An Opportunity for Improvement: Batch Feed System Retrofit at Verallia Milford

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Outline

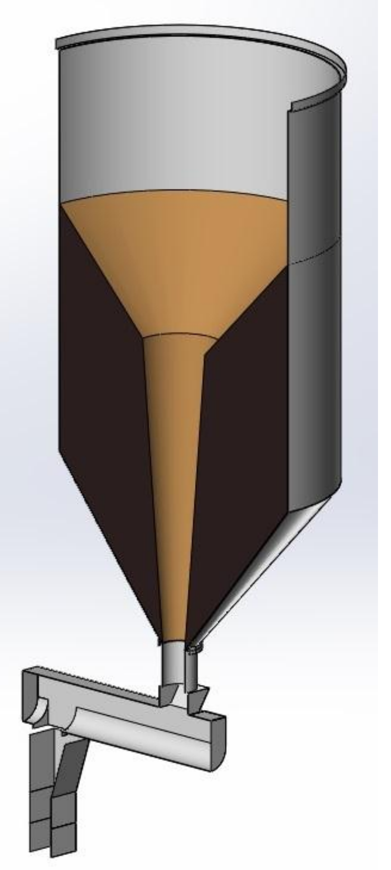
- Motivation
- Assessing material flow
- Flow patterns
- Flow properties and tests
- Furnace feed system design development
- Implementation during rebuild

Motivation

- Planned rebuild in late 2010 of amber glass Tank 15 at Verallia plant in Milford, Massachusetts, which typically runs 85% cullet.
- Rebuild would involve the conversion of the furnace to oxy-fuel firing, as well as end port feed of batch instead of previous side port feeding.
- Due to anticipated time and effort required for repositioning, the bins were to be left in their current (furnace side) locations.

Motivation

- Frequent flow interruptions from the batch bins were an ongoing concern. Hardened chunks of material were plugging the outlets. These were generally cleared quickly, but several times a year significant maintenance efforts were required to re-establish flow.
- Use of a charger hopper with a level control sensor resulted in frequent stopping and starting of the wetting screws (which controlled bin discharge).



Assessing material flow

"*Flowability*" is an observed behavior, and a function of the material AND the equipment:

- "Poor flowing" material can be handled easily in properly designed equipment
- "Easy flowing" material can present flow problems in poorly designed equipment

Common flow problems

Arching

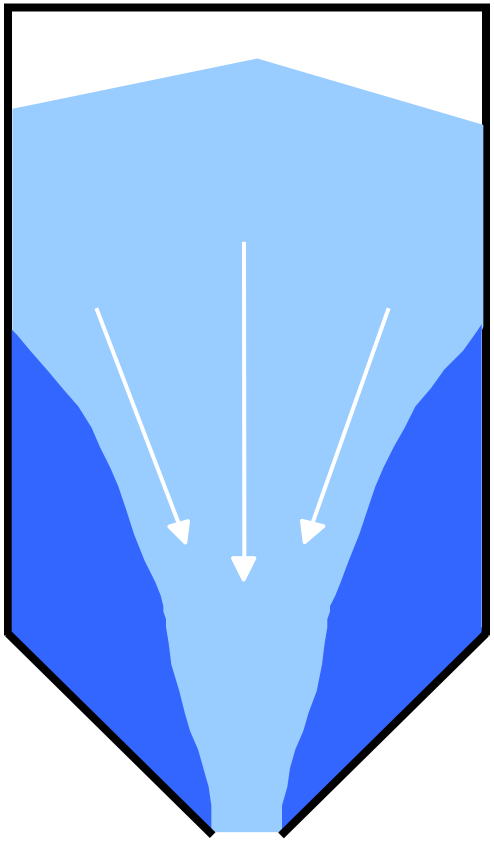
Ratholing

Fill and discharge sequence: Flow patterns in hoppers, bins

- Funnel flow
  - Some material is in motion while the remainder is stagnant
- Mass flow
  - All material is in motion whenever any is discharged
- Expanded flow
  - Combination of mass flow and funnel flow, designed to prevent ratholing

Funnel flow

- Features
  - *First-in, last-out* flow sequence: material at walls discharges last
  - Segregation often made worse
  - More likely to yield flow problems, such as ratholing
  - Most common



