

# CALCINED SHALE AS A LOW COST SUPPLEMENTARY CEMENTITIOUS MATERIAL

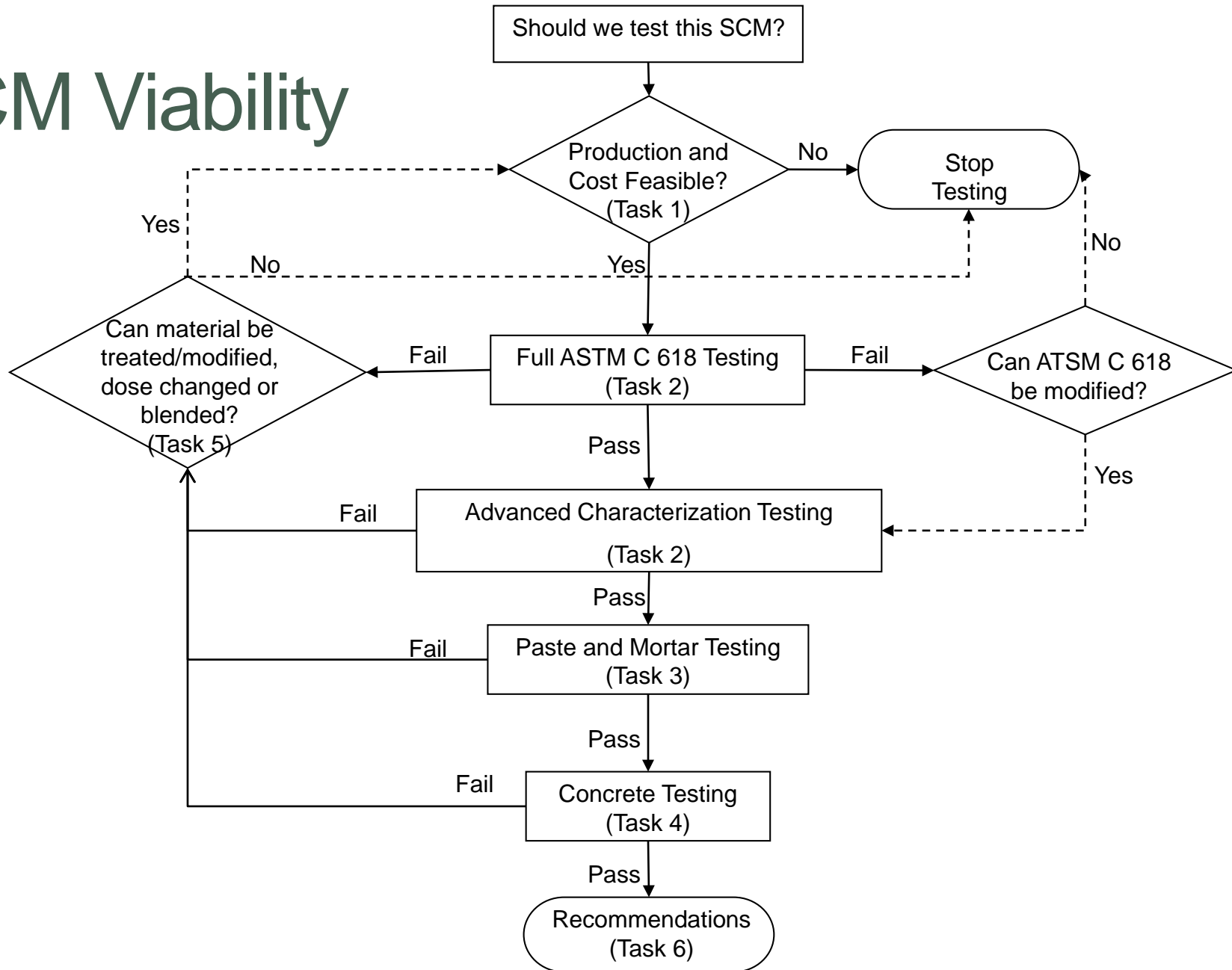
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**Maria Juenger**

