

WHAT QUALITY REALLY MEANS IN SPECIALTY GEOTECHNICAL CONSTRUCTION



2025 Lymon C. Reese Distinguished Lecture

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AGENDA

1. Background
2. Conceptual Design of the Project
3. Site Inspection
4. Design Development and Documentation
5. Specifications and Their Development
6. Contractor Work Plans
7. Contractor Construction Records
8. Performance Verification
9. Closing Remarks



1. BACKGROUND

- Focus is on geotechnical engineering applications of the principles of Total Quality Management (TQM).
- Emphasis on “Small Hole” techniques:
 - Drilling, Grouting, Micropiles, Anchors
- However, the same basic principles apply to other “Large Hole” techniques:
 - Large Diameter Bored Piles, Driven Piles, Diaphragm Walls
 - Deep Mixing, Deep Dynamic Compaction, Vibroflotation
- Each of the seven successive steps are evaluated, and General Observations are followed by technique-specific Recommendations.





■ What do we mean by QUALITY?

- Quality Assurance / Quality Control is an integral part of every project.
 - However, it is most certainly not limited to the implementation of required Field Testing.
- It is synonymous with ensuring that every phase of a project from concept to final performance verification is focused on achieving the mutual goals of all parties.
- It is achieved through Two Fundamental Principles of TQM:
- Focus on optimizing every successive step or process.
 - Eliminate / Avoid “Rework” – do it right the first time!
- Beware of “Internet Experts” –

Google searches do not and can not replace
Education, and relevant Experience –
Boots on the Ground!

2. CONCEPTUAL DESIGN OF THE PROJECT

2.1. General Observations

- The design must be:
 - constructable
 - cost effective
 - compliant with prevailing
 - codes
 - standards
 - recommendations.
- The Designer must be experienced (or extremely knowledgeable) in the techniques that are being considered.
- Internal / external peer review (Individual or Panel) is essential at this stage.
- Even up to the 30% Design phase, focused workshops are very beneficial and cost effective.



2.2. Specific Recommendations

- Evaluate the foreseen drilling and grouting methods for:
 - viability and admissibility
 - specific ground conditions (difficult ground, karst)
 - certain applications (drilling through and under existing dams)
- Consider what the contractors can reasonably deliver, for example
 - readily achievable anchor and micropile capacities
 - realistic residual permeabilities in rock grouting
 - homogeneity within a jet grouted block
- Pursue the preliminary Alternatives Evaluation process, this may result in:
 - major modification of a design concept
 - complete abandonment of a design concept
 - confirmation that the design concept holds



