



Inspection, Design, and Execution of Remedial Works for **Silos, Storage Tanks and Bunkers**

PENTA has significant experience in the inspection and rehabilitation of material storage structures. Our staff combines its experience in silo, bunker and bin design with our know-how in defining and performing the required remedial works.

PENTA has developed a systematic approach which ensures the safest and most economical solution.

1. Visual Inspection and laser scanning
2. Detailed Inspection and testing as required
3. Remedial Works, oversight, and quality control

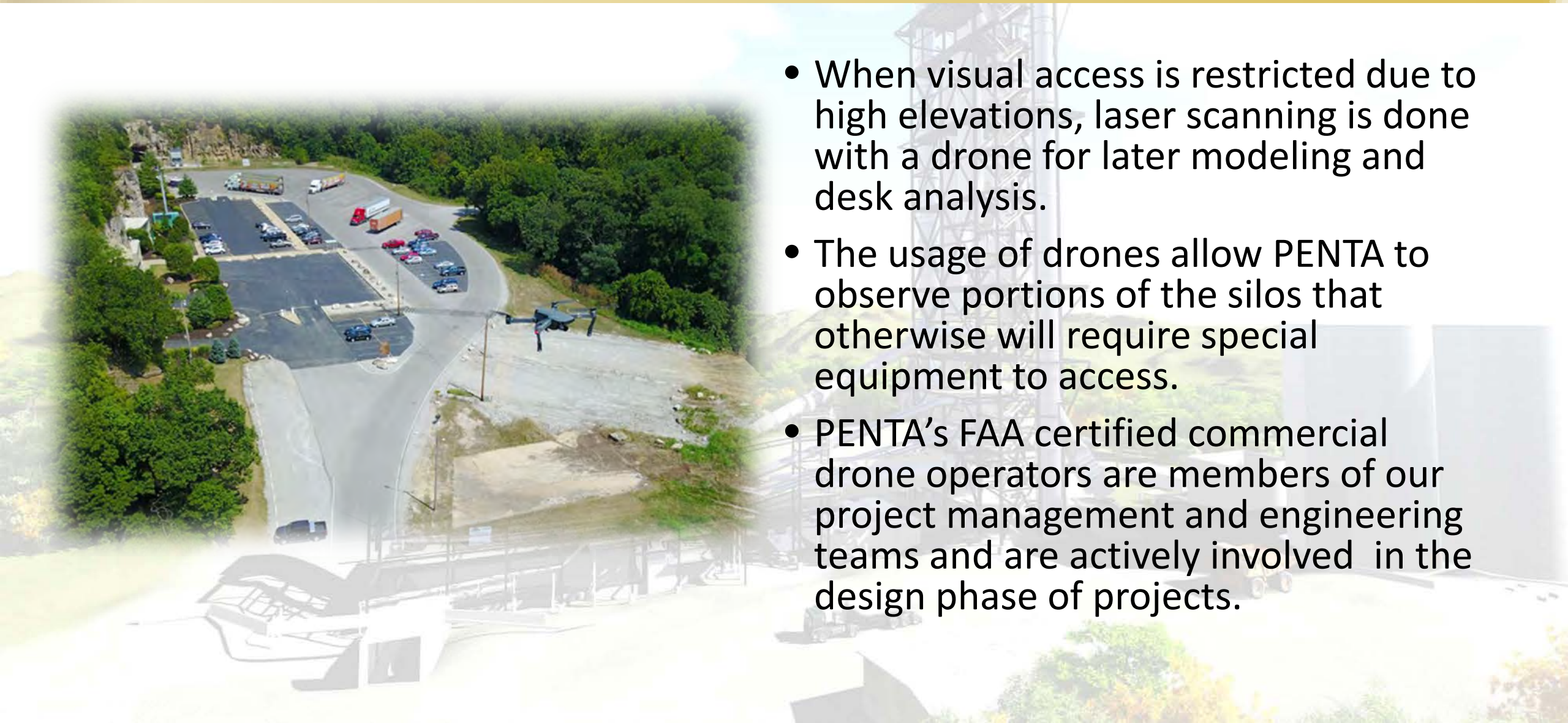


STEP 1 – Visual Inspection of Structures

1. Visual Inspection by a Sr. Structural Consultant of conditions identified by plant personnel.
2. Initial assessment of the condition of structurally critical areas.
3. Special attention to signs of structural distress.
4. Report with findings and recommendations for follow-up work if required.



STEP 1 – Visual Inspection of Structures



- When visual access is restricted due to high elevations, laser scanning is done with a drone for later modeling and desk analysis.
- The usage of drones allow PENTA to observe portions of the silos that otherwise will require special equipment to access.
- PENTA's FAA certified commercial drone operators are members of our project management and engineering teams and are actively involved in the design phase of projects.

