Purdue Geotechnical Society
Workshop and 4th Leonards Lecture

CONSTRUCTION FAILURE OR FLAW, THE ROLE OF ENGINEERING JUDGEMENT IN DECISION MAKING

Presented by:
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Geotechnical Engineering Top 10

1. You are more likely to own “Holtz and Kovacs” that “Dolce & Gabbana
2. You want to name your kids Sandy, Clay, and Peat
3. You want to put your dog house on piles
4. You care about the difference between “dirt” and “soil”
5. You are willing to work on dam problems for days on end
6. Your vacation photos always include retaining walls and slope failures
7. You know that SPT doesn’t stand for Stupid Penetration Test
8. You build sand castles with seaweed tiebacks
9. You recommend boring plans to your client as part of your job
10. You put the word ”Geo” in front of everything

Workshop Theme: *Coping with Disasters Large and Small*

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Workshop Theme: *Coping with Disasters Large and Small*

Presentation Outline

- Background – set the stage!
- Medley of example projects
- Practice area needs

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- **Medley of example projects**
- **Practice area needs**

Engineering judgment

Engineers' Panel Urges Study Of All Levees in New Orleans

By JOHN SCHWARTZ

The safety of New Orleans's battered levees is "open to question" until the entire system can be analyzed in light of new information about how the 17th Street Canal levee failed after Hurricane Katrina, according to a review panel of civil engineers.

In a strongly worded letter sent Friday to Lt. Gen. Carl A. Strock, the chief engineer of the Army Corps of Engineers, the panel, from the American Society of Civil Engineers, said that "a determination of the overall safety of the hurricane protection system cannot be made until such time as the remainder of the system can be evaluated with the benefit of this new information."

The Corps has been racing to repair damaged sections of the levees by June 1, the start of the Atlantic hurricane season. The letter argues that regardless of the quality of those repairs, the parts of the system that survived the hurricane and were built to the old standard should be given a close look before the city can be declared safe.

Over all, the group found that the 17th Street Canal floodwall "appears to reflect an overall pattern of engineering judgment inconsistent with that required for critical structures."

The design, the letter said, did not include a margin of safety allowing for stresses beyond the expected. For example, I-shaped walls were used when an inverted-T shape would have provided greater strength.

The review panel, which the Corps formed to analyze the work of its own investigation of the levee failures, was responding to a March 10 report by the investigators. The report found that the designers of the levees and floodwalls had not anticipated that floodwaters might push the floodwall away from the soil base, allowing water to course down into the gap and push the structure aside.

A 1988 report by the Corps showed that such a chain of events was possible. That and other studies, apparently, "never triggered an assessment of the impact that such a gap would have on the stability of the existing levee and floodwall system," the panel of engineers said.

The Corps investigators' report said a second factor in the 17th Street Canal failure was soft soils behind the levee that did not withstand the push from within the canal.

All such soils should be tested and "all I-walls should be re-evaluated" immediately to see what stress they can withstand, the engineers' group said in its letter.

Ivor van Heerden, a leader of Team Louisiana, the group studying the levee failures for the state, said he was pleasantly surprised to see that the panel had reached similar findings. The fact that the groups the Corps formed to review its work have taken such a strong stand, he said, means "it's not just the crazy Cajuns with funny-sounding accents" criticizing the Corps.

A Corps spokesman, Paul Johnston, said that "in general, we agree" with the engineers' concerns, adding, "In fact, we're already implementing a lot of those recommendations."

The review panel's chairman, David E. Daniel, said in an interview that he was encouraged to see that the Corps accepted the conclusions. But, he said, "Simply restoring levees to pre-Katrina levels does not address the question of whether the design was adequate in the first place."

Dr. Daniel, who is also the president of the University of Texas at Dallas, also criticized the tendency of some Corps officials and public figures to proclaim the levees safe.

People deserve "the straight scoop on what the risks are, for those who do decide to return to New Orleans," Dr. Daniel said.

NY Times, March 26, 2006

Over all, the group found that the 17th Street Canal floodwall "appears to reflect an overall pattern of <u>engineering judgment</u> inconsistent with that required for critical structures."

Where does engineering judgment come from?

Good judgment comes from → Experience

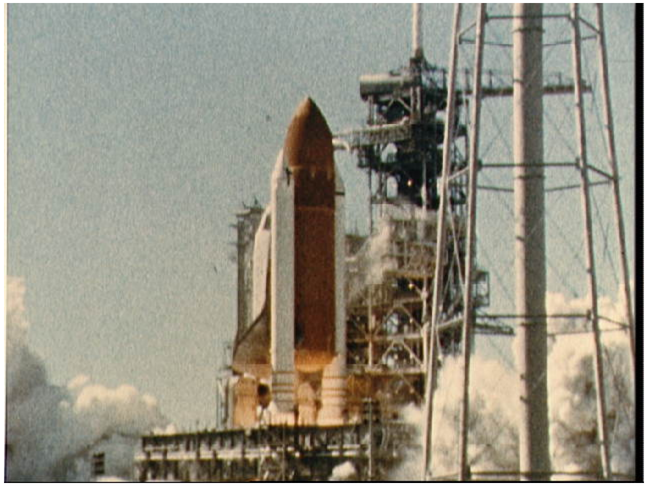
Experience come from → Bad judgment

Where does engineering judgment come from?

Where does engineering judgment come from?

Where does engineering judgment come from?

When I hear the words "engineering judgment," I know they are just going to make up numbers. (Feynman, 1993)



Background

The Code of Hammurabi:

- If a builder build a house for some one, and does not construct it properly, and the house which he built fall in and kill its owner, then that builder shall be put to death.
    - If it kill the son of the owner the son of that builder shall be put to death.
    - If it kill a slave of the owner, then he shall pay slave for slave to the owner of the house.
    - If it ruin goods, he shall make compensation for all that has been ruined, and inasmuch as he did not construct properly this house which he built and it fell, he shall re-erect the house from his own means.

- If a builder build a house for some one, even though he has not yet completed it; if then the walls seem toppling, the builder must make the walls solid from his own means.

