



SINTEF



Powder Storage- Silo & Hopper Design

Powder storage in silos is a common method for storing and handling powders and particulate materials. Silos are tall, cylindrical structures made of steel or concrete that are designed to hold large quantities of powders. Correct silo design is critical to achieve stable operation and good quality of the stored material.

Some of the key factors that must be considered in silo design include the material's flow characteristics, the silo's shape and size, and the material's properties, such as particle size distribution and mechanical properties. Figure 2 shows some examples of the operational challenges that can occur. Other challenges may include caking, segregation, or moisture migration. Proper design procedures, maintenance and monitoring can help mitigate these challenges and ensure safe and efficient silo operation.

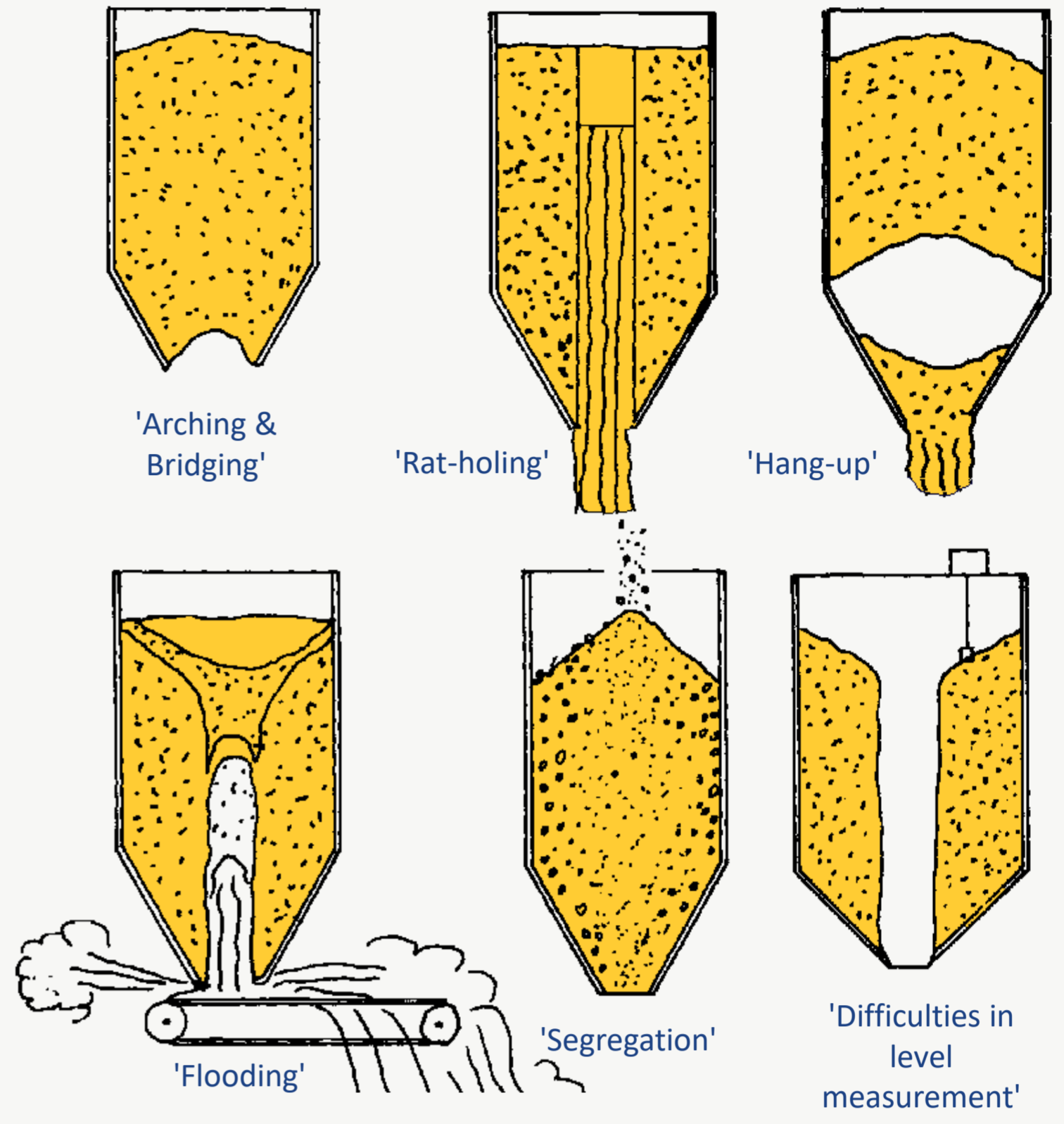


Figure 2: Typical silo operational challenges and problems. Bridging or rat-holing are two examples which can impede material flow and cause structural damage to the silo.

Mass Flow vs. Funnel Flow

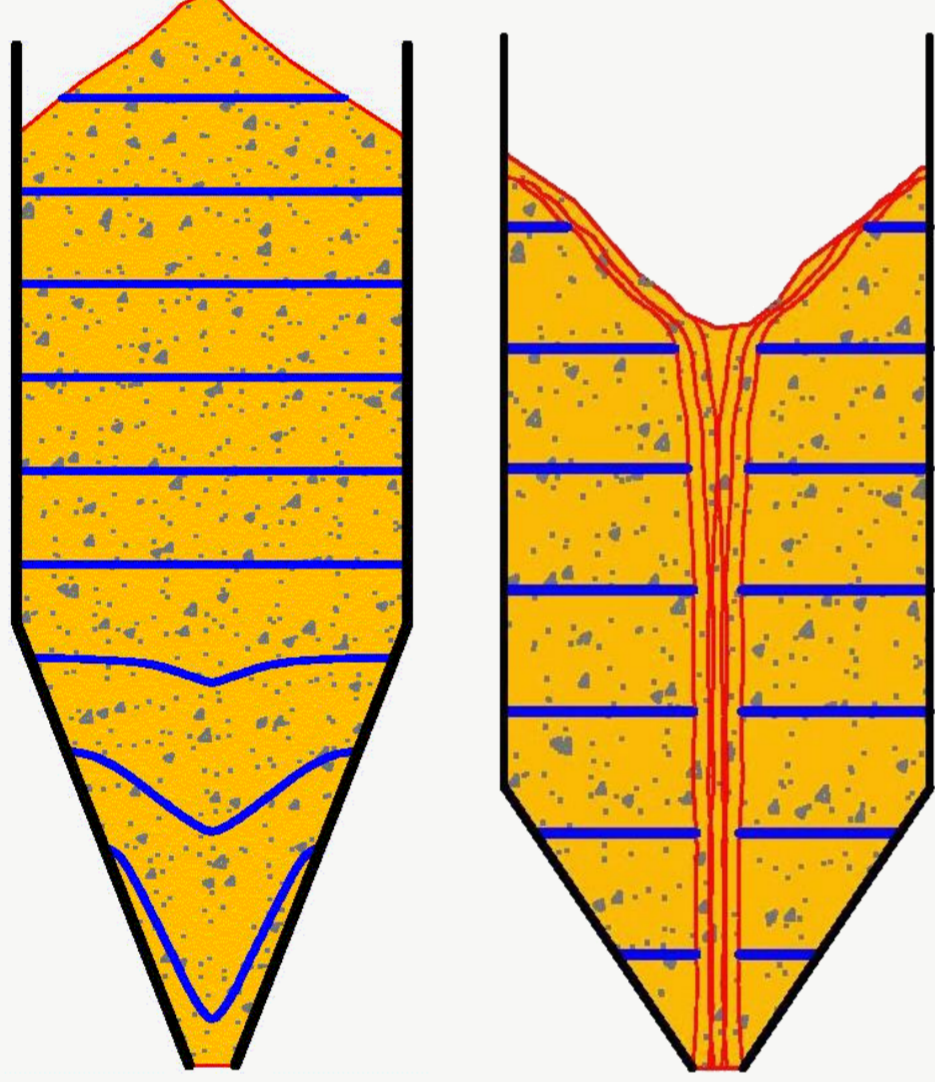


Figure 3: Mass flow and Funnel flow silo configurations. Andrew Jenike and Jerry Johanson at the University of Utah, Salt Lake City, (1952 – 1962) made the pioneering work, introducing and explain the silo discharge patterns