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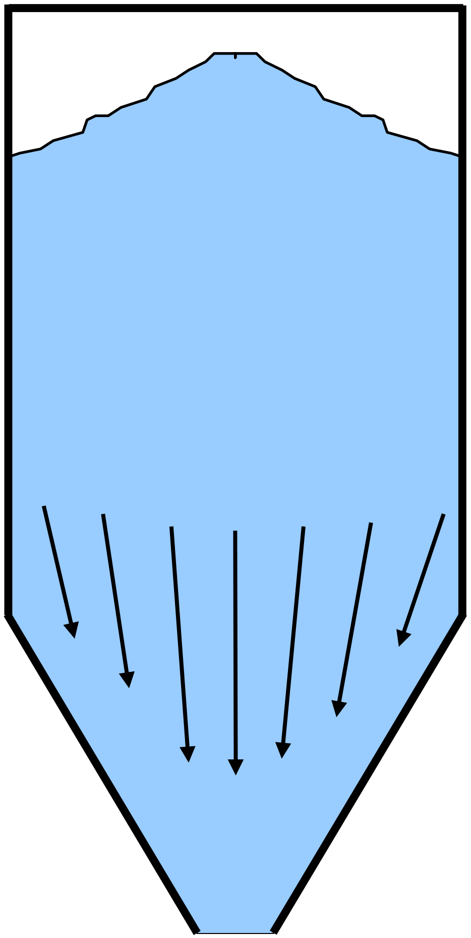
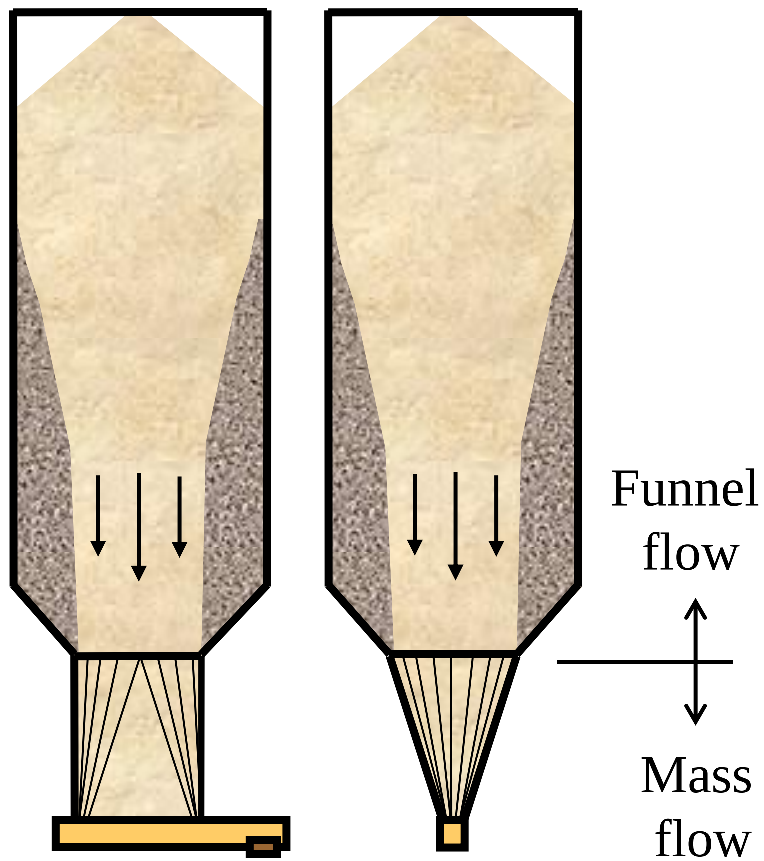
Mass flow

- Features
  - *First-in, first-out* flow sequence: material moves as a mass
  - Flow along hopper walls required
  - Flow problems typically minimized, ratholing eliminated
  - Segregation *generally* minimized
- Hopper angle & outlet size limits can be determined through testing



Expanded flow

- Features
  - Mass flow in lower hopper section to prevent ratholing
  - Headroom savings by use of funnel flow in upper hopper section
- Critical juncture (size) between mass flow and funnel flow sections can be determined through testing



Measuring flow properties

- Many techniques available:
  - Angle of repose
  - Compressibility Index (Hausner Ratio)
  - Flow through an orifice
  - Shear cell methods

However, these methods do not provide the level of detail needed to base equipment designs on

- Shear cell methods are proven and repeatable:
  - Provide engineering data that can be used as design criteria
  - ASTM and other international standards covering

Flow properties tests

- Use lab-scale, shear cell tests to predict what will happen at the manufacturing scale:
  - Avoid arching and/or ratholing,
  - Ability to achieve mass flow, etc.
- Quantified, absolute dimensions/angles
- ASTM Standard:
  - D6128 Direct Shear (Jenike)

