the service lifetime.

A proper concrete layer over the rebar overlapping make sure, that the tension force in the rebars can be transmitted between one rebar to the other. The chosen concrete cover is not only important for this transmission, the concrete cover is also important for the protection of the rebars from acid environmental influences.

One important item to calculate the remaining service lifetime is the depth of carbonation in the concrete cover. Carbonation is the zone of concrete at the surface which has changed from naturally base to acid. Air pollution, salt water and acid rain are speeding up this procedure.

If the carbonation zone is reaching up the rebars, the steel starts to corrode until there is no iron left.

Depending on the results of the investigation, the remaining service lifetime can be calculated and estimated.

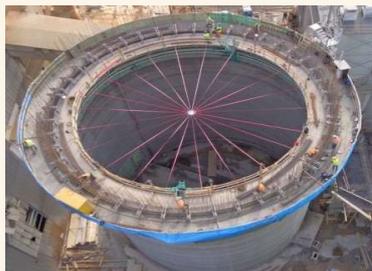
In average the carbon depth of a 50-year-old concrete surface is around 20 mm, because this 20 mm was also used in the past for the concrete cover of the rebars, the lifetime of old silo structure is limited to 50 years in average.

This process is easy to detect because after the carbon dept reaches the rebars, the rebars are not protected anymore and start to corrode. Because corroded steel needs more space, the concrete cover will flake off. This is the moment anybody can see that the condition of that structure will be limited...

What kind of repair solution is required?

If the owner is not satisfied with the calculated remaining service lifetime, the structure must be reinforced. For the repair concept, the results from the design analysis and the concrete cover & carbonation depth are required. If the design analysis is not to satisfaction, the rebars must be reinforced in combination with a concrete repair solution or without.

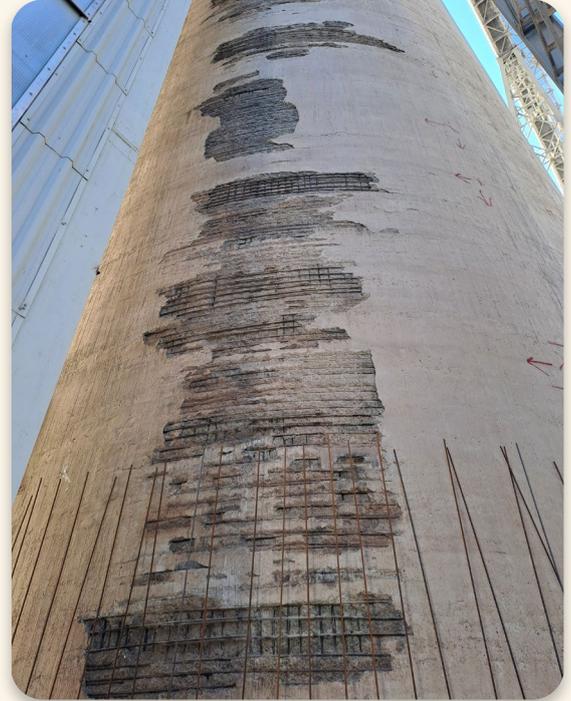
Not only the condition of your existing silo is important to select a repair concept, but also the height of a silo is important to choose the most economic concept. A traditional soft repair with hydro jetting the concrete surface and sandblasting the corroded rebars and backfill the missing concrete cover with modified mortar or shotcrete has a limit in height. The costs for scaffolding, hydro jetting as well as for sandblasting increase with height squared. Up to a height of 25 m, a soft repair is cheaper than a new shell. Over a silo height of 35 m, a new shell is cheaper and much quicker than a soft repair. For a height between 25 and 35 m it is worth checking on the local market, what solution is more economic.

soft repair	new shell (Reinforced)	new silo
service lifetime 10 - 15 years	service lifetime 25 - 35 years	service lifetime > 50 years
civil costs approx. 15 %	civil costs approx. 30 %	civil costs 100 %
		

Repair overview

New shells for homosilos in Turna (Slovakia):

Danucem Slovakia ask Wuerth Consulting Engineers for a repair concept of their unusual two 105 m high homosilos build around 1965 in Turna, East Slovakia. The condition of the silos after running the plant over 60 years were as follows:



View on Homosilo in Turna (Slovakia)

Just a short view on the outer concrete surface of the shell (see pictures above) and it is obviously that the silo has some major safety problems:

- Concrete cover flaked off
- Rebars are corroded
- Rebar overlapping was made without end hooks and without the concrete cover, the rebar anchoring for tension forces is not given anymore
- Rebars where not bended and joints have no offset (->zip effect)

The design recalculation of the silo shell based on the current silo codes showed also that the safety factor against shell collapse during operation was below 1.0 instead of 1.5 – 1.75! Because the owner decided years before only to use the storage silo up to a filling level of 50 % a collapse did not happen.