Background

Metro construction site collapse

- Lijia Station on Metro line 3
- TBM excavation
- Heavy rainfall

Guangzhou capital of Guangdong Province

Background

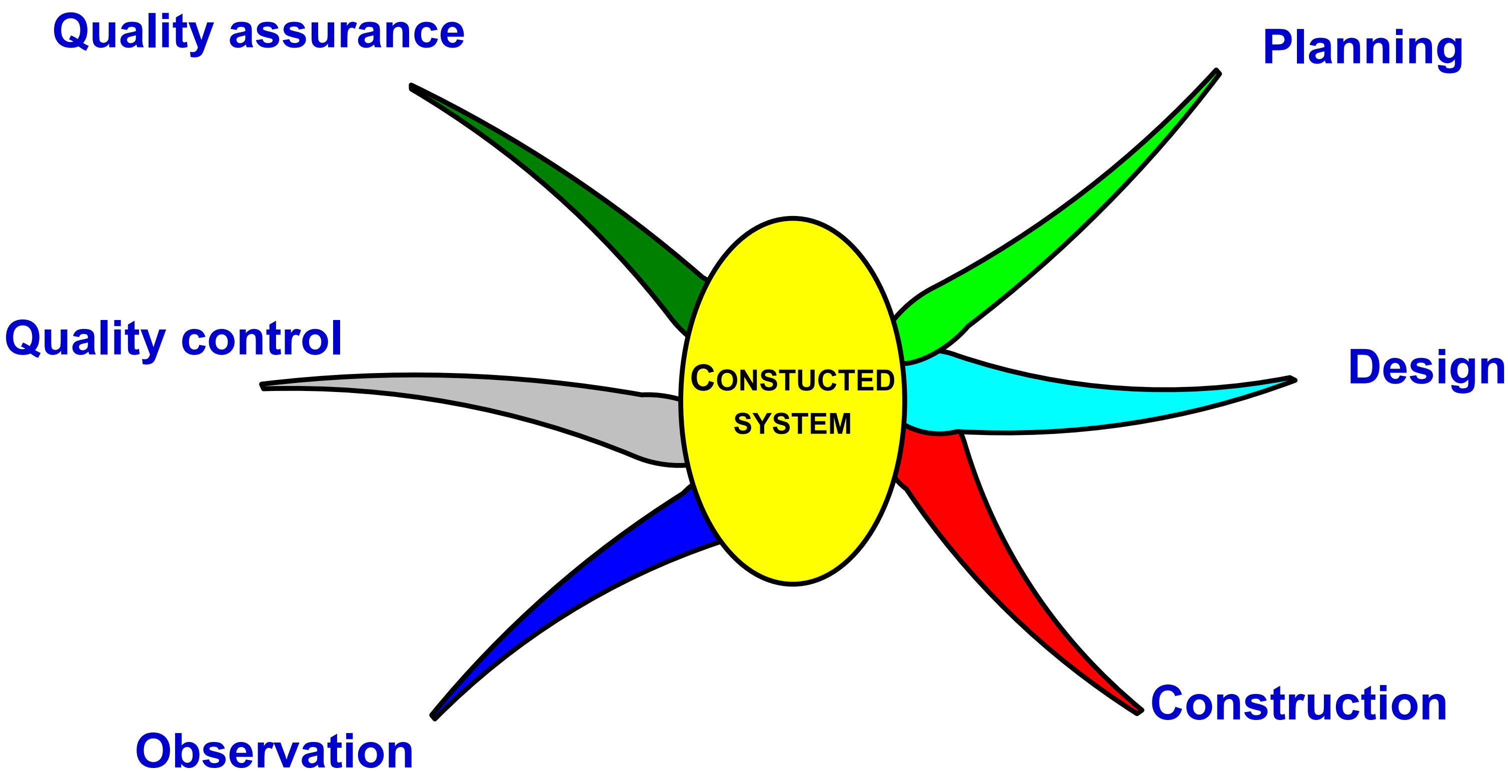
Maumee River Crossing

- Single pylon cable stayed bridge
- Tower height ≈ 380 ft
- Foundations: Drilled shafts
  - 256
  - Diameter 7-8 ft.
- Construction ≈ $220 mil

At 15%, foundation costs are ≈ $33 million

Background

Systems perspective



Presentation Outline

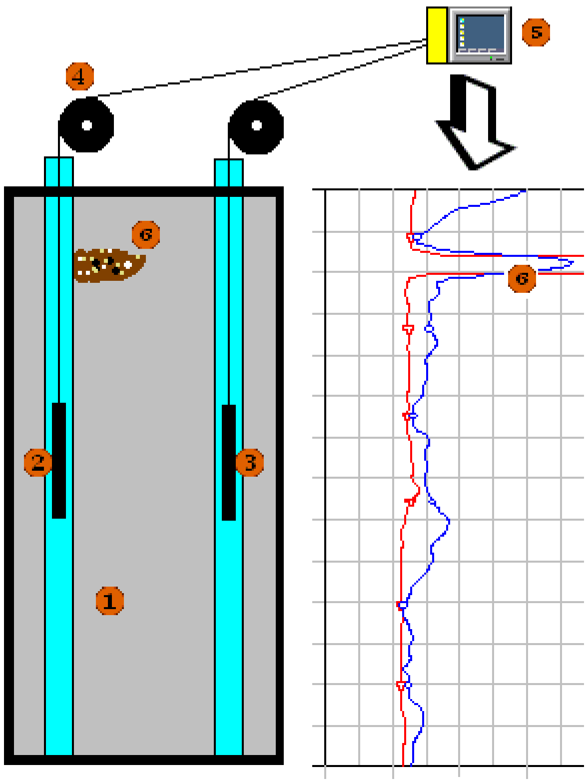
- Background – set the stage!
- **Medley of example projects**
- Practice area needs

Perry Street Crossing

Foundation system: Drilled shafts

- Diameter: 72 inches
- Length: 35 feet
- Unconfined comp. strength: 4,500 psi
- Reinforcing steel: 60 ksi
- Integrity testing: Cross hole sonic logging

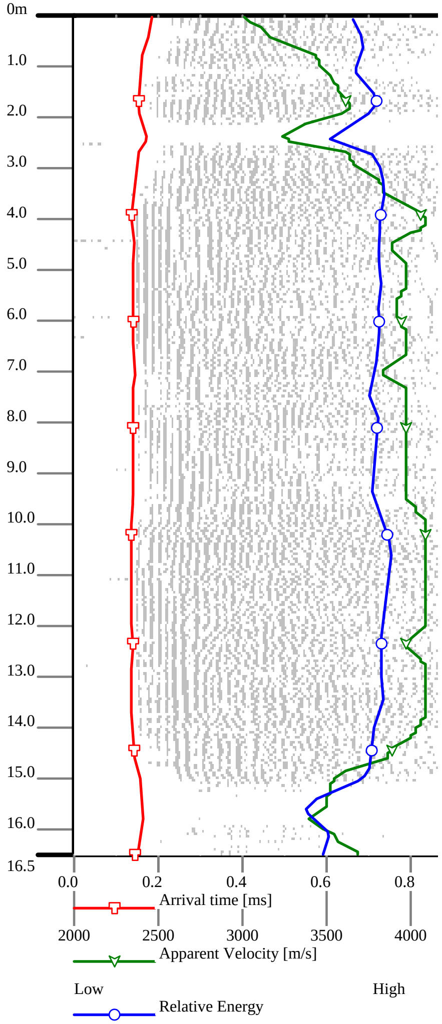
Cross hole sonic logging



<u>Integrity testing:</u>

- In accordance with ASTM 6760
- Defect analysis and impact
- Foundation design
- Inspection
- Construction engineering
- Mitigation planning and design