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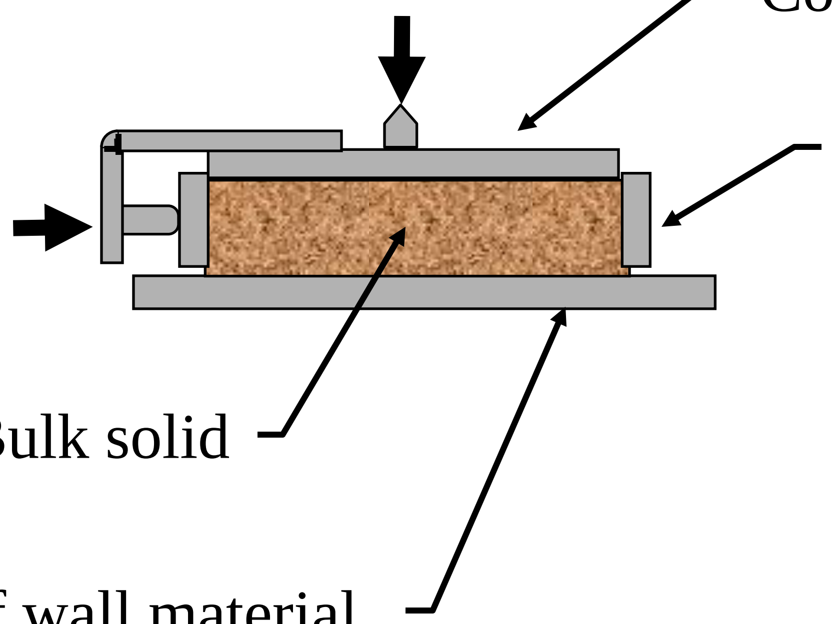
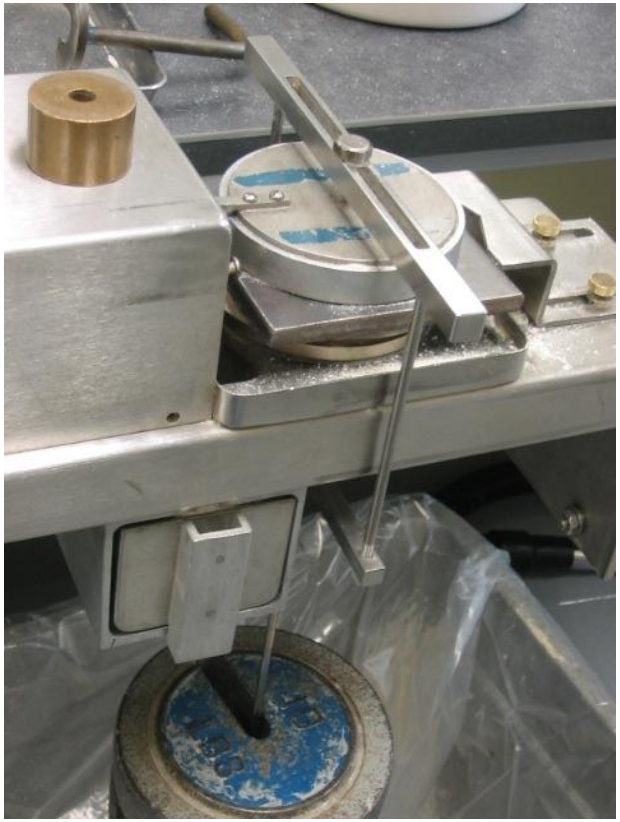
Wall friction test



