Letter to the Editor, Geosynthetics

Examples of Paradigm Confusion in the June/July 2010 Issue

By Robert K. Barrett
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"Magic" is an appropriate description where the two significant elements of very different properties are combined to produce a unique composite stronger than either element. Concrete and asphaltic concrete are two examples of "unique composites". We don't fully understand these, nor do we have mechanistic designs to explain unique composites - imagine the folly of trying to model pavement performance based only on the properties of a bucket of liquid asphalt and a sack of gravel.

Yet we can easily predict behavior of simple composites like tiebacks and soil nails, whose properties are additive to their geo-environment. Our mechanistic equations for these seem accurate where granular backfill is used. These fall into the class of simple or basic composites.

We are at a watershed of understanding these two profoundly different forms of composites, and it is important to our practices to learn those differences. Fortuitously, the June/July 2010 issue of Geosynthetics is a great resource for examples of mixing these two dimensions or paradigms of soil improvement, i. e. simple composites (tiebacks, soil nails, MSE) vs. unique composites (concrete, GRS).

On pages 10 and 36, editors and author Terry Sheridan tout bridges on Geosynthetically Reinforced Soil (GRS) abutments, which are indeed "magic" since our engineers are unable to produce an extendable, mechanistic model that predicts that stellar performance. These closely spaced constructions are superior to wide spaced Mechanically Stabilized Earth (MSE) simple composite approach; however, until just now, we did not understand intellectually what we felt intuitively. It appears that the editors and authors of this magazine have yet to recognize the dichotomy as well.

We, and I mean all of us, started off on the wrong foot with our first "fabric wall" built by John Steward and John Mohney of the USFS in the 70's. We looked but we did not see, and collectively began the quest to develop mechanistic protocols to define that performance through element contribution, as per simple composites like tie backs and soil nails. What we did not see was that we had created a Unique Composite, more analogous to concrete and asphaltic concrete. Unique Composites exhibit behaviors that exceed the sum of the constituents and **cannot be accurately modeled using an additive representation of their constituent elements.**

The "equations" are as follows:

Bucket of Sand + Tensile Inclusion (tieback, soil nail) = Basic Composite
Bucket of Sand + layers of geosynthetics on 24-36 inch spacing = Basic Composite
Bucket of Sand + Sack of Cement + Water = Unique Composite
Bucket of Sand+ jar of asphalt = Unique Composite
Bucket of Sand + sheets of geosynthetics on 8 inch spacing = Unique Composite

Design for simple composites can be done preconstruction. Unique Composite are designed and tested post-construction, i. e. concrete cylinders. Which brings on the need for a new testing protocol for GRS. This should be great news for our universities. But I digress.

The article beginning on page 43 describes a classic MSE design to support a lateral load. Costs for that project would have been significantly less had they used NCHRP Report 556 and proven GRS technolgies as bases for design. Both vertical and lateral load capacities in GRS are exponentially superior to MSE. (Go back to Pages 10 and 36 of the same magazine.) The light, durable (cheap) facing blocks used for GRS would have seen much less distortion. And GRS would not have required a meter of embedment, which wastes of a lot of facing blocks (expensive in the case of MSE) – and which misadventure made the wall taller and geogrids even wider, which favors the vendors, which is probably why they support AASHTO, FHWA and NCMA's often baseless guidelines. (I can say this – I chaired the TRB Committee on Geosynthetics 90-97 when these were developed and frozen in time. I was part of the problem.)

Deep Patch – A Good Bad Example of Mixing Paradigms

In the 1980's the USFS developed an empirical technique for slide repair they called the "Deep Patch". Let me digress to compliment those folks for real field engineering leadership – hard to find anywhere these days. The deep patch was used on roads in mountainous terrain where cut/cast construction resulted in sliding in the cast material. Those innovators would excavate vertically 6-10 feet and laterally to behind the failure scarp in the road, and replace that excavation with granular fill and sheets of non-woven geotextiles on close spacing. It seemed to work most every time.