Cross hole sonic logging



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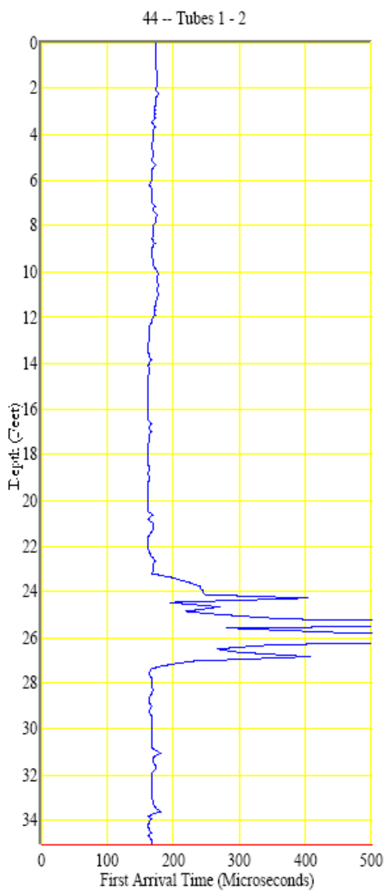
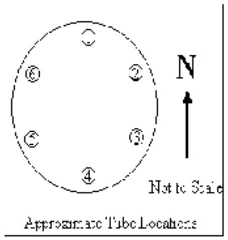
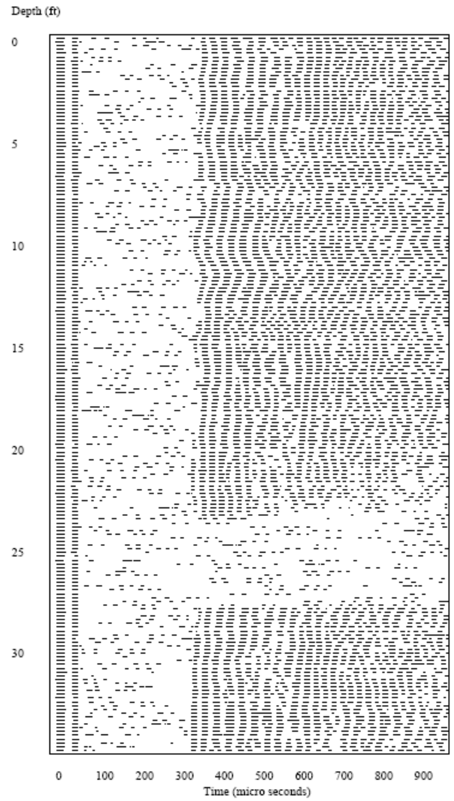
Perry Street Crossing





Tube Spacing :	29.50	inches
Signal Gain :	200	
Threshold :	1.50	
At Depth of	2.02	ft
Velocity	14100	ft/sec
First Arrival Time	174	us
Signal Energy	501.76	V-us



