

FROM DATA TO INSIGHTS: INTELLIGENT BIG DATA APPROACHES IN GEOTECHNICAL PROJECTS

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OBJECTIVES

- > What can you do with standardized data formats in geotechnical engineering?
- Regardless of your current stage, how can you seamlessly leverage the power of big data in your workflows?

BIG DATA IN GEOTECHNICAL ENGINEERING



TYPICAL DATA WORKFLOW



GEOSYNTEC CONSULTANTS

ENHANCED DATA WORKFLOW



A UNIFIED WEB-BASED PLATFORM

GeoCentral Xplorer





Geotechnical Data

- Field Investigation Planning and Tracking
- Soil Borings
- Geotechnical Laboratory Testing
- Cone Penetration Tests (CPTs)
- Instrumentation Monitoring
- Remote Sensing
- Environmental Sampling Testing
- Survey Data
- CQA Data



Have you ever worked on a project that involved more than

20,000 CPT soundings?

Data size for same drilling depth: 20,000 CPTs ≈ 1.2 Million or more soil borings

PROJECT BACKGROUND



<u>Goal in Phase I of one project site</u>: Use the web-based platform to analyze geotechnical data from **1,800+ CPTs**, **100+ boreholes** with laboratory testing results in **1 week**. Have the selected geotechnical material properties ready for engineering evaluations at the end of **2 weeks**.

Project Site with 11,000+ CPTs and 300+ Soil Borings





Dynamically cut any CPT cross-section in seconds Efficient were defined and a set of the set



Dynamically cut crosssections with both soil borings and CPTs in seconds

Efficiently and interactively compare CPT and soil boring data in a crosssection view



Geospatially identify critical soil layers in plan view at any project area with dynamic data filtering. Select locations with your cursor on the browser

Where are the CPTs with sand layers having Phi' less than 26 deg.?



Efficiently develop soil design parameter profiles at any area of the site in seconds

900+ CPTs selected from the map in this example



Select and interpret different soil design parameters

More than 20 soil parameters have been added in this project for slope stability, settlement, seismic, and numerical analyses



Dynamically <u>add lab testing data</u> from nearby soil borings to compare with CPT correlations

Data percentile lines for lab testing data are calculated on the fly for evaluation

INTERACTIVE 2D AND 3D VIEWS

Project Site with 1,300 + CPTs

AA54 CPT-AB57 CPT-AD58 PRE-CPT-AE61 RE-CPT-AG62 CI-PRE-CPT-AH65-R CI-PRE-CPT-AH65 CI-PRE-CPT-AJ67 CI-PRE-CPT-AN68 CI-PRE-CPT-AN68 CI-PRE-CPT-AV69 CI-PRE-CPT-AU68 CI-PRE-CPT-AU68 CI-PRE-CPT-AU69 E-CPT-AZ67 CPT-BC67 -CPT-AI 61

-BK59 CPT-BL62



Ic>2.5, Layer Thickness Contour Between EL. -14 and 3



Longitude Decimal (deg.)

Dynamically generate interactive 2D contour view to identify the thickness of clay layers throughout the project site

Rule to define clay layers: Ic > 2.5 Observation: Two major areas with up to 2.5m thickness of clay layers



Ic>2.5, Layer Thickness Contour Between EL. 0 and 3



Longitude Decimal (deg.)

Dynamically cut contour slices to further identify the clay layers in different elevation ranges

Elevation Range: +3 to 0 m Observation: Approximately up to 1-m thickness clay layers in the **central** area



Ic>2.5, Layer Thickness Contour Between EL. -3 and 0



Longitude Decimal (deg.)

Dynamically cut contour slices to further identify the clay layers in different elevation ranges

Elevation Range: 0 to -3 m Observation: Approximately 1.5-m thickness clay layers in the **central** area



Ic>2.5, Layer Thickness Contour Between EL. -6 and -3



Longitude Decimal (deg.)

