Addition of casein in lime mortar

Kristian Falkjar

Addition of casein in lime mortar

- Found to be used in historic mortars [1]
- Found to improve workability
- Little existent literature on strength

1. L. Ventolà, M. Vendrell, P. Giraldez and L. Merino, "Traditional organic additives improve lime mortars: New old materials for," *Construction and Building Materials,* no. 25, pp. 3313-3318, 2011.

Workability

- Not a quantitative metric
- Photographic comparison of cube quality
- It was noted that the higher the casein content, the more readily the mortar filled the forms.

Sample Mortar Cube – 0.1% Casein

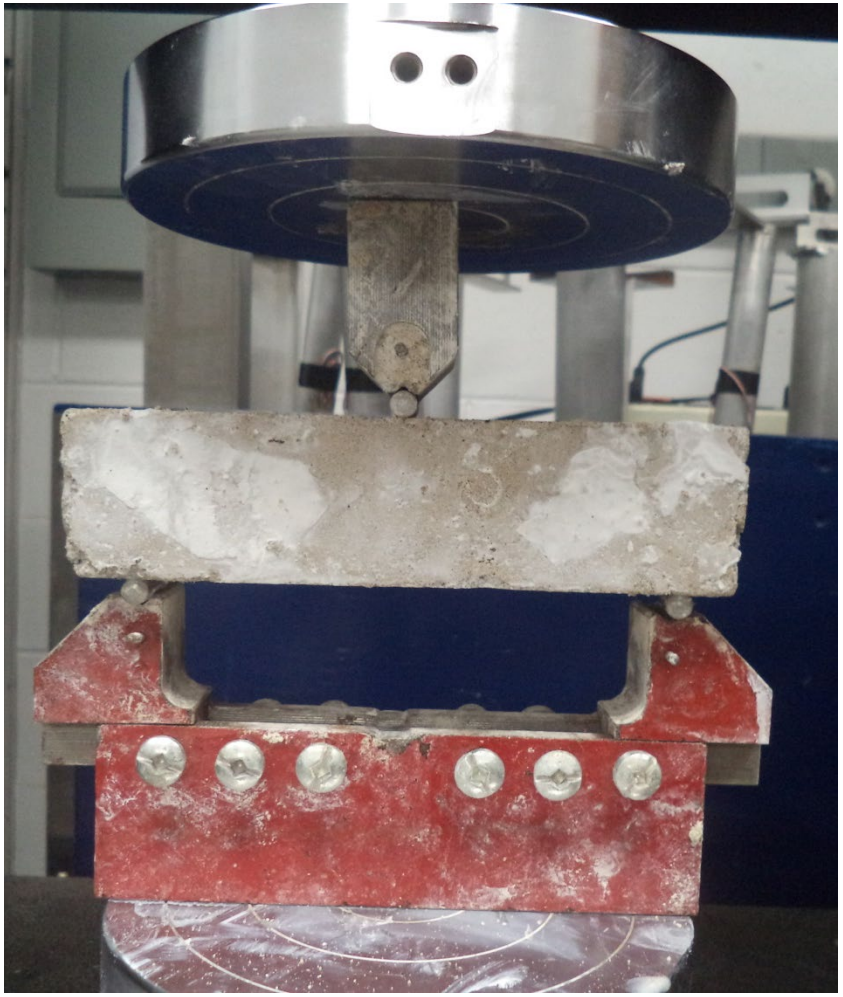
Mortar cubes with a casein content of 0.5% and higher did not show voids around the edges