Shaft Name: 44

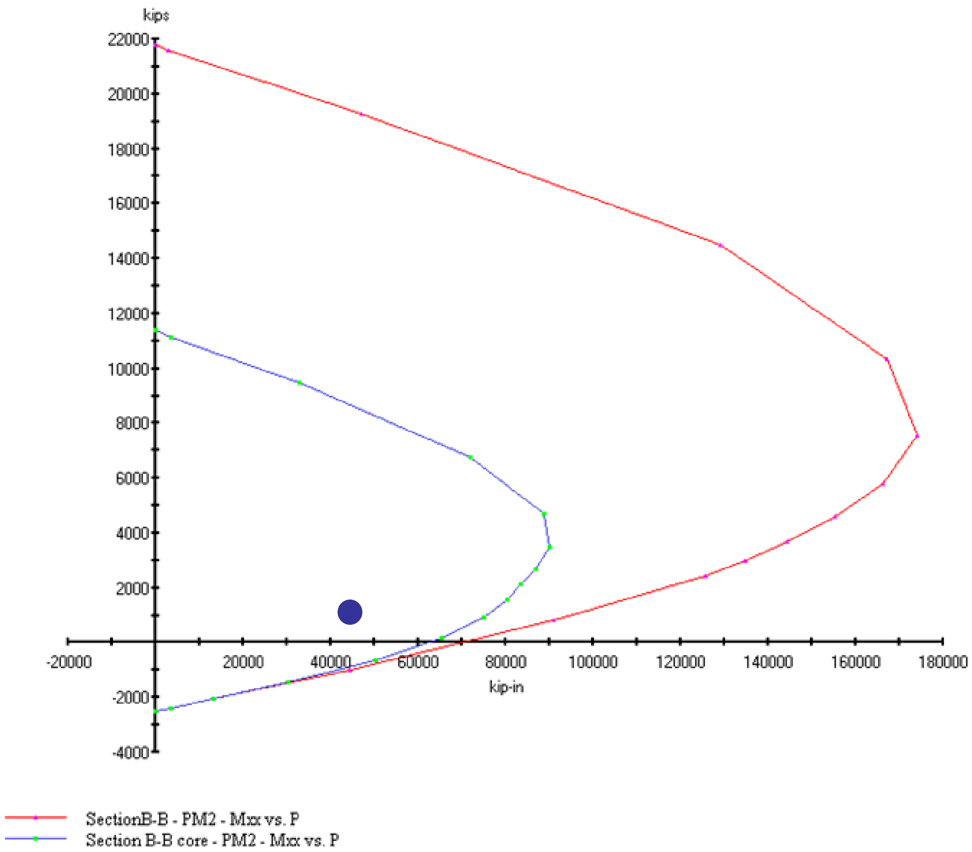
Tubepair: 3 - 6

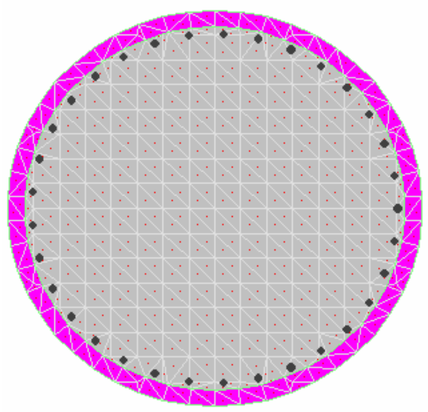
Number of Tubes: 6

Tube Spacing: 61.5 inches

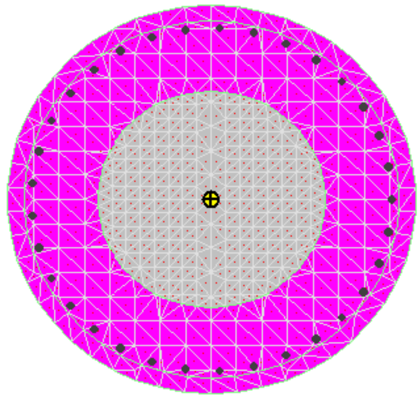
Figure A.0

Perry Street Crossing





As-designed



As-constructed

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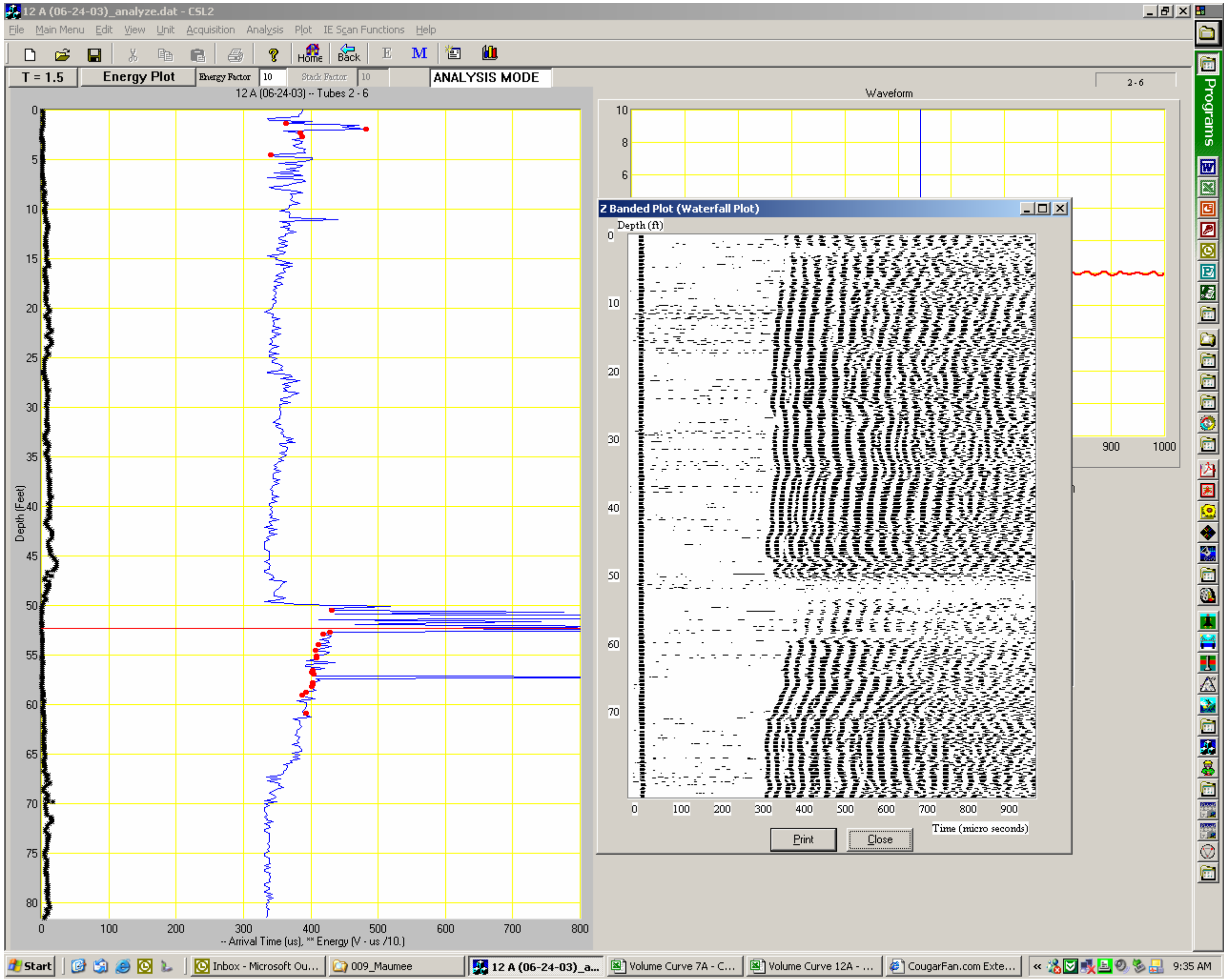
Maumee River Crossing

Foundation system: Drilled shafts

- **Diameter: 7-8 ft.**
- **Length: 100 ft.**
- **Number: 256**
- **Unconfined comp. strength: 5000 psi**
- **Integrity testing: Cross hole sonic logging**

Maumee River Crossing



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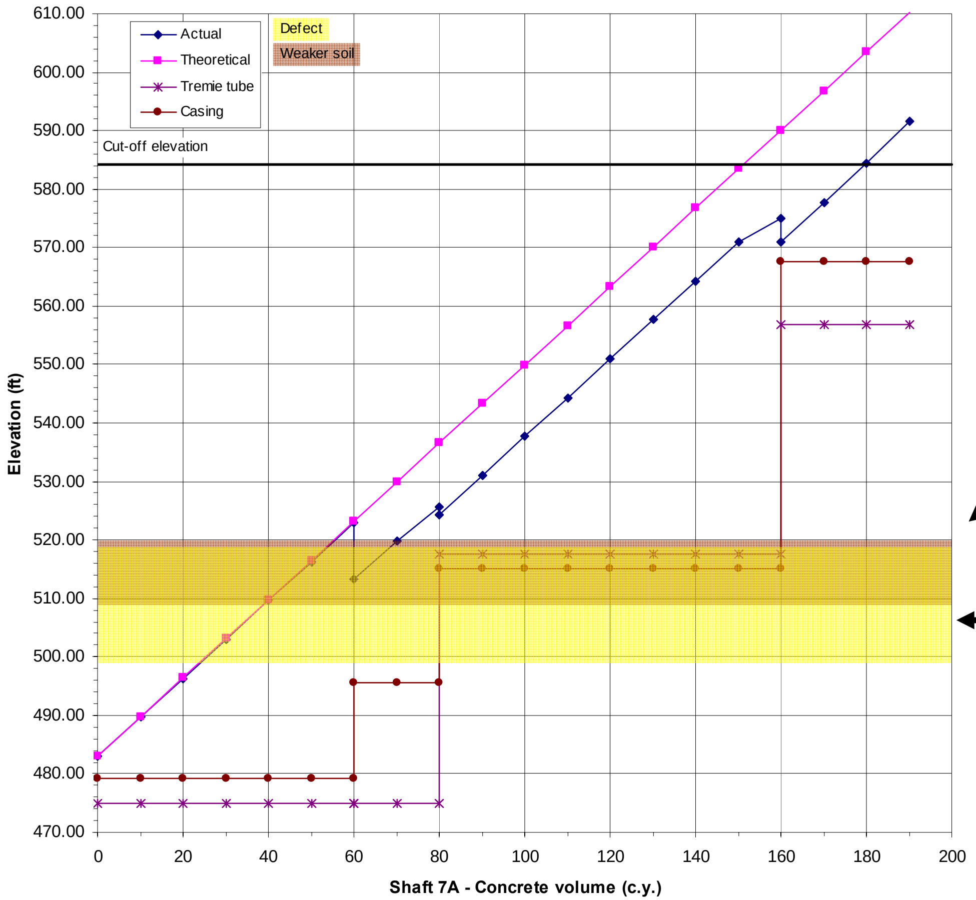
Maumee River Crossing



