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# General Report Session No. 8 & 9: Forensic Engineering — "Where Things Went Wrong". Geo-Economy-Adequate Geotechnical Solution

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# Forensic Engineering - "Where Things Went Wrong" Geo-Economy-Adequate Geotechnical Solution

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Today's economies in engineered construction must rely heavily on the application of sound geotechnical principles to variable site geologic conditions. We are pleased that the collection of papers in the combined Sessions VIII and IX represent this needed coverage so well and offer so much evidence that we must eternally be on guard to detect variable site conditions.

Urban redevelopment often makes use of available spoiled soils. In Metro Manila, **Morales** (8.01) was called upon to discover the cause of floor-slab and tilt-up wall deformation at a factory located in an area not known for expansive soil deposits. The 0.5-m of "heavy aggregate" base course underlying the concrete slab proved to be comprised of deleterious steel-mill slag set into swelling degradation by flood wetting. A method was devised to repair the damage while allowing the industry to remain active in the structure.

Mexico perhaps represents the world's major suite of ancient volcanically-influenced foundation conditions. **Padilla** (8.03) reports that Guadalajara is yet another city founded on a thick sequence of volcanic ash, here, more than in Mexico City, subjected to now obscured ancient and historic water courses, many of which are now filled with highly transmissive pumice deposits. In reading this account it is an easy matter to appreciate the construction problems encountered when excavation of a cut-and-cover transit tunnel met with a water-filled gully. Review of historic aerial photographs quickly led to the discovery of a stream bed infilled in the intervening fifty years and to devise a corrective action.

From Saudi Arabia, **Stipho** (8.05) chronicles the predictable degradation of typical properties of water-sensitive sabkaha-type soils of the arid-lands. Into this geologic environment of up to several millions of years in age, come the discharged effluents of treated sewage, often leading to elevations in the ancient groundwater surface, resulting in destructive dissolution of particle-binding soil cements. Engineering geologists have classified several typical geological regimes in terms of their service and sensitivity for use as foundations soils and now comes the time of awareness of how the dry-strength attractiveness of such units can be so easily destroyed by rising groundwater levels.

A major highway route at Bombay became disabled due to formation of severe undulations and potholes within a year of its opening to use, but after four years of post-construction consolidation. **Rao** (8.07) reports that a systematic investigations of its cause led to determination that monsoon ponding around the affected embankments of low-plasticity inorganic silts built over a natural marine clay substrate. Sources of the fill soil typically proved to be hillocks of tropically-weathered trap rock (diabase) rich in allophane a clay mineral imparting unusual compaction characteristics of low density at relatively high optimum moisture content, the first reported instance in India.

**Houston, Houston,** and **Walsh,** (8.09) write about the employment of a standard arid-lands (Arizona) intermediate foundation technology, drilled piers, in which on-site use of hoe-ram concrete demolition equipment had so disturbed site soils as to make a second round (post-demolition) of pier installation unsuccessful due to caving. The authors show that significant adsorption of dynamic demolition energy had concentrated at the 20-40-ft depth, due to geologic stratigraphy and had extended for some 40-feet beyond the centers of application. An interesting argument is placed such that the destroyed cohesion was made up of minor, natural grain-to-grain soil cementing, itself susceptible to destruction at the 12-cycle-per-second period of demolition vibration.

**Vitton** and **Brown** (8.6) deal with an accessory excavation alongside an older building sited on an Alabama floodplain, in which a utility trench excavation caused caving of an outer structural wall. Cause of the distress way flowage of a saturated silt unit into the trench, illustrating the always-present dangers of construction in or on floodplains. Geotechnical assessment here was for the purpose of repair and assignment of liability.

Inattention to subsurface variations in the geotechnical profile along a wastewater treatment plant effluent outflow channel led to unacceptable post-construction settlements. **Scherer** and **Weiner** (8.12) report how they conducted a systematic site investigation, defined the presence of previously undetected soft organic silt, and subsequently supported the reconstructed channel utilizing compaction grouting applied to small, driven steel piles.

A worst-case residential land-development project was undertaken in previously-mined Florida phosphate land. **Ericson, Moore** and **Madrid** (8.13) report on the results of this venture, as originally conducted without the aid of a geotechnical investigation. State land reclamation funds were obtained and the property was made suitable, with geotechnical assistance and careful property-zonation of the site. Highly-compressible, highly-plastic phosphatic clays of low shear strength were then carefully incorporated into design, recognizing relative positions of abandoned strip cuts and alternating spoil piles.