**Saamiya Seraj, Rachel Cano, & Raissa Ferron**

The University of Texas at Austin, USA

# SCM Viability



# SCM cost and production

Material	Cost	Use/Availability
Fly ash	40 USD/ton	130,000 tons/year*
Metakaolin (not highly reactive)	325 USD/ton	30,000 tons/year
Pumice	116 USD/ton	200,000 tons/year
Vitric Ash	130 USD/ton	300,000 tons/year
Expanded (Calcined) Clay Shale	50 USD/ton	500,000 tons/year

\*approximate amount of fly ash used by the Texas DOT for structural concrete.

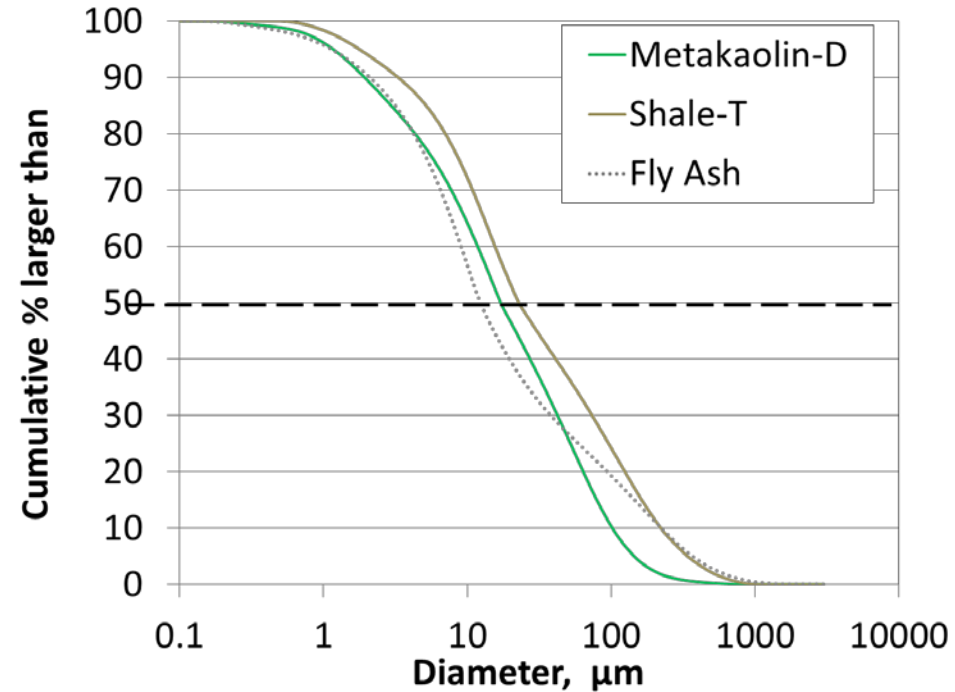
# Expanded Clay Shale

- Clay shale (referred to as shale) is a fine grained sedimentary rock formed from the compaction of clay minerals and other particulate debris
- Produced in a rotary kiln
- Used as lightweight aggregate
- The crushing process results in waste fines that can be used as SCMs