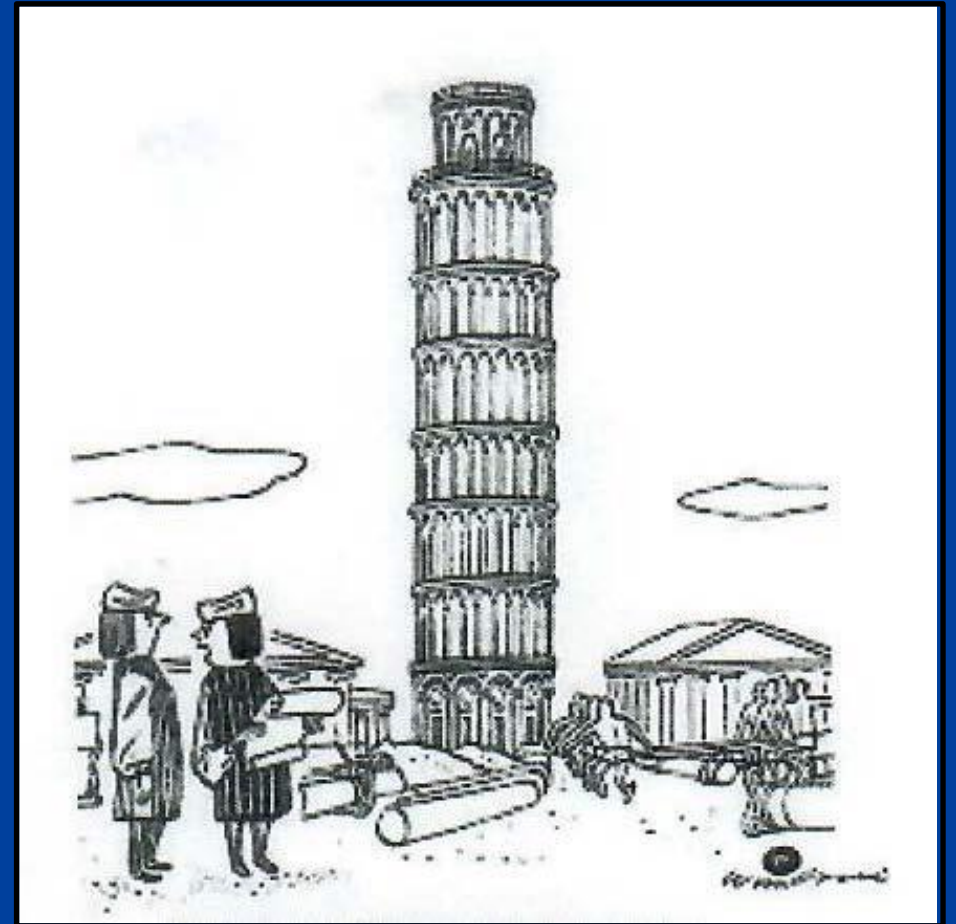
3. SITE INVESTIGATION

3.1. General Observations

- Paradigms
 - Never enough boreholes
 - They're in the wrong place
 - They're at the wrong orientation
 - They're not deep enough
- Exploratory borings do not guarantee conditions except at the borehole locations.
 - Assuming straight-line correlation of geologic units or features between boreholes may not be accurate and can prove to be misleading.



- Beware of using average values for parameters – especially for in-situ permeabilities.
- Results of the site investigation:
 - Are the underpinning of the design
 - Are the basis for determining
 - Design PFMA
 - Construction PFMA
 - Foreseeing performance related issues “down the line”
- Scope of any site investigation is dictated by:
 - Cost
 - Access
 - Sub-surface variability / complexity



“So, we’ve saved another 100 lire by missing out this site investigation thing. No one will notice.”

3.2. Specific Recommendations

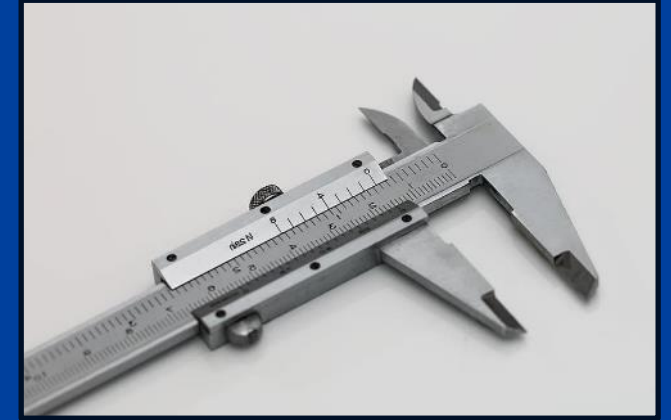
- Scope and type of investigation must address the design, construction and performance characteristics of the technique(s) foreseen.
- A Geotechnical Data Report is essential, a Geotechnical Interpretive Report is very useful, and a Geotechnical Baseline Report should be considered with care.
- All historical investigatory information should be studied and presented with judgement.
- All site investigation data should be disclosed at bid stage:
 - improves quality and price of bids
 - helps to avoid embarrassments during litigation.
- Maintain all samples for inspection by bidders during the (mandatory) prebid site visit.



4. DESIGN DEVELOPMENT AND DOCUMENTATION

4.1. General Observations

- ❖ A high-quality design must address:
 - consistency with site conditions (above and below ground)
 - consistency with project goals
 - consistency with most up-to-date codes
 - the realities of cost and schedule
 - flexibility for field modifications
 - ability to be verified as being “fit for purpose”
 - **ABILITY TO BE CONSTRUCTED!**



4.2. Specific Recommendations



- Peer review is essential –
 - not just a numerical check on calculations, quantities and dimensions
 - thorough review of the fundamentals of the design.
- Share the Design Basis Memoranda with bidders.
- Clearly define acceptance criteria, and what can be done if these are not met.
- A Full-Scale Field Trial is an excellent design risk management strategy.
- Do not permit Production Works to commence until the results of the Full-Scale Field Trial have been analyzed and approved by the Designer. Allow for this hiatus in the development of the project schedule.

