The Choice Between Aluminum Silicates and Fused Silica for Stucco

Tom Branscomb, Director of Technology
Buntrock Industries, Inc.

Abstract

The use of Aluminum Silicate stucco as a replacement for Fused Silica stucco is investigated. Two different types of backup slurries and three different stuccoes were evaluated. A new test is described and used to measure the ability of the slurry and/or stucco to build a uniform shell thickness. Much of the economic advantage of Aluminum Silicate stucco is lost when other factors are considered.

Introduction:

Many investment casting foundries use fused silica based slurries with either fused silica stucco or Aluminum Silicate stucco. Invariably, the reason given for using Aluminum Silicate stucco is that the price per pound is roughly one half the amount for fused silica sand. However, in addition to price per pound, there are other issues to consider that effect the overall economics of this decision. These include:

Specific Gravity of the Material

Number of dips needed

Ability to produce a crack free shell

Probability of operator injury while dipping or casting

Ease in shell removal

The specific gravity of a typical 47% alumina silica grain is 2.64 and that of fused silica is 2.20 grams/cc. So, before one even begins to dip, you will have to order 20% more pounds of aluminum-silicate grain because it’s heavier.

For the same specific gravity issue, fused silica shells are light in weight and easier to lift and manipulate than those using Aluminum silicate. There have been comments made by both investing personnel and foundry personnel, that they prefer the lighter weight fused silica shell molds. While I don't have any direct evidence, it is not too much of a leap in faith to assume that there will be fewer muscle injuries handling lighter weight shells.

Regarding number of dips needed, this is not as straight forward as specific gravity differences. In using these stuccoes in the lab, I noticed that often times it appeared that 30 x 50 mesh fused silica would produce samples that were at least as thick as the more coarse 22 mesh aluminum-silicate sand. For this reason as well as being able to quantify how uniformly a slurry tends to build, I developed a Shell Build test that would discern differences in shell thickness and uniformity that a certain slurry or stucco tends to build on a test specimen. I then used this test to determine if there was an advantage to size or type of stucco used and type of slurry used to make investment casting shells.

The remainder of this paper is dedicated to describing the Shell Build test, and using it to determine if there are advantages in the ability of one stucco over another in overall thickness and in shell uniformity when considering edges versus flat surfaces. In addition to stucco type, it will also be shown that there are measurable significant differences in the values obtained for Shell Build when different types of slurries are used.

Shell Build Test Description:

Purpose: To determine the relative ability of a specific slurry and stucco combination to build a thick and uniform shell around a wax specimen.

Wax Specimen: Equilateral Triangle shaped extruded wax (1.125"x 8") with hole for inserting a handle. Radius on corner of triangle is 0.070". See Figure 1.

Dipping: One prime with zircon stucco, four backup dips with backup stucco, and a seal dip. Slurry draining is critical and must be carried out using a specific sequence. Draining is continued until essentially no more slurry is dripping from the piece.

Stucco Application: Must be consistent. All samples in this test were hand sanded unless otherwise stated.

Dewax: Three transverse slices are made at the center and 2" either side of center using an abrasive saw. Top, Middle, Bottom are marked on the pieces for measurement, then wax is removed. See Figure 2.

Measurements: Using a caliper, measure each of the three sections at the center of each face and each corner. This yields 9 corner and 9 face thickness measurements for calculations. Enter data into spreadsheet. See Figure 3. Use three or four specimens for good confidence.

Calculations:

1. Average Corner Thickness = (C) inches

2. Average Face Thickness = (F) inches

3. Ratio: Corner/Face thickness = (C/F)

   If C/F = 1.00, shell is perfectly uniform. Values usually range from 0.5 to 0.9.

4. Shell Build Factor = C x (C / F) inches. Emphasizes corner thickness. Bigger is better as corners are where many dewax cracks occur. For this test, values approaching 0.3 inches are very good.