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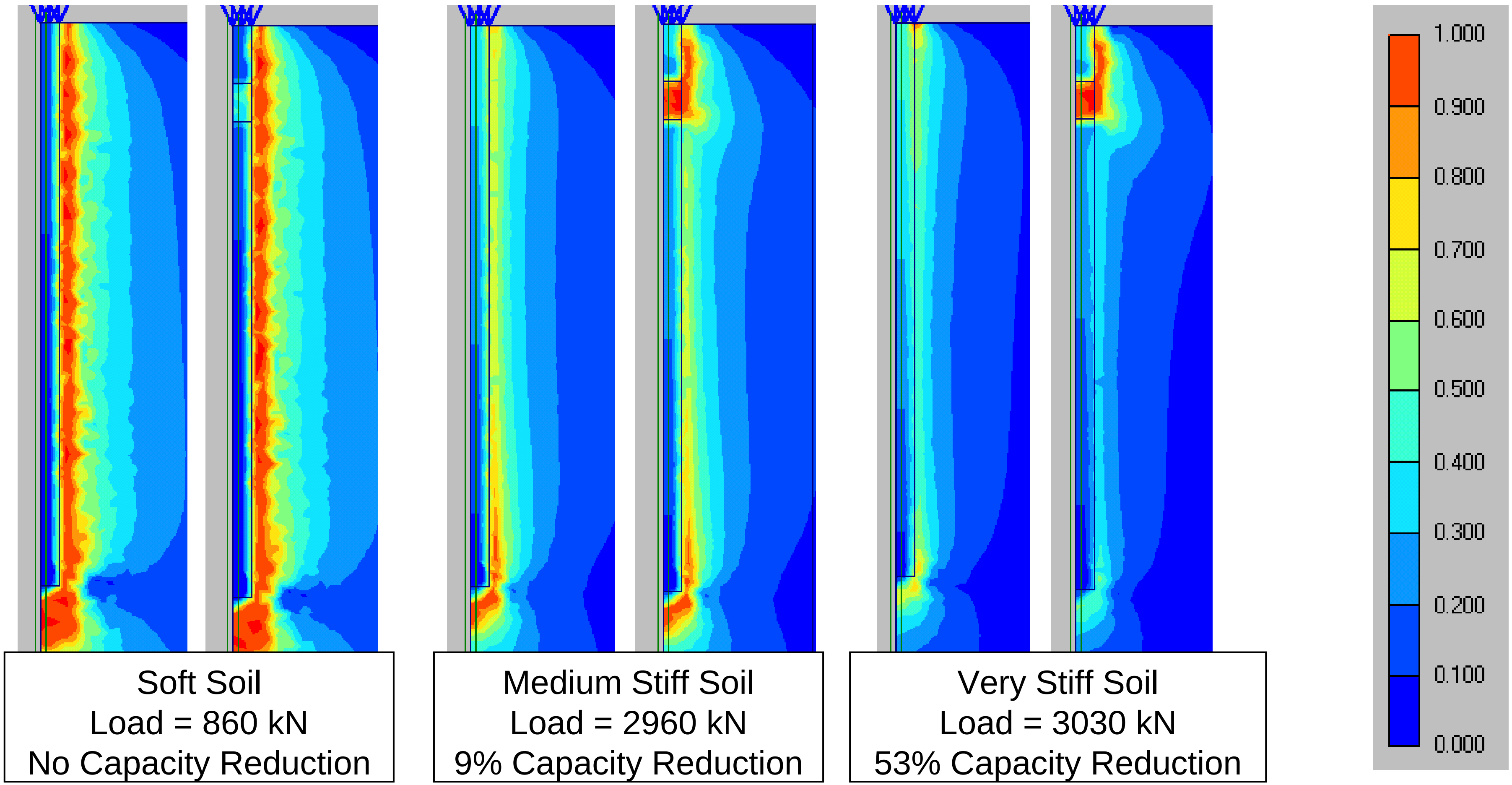
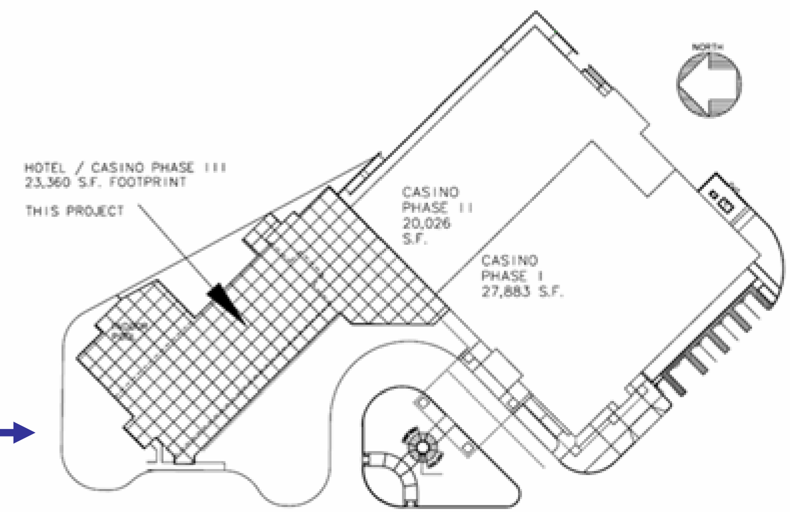
Research: Defect and acceptance criteria



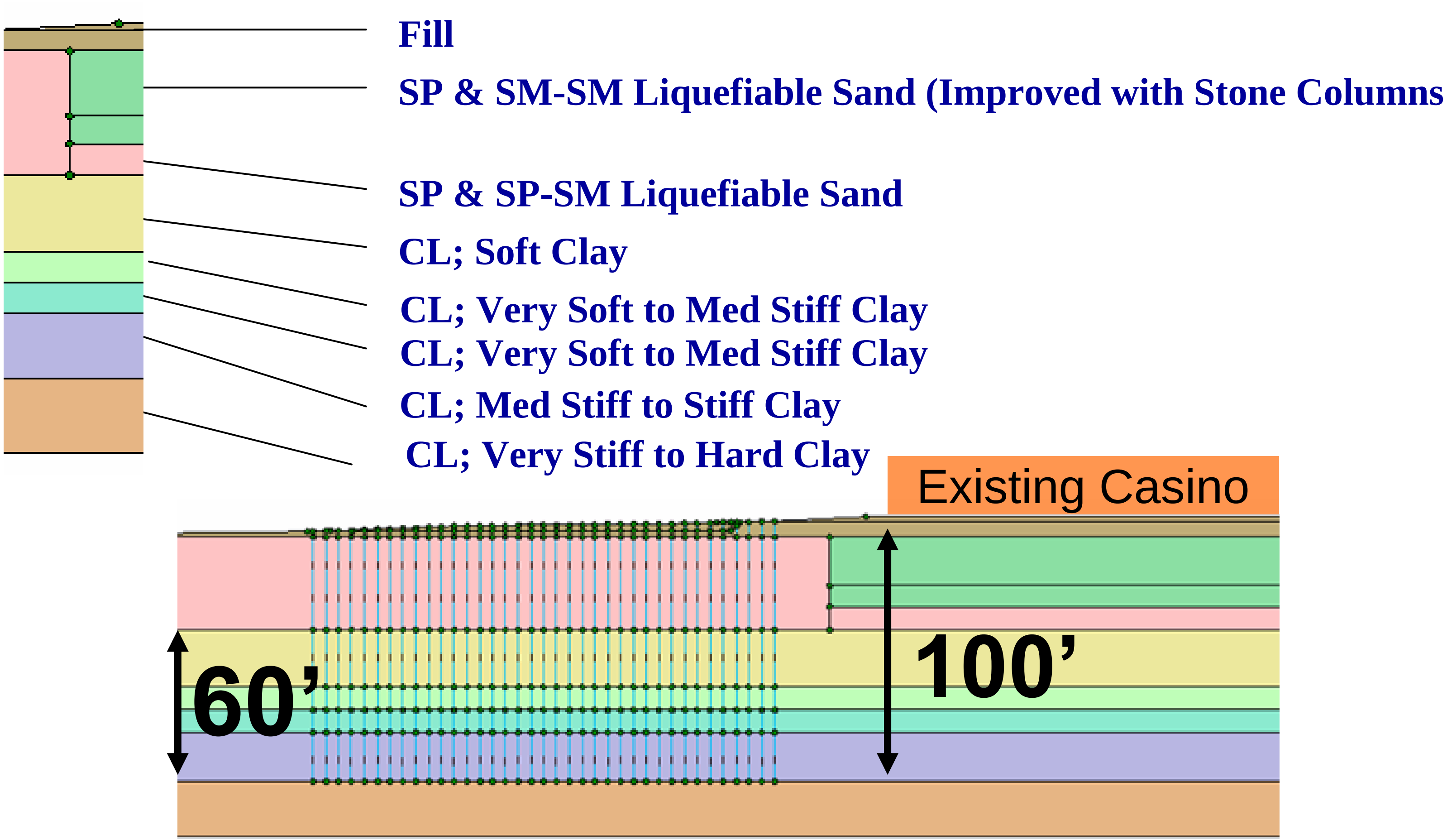
Example project: “Traditional Geotech”

