

Appendix 5

Bridges on GRS/GCS®/GeoMonolith Abutments and Piers

Longer Lasting, Faster, Less Expensive, and No Bump

Introduction- Setting the Stage

In the beginning, researchers did not consider “reinforced earth” structures as suitable or capable of supporting bridge superstructures. Al and I first treated the “fabric walls” as more of a novelty and expected to find severe limitations to their use. This was a fairly common first reaction to them. I had a confrontation with Jim Mitchell, then of Cal/Berkeley, related to his articles describing these structures as suitable for “low volume roads”. I countered in a letter to the editor that we were investigating the mechanics involved in reinforcing soil with tensile inclusions, and that these implied limitations were irrelevant and could besmirch their perceived future value to transportation engineering. At this time, I was on the NCHRP panel that included Ray Forsyth of Caltrans and chaired by Dr. Mitchell that produced Transportation Research Record 290. We investigated mechanisms that may be involved in this counterintuitive performance of soils with tensile inclusions and prepared some rudimentary (and incorrect) explanations and design guidelines. We were laboring, as we did for decades to come, with trying to explain Unique Composite behavior in mechanistic terms of simple composites.

Rich Barrows and Dan Alzamora summarized MSE research and constructions in their Research Pays Off article in TR News 249. That article really captures the paradigm fixity of seeing these Unique Composites in terms of element contribution. You can see our instant migration from the demonstrated performance of those flimsy non-wovens to stiff, strong “reinforcements” (tiebacks). There was never one of those “Just a Moment Here!” pauses to look at **Unique Composite behavior in which the product is greater than the sum of the parts**....and consider testing the combination after it was combined....as we do with concrete. We would have discovered the critical and non linear importance of spacing, and may never have devolved to using grids and big blocks and strong connections. And not have included overturning and embedment and face drainage layers, and multiplying reduction factors and all the trappings that go with starting on the wrong assumption.

Al and I knew there was something very wrong. We just could not quantify it until now.

The Future for MSE

Certainly MSE will be with us for a while longer. It is a subset of internally reinforced soil structures that can and does sorta perform as per Rankine modeling as a simple composite where the sum of the elements predicts performance. Caveats would include that spacing is a practical factor even here. Some modeling vehicles would allow 10 foot spacing if the inclusion were strong enough. What is new to the community is that by going back to day one and re-evaluating what we had built with those “fabric walls”, we now see that the true science follows Unique Composite definition and behavior and not quasi tieback simple composite behavior. And without recognizing the violation to our research findings, we “improved” our model from closely spaced weak confining elements to widely spaced strong tiebacks.

Generic GRS/GCS®/GeoMonolith concepts allow the engineer to exponentially increase the factor of safety in his/her structure without an increase in cost. These Unique Composites are exponentially more versatile as well. However, supporters of the status quo, particularly those with vested economic interests will resist this paradigm change.

I am bitterly disappointed that Al or I did not see our Day One Error in jumping to simple composite explanations until now...2010; however, just plain ecstatic with this revelation. The thrill of victory. It may several readings of this and a few weeks of contemplation to fully appreciate the magnitude of this sea change. But when the light bulb comes on.....

Bridges on GRS/GCS®/GeoMonolith Abutments

Al Ruckman and I intuitively understood Unique Composite behavior and were the first implement GCS® wall technologies. Our basis for “design” was our research at the University of Colorado/Denver under the direction of Dr. J. T. H. Wu and funded primarily by the Colorado Department of Transportation and some vendor assistance including Amoco and Tensar. This was where we learned to design backwards.....we tried to fail these amazing features and were continually frustrated. So if we can’t fail them, what is the problem with implementation? That we could not produce a mechanistic design protocol did not deter us. While we continued to look, but did not stop the clock in the meantime. We have participated in hundreds of millions of dollars worth of these and related adventures.

We were years into research before we considered bearing capacity separately. Another one of those super obvious birds that flew right over our heads without being seen. We could not get airbags or loading plates or jacking systems strong enough to fail our fabric walls, yet we did not at first equate this seemingly infinitely stiff “GeoMonolithic” behavior to bearing capacity.

When we did, Mike Adams of FHWA's Turner Fairbank Highway Research Center joined in and we built a 20 foot high bridge pier at his facility and tested it to 10 tons per square foot...the capacity of the jacks....without failure. Stellar performance! I then built a pier with cotton bedsheets as inclusions and loaded it with a stack of concrete barriers 18 feet high. I removed the facing on that demonstration to illustrate that facing pressure is very low on GCS® GeoMonoliths.

Mike Adams went on to trump my bedsheet demo with a similar one with cheese cloth as the inclusion and then demonstrating bearing capacity in excess of **20** tons per square foot. That is equal to bedrock. What Adams discovered was that **closely spaced inclusions elicit interparticle shear as does concrete, contrasted with MSE and tiebacks, which fail through the much easier pathways of intraparticle shear. 20** tons per square foot.

The evolution of that implementation program has yielded bridges and boxes that can be built in one day, bridge and box constructions that avoid detours, bridges without bumps, bridges and boxes with significantly longer service lives, and bridges that save a third on costs. Three bridges for the cost of two traditional bridges.

FHWA estimates that 20% of the bridges in the U. S. and world could be candidates for GRS/GCS® abutments. **Potential savings is in the billions.** Our NCHRP research showed that **these abutments can tolerate any credible earthquake.** If only it were not for paradigms.

Barriers to Implementation of Bridges on GRS/GCS®/GeoMonolith Abutments

If you have read other essays in this suite, you have seen the power of paradigms. Bridges are the domain of bridge engineers. They have neither training nor aptitude in advance soil mechanics. They have a process, a paradigm, for how a bridge is conceived, planned, designed, constructed and maintained. GRS/GCS®/GeoMonolith abutments have no place in that paradigm.

The folks who could provide these billions in savings, provide the longer lasting, better performing abutments are our geotechs. Ever try to get them to challenge a bridge engineer? Better call me or Al if you want to see that take place. Even with the FHWA (Mike Adams) leading the research and assisting with implementation throughout the U. S., the rest of the FHWA rejects this powerful technology....and paradoxically the FHWA geotechnical engineers.

Following are some photos from research and from field constructions. There is nothing left to test or demonstrate. We can now break the barriers. We are always ready to comment, advise, assist and even visit your site, and all for free. Good luck to you.

Robert K. Barrett, July 2010