Experimental Procedure:

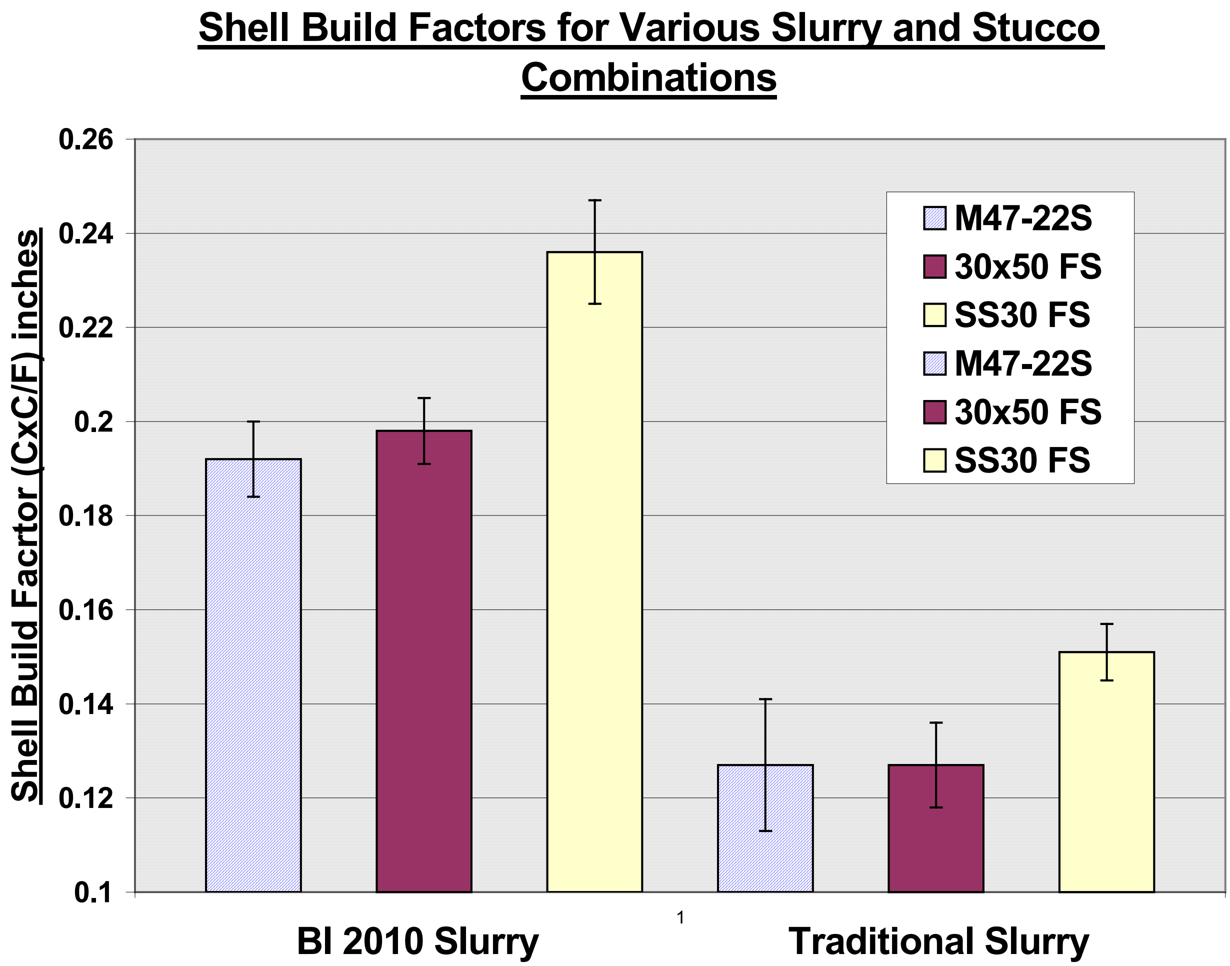
Four Shell Build wax specimens were prepared for each combination of two slurries and 3 stuccoes. One slurry was a typical fused silica (120 and 200 mesh flour) with Nyacol 830 small particle binder and no polymer. Viscosity was 14 seconds using a #4 Zahn cup. The other slurry was BI2010, which is a Buntrock developed Wex Chemical nylon fiber enhanced slurry, operating at 15 seconds on a special cup designed for fiber slurries. This cup yields similar readings to a #5 Zahn when used on slurries without fibers. These two slurries were selected to represent the extremes of the types of backup slurries currently being used in the industry. The stuccoes used were CE Minerals Mulgrain 47-22S, 30x50 Fused Silica, and a coarse fused silica called SS30.