5. SPECIFICATIONS AND THEIR DEVELOPMENT

5.1. General Comments

- A high-quality specification is essential for the successful and non-confrontational management and execution of a project.
- The reverse is true:
 - A poor-quality specification typically will be badly written, internally inconsistent, “cobbled together”, unaware of current codes, and probably concocted by internet experts.
 - The phrase “defective specifications” is the nightmare of Consultants and Owners, and a lifeline to Contractors in a project which has turned “sour”.
- Good guidance is provided in PTI (2014), highlighting that most specifications combine Prescriptive and Performance elements in some proportion. Innovation should be encouraged.



5.2. Specific Recommendations



- Present clear definitions of “Measures of Success” and how they are to be quantified.
- Provide clear instruction as to what construction techniques are not to be used (e.g., compressed air as drill flush in and under an embankment dam or levee).
- Include individual and corporate experience criteria specific to the technique to be used and the ground conditions that are expected.*

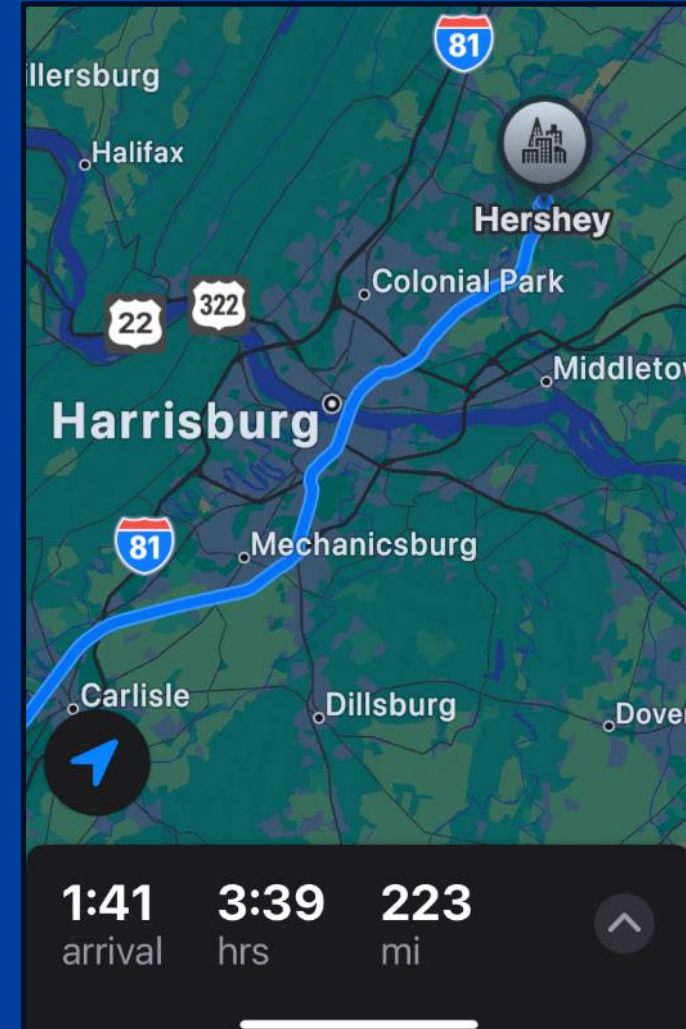
*The significance of this cannot be overstated, especially if the award is to be made based on “Low Bid”. Requirements – especially for personnel – should not be relaxed, since unqualified personnel inevitably leads to inferior construction quality. We find that certain Contractors are pushing hard for relaxation of experience criteria for key field personnel due to a nationwide shortage of staff.



6. CONTRACTOR WORK PLANS

6.1. General Comments

- Required scope is typically included in the specifications.
- Work Plans are vital for the implementation, supervision and verification of the work providing a step-by-step road map for construction.
- They are integral to project documentation, including as-built reports.
- Experience suggests that in many cases, this is the first time the Contractor has really “thought through” the project.
 - Clue: the plan is short on narrative, long on data sheets and catalogue cuts.