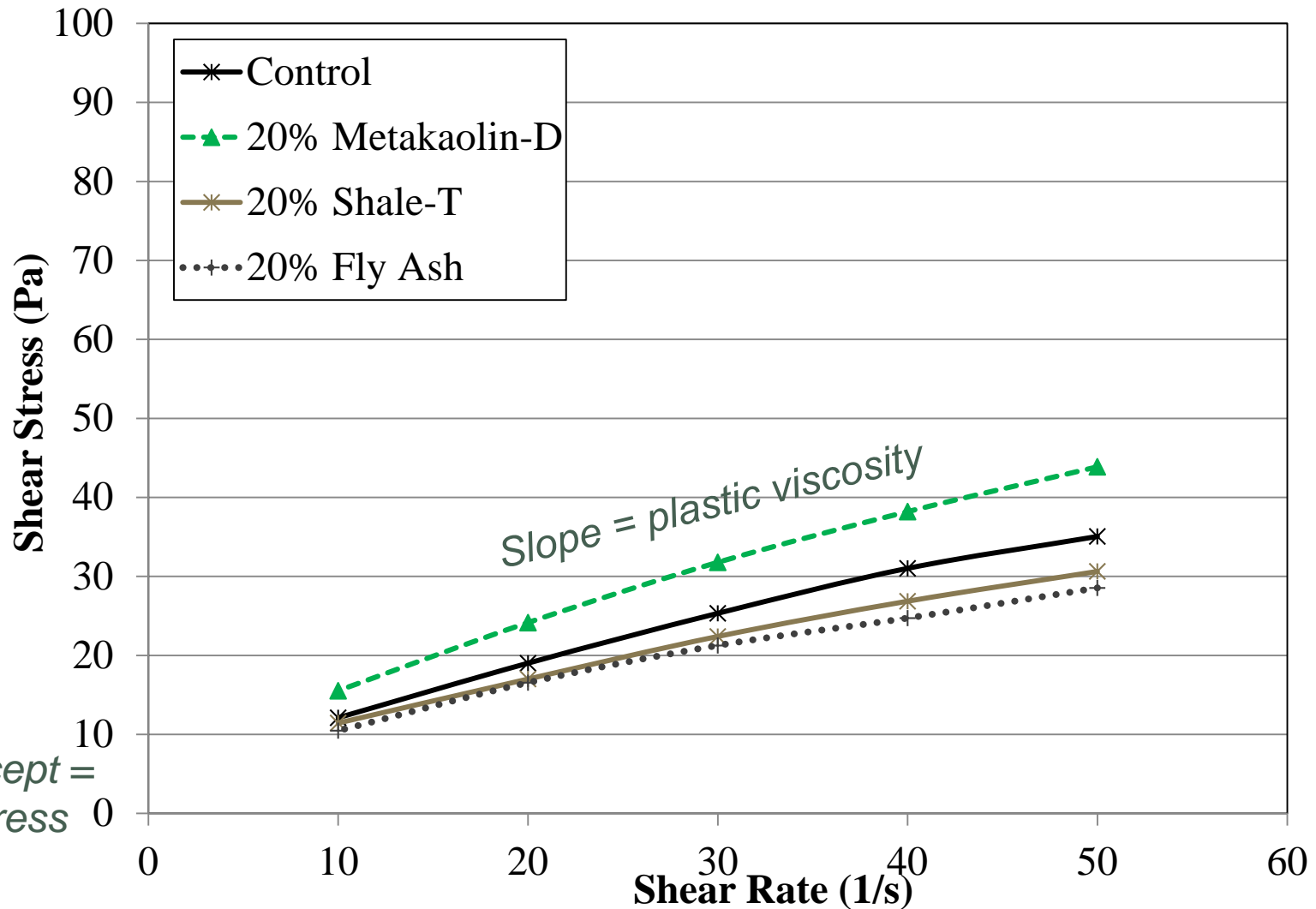


# Materials

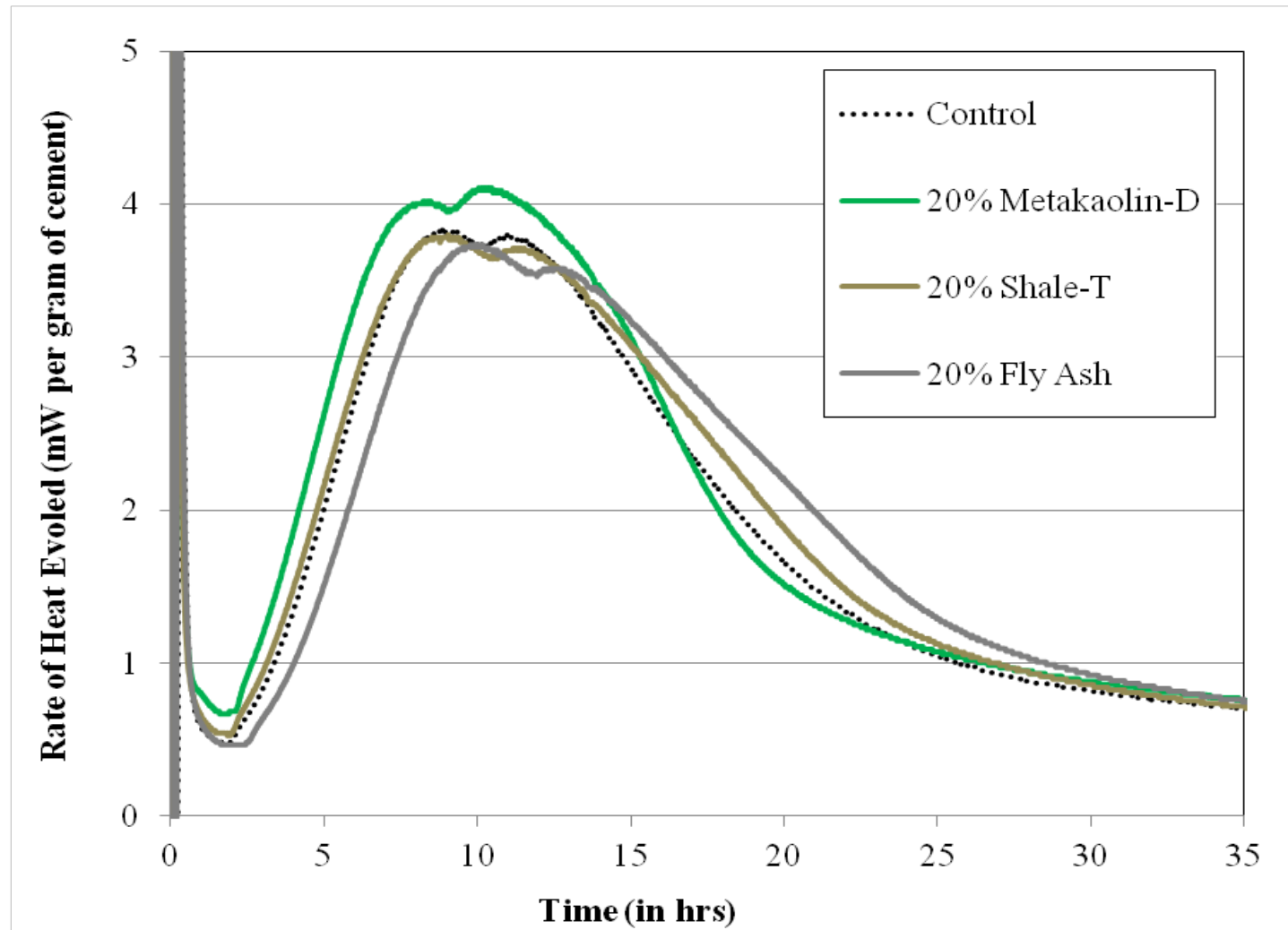
Oxide	Metakaolin	Shale	Fly Ash
SiO <sub>2</sub> (%)	51.66	65.43	52.1
Al <sub>2</sub> O <sub>3</sub> (%)	35.23	14.55	23.1
Fe <sub>2</sub> O <sub>3</sub> (%)	1.98	5.72	4.0
CaO (%)	0.57	2.44	11.6
MgO (%)	0.45	2.30	2.1
SO <sub>3</sub> (%)	0.06	0.39	0.5
Na <sub>2</sub> O (%)	0.10	1.14	0.4
K <sub>2</sub> O (%)	1.42	2.88	0.7