- Existing Casino 48,000 sq. ft.
- Expansion includes:
  - 23,360 sq. ft. of New Construction
  - 6-Story Cast-in-Place Concrete Hotel
  - 60,000 Gallon Water Tank
  - Grading/Landscaping/Parking

This Project →



Example project: “Traditional Geotech”



Example project: "Traditional Geotech"

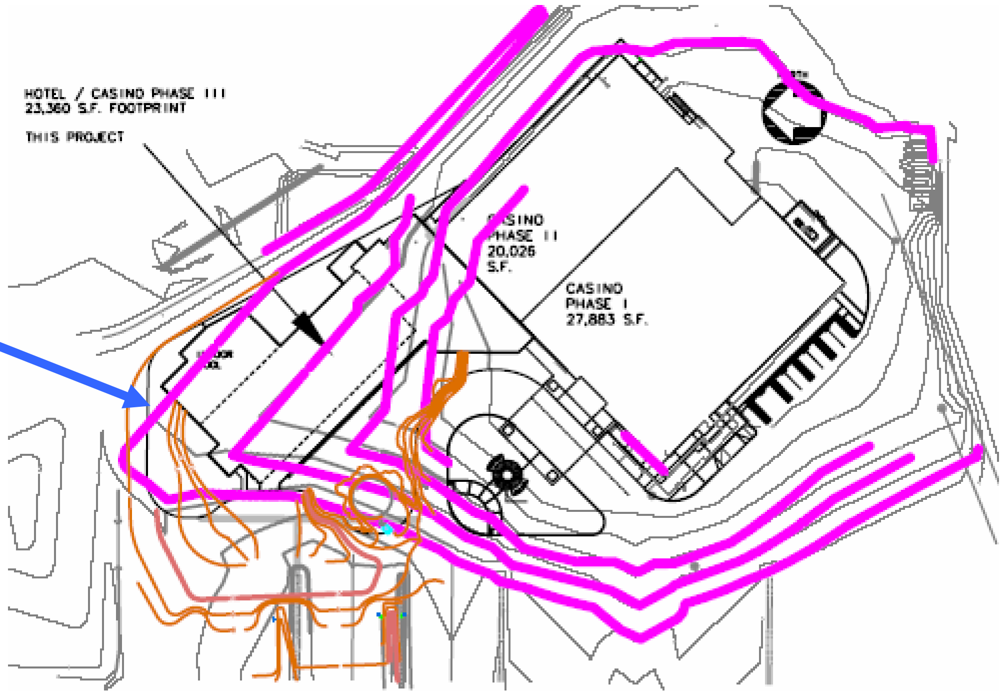
Recommendations to owner

- Expect settlement 18 to 24 inches of
- Expect settlement to take 20 years
- Install stone columns to a depth of 35 ft.
- Foundations:
    - Deep piles
    - Compensating foundation
- Build somewhere else

Example project: “Traditional Geotech”

- At least three episodes of previous grading
- Fill thickness varies from 0 to 10 feet
- No settlement monitoring performed following mass grading

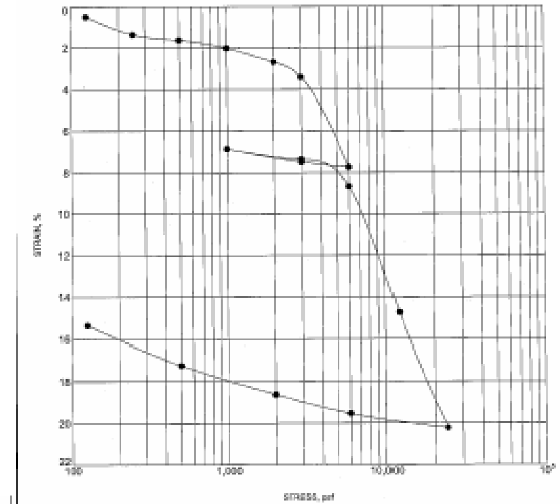
This Project

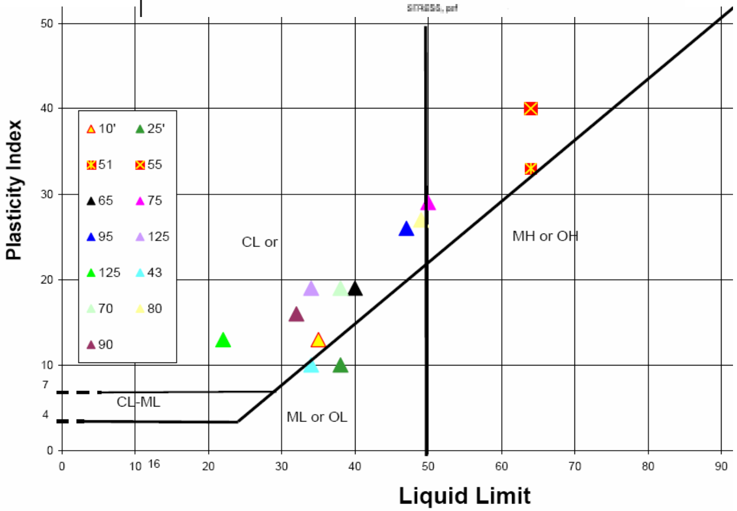


- Grey contour lines Phase I grading
- Pink Contour lines Phase II grading
- Orange contour lines Phase III Grading

