Journal of Zhejiang University-SCIENCE A

Cite this as: Qing-shuai CAO, Yang ZHAO, 2017. Buckling design of large steel silos with various slendernesses. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, 18(4):282-305. http://dx.doi.org/10.1631/jzus.A1600369

Buckling design of large steel silos with various slendernesses

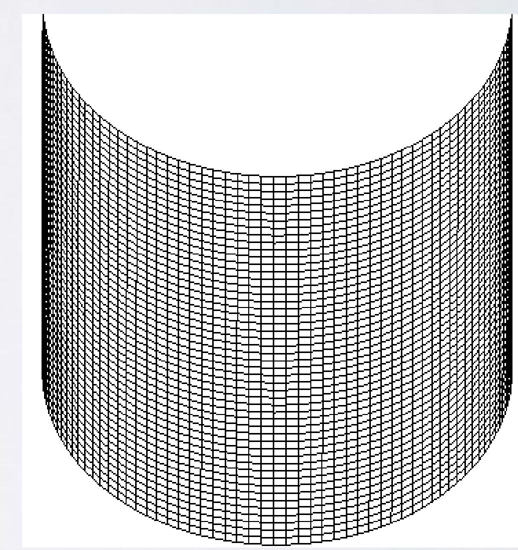
Key words: Steel silo, Shell, Slenderness, Buckling, Patch load, Nonlinear, Large eccentricity

- This paper investigates the buckling behavior of large steel silos through numerical analyses, with slenderness ranges from 4.77 to 0.35, which we can characterize as very slender, slender, intermediate slender, squat and retaining silos.

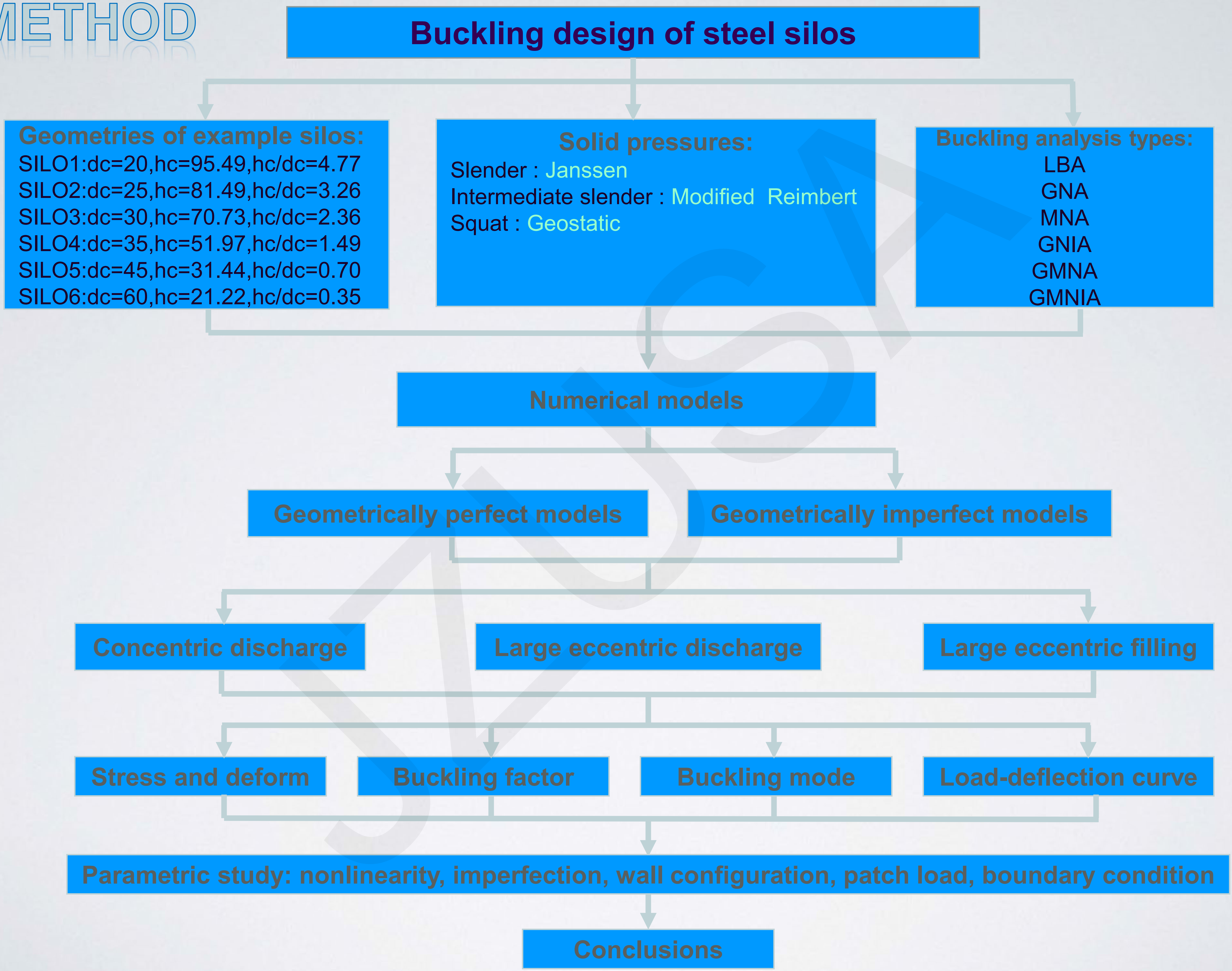
- For the determination of load carrying capacities when checking the buckling limit state, six types of buckling analysis, which is also recommended by EN 1993-1-6, are carried out for the numerical investigation.

- Buckling behavior of silos under concentric discharge, large eccentricity discharge, large eccentricity filling is mainly investigated.

- Effects of nonlinearity, imperfections, patch load, wall thickness configuration, boundary condition, etc on buckling of steel silo are evaluated.



METHOD


Buckling design of steel silos
Geometries of example silos:
SILO1:dc=20,hc=95.49,hc/dc=4.77
SILO2:dc=25,hc=81.49,hc/dc=3.26
SILO3:dc=30,hc=70.73,hc/dc=2.36
SILO4:dc=35,hc=51.97,hc/dc=1.49
SILO5:dc=45,hc=31.44,hc/dc=0.70
SILO6:dc=60,hc=21.22,hc/dc=0.35
Solid pressures:
Slender : Janssen
Intermediate slender : Modified Reimbert
Squat : Geostatic
Buckling analysis types:
LBA
GNA
MNA
GNIA
GMNA
GMNIA
Numerical models
Geometrically perfect models
Geometrically imperfect models
Concentric discharge
Large eccentric discharge
Large eccentric filling
Stress and deform
Buckling factor
Buckling mode
Load-deflection curve
Parametric study: nonlinearity, imperfection, wall configuration, patch load, boundary condition
Conclusions

Conclusions

- The load-displacement curves for nonlinear buckling analysis are highly nonlinear and predict a distinct maximum load followed by a descending path. The silo with smaller slenderness is superior in structural ductility and plasticity to that with a larger slenderness, and the retaining silo or squat silo is preferred in practical structural design.
- The material nonlinearity is strong and detrimental to buckling behavior of all slenderness of example silos, resulting in a decrease of buckling resistance for both perfect and imperfect models.
- The wall thickness type and its distribution has the most important influence on the buckling modes and buckling strength of steel silos. Under the condition of the same amount of steel used in construction, different schemes for wall thickness arrangement are suggested in buckling design of steel silos to achieve the optimal buckling strength.
- Large eccentricity both in discharge and filling would result in a strong decrease of storage efficiency of a steel silo.