All samples were dipped according to the technique already described.

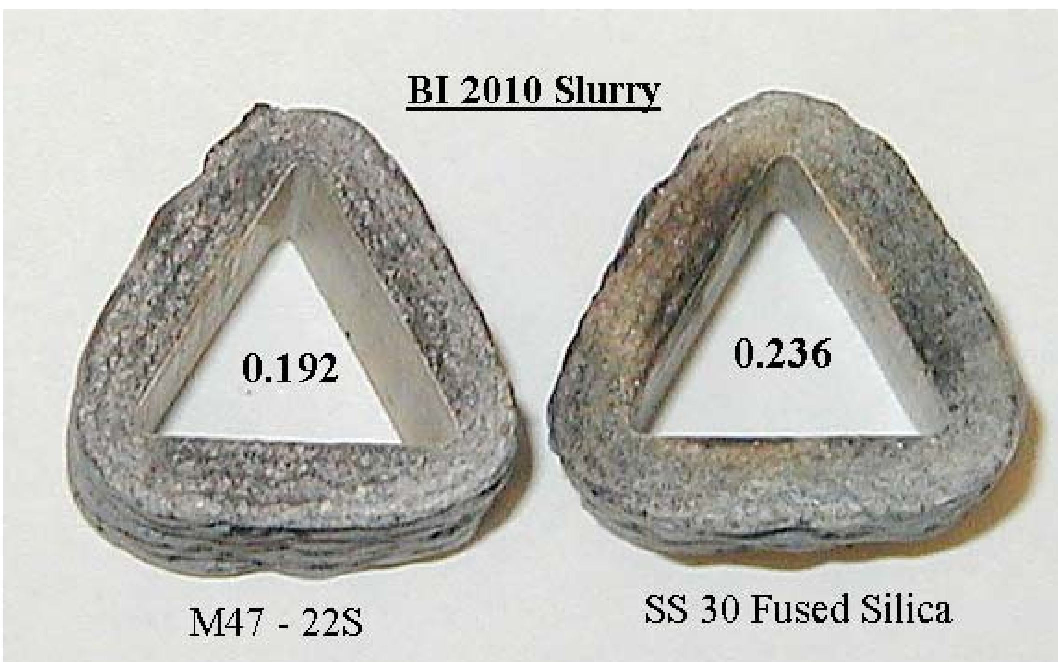
Shell Build Results:

	Stucco Type		
Slurry	M47-22S	30x50 Fused Silica	SS30 Fused Silica
BI 2010	0.192 +/- 0.008	0.198 +/- 0.007	0.236 +/- 0.011
Traditional	0.127 +/-0.014	0.127 +/- 0.009	0.151 +/- 0.006

Note: Values are in inches and the +/- values are 95% Confidence Intervals. These data are plotted below.