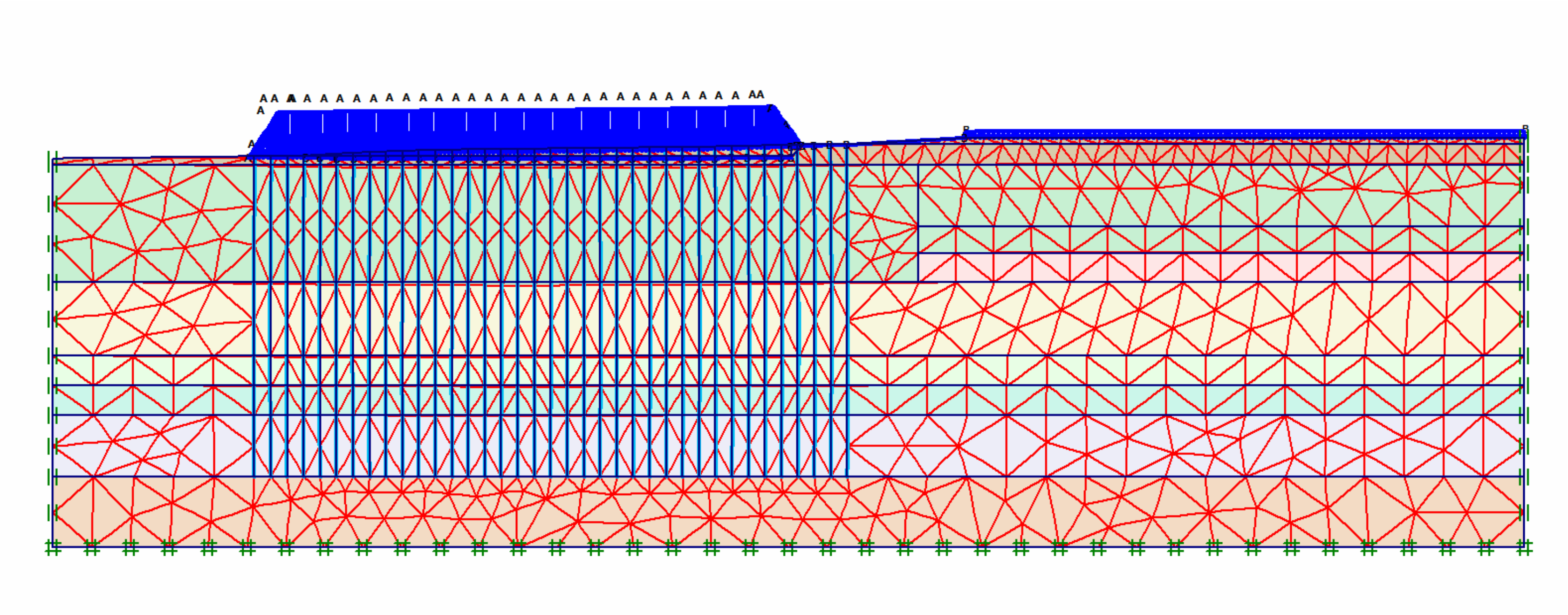
Example project: “Traditional Geotech”

- Developed a judgment based soil profile
- Selected reasonable soil properties based on available lab test results
- Refine selected soil properties to “predict” previously observed settlement thereby verifying FEM Model.
- Compare results with tolerable settlement performance criteria.
- Refine as required





Example project: “Traditional Geotech”



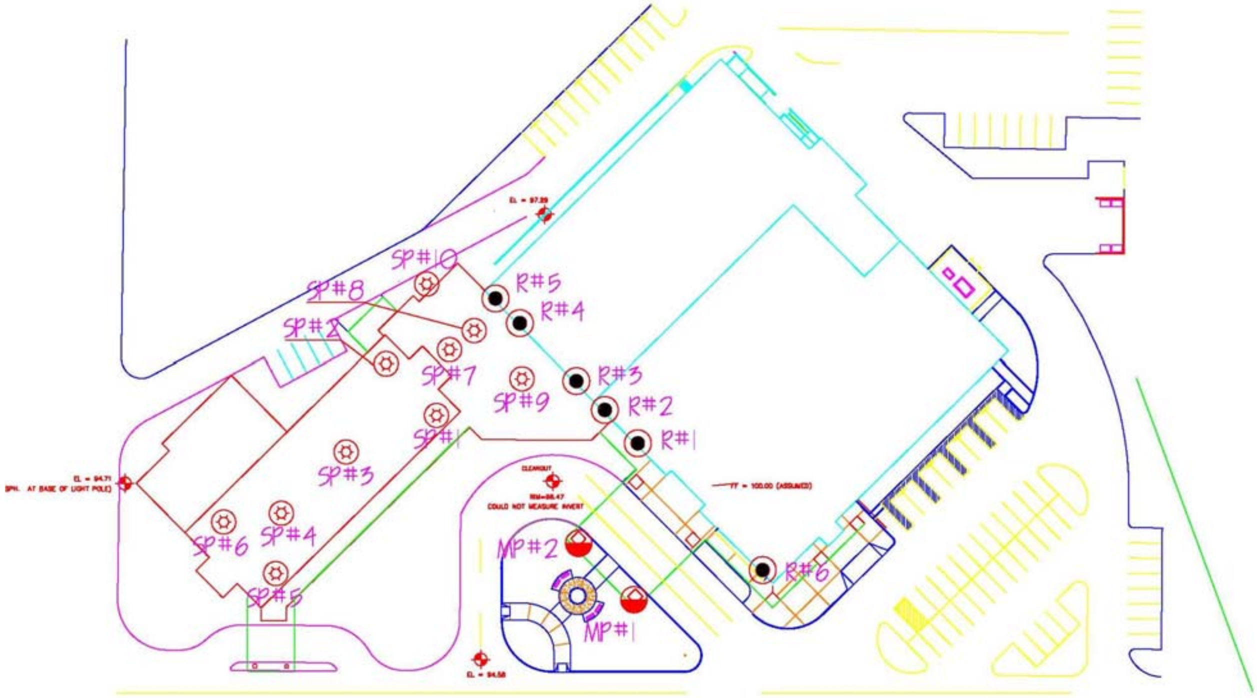
- Past fill
- Consolidation
- Stone columns

- Drains
- Fill
- Consolidation

Example project: "Traditional Geotech"

Phase	Phase No.	Start phase	Calculation type	Load input	Time (days)
Initial phase	0	0		-	0
Casino stone columns	1	0	Consolidation	Staged Construction	25
Phase1 and 2 fill	2	1	Consolidation	Staged Construction	25
Wait 90 days	3	2	Consolidation	Staged Construction	90
Casino load	4	3	Consolidation	Staged Construction	90
Wait 1000 days	5	4	Consolidation	Staged Construction	1000
Hotel stone columns and wicks	6	5	Consolidation	Staged Construction	60
Preload 60 days	7	6	Consolidation	Staged Construction	60
Preload additional 120 days	8	7	Consolidation	Staged Construction	120
Switch soil properties	9	8	Consolidation	Staged Construction	2
Remove preload	10	9	Consolidation	Staged Construction	21
Excav, add hotel load, no expansion	11	10	Consolidation	Staged Construction	180
Final consolidation	12	11	Consolidation	Minimum pore pressure	53

