BSI Status Report: Mid-July, 2016

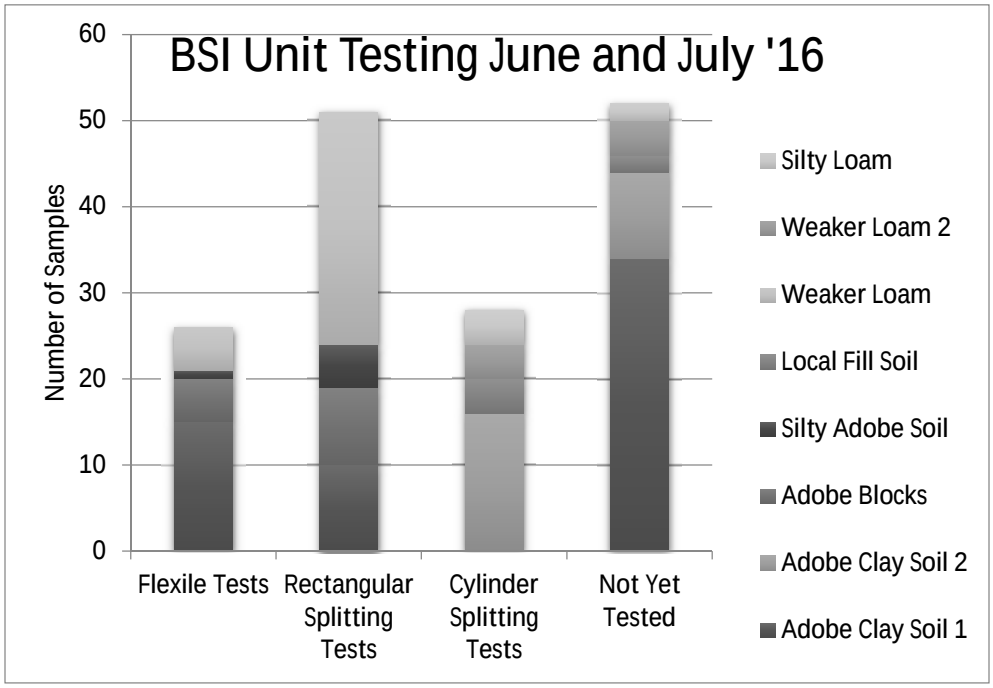
1 Recent Testing

Since his arrival in early June, intern Christian Ernstsen (photo at right) has provided vision casting and practical help to bring BSI to a higher level of accurate and repeatable research.

113 new samples have been created, with a growing emphasis on larger sample sets and subsets that are more uniform.

Since earthen units must be fully cured to reveal full strength, first priority is to establish simple ways to assure curing. Units remaining to be tested include a set of 34 samples that have been weighed daily for several weeks. These samples will compare the resultant strengths of different curing techniques, so that builders speed-curing samples can accurately predict ultimate soil strength in their walls.

Splitting tests have been explored as well as flexile tensile tests over a span. Splitting or indirect tensile tests have a reputation for a closer correlation than the span tests to unconfined compressive strengths desired by engineers. Samples for splitting tests can also be significantly smaller (less fragile, quicker to cure) than samples that must span a distance 4x their thickness.



Some of these tests have been used to develop a series of four soil mixes of sequential strength. Soils of different but known strengths are critical to upcoming research.

2 POTENTIAL TESTS 2016

An important short-term goal is to create a field test more accurate than the preliminary ball crush tests, but smaller than samples for span testing. Ernstsen is investigating the use of common manufactured elements as sample forms the size of a soda or smaller. He intends to test them with the use of a simple mini-lever. He will be trying both splitting (using two pipes along the cylinder) and a double-punch techniques that splits by inserting bolt heads into opposite ends. These will need to be compared both with natural soils and with screened soil with aggregate removed.

Three 16 sf solid (mesh tube) wall samples (two in photo at left) have been curing since mid-June. One has no reinforcement or barbed wire, another has standard barbed wire and inserted rebar, and the third has barbed wire attached to anchored, exterior rebar. These shear tests will provide needed strength and yield point and elasticity information for the different reinforcement levels.

As soon as the current wall samples are tested, a similar set of modular (solid-weave bag) wall samples can be created on the available bases.

Different soil strengths will also be used for pull-out testing of barbed wire and mesh reinforcement, as well as in assemblies of two bags with barbed wire and pins between for shear box testing of both modular and solid-type construction.

A tilt table test of a 3' x 7' U-shaped wall sample will be built at 60% scale if time permits before cold weather. Placing more than 4,000 lbs of earthen walls on a platform that can be tilted will provide some indication of the out-of-plane strength and resistance to horizontal forces that earthbag walls can provide during earthquakes.

3 CURRENT EQUIPMENT

Although BSI lost its testing shed last winter, a more convenient site close to the UNM campus has been developed (shown at right with a custom cradle under a fish scale accurate to 10 grams). This includes a storage shed and dedicated areas for mixing, weighing. Protected storage shelves can store up to eighty 50% scale samples for extended curing.

Recent equipment upgrades include the testing frame with vertical motion guides (of strong aircraft aluminum) and pre-located span and splitting supports. Samples can be quickly tested with forces up to 1600 pounds (see far right for span setup and near right for splitting test setup).