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|---|--|
| <ul style="list-style-type: none"> + First in – first out + No segregation + Reliable, even flow + No flooding + Constant bulk density + Simple level control - Wear of silo walls - Tall hopper (space restrictions) - Usable for one type of powder - More expensive to built | <ul style="list-style-type: none"> - First in – last out - Segregation - Unreliable, uneven flow - Flooding may occur - Varying bulk density - Difficult level control + No wear of silo walls + Low hopper + Usable for many types of powder + Cheaper to built |
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Calculation of critical parameters for silo design includes calculation of hopper inclination and outlet dimensions. The wall material selection must also be included in the evaluation. Insert in the outlet region could also be needed to convert funnel flow silos to mass flow silos

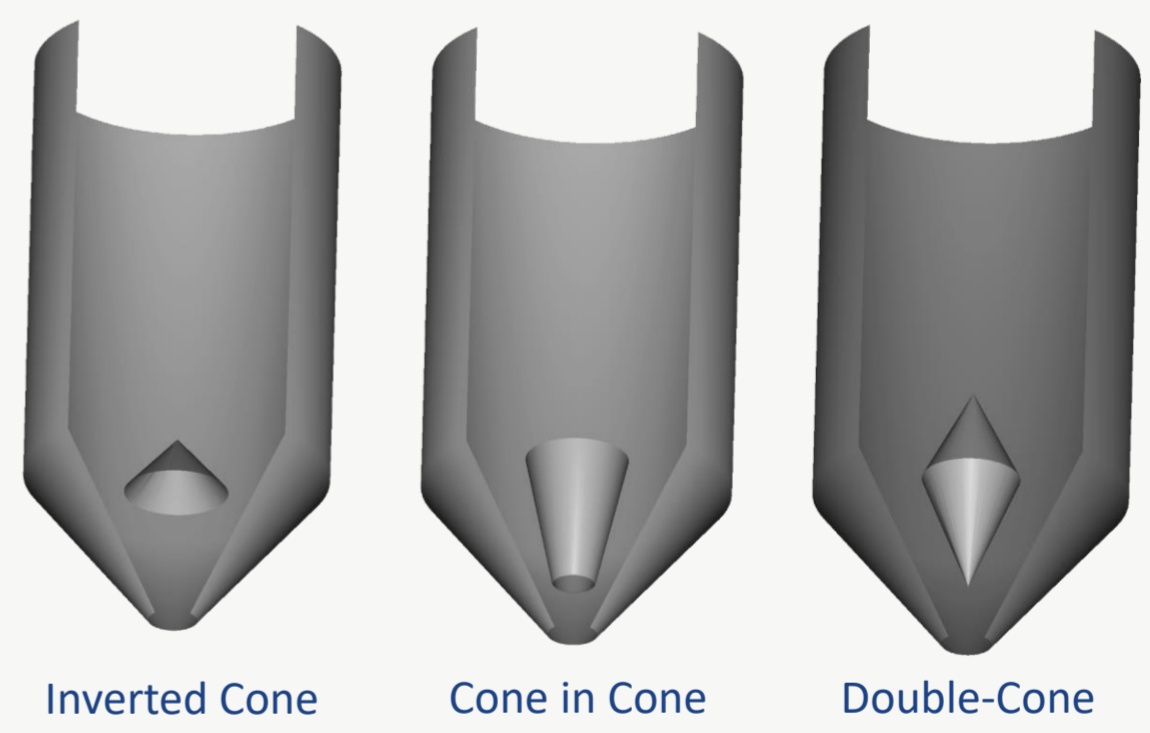
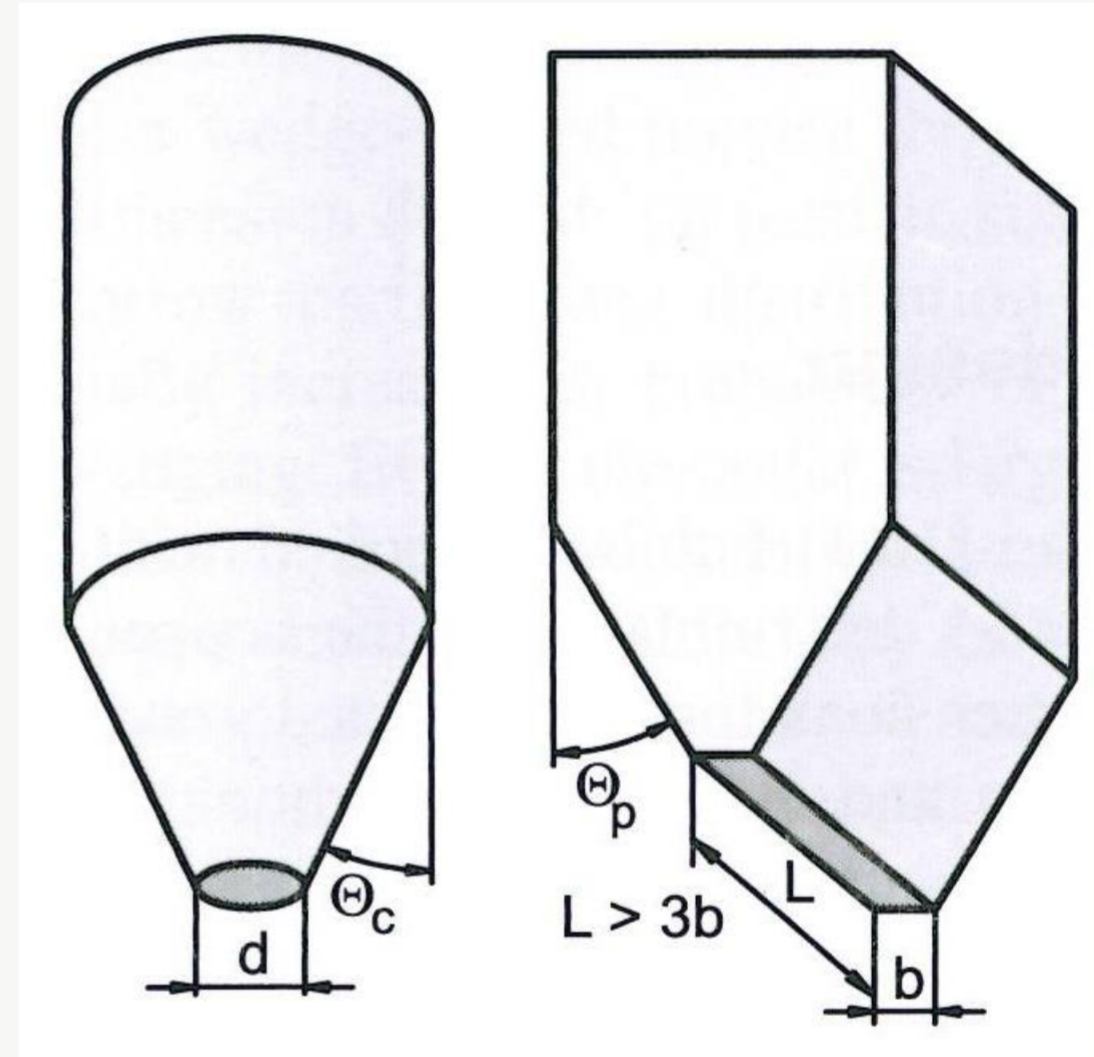
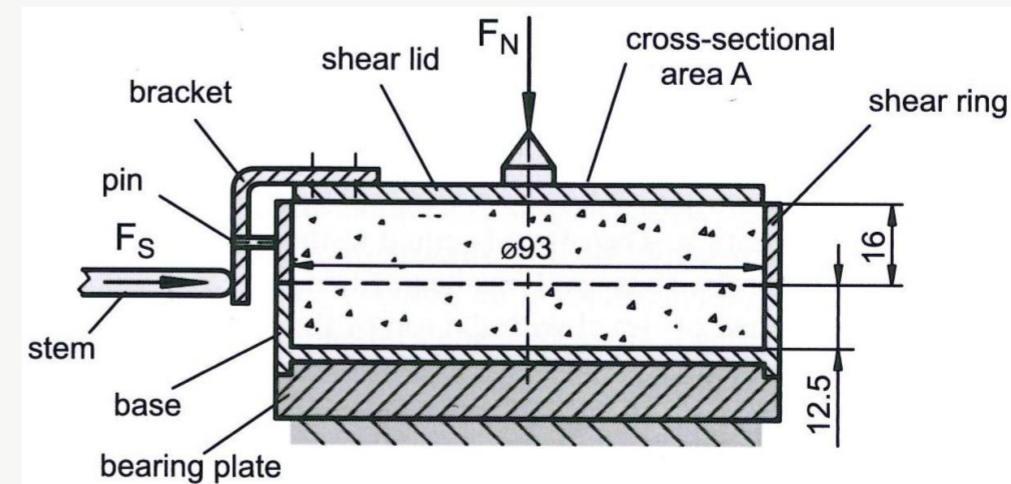
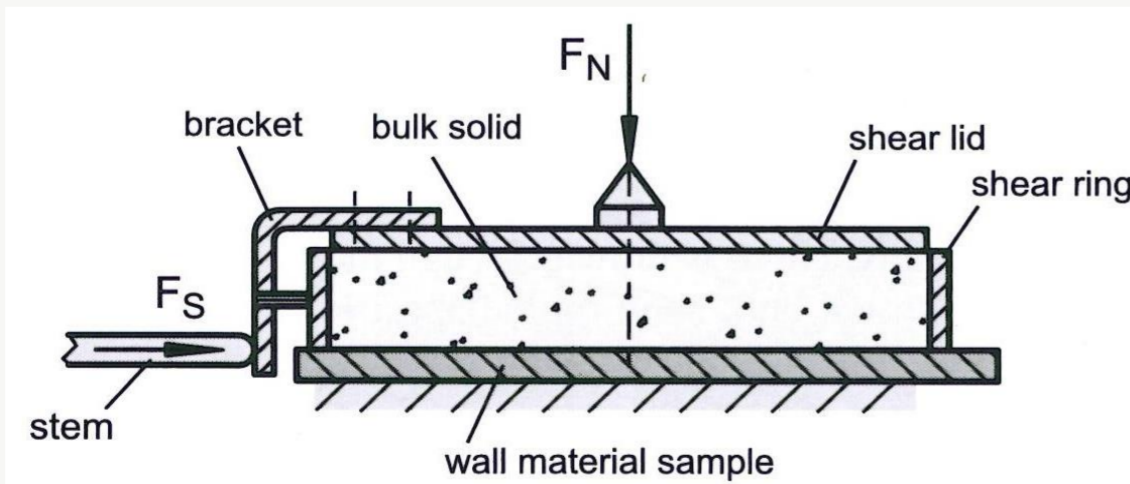


Figure 4: Use of inserts to convert funnel flow to mass flow

✓ Wall Friction



- ✓ Internal Friction
- ✓ Cohesion
- ✓ Compressibility
- ✓ Bulk Density

Figure 4: Jenike Shear tester. A scientific approach to design of silos for reliable discharge

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