During my tenure with Colorado DOT, I became enamored with this simple solution for that class of slides. That was before we had the Soil Nail Launcher. I obtained funding and partnered with Dr. J. T. H. Wu at CU/Denver to build a huge steel frame, inside of which we could build a full-scale embankment prototype. (Dr. Wu borrowed Japanese techniques to lubricate the sides of the test fills to negate edge effects and allow plane/strain behavior.) We discovered or demonstrated that this "Deep Patch" concept significantly unloaded the driving forces to the extent we were almost "cantilevering" dirt. What I now realize that we did create a form of cantilever. Model this as a GeoMonolithic beam, and the results are closer to what we observed.

Paradoxically, and in staying on the fundamentally wrong track from the getgo, the engineering mindsets had to describe the successful Deep Patch in terms of element contribution. In writing design guidelines for the Deep Patch, they deduced that the only explanation for this behavior was due to the added tensile capacity of the inclusion, and therefore concluded that the same results could be elicited with one sheet of stiff, high strength inclusion. It became economical on paper to use just one layer of high strength grid, which meant the excavation could be much shallower. It then looked like a simple tieback, not a unique composite to them. Engineers live in the paradigm of tie back behavior and did not question that their model was diametrically opposed to that demonstrated technique.

CDOT DEEP PATCH TEST FRAME

Even to this day, and after an impassioned request on my part for reconsideration, the USFS design manual for their Deep Patch does not follow my demonstrated successful research project nor USFS field experiments that led to the research. Most engineers and professors cannot yet separate the concepts of tieback and GeoMonolithic Composite behavior of GRS….and they have yet to see all the warts on the quasi-tieback MSE concepts. MSE has a failure rate! So will this misguided version of the Deep Patch.

Rich Griffin, since retired as Colorado Department of Transportation Director of Research, quipped that paradigms change one funeral at a time. The way to avoid getting stuck on the fly paper of paradigm fixity is to question every precept. Why accept anything? They were wrong that the earth is flat, however almost everyone who has ever lived on earth thought that. That conventional wisdom can be wrong is not news any more. We surely erred in our first explanations of “fabric walls”. Now we can set the record straight. GRS and MSE are very different technologies.

It seems there are more paradoxes that not. This has been particularly the case in the checkered and confused history of MSE and GRS. We see this in practice and in organizations like AASHTO and NCMA – and the FHWA where one group does leading edge research and demonstrations showing the value of GRS and another continues telling the state DOTs that MSE is the way to go. Perhaps the editors of Geosythetics can take a second look at their article selection process and begin presenting more Unique Composite case histories…..these are the wave of the future.

One of the most important articles in a while begins on Page 17, http://geosyntheticsmagazine.com/articles/0610_f2_slopes.html wherein Dr. Dov Leshchinsky, one of the world's most renowned researcher and author, presents a passionate case that MSE systems will ultimately be reduced to element contribution as is already a design assumption of tiebacks and soil nails. Dr. Leshchinsky, in my estimation, was speaking in understatement particularly to the morbidly flawed concept of reducing tensile strength and widening spacing of the stiff geogrids in MSE walls based on observed behavior in a few perfectly constructed test walls. (The K something modification.) In keeping with MSE concepts that spacing is not relevant, performance in those perfectly constructed sample walls was not differentiated based on spacing. Anyone with basic intelligence would know that a proposed design revision for MSE that includes either weaker grid or wider spacing is not appropriate. There are already enough contractor error and outright failures with those constructions.

Finally, I am fascinated with the trend in MSE to keep lowering the quality of the backfill without field testing these combinations. The empirical formulae that sorta works for MSE is based on granular backfill.

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Chair, TRB Committee on Geosynthetics, 1990-97
Chair, NCHRP 12-59, Geosynthetically Reinforced Soil Abutments
(NCHRP Report 556) 2000-2006
Chair, NCHRP Panel, Developing Seals for Geotechnical Borings
Retired: President of Soil Nail Launcher, Inc.
Manager of Bridge Design and Construction, Yenter Companies
Manager of Geotechnical Research, Colorado Transportation Institute
Manager of Geotechnical Research, Colorado DOT
2009 Nova Award for Innovation (GRS Bridge Abutments)
1997 IFAI International Achievement Award for Design of a 55 Foot High GRS Wall
8 Patents for Retaining Walls, Soil Nails, Seismic Upgrades, Rockfall and Scour
Protection