Other recent upgrades:

Stronger piston of more than 3x the area than the smaller piston.
Large analog dial for use with the piston up to 1000 psi, accurate to 1%.
2 scales- up to 50 kg by 10 grams and up to 5 kg by 1 gram.
Solar drying box with triple wall greenhouse glass for 12- 20 samples.
Used laptop.
Access 2013 database of test samples and results, currently listing 113 samples.

4 NEEDED EQUIPMENT

BSI's goal is to complete tests that engineers can rely on and compare these carefully to field tests that builders can use.

As we learn more about testing, we find that slow hand-operated jacks sometimes cause micro-fracturing of samples that lower ultimate strength test results in comparison to actual strengths in walls and to laboratory tests which occur at high speeds. BSI hopes to receive some lab confirmation by persuading students at the UNM materials lab to perform unconfined compressive strength and modulus of rupture testing on samples of our soils.

Being able to read even the hand operated jacks more accurately will assist in correlating field values with laboratory values. Recently we have found that using an iphone 5 to videotape gage values returned higher results than even careful operators were able to note. With better measuring devices we can provide better quality research:

4 channel datalogger with sample rates to 3000 per second	$150
2 beam type load cells to measure force for assembly and wall tests	$180
Regulated power supply	$40
6 potentiometer-type motion sensors	$60
1 humidity sensor to determine when wall portions are cured	$110
Sports video camera to 240 frames per second for checking gage values	$60
Technology total:	$600

Additional construction supplies needed during the autumn will include:

Brick base of a curing chamber (using an existing kiln heat source)	$80
Strong timbers for the tilt table test platform	$100
Strong steel angle to use in welding a moveable testing frame	$200
Total construction supplies and technology upgrades:	$980

If the current shear walls prove too strong for the current combination of two 10,000 pound straps and wood framework. BSI intends to create more test structure to attach to existing test wall bases instead of admitting defeat. A moveable steel testing frame of two triangular sides and a force plate will be welded and bolted into location on the existing bases.

5 POTENTIAL STAFF

Build Simple currently has no funding for either stipends or salary for workers, or for hourly costs for laborer help.

Although we have discussed applying for future grants with some UNM faculty, BSI has not yet identified a grant-writing faculty partner. In the past the civil engineering head offered a graduate student to pursue BSI testing for a full year if BSI could raise a minimum of $20,000. Currently smaller amounts for shorter periods of assistance may be acceptable. Regionally located Texas Tech has performed analysis of earthen building systems in the past.

Build Simple is currently exploring the possibility of unpaid intern help from UNM, but this is usually possible only for undergraduates with low levels of needed skills. One architecture student assisted with testing last winter, and an international student studying business assisted one morning a week with bookkeeping and accounting reports this past spring. We will be actively seeking more help for web design, photography, and drafting from university students in this way. But the need for skilled assistance with technical testing cannot be filled by occasional student helpers.

This summer's research output has been greatly increased by the willing help of our intern. He came from Denmark to give us two months of free help onsite, after already donating hours of assistance in writing soil test information during the spring.

Christian comes to BSI with a good understanding of earthen construction, and high level analysis and testing skills from work in health care materials testing. He experienced our lever equipment for testing samples (shown at left) before helping to develop more efficient testing systems.

His family's US visa expires in mid-August, but their housing will no longer be available as of August 5th. BSI could benefit greatly from his assistance for any extent of additional time if funds were available to pay a salary that would cover his housing and visa-related expenses. The family is considering serving in South America next, but does not have a tight deadline for their next step.

Laborers to assist with mixing soil and building also greatly speed the construction of wall portions. Even with 24 hours of assistance from a strong international student (shown at left), the 3 wall portions built during June made for a very tiring week for BSI's only full-time (but unpaid) staff. Recently BSI has been earmarking donations for this type of labor, but there are no reserves available at this time.

6 POTENTIAL COLLABORATION

Many engineering students have contacted BSI for advice and assistance on research projects (student leaders of UNM4Nepal group shown at left). Engineers and students in Nepal and concerned about Nepal are more aware of earthen construction potential than at any time in the recent past.

BSI is always pleased to help. Unfortunately to date most contact us too late in the planning process to transform their project descriptions or their limited course time into needed research.

Earthen wall construction techniques and soil mixes for building are complex topics that most engineering professors and students have not yet investigated. BSI feels that detailed soil tests can best be handled in-house at this time as we are laying a groundwork of basic knowledge.

But massive testing frames and computer-coordinated pressure sources needed for violent cyclic-dynamic wall tests and shake table tests on building portions at 60% scale or higher are not practical for BSI to replicate. We hope to work with students or researchers who have access to this equipment to determine the seismic function of different elements of the contained earth construction system.

For researchers with access to seismic testing equipment, time to cure sample walls or building portions may be the limiting factor. Research facilities in dry climates may be critical for this reason. On alternate option is to build test walls alternating cured units between wet earthbags. We hope to discover how much this can speed curing. Most ordinary earthbag walls several months to fully cure.

Even more critical than curing time is a professor who specializes in seismic-resilient design on staff or available to mentor students. The staff at PUCP, the Catholic University of Peru, have a long tradition of research into seismic issues of adobe.

Collaboration between BSI and professors may be most fruitful with an institution that is already involved in research into earthen building systems in hazardous areas.

(Right: Soil samples of high to low strengths pre-soaked for samples)