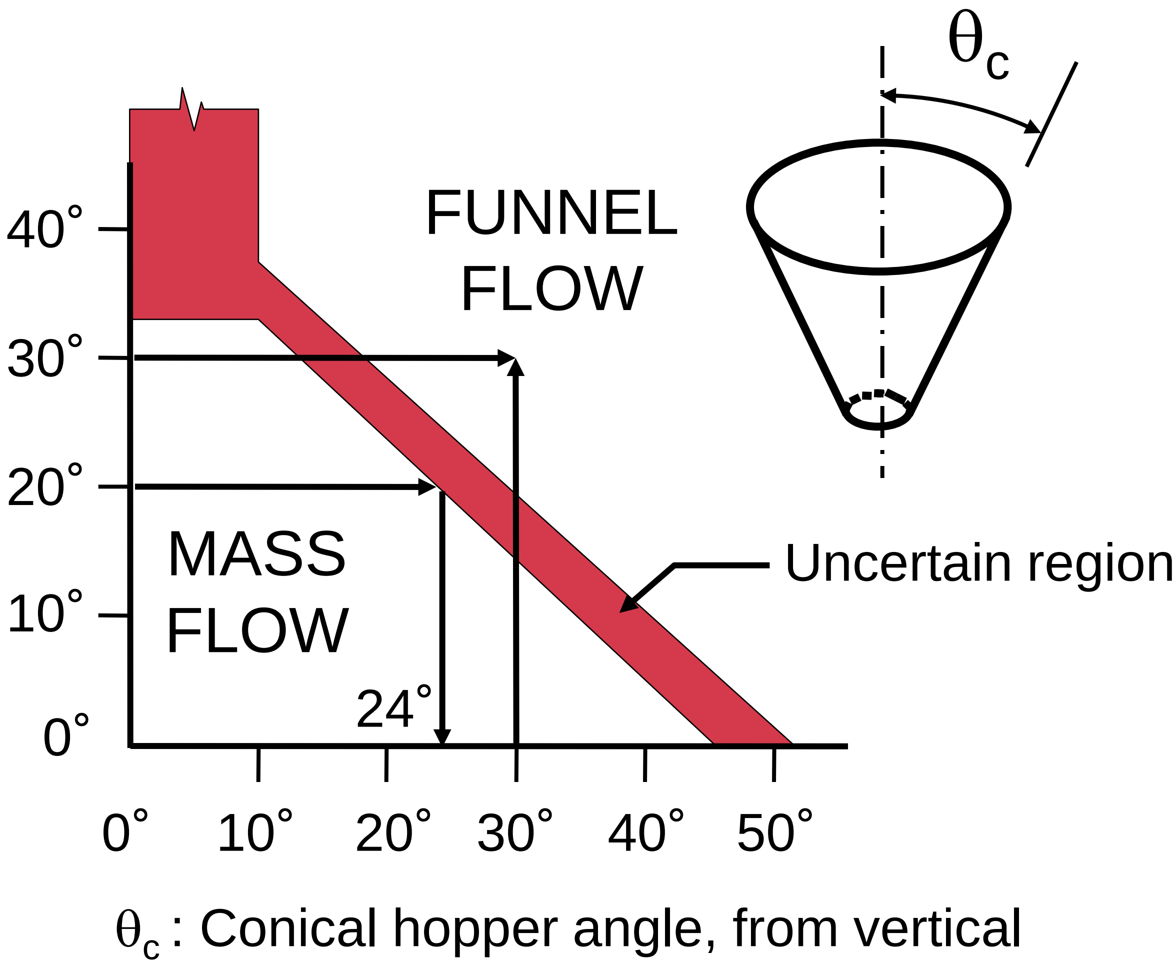
A = Area
W = Weight
F = Force

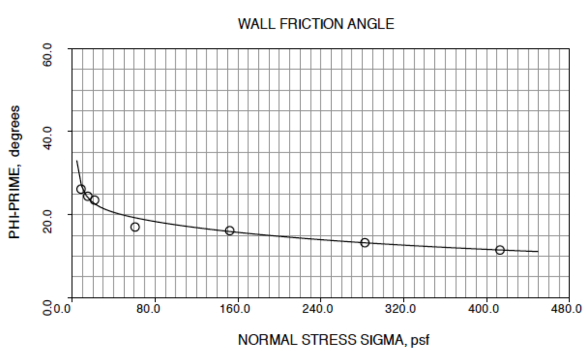
Wall friction test



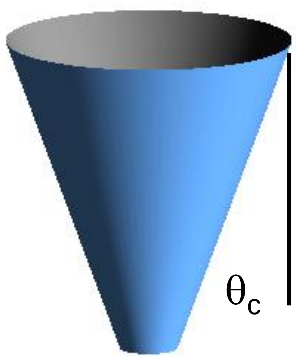
ASTM Standard D 6128

Conical hopper design chart

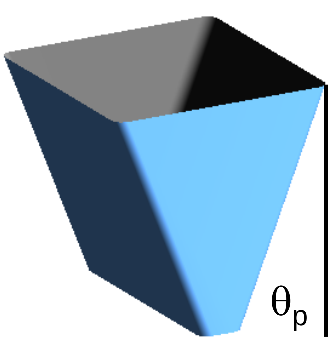




Mass flow: cones vs. wedges

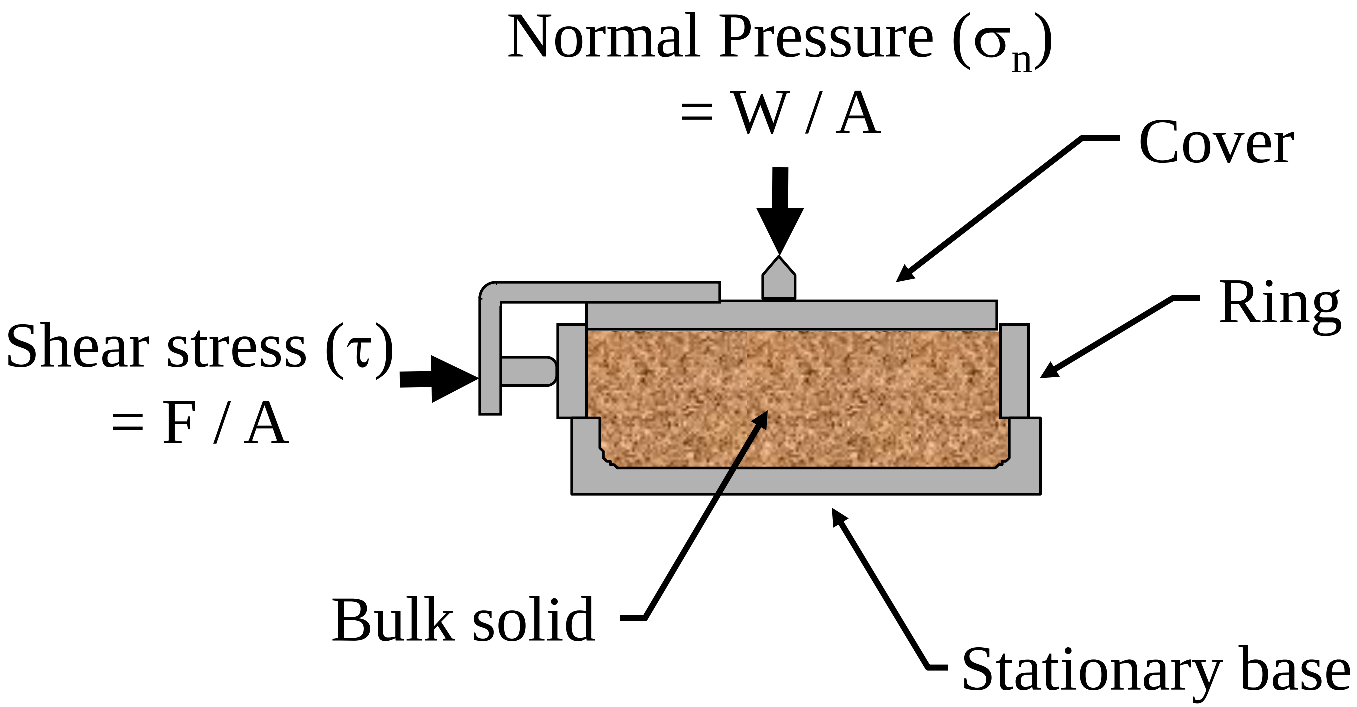


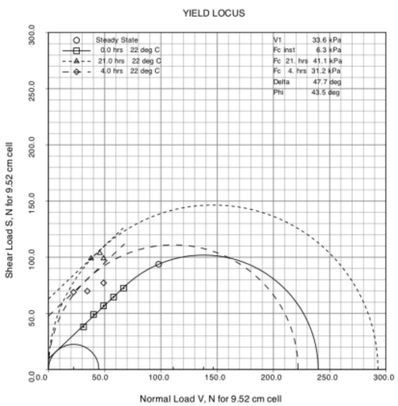
– Cones:
  - Steeper than wedges by 10º - 12º (in general)