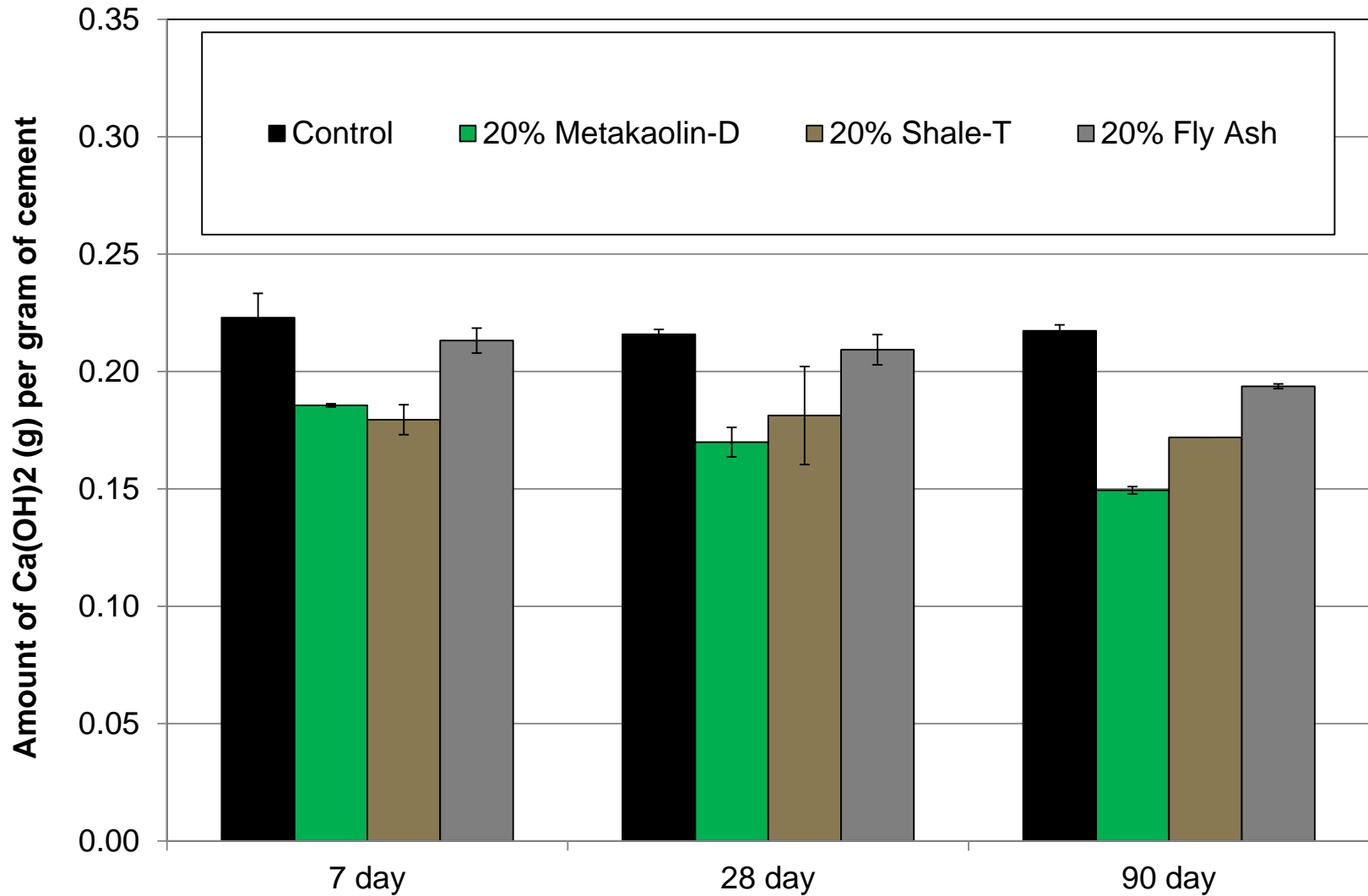
# Rheology (Workability)



