The Most Critical Component of Ground Risk Today

The greatest risk in infrastructure design and construction is the ground risk. Ground risk comes from two founding soil components: 1) the earthen fill elements, and 2) the natural underlying (in-situ) soils. Essentially all infrastructure developments include fill elements. Fills include structural base fills, replacement soil depths, re-compacted soil depths, grade raise fills, embankment fills, barrier fills, treated subgrade depths, subgrade courses, and backfills - much of which is also a part of the design that manages the conditions of underlying, natural soils.

The requirements for soil (fill) construction are no different than any other element of civil construction: engineering design must be achieved in construction. An important distinction here though, is that civil infrastructure depends fill construction for its foundation. Earthen fills are founding elements of most civil construction. All fills must provide the long-term strength and stability required to support the infrastructure built on the fills, so that the development remains stable and durable for the long term without damage from underlying movement. The slightest movements - measured in millimeters - from fills as thin as just a lift or two - can damage rigid infrastructure.

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In construction, the differences in lift compression - from the loads ranging between the largest and smallest compactors - can be as much as 2 inches. Yet the lift loads in construction are never compared to the fill loads after construction. Further, strength of soil construction is never known - and nor is the compaction state and associated properties that govern stability with moisture change over time.

The greatest problem in infrastructure is differential foundation movements occurring from strength loss, settlements and shrink-swell problems primarily from moisture change below our foundations. These problems are the primary cause of US property damages now amounting to $19 billion annually and escalating by $0.35 billion each year. Most of this damage comes from the fill elements of our foundations more than from natural subsurface soils, because underlying in-situ soil conditions are conservatively managed in design, and fills are a common remedial component of this management. Never is a construction investment made to build infrastructure when the underlying ground is expected to settle or move adversely beneath the foundations. Underlying natural soil conditions are always investigated and dealt with conservatively, and all remedial and supporting fill components are always assumed to be good. Therein those assumptions that the fill components are good lies the oversights with in-situ treatments and foundation fills.

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Compaction is largely misunderstood in the industry, and fill construction is largely taken for granted. The results are deficient foundation fill elements. These conditions result primarily because the specified compaction standards are not achieved in fill construction as engineers traditionally assume. ESOL provides the controls needed to prevent these problems, with real-time control and direct data verification.

All construction is built with process controls. Process controls are intended to ensure design requirements are ultimately achieved in construction. For example, in concrete pours, controls including water-cement ratios, concrete slump, vibration, and curing, are a part of the construction process to ensure the concrete structure uniformly achieves all design strength requirements. Process controls work well in all elements of construction, except for soil construction. Only soil construction is built with assumptions and trial & error exercises for process controls, which inadvertently fail to achieve the specified compaction standards or design strength and stability requirements. This is a typical occurrence. Because of these conditions, many longstanding and newer process control methods and procedures are widely used and continuously modified (e.g., field compaction curves, lab compaction curves, family of curves methods, estimated lines-of-optimums, computer modelled compaction curves, varied lab compaction energies, etc.) in efforts to achieve design requirements in fill construction. All of these process control methods are widely accepted, but used for the same compaction standards in the same compaction specifications. Only the process controls vary and evolve, while the compaction standards remain the same. As with many other elements of civil construction, process controls may vary, but the finished construction standard remains constant.

In fill construction, all process control efforts to date, conflict with the mechanical performance of the actual compactors used in construction. Therefore construction personnel are continuously forced to find ways to "meet" specifications requiring compaction performance that is different than what the compactors produce. All compactors compact soils well, but the process controls specified by engineers force contractors to try to make compactors do something they cannot. This is what forces engineers and field personnel to make assumptions with trial & error exercises, which is necessary to find ways to keep the work going. Without the assumption driven trial & error, fill construction would essentially never get done. Moreover, the end result is adverse to both the engineering needs and the construction needs.

- <u>Common trial & error exercises</u> - all of which are based on assumptions – include: lab curves used as field "targets", lab curve "shopping", field data "shopping", one-point lab methods, one-point field methods, computerized lines-of-optimums estimated from many lab compaction tests, computerized compaction curve selections from computerized lines-of-optimums, varied lab test energies, etc.

- <u>Typical assumptions</u> - all of which are incorrect – include: lab curves simulate construction, lab curves simulate field curves, lab curves represent optimum moisture and maximum density, soil properties are the key variable, lab curves represent soils used in construction, lab curves represent "a level of compaction" in construction, equal moisture-density spaces equals lab and field compaction properties, lab test curves signify ZAV line locations and thus SG of the soil, construction lines-of-optimums equal constant degrees of saturation or constant air lines, many lab test curves can be used to obtain field lines-of-optimums, full compaction is not necessary, less than full compaction is sufficient, etc.

Because of these everyday conditions, cohesive earthen fills are the only element of construction inadvertently conducted with engineering compromise and deficient results. These deficient results are proven by direct data and standard engineering science on all projects. Thus, cohesive fills often do not achieve engineering requirements, and are the only element of civil engineering & construction (E&C) that does not achieve our standards of practice. Cohesive fills are the only element of civil design not verified with direct data proof or real-time control in construction.

These collective conditions are the primary reasons why moisture change in founding fills is the primary cause of the deficiencies that plague our infrastructure capital globally, and the primary source of $19 billion in annual US property damage -- escalating by $0.35 billion each year in the US alone. This escalating property damage is the greatest problem in infrastructure E&C. Removing assumptions and inadvertent errors from the design and construction of fills is an important need. Removing that deficiency and uncertainty while achieving the overall engineering standard of practice in fill construction with direct data verification and real-time control is a major solution. ESOL provides the controls needed to remove these assumptions and deficiencies, with real-time control and direct data verification. Without ESOL's controls, these foundational problems will continue to occur and escalate. Read more about the greatest problem and solution in infrastructure.