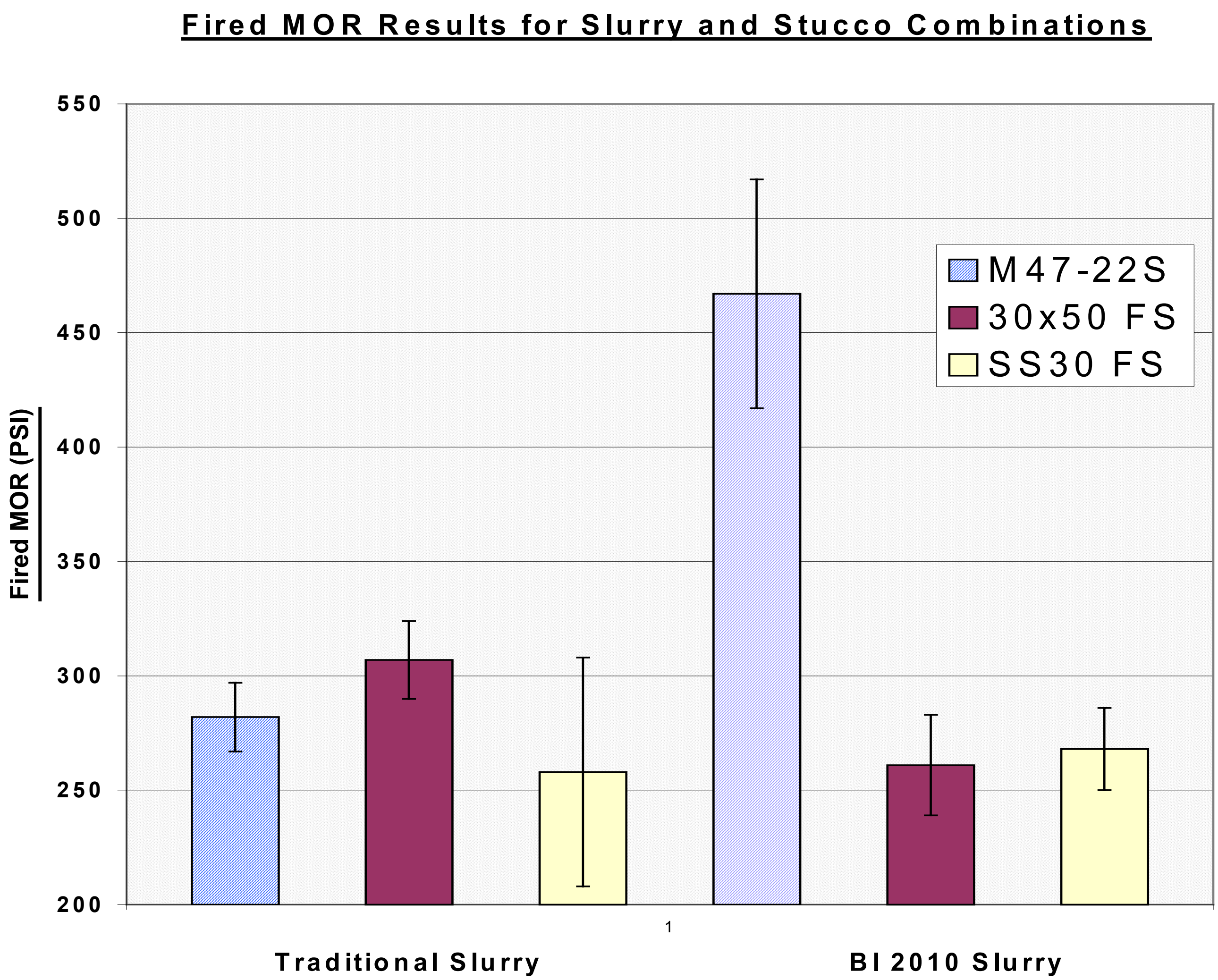

Shell Build Factors for Various Slurry and Stucco Combinations
0.26
0.24
0.22
0.2
0.18
0.16
0.14
0.12
0.1
Shell Build Facrtor (CxC/F) inches
M47-22S
30x50 FS
SS30 FS
M47-22S
30x50 FS
SS30 FS
1
BI 2010 Slurry
Traditional Slurry

For a visual comparison of the graphical results above, I have included photographs of some of the actual shell build samples with their respective Shell Build Factors.



Fired MOR Results:

Samples of all slurry/stucco combinations were made and then tested after firing for 2 hours at 1800 deg. F. and rapid air quench to room temperature. The results are shown below in graphical form.



These data suggest that with at least some slurries M47-22S may be more difficult to remove the shell after casting.

Conclusions:

1. A new test for evaluating the tendency for a given slurry/stucco combination to produce uniform and thick shell around corners is described and is shown to be useful.

2. M47-22S and 30x50 Fused Silica yield approximately the same shell build in the two slurry systems tested even though 30x50 is a finer particle size.