  - Require twice the outlet size of a wedge to prevent arching
  - More sensitive to material changes



– Wedges and transitions:
  - Can be shallower by 10º - 12º (in general) than cones and still achieve mass flow
  - Require half the outlet size to prevent arching
  - Far less sensitive to material changes

Cohesive strength test





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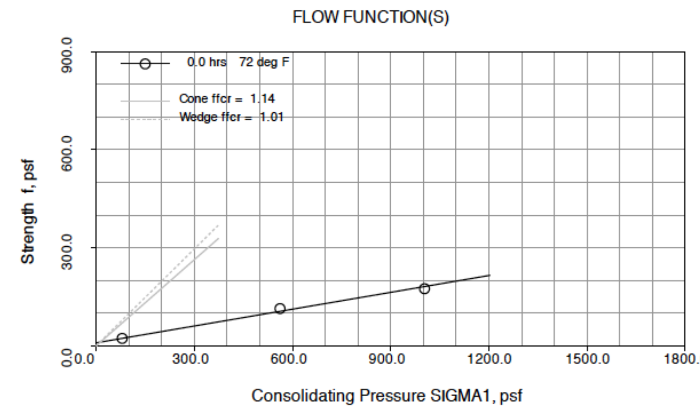
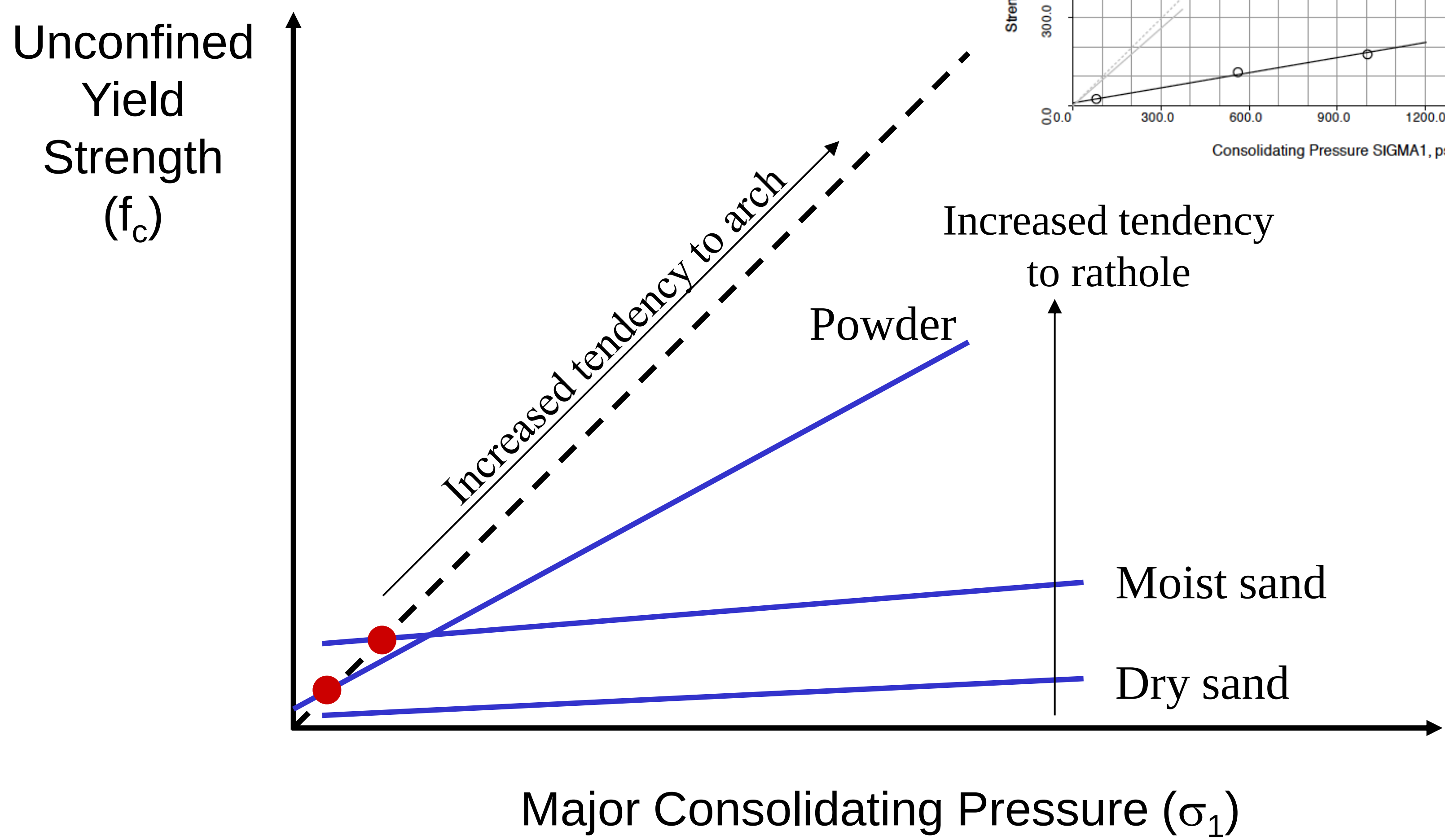
Cohesive strength test