6.2. Specific Recommendations

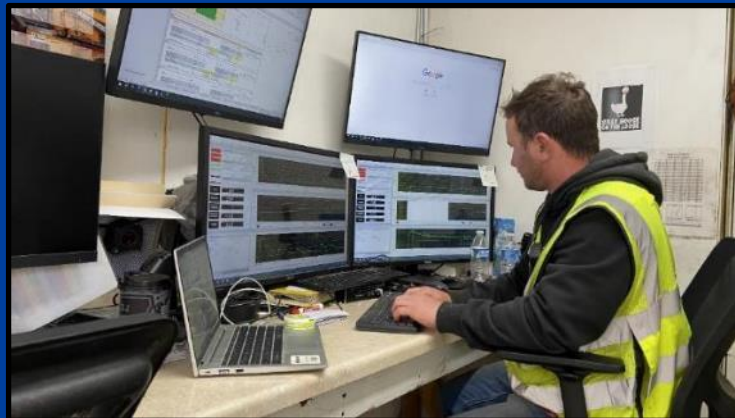
- Consider exchanging "Draft" versions following discussions but be aware of accepting "Design by Comment" responsibility.
- Contractor should aim to submit on or before schedule, but Engineer / Owner should review and return as expeditiously as possible (28 days, like UCS testing, is a paradigm).
- All project personnel must be acquainted and familiar with the contents of the Work Plan: a preconstruction workshop is very helpful.



7. CONTRACTOR CONSTRUCTION RECORDS

7.1. General Observations

- Quality is reflected in their completeness, accuracy, clarity and timeliness.
- Fundamental to sharing information in real time on and off site and to track and assess progress.
- Basis for interim payment.
- Basis for prosecution / defense of Claims.
- Large projects may require an automated Data Management System:
 - Don't underestimate the effort, especially early in the project!



7.2. Specific Recommendations

- A ten-point plan for a compliant and cooperative QA / QC program is provided in Bruce, Cali, and Jefferis (Deep Mixing Conference Gdansk, Poland, June 15-18, 2020).
- A common theme is efficient cooperation at all levels, and the use of properly qualified personnel.
- Special attention should be paid to quick and conclusive resolution of apparent discrepancies and omissions.
- Avoid participating in a “war of letters”.



8. PERFORMANCE VERIFICATION

8.1. General Observations

➤ Remember TQM:

- After a product is built, you cannot inspect quality into it.
- By using successive processes of high quality, a high-quality product will result.

➤ But:

- There is a difference between process optimization and product verification / acceptance
- Verification is essential to all parties:
 - comfort to the Owner that the work is “fit for purpose”.
 - confirmation to the Engineer that the design has been constructed in a compliant fashion.
 - validation of the Contractor’s workmanship, and justification for submitting an invoice.



8.2. Specific Recommendations

- Each specialty geotechnical construction technique requires its own specific set of verification / acceptance criteria:
 - Conduct **Anchor** performance verification per PTI (2014), preferably using progressive cycling to Test Load. Even for Proof Tested anchors, a return to AL (as is done in the Performance Test) before raising to Lock-Off is essential for load transfer analysis.
 - Similar comments apply to **Micropile** Testing (governed by FHWA 2005).



- Grout curtains should be judged acceptable in the short term by confirming that the target residual permeability has been met (e.g., 5 Lugeons or less). Longer term verification is provided by evaluating the curtain's impact on piezometric levels, seepage rates, or other measure of success (e.g., elimination of "signs of distress" such as sinkholes).
- Jet Grouting is verified by consistency of process control based on the successful implementation of a Full-Scale Field Test, and by verification by coring and subsequent testing of production columns (ASCE, 2016) .
- Compaction Grouting verification features analysis of grout takes and pressures, and the measurement of in-situ soil densities between columns (ASCE, 2019).



9. Closing Remarks

- “Quality” is not just limited to QA / QC Field Testing.
- “Quality” must permeate each and every successive process from concept to construction to verification.
- “Quality” will result in budget and schedule benefits (as well as product compliance) but will also contribute to the enjoyment and pride of all parties who participated in completing a successful project.

That’s what “Quality” really means



I hope that Chief Petty Officer, but later, Professor Reese would agree: it’s all about the people!

