Learning Brief

Organisational Learning New Nuclear Build

Silo Structural Failure and Collapse

Hinkley Point C **SELMA no.: SAEI-41324** **10 June 2020**

A Ground Granulated Blast-furnace Slag (GGBS) silo collapsed suddenly and without warning, while not in operation. Failure of the structure occurred from the overloading of a bolted joint. The cause of the overload was made possible by the inadequate design of the silo.

What happened and why?

At 07:04 on 10th June 2020 at the Hinkley Point C (HPC) construction site, a 5,000-tonne silo containing GGBS for use in making concrete collapsed suddenly and without warning. Nobody was injured in this event, the silo being in a dormant state at the time, with operations scheduled to begin at around 07:30 on the day.

The silo was erected in June 2018 as a temporary works structure used in construction and was not a permanent part of the power station. The silo was of a bolted design with welded flanges, as opposed to lap joints. The main cylinder was installed in five ring sections, each three panels in height (28 individual panels per ring). The cone/hopper section was manufactured in three sections; a transition section (18 panels) and upper cone/lower cone sections (36 panels each).

The panels were specified as 15 mm thick for the cone and lowest cylinder ring section and 10 mm thick for the remaining four uppermost cylinder ring sections. The panel flanges were made with a 6mm throat thickness single-sided fillet weld on the outside of the panels. No welds were specified on the inside of the panels. M18 gr8.8 structural bolts joined the cone and cylinder panel flanges together.

During operation, the silo had been constantly topped up to notionally full over about one year and was holding some 4250-tonnes of GGBS at the time of failure. The silo had not been operated for a period of 10 days prior to the failure. There is no evidence that the silo had been operated in a manner that was outside of its intended design parameters or was misused in any way.

There are no other silos of similar size and construction to this one at the HPC site.

A detailed investigation has been carried out, focussing on three aspects; namely the silo design, its operation and any possible degradation. This was completed by EDF in conjunction with the silo operator (Bylor), with involvement of representatives from third party insurers and specialists in the fields of forensic metallurgy, silo design/ construction and bulk solids handling. The investigation concluded:

- Collapse of the silo occurred by mechanical overload (structural failure), most likely of a vertically aligned bolted joint in the cone section. Damage to the cylinder section of the silo was considered to be consequential damage, caused by the rapidly descending material which resulted in vacuum collapse of the roof and a related overload of the lower cylinder section.
- The cause of the mechanical overload was considered to be directly related to an inadequate design of the silo, particularly in relation to the bolted joints.
- The silo design lacked staggered joints that may have limited the spread of damage or collapse from foreseen or unforeseen loads and improved the structural robustness of the design.
- Changes in temperature (differential thermal ratchetting or racking effects) over the preceding days is considered to have generated an increase in load on the silo that directly contributed to the failure.
- The degree of variation in the mechanical properties of the structural bolts could mean that a significant number of bolts may not have met the specified minimum strength grade requirement.

What should YOU do now?

For silos of a bolted construction with welded flanges:

- Consider reducing the fill level of the silo regardless of whether the silo has been operated at full, or near full, conditions for an extended period.
  The maximum fill level should ensure bolt loads are below the allowable design strength with an appropriate margin of safety.
- Review design calculation dossiers to ensure adequate margins of safety, especially in bolt calculations.
  The design load envelope and structural strength assessment techniques should be understood, cover variations in the stored material characteristics and accurately predict the structural behaviour, with supporting validation.
- Identify if the silo joints are potentially susceptible to progressive failure.
  A silo incorporating design features, such as vertically staggered joints, provides increased robustness that may halt progressive damage or collapse, adding margins of safety.
- Check the structural bolts supplied comply with standard requirements.
  Independent verification should always be considered of the test results and material analysis from the manufacturer to ensure the bolts match the certification supplied with each batch, especially if close to lower limits.
- Carry out a visual inspection of the silo to identify any areas of concern.
  Dust emissions could suggest a poorly tightened or strained joint.