ASTM Standard D 6128

Flow function



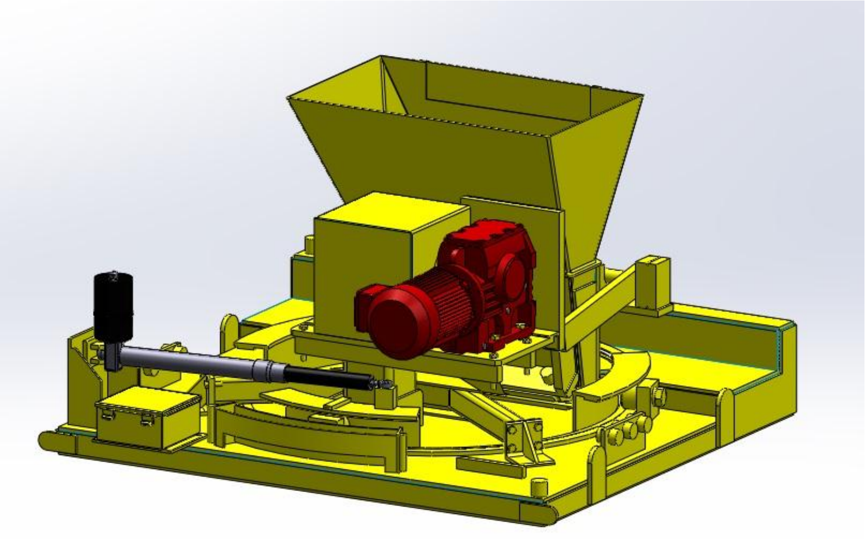


Basis for batch bin design

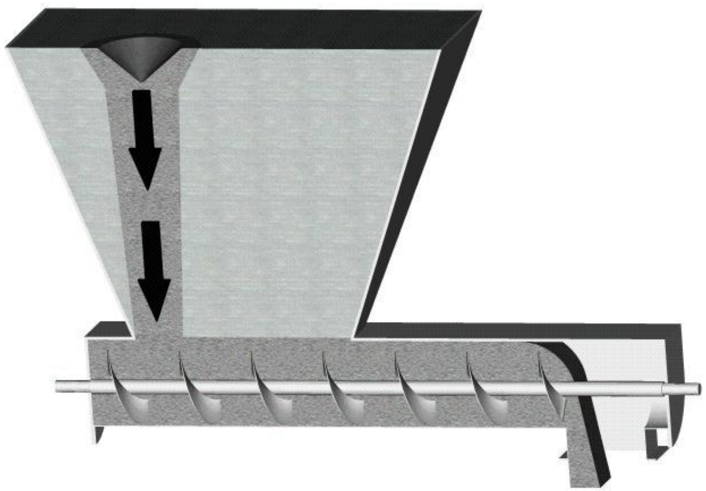
- Flow property tests confirmed that ratholing would occur in funnel flow, with large active channels (4-5 ft diameter minimum) required to overcome in mass flow (or expanded flow).
- Conical hopper angles required to achieve mass flow were very steep, on the order of 15° from vertical, depending on the surface and finish.
- The use of a transition hopper would provide mass flow with more reasonable wall angles, while also reducing the chance of arching after periods at rest.