The reduction of the safety factor was based on the corroded rebars, the missing concrete cover for the rebar overlapping joints as well as the “new” code regulation for the load case discharge bulk material.

The client must use these homo silos for the clinker production. Kiln shut down for more that 2-3 weeks during wintertime is not possible. In summertime the plant is running 24 hours by 7 days a week.

The client checked out a location next to the existing homosilos to build new ones and send the raw meal later on over these new homosilos. In theory everything was perfect with this replacing project but the costs for such a solution came to 10 million Euros more than a heavy silo repair! This circumstance made it easy for the client to decide to add new shells on the existing silos to use them for the next 25 to 35 years.

A soft repair with mortar was not adequate because of the height of the silo (scaffolding costs) and the fact, that the structure must be reinforced to full fill the current codes (safety factor > 1.50) and the several structural imperfections.



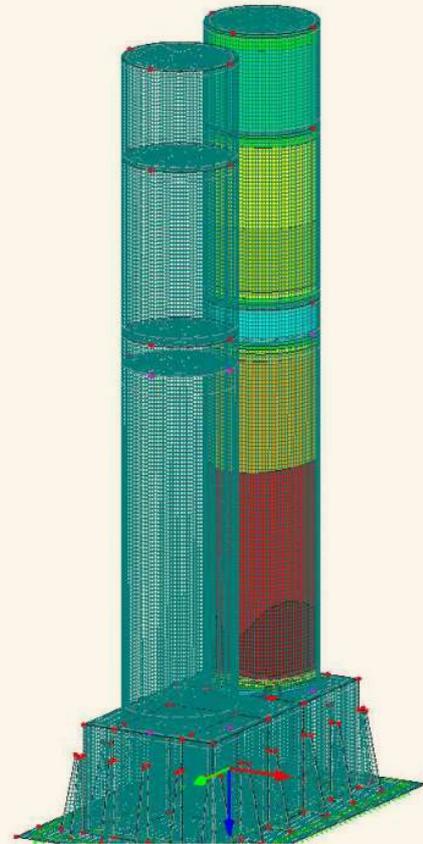
Silos during slipform procedure

A redesign of the silo structure was required to calculate the reinforcement in the new shell as well as to check the foundation if this has been reinforced or not according to the additional dead load weight of the new shell.

The execution of this silo repair took 4 weeks for these two very high silos plus lead and follow up time of approximately one month. Start of slip forming was September 1st and slip form finish is foreseen for the end of September 2025.

The idea to add to the old silos a second shell outside (or inside if required) is simple and easy but there are a lot of problems to realize such an idea! The main problems to solve are the deviations of the existing silos and the available space around the silo.

Because slipform work 60 years ago was different to the one we have today and the fact, that the procedure of a one-sided slide platform (slipform) is technically very sophisticated makes such a job to a professional task!



3D model with intermediate platforms

The new shell made by a quite stiff formwork (required because of only one-sided scaffolding platform) must follow the existing deviations in vertical and circumferential direction made many decades before with a flexible formwork system fixed in the centre of the silo circle by cables.

The slipform procedure needs cleared space around the silo structure. What to do with existing platforms, supports, nearby columns and pipelines? This is the main target for the engineering team to find easy and possible solutions for these questions. Understanding the process of slip forming with one-sided platform formwork is the main key for a successful project implementation.

The numbers of engineers and slipform contractors for such projects are limited on the market but because they have together only around 15 to 20 % of the contract value, the local market with different civil contractors can still compete and will bring the client in a good position for negotiation.

Conclusion:

Many cement producers are in the situation that they had to replace or repair old silos but need them for production. Space nearby the production line is not available for a new building and transport the bulk material away & back is expensive and the investment costs for the civil and equipment part is high.



In just 2 to 3 weeks, you can change the status of your silo from old to new and this under fully operation your plant!

Retrofit your old silo structures with a new shell can solve your problem quick, cheap and does not disturb your production capacity. With such an investment you can operate your old facilities



Looks easy, but this is a task for professionals to handle all the obstacles!

safe and easy for the next 25 to 35 years. Just a fraction of the costs you must invest to operate your silos for the next generation instead of building new facilities.