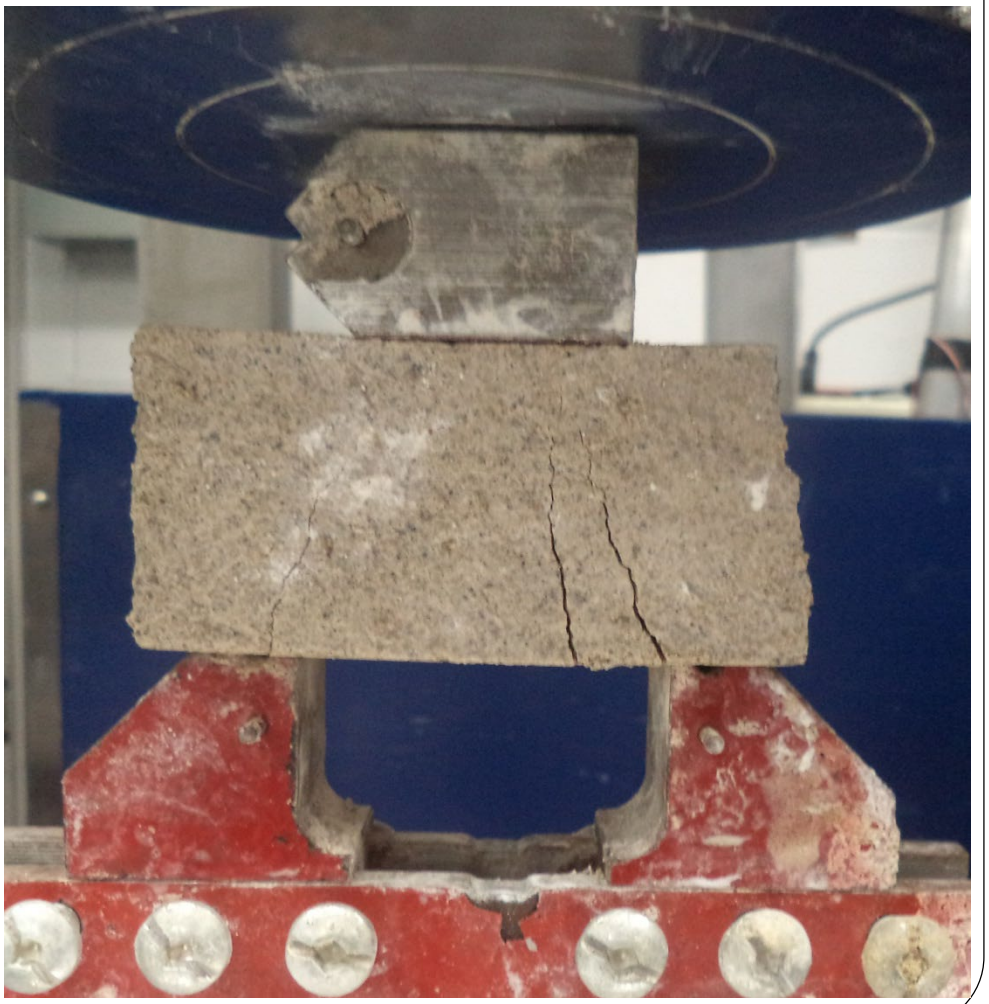
The Tests

- Compression
- Tension
- Flexure
- Shear
- Flow Table

- 0% Casein (Control)
- 0.1% Casein
- 0.25% Casein
- 0.5% Casein
- 1.5% Casein

Flexure (Left) and Shear (Right)