# Rate of Cement Hydration

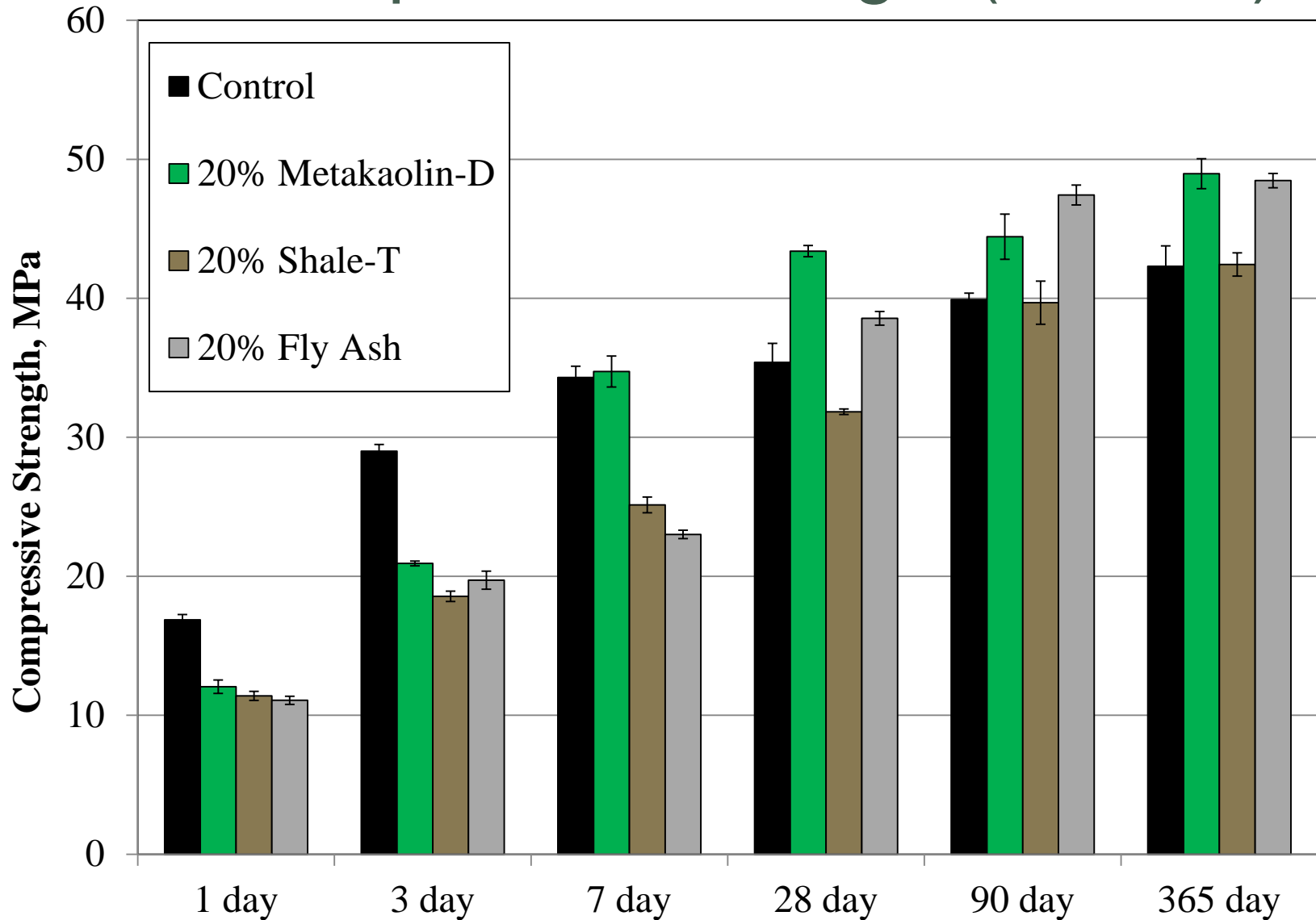


# Portlandite Consumption

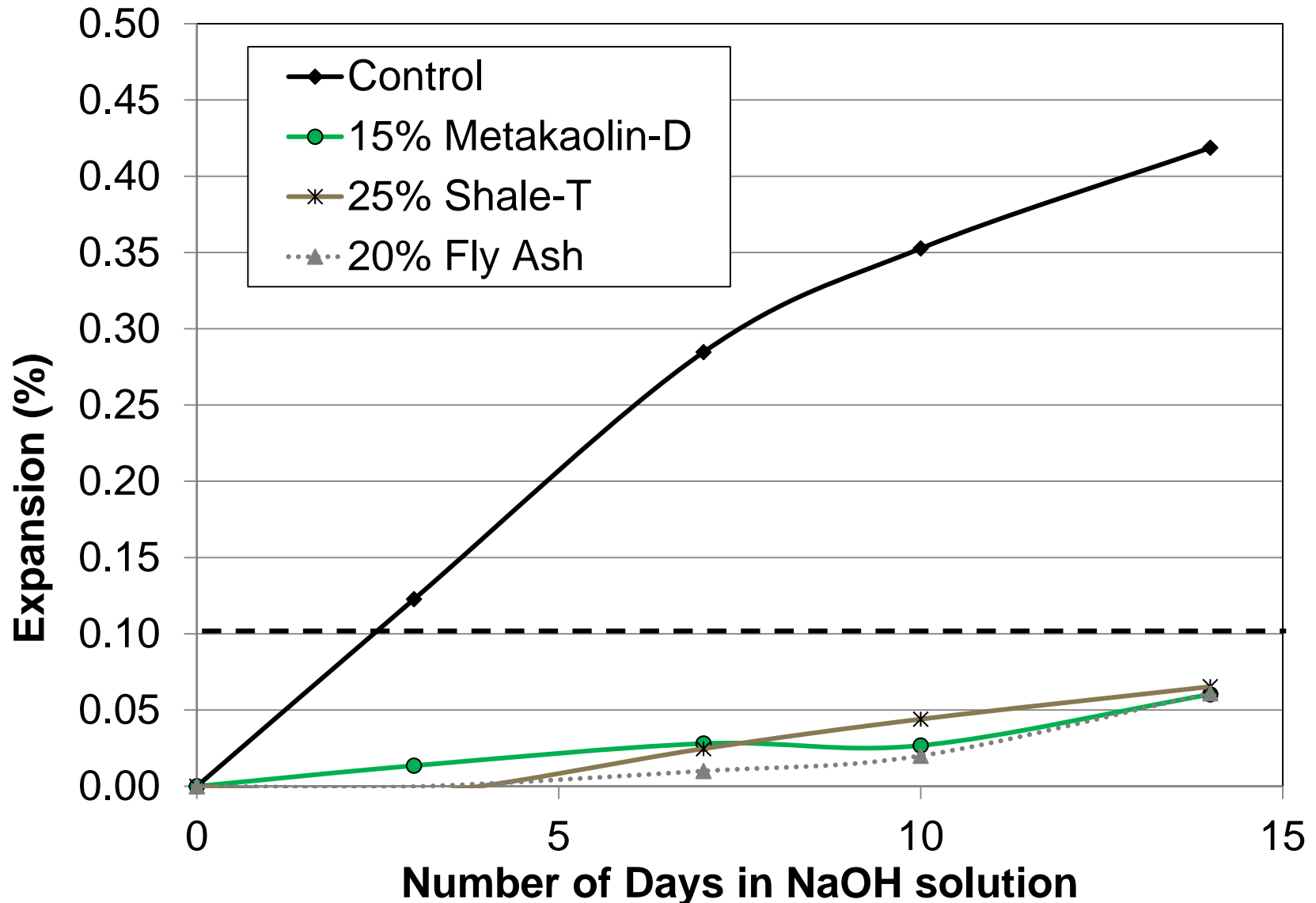




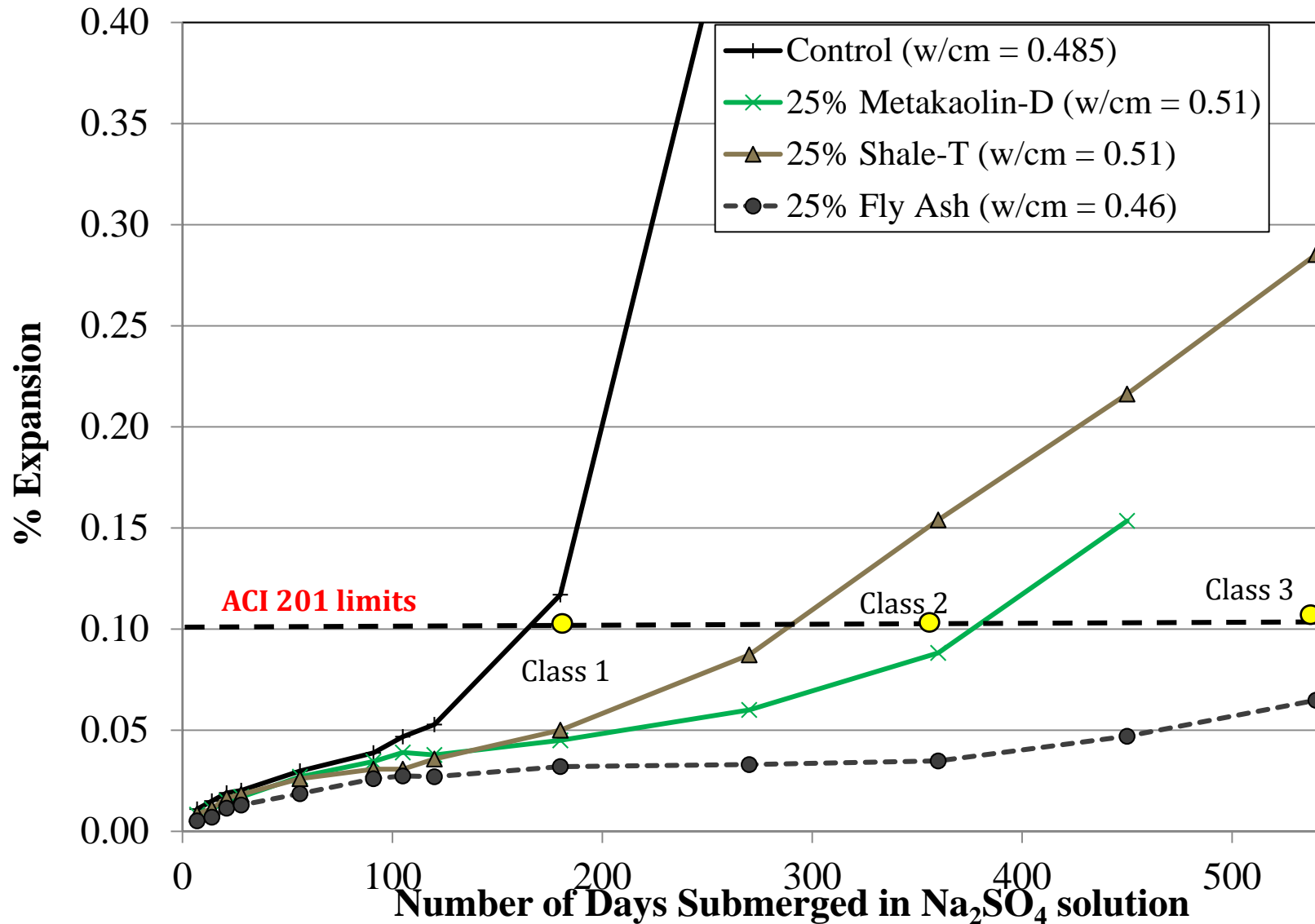
# Mortar Compressive Strength (w/c=0.5)



# Alkali Silica Reaction: ASTM C1567



# Sulfate Attack (ASTM C1012)



# Conclusions

- Calcined shale from the lightweight aggregate industry is a pozzolanic SCM that can compete with metakaolin and fly ash
- Shale has a lower cost than metakaolin
- Metakaolin outperforms shale in long-term compressive strength and control of ASR
- However, given the cost, the performance of shale is adequate and it can be considered a feasible replacement for fly ash