**Som** (8.19) revisits the troublesome occurrence of uncontrolled fill placed so as to bring an uneven site topography to a usable grade prior to sales to the developer of a walled residential complex of 13 buildings placed in lose proximity. Calcutta, a major city of some antiquity, would be expected to harbor such sites. Here the areal distribution of a bowl-shaped body of demolition wastes, unfortunately arrayed such that it led to torque-type distortions affecting the vertical stability of not one building but three. Rule: Urban redevelopment is older cities requires the highest order of site characterization.

Post-placement inundation of expansive fill has cost billions of dollars in structural damage, most notably to floor slabs and pavements. **Madhavan** and **Janardhanam** (8.21) provide yet another example in eastern Pennsylvania, where contractor activities left the construction site subject to severe swelling damage due to an unfortunate combinations of inappropriate grading and drainage conditions in residual soil of a sandstone and shale sequence

Perhaps fitting to end this session is the interesting Zambian case of macro-effects of site geology, reported by **Slichter** and co-workers (8.22). Dam designers always have grave concerns for foundation explorations and often hardly know when to call the limit to geotechnical investigations. But, here, in a region seemingly underlain by the most stable ground - granites and marble - a 50-m-high earth-rock dam was placed across a valley infilled with Karroo mudstones, then found unexpected warm-water springs appear downstream of the embankment. A sophisticated system of piezometers was installed, the mudstone explored further, water chemistry examined, and regional geologic history carefully reviewed. The cause: An unexpected coincidence of an otherwise unknown ancient rift valley, a previously undetected body of marble, and geochemical degradation and dissolution of weathered bedrock came to create a complex pathway for leakage of reservoir water under high-water head.

**Jedele** and **Bedenis** (9.1) bring to the Detroit practice a fine technique of dealing with lodgement till ("*hardpan*") as the bearing horizon for drilled piers and center on the decision relating to construction of bells to extend the pier load capacity. Here a one-meter layer of loose, water-saturated glacial outwash sand overlies the till surface and causes construction difficulties for the belling process. The authors' alternative design was proposed, in which the piers were extended into the till, skin friction and bearing capacity of the pier stratigraphy were re-evaluated and given substantial increases. A commensurate increase in estimated design settlement was design-accommodated and led to use of smaller-diameter piers and bells, with subsequent savings in concrete. A test pier was in-hole evaluated by placement of the Osterberg cell at the pile tip and correlating loads felt at the bearing horizon with overall pile settlement.

Complex geologic conditions confront the ongoing development of the Los Angeles Metro Rail Subway Project. For this project, **Ghadiali, Smirnoff** and **Murthy** (9.2) identify ten strong influences on the feasibility and cost of tunneling for the Metro, all of which are relate to the geologic character and origins of the rock, weak rock and soil encountered along the alignments. Discovery of a previously undetected former manufactured gas plant led to an alignment change in favor of remediation of these widely variable organic contaminants. On this project, the innovative scheme of *Geotechnical Design Summary Reports* carries forward the long-standing contributions (since 1974) of the U.S. National Committee on Tunneling Technology, with its *Better Contracting Methods* program to improve the process of underground construction by limiting litigation over unexpected site conditions.

This combined session has amply shown that site geologic conditions continue to provide ongoing challenges to geotechnical design. With new emphases on environmental remediation and redevelopment of urban lands geologic relationships now also apply to wastes and uncontrolled fill bodies as representing important types of unexpected varying site conditions.

**Session X, XI, XII - Opening Remarks**

by Chairman Shiming Wu, Ph.D.
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General Reporter, Dr. Hari D. Sharma, gave us a very good, detailed and comprehensive general report, summarized the papers presented in this session, "Case Histories of Geotechnical and Hydrological Management and Remediation of Solid, Hazardous and Low-Level Radioactive Wastes, Case Histories of Liner and Final Cover Systems for Solid, Hazardous and Low-Level Radioactive Wastes."

This afternoon, we had a free discussion because there were not many papers in this session. This session involves many fields, such as biology, geology, chemistry, environmental engineering, geotechnical engineering, social science and even law. Analytical approaches are necessary for solving the problems, but more important, case histories are extremely needed. Some projects were made ten or twenty years ago, even earlier, the engineers still keep getting the data for a long time. It is a special need for us to exchange the case histories for improving the regulations, designs, monitoring approaches and analysis.

We hope that we have more case histories presented in the conference.