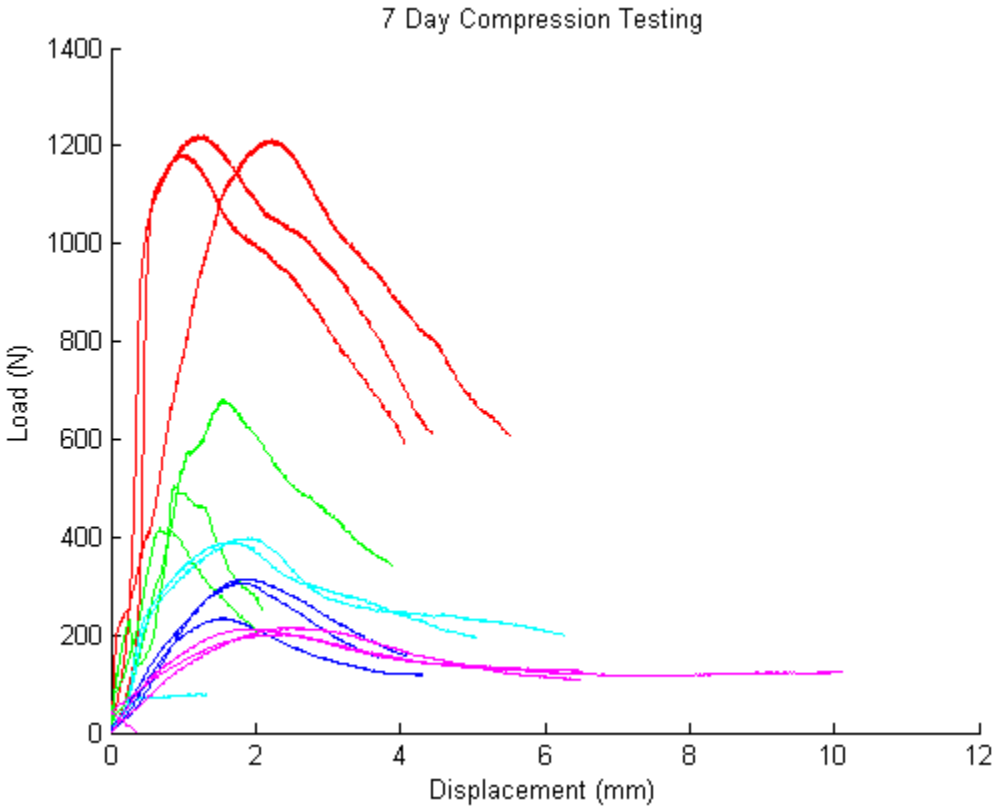


Specimen Sizes

- Compression and Tension
  - 50 mm × 50 mm × 50 mm
- Flexure and Shear
  - 40 mm × 40 mm × 160 mm

Load-Displacement Curve in Compression

- 7 Days

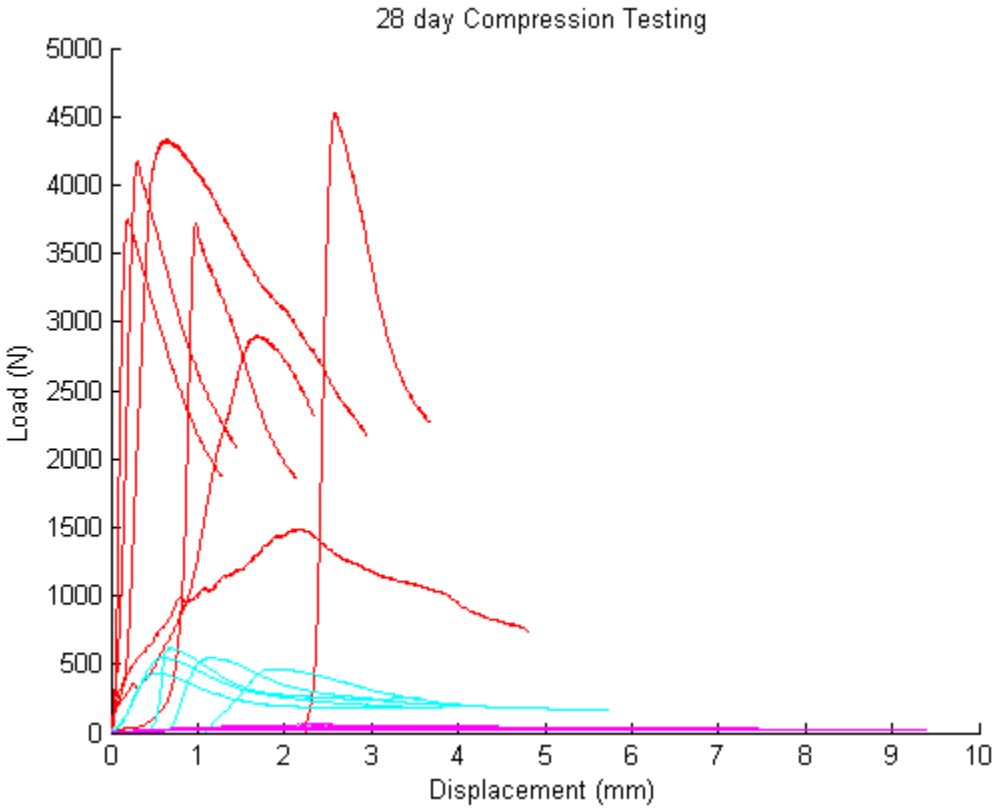


Legend

Red – 0 casein
Green – 0.1% Casein
Light Blue – 0.5% Casein
Dark Blue – 1.0% Casein
Magenta – 1.5% Casein