Basis for feeder design

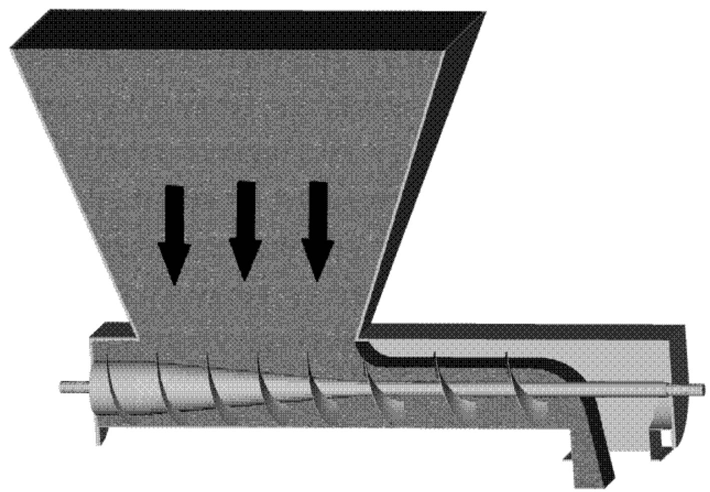
- A screw feeder below each bin’s hopper outlet would provide both rate control and some of the offset (conveying distance) needed to deliver batch material from each bin “around the corner” to the end of the furnace.
- Wetting screws were planned as part of the installation all along, as were plate chargers.



Importance of feeder design

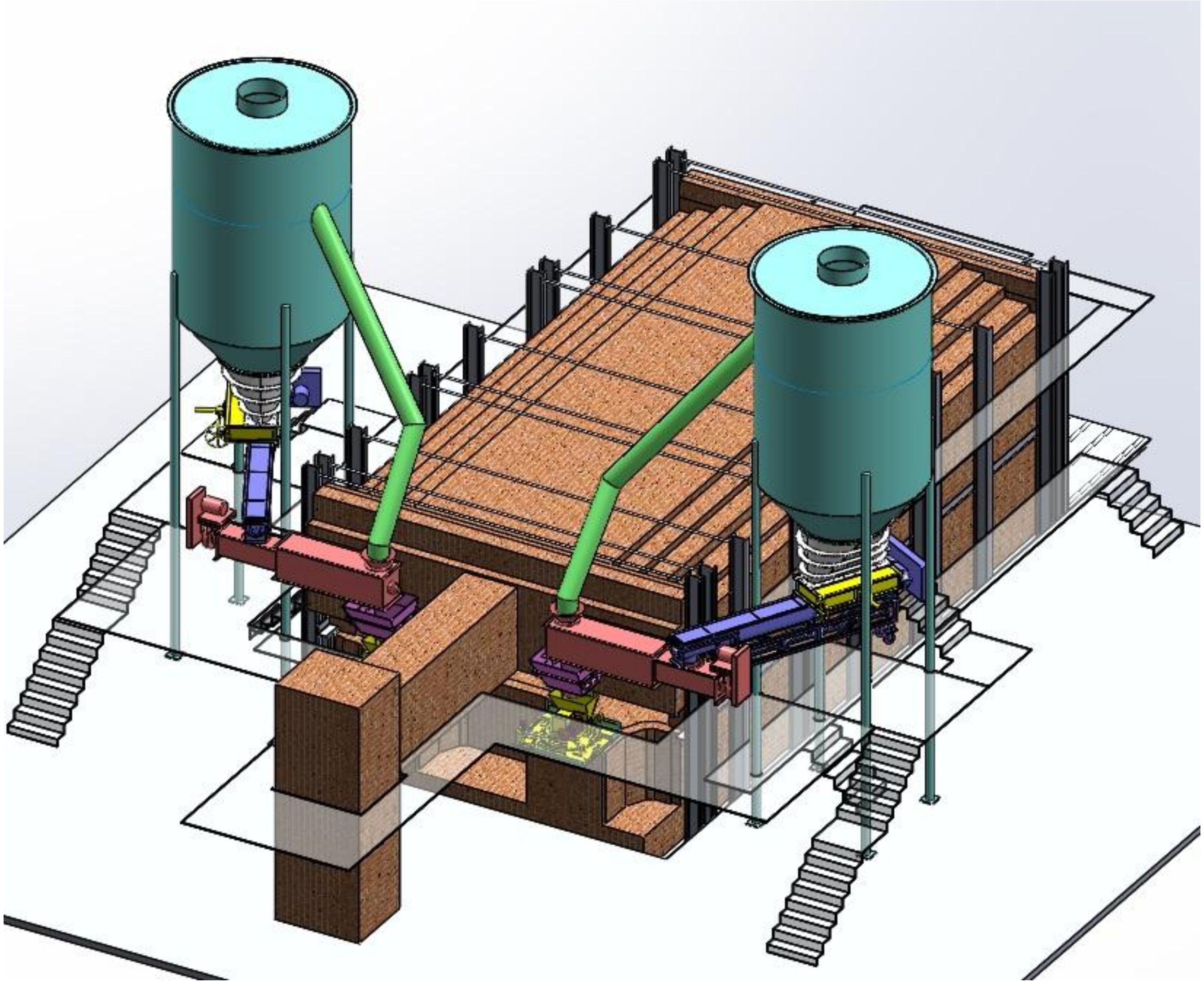


Constant pitch results in
feed from back of the hopper
only, resulting in a rathole
even if hopper designed for mass flow