STEP 1 – Visual Inspection of Structures

Based on the recommendations made in the Visual Inspection Report and the Client's preference:

- If the structure does not exhibit signs of structural distress, but surfaces show signs of moderate deterioration, monitoring by periodic visual inspections is recommended.
- If the structure does not exhibit signs of structural distress, but surfaces show signs of significant deterioration, detailed inspections and testing is recommended. A CapEx is developed for all required work, including for destructive and non-destructive testing of the structures.
- If the structure exhibits signs of structural distress, immediate remedial works are recommended, a program is presented to the customer for the work required for the structures to operate safely.

STEP 2 – Detailed Inspection

An in-depth assessment of the condition is performed:

- Core samples are obtained for testing, as well as chipping surfaces and sounding them to detect areas affected by spalling.
- Reinforcement mapping is performed on sample areas of the structures to define the level of deviation from the design drawings.
- A more detailed 3D scan is done as a base to generate the repair drawings.



STEP 2 – Detailed Inspection

- The information from the detailed inspection and results from different tests are gathered and used for the structural assessment of the state of the structures.
- Since many silos were built 50 or more years ago, PENTA will do the assessment against the provisions from the original design code and then against the current design code.
- With this knowledge, PENTA will develop a CapEx for the remedial works associated with bringing up the structures to meet the requirements of the original code and also the cost to upgrade the silos to the current design code.
- The findings of the detailed inspection are presented in a comprehensive report, with a CapEx for all recommendations.

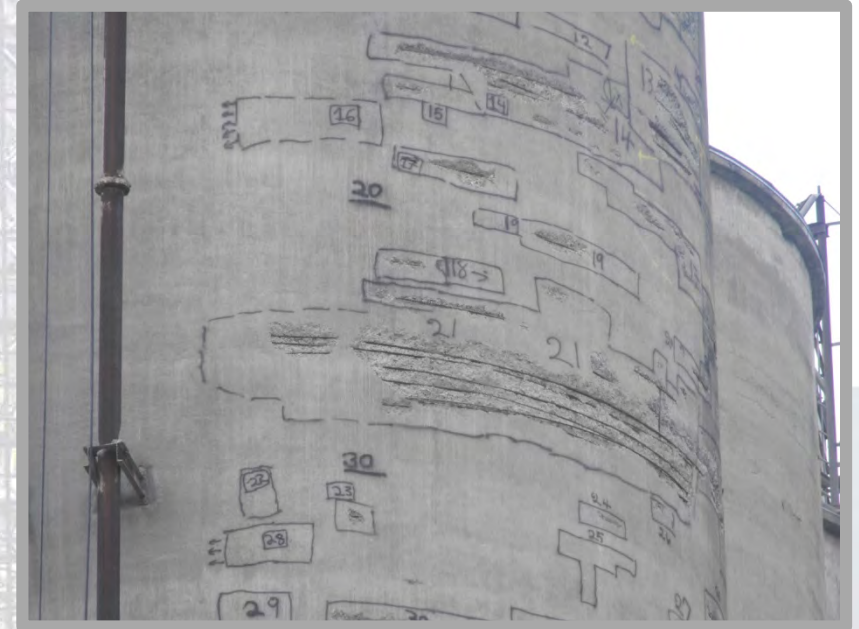


STEP 3 – Remedial Works



- Develop detailed design of the remedial works. Mobilize sub-contractors to the site.
- Supervision by experienced construction managers supported by the engineering team.
- Design engineer periodic inspection of the work to ensure adherence to design documents.

Silo Repair Experience Example



Detailed Inspection of a group of silos.
Identification of areas with spalling concrete
that had to be removed.

Silo Repair Experience Example

Loose concrete being removed with mechanical means and water blasting



- Based on the assessment of the existing rebar, structural engineers calculate the required additional reinforcement.
- The new rebars are anchored to the existing concrete and work as an independent layer of reinforcement or mechanically coupled with the existing bars if only local replacement is needed.

Silo Repair Experience Example



After the installation of the new reinforcement, 4 inches of shotcrete are applied to seal the walls.



Silo Roof Beams' Pockets Repair



Many silos have issues with their roof beams pockets. Due to the nature of the roof slab/steel beams system, there is a lot of thermal movement which leads to deterioration of the beam wall pockets. In these cases, a visual inspection of the silo pockets that need further attention is performed.

Silo Roof Beams' Pockets Repair



- The silo roof beams pockets are opened and, based on the findings, the best approach for remediation of the issues are recommended.
- Engineering develops detailed design and works with the construction manager to ensure that the site work is done in accordance to the design drawings.
- The beam pockets are restored to meet the requirements established in the design.

WHY PENTA?

- 30 plus years of Engineering, Procurement, and Construction Management.
- High expertise in structural design.
- Self-performed 3D Scanning from ground level and drone operation.
- Strict Quality and Document Control



THANK YOU

We look forward to supporting your continued success