Load-Displacement Curve in Compression

- 28 Days

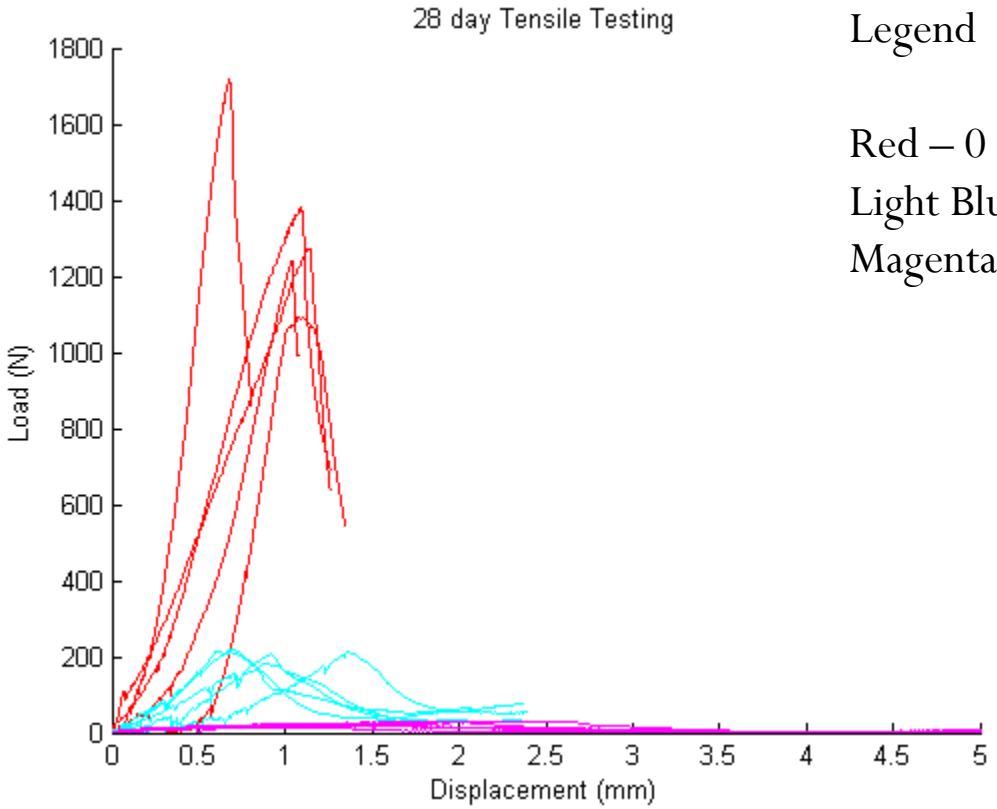


Legend

Red – 0 casein
Light Blue – 0.5% Casein
Magenta – 1.5% Casein

Load-Displacement Curve in Tension

- 28 Days

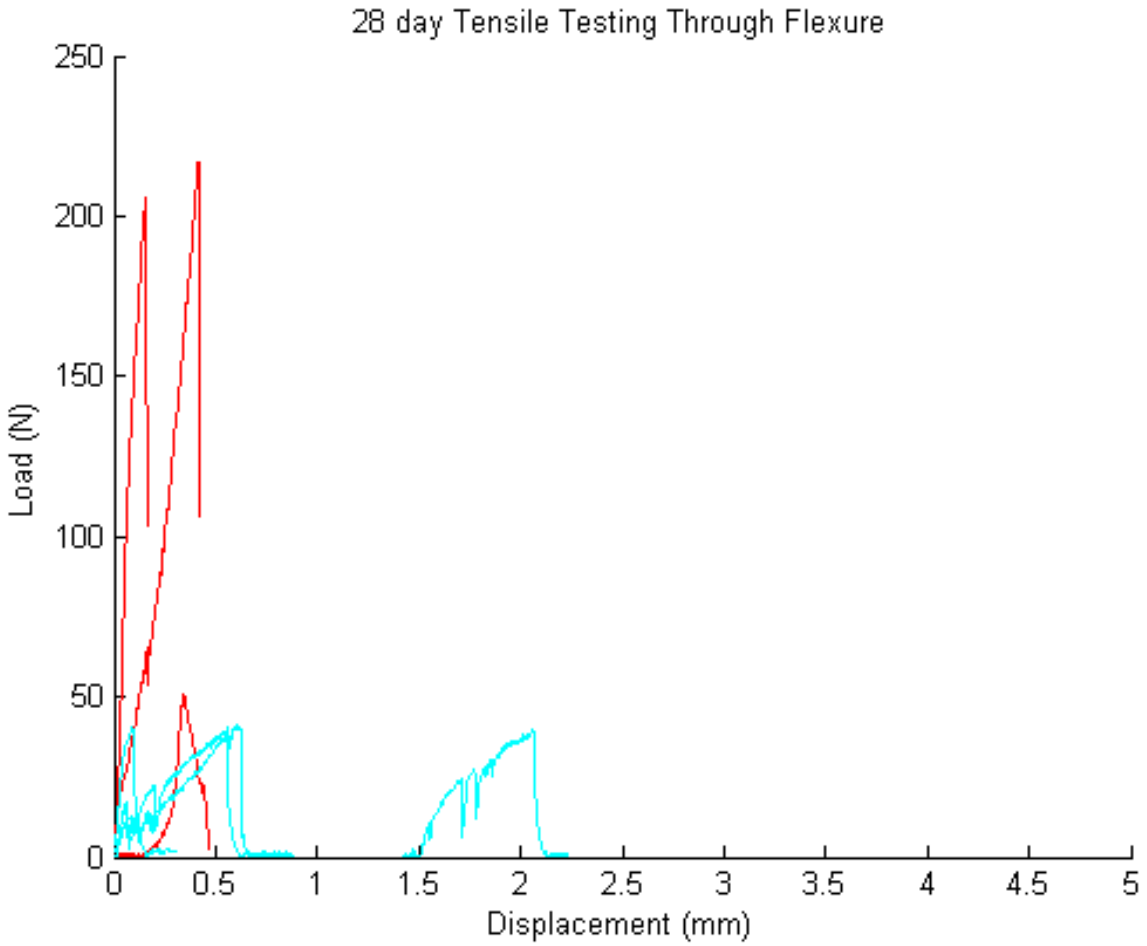


Legend

Red – 0 casein
Light Blue – 0.5% Casein
Magenta – 1.5% Casein

Load-Displacement Curve in Flexure

- 28 Days

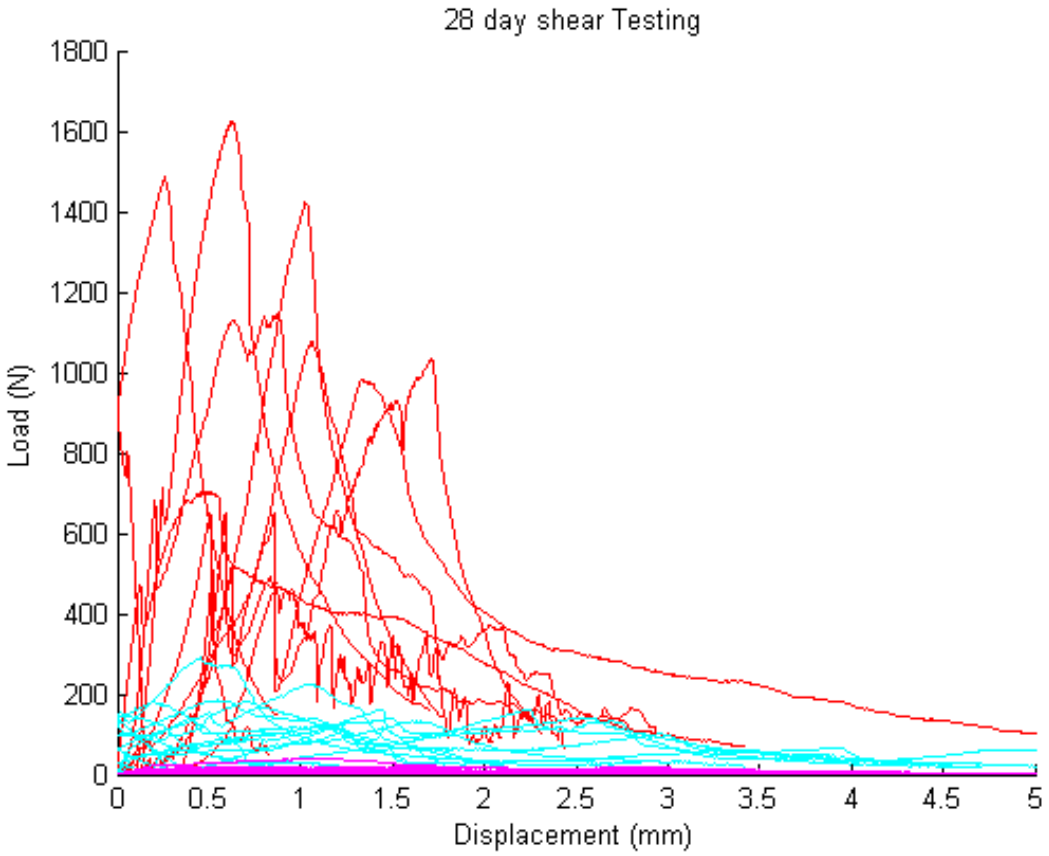


Legend

Red – 0 casein
Light Blue – 0.5% Casein
Magenta – 1.5% Casein

Load-Displacement Curve in Shear

- 28 Days – Wildly variable results in shear



Legend

Red – 0 casein
Light Blue – 0.5% Casein
Magenta – 1.5% Casein

Comparison between tensile Methods

Casein Content (%)	Tensile Stress using flexural theory	Tensile Stress using split tension cubes
0	1.412	0.2234
0	1.3217	0.2297
0	1.255	0.1971
0	0.309	0.2487
0	1.3834	0.3095
0.5	0.2452	0.0389
0.5	0.2428	0.04
0.5	0.2504	0.0375
0.5	0.2341	0.0383
0.5	0	0.0332
1.5	0	0.0052
1.5	0	0.0031
1.5	0	0.0038
1.5	0	0.0032
1.5	0	0.0052