3. SS30 Fused Silica stucco is more nearly the same particle size builds shell faster and more uniform than M47-22S.

4. It is recommended to evaluate SS30 size fused silica stucco in your shop with an objective of reducing one dip. If this is practical, the economics may tilt toward fused silica as the overall least expensive choice of stucco.

Figure 1. **Wax Sample used for Shell Build Test.**

Figure 2. **Sectioned and dewaxed Shell Build specimens ready to be measured.**

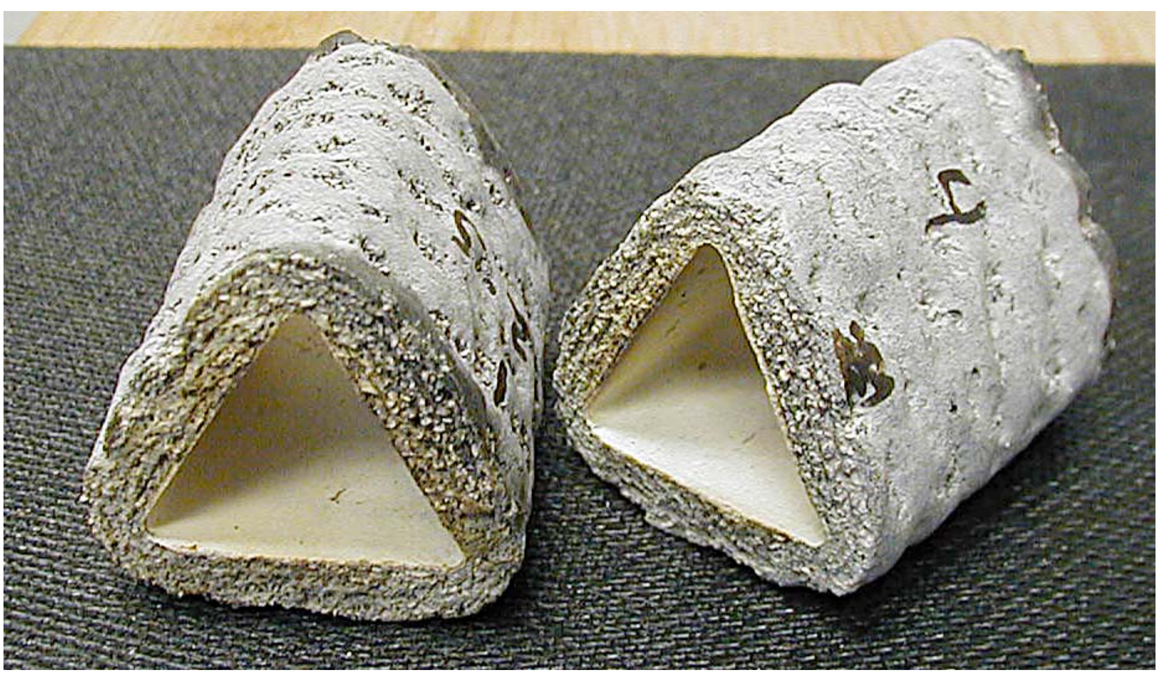


Figure 3. Shell Build Data Entry Spreadsheet.

	Face	Corner	**C/F Ratio**
Top 1	0.333	0.290	0.871
Top 2	0.340	0.222	0.653
Top 3	0.332	0.292	0.880
Average	0.335	0.268	0.801
Middle 1	0.321	0.267	0.832
Middle 2	0.343	0.250	0.729
Middle 3	0.314	0.221	0.704
Average	0.326	0.246	0.755
Bottom 1	0.323	0.248	0.768
Bottom 2	0.331	0.252	0.761
Bottom 3	0.315	0.226	0.717
Average	0.323	0.242	0.749
AVERAGE	0.328	0.252	**0.768**
Std. Dev.	0.010	0.027	0.078
95% Conf Int	0.007	0.018	0.051

Shell Build: $(C_{avg} \times C_{avg}) / F_{avg} =$ **0.194**

<u>Figure 4.</u> **Stucco Screen Analysis**