Example project: “Traditional Geotech”



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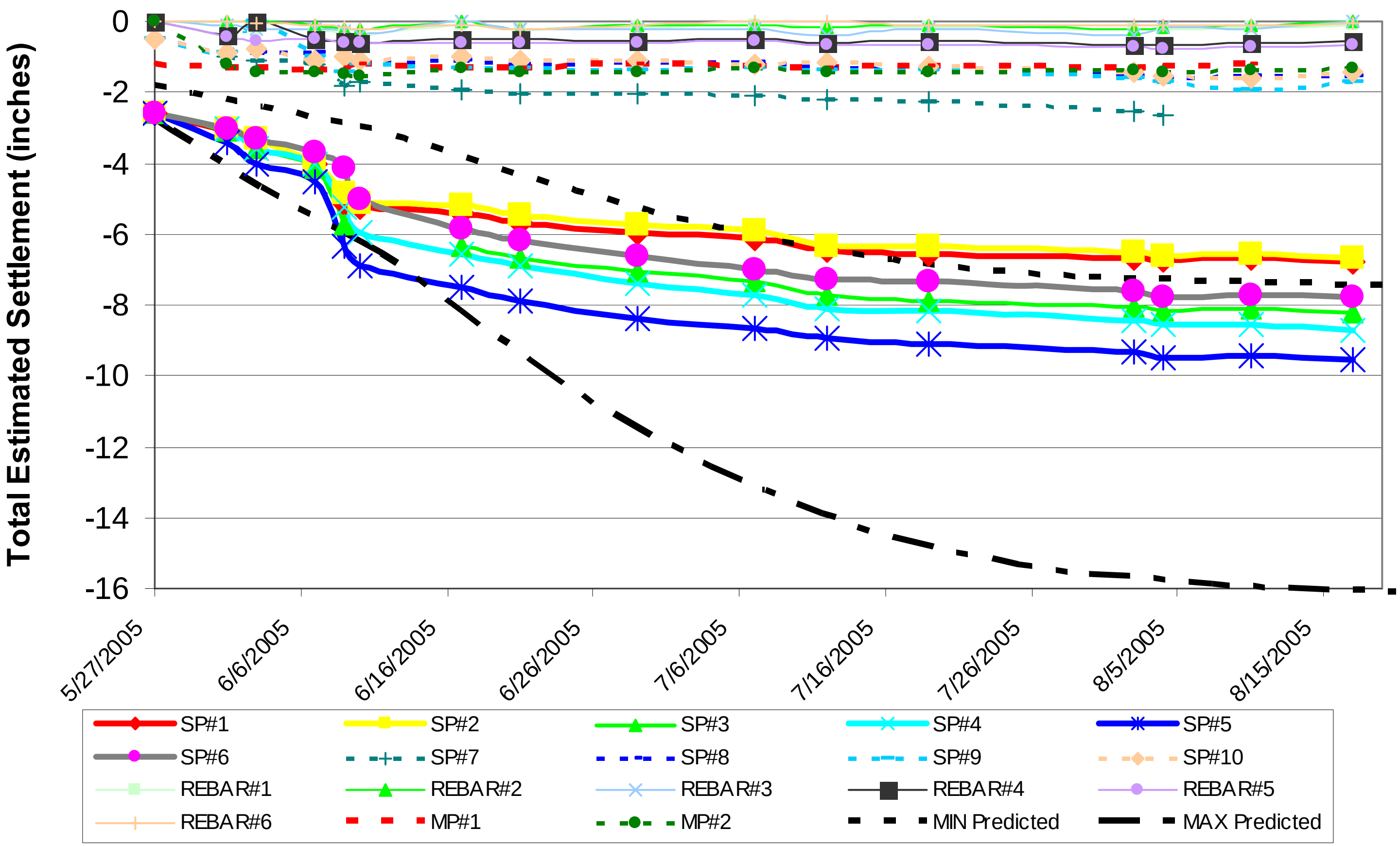


Example project: “Traditional Geotech”

Distance from hotel mat foundations	Settlement	
	Predicted	Observed
30	4.5	2.75
45	2	1.75
60	2	0.75
75	0.25	≈ 0
90	< 0.25	≈ 0
105	< 0.25	≈ 0

Example project: "Traditional Geotech"

Presentation Outline

- Background – set the stage!
- Medley of example projects
- **Practice area needs**

Practice area needs

The Direction of Our Profession

"Construction deserves more attention in design." (Peck, 1973)

Practice area needs

Construction focus

Sound transit

Tacoma narrows

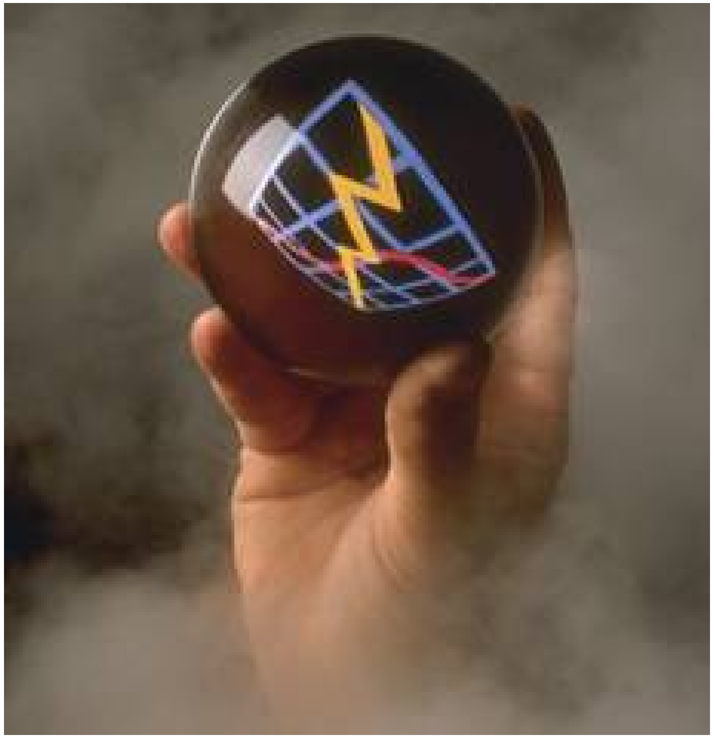
Benicia

Tren Urbano

Practice area needs

Construction focus

- Code evolution (LRFD)
- Project delivery systems
  - Traditional – Design/Bid/Build
  - Performance/financial
    - Design build
    - BOOT
    - DBOM
    - PPP
- Performance specifications



Practice area needs

- Implement “hands-on” construction
- Greater emphasis on structural foundation engineering
- Introduce uncertainty and variability into widely used simple models
- Earlier introduction of simple models and numerical analysis to reinforce theory and construction
- Material property estimation
- Regional model needs
- Practitioner training

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Questions