Split tensile test typically underestimates the strength, however, it does not typically underestimate the strength by a factor of 6.

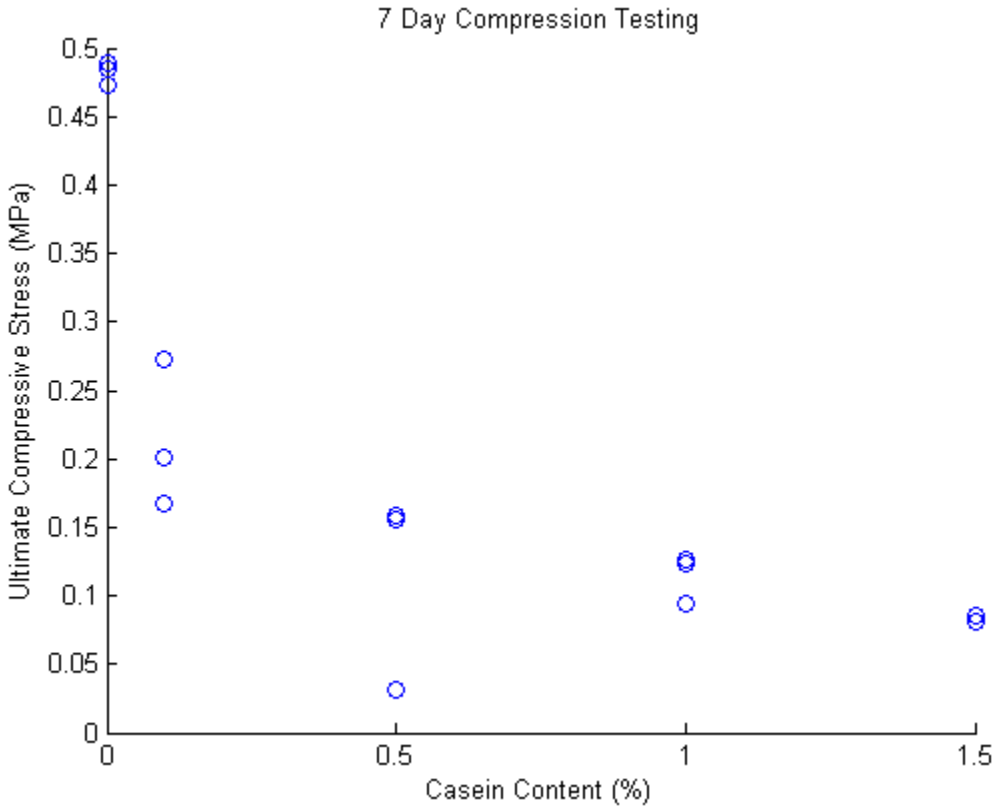
Flexural test may exhibit bearing effects, which may overestimate the flexural strength.

Qualitative Observations

- Adding 0.5% casein by mass lowered all strengths by 70% - 80% in comparison to the control sample.
- Increasing the concentration of casein lowered the strength further, however, the reduction was found to be non-linear.
  - 1.5% casein caused a 90% reduction in strength compared to the baseline control
  - 0.1% casein caused a 40% - 60% reduction in strength compared to the baseline control

Compressive Strength Comparison at 7 days

- Ultimate Strengths vs. Casein Content



Challenges

- Environmental
  - Lack of moisture chamber made for humidification challenges
  - Testing own control samples to compensate
- Differences between samples often in excess of that tolerated in ASTM standards

Challenges

- Flow of mortar
  - Filling to 50 mm height would overflow table for high-casein samples
  - This test is only intended to be used for comparison purposes, specimens were all filled to a height of 25 mm
  - Diameter increases exceeding 150% were recorded in testing for the samples containing more than 0.5% casein

Further Considerations

- 56 day tests not yet conducted
- Use mortar cubes with 0.5% casein, but with a reduced water content from that used as the standard in all experiments to date.