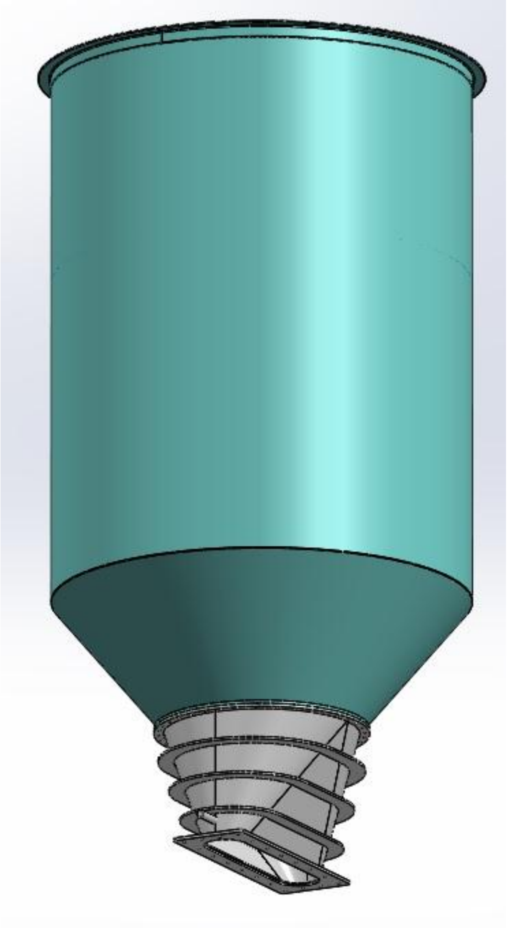


Variable pitch and shaft
diameter, to ensure feed
over entire hopper
outlet length

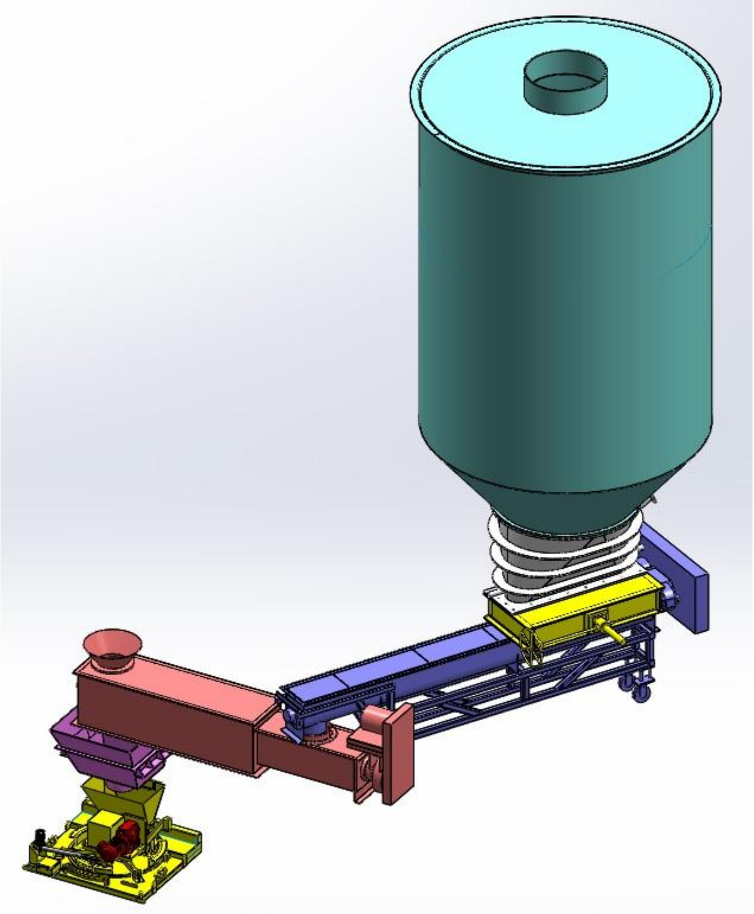
Overall arrangement



Arrangement details



Bin with transition hopper retrofit



Equipment layout

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Implementation

Hopper sections in fabrication

Equipment installed

Assessment

- Greatly improved flow performance has been achieved with the new system, with no plugging at the bin outlets; the plant did not bother re-installing air cannons at new positions on the bin hoppers.
- Wear performance of the screw feeder augers has been good, thanks to hard-facing its surfaces, with the first set of shafts still in service today (2.5 years on).
- The feed system arrangement provides the future option of adding batch/cullet preheating in the open area behind the furnace.

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