Dynamically cut contour slices to further identify the clay layers in different elevation ranges

Elevation Range: -3 to -6 m Observation: Approximately up to 2-m thickness clay layers in the **western** area



Ic>2.5, Layer Thickness Contour Between EL. -12 and -6



Longitude Decimal (deg.)

Dynamically cut contour slices to further identify the clay layers in different elevation ranges

Elevation Range: -6 to -12 m Observation: No major clay layers identified in the site area



Select 600+ CPTs in the central area to develop strength lines for clay layers between El. 0 and -3 m

Median Lines of Su: From 16 KPa (340 psf) to 36 KPa (750 psf)



Select 80+ CPTs in the western area to develop strength lines for clay layers between El. -3 and -6 m

Median Values of Su: From 23 KPa (480 psf) to 48 KPa (1000 psf)

INTERACTIVE 3D VIEWS

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Interactive 3D views can be generated on-the-fly: Warm colors (**red** and **yellow**) indicate clay layers

UNDER THE HOOD



Data Ingestion

40

Standardized Digital Data

Add B1/Da
 Image: Add B

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GeoCentral Xplorer



KEY TAKEAWAYS – PART I

- ✓ The purpose of data management extends beyond merely organizing data.
- ✓ It's about leveraging the power of big data to <u>enhance decision-making</u>, <u>streamline design and construction processes</u>, and <u>achieve cost savings</u>.
- We've broadened the use of this <u>unified web-based platform, GeoCentral</u> <u>Xplorer</u>, in our current geotechnical projects and plan to integrate it into many upcoming projects at Geosyntec. Its current capabilities extend beyond handling, visualizing, and interpreting data from over **20,000 CPTs**.



BIG DATA STRATEGIES FOR DOT PROJECTS

HOW CAN DOTS INCORPORATE STANDARDIZED DATA FORMATS INTO CURRENT WORKFLOWS?



IS IT POSSIBLE TO NOT CHANGE CURRENT WORKFLOWS WITH PDFS IN THE ERA OF BIG DATA?



AI IMPLEMENTATION EXAMPLE: LAB SHEET DIGITIZATION IN A GEOSYNTEC PROJECT

400+ pages from a scanned pdf report





90+% time savings compared to traditional manual data entry.

4000+ rows of digital data for engineering interpretation

	Α	В	С	D	E	F	G	н
1	Location ID	Sample ID	Depth Top	Depth Base	USCS	SIEVE SIZE	PERCENT FINER	
2	BH-01	1	1	1.45	SP-SM	1/2 IN	100	
3	BH-01	1	1	1.45	SP-SM	1/4 IN	85	
4	BH-01	1	1	1.45	SP-SM	#4	83	
5	BH-01	1	1	1.45	SP-SM	#10	79	
6	BH-01	1	1	1.45	SP-SM	#16	78	
7	BH-01	1	1	1.45	SP-SM	#30	75	
8	BH-01	1	1	1.45	SP-SM	#40	68	
9	BH-01	1	1	1.45	SP-SM	#50	59	
10	BH-01	1	1	1.45	SP-SM	#80	50	
11	BH-01	1	1	1.45	SP-SM	#100	44	
12	BH-01	1	1	1.45	SP-SM	#200	12	
13	BH-01	2	3	3.45	SM	#10	100	
14	BH-01	2	3	3.45	SM	#16	99	
15	BH-01	2	3	3.45	SM	#30	99	
16	BH-01	2	3	3.45	SM	#40	97	
17	BH-01	2	3	3.45	SM	#50	94	
18	BH-01	2	3	3.45	SM	#80	90	
19	BH-01	2	3	3.45	SM	#100	82	
20	BH-01	2	3	3.45	SM	#200	17	
21	BH-01	3	8	8.45	SM	#4	100	
22	BH-01	3	8	8.45	SM	#10	99	
23	BH-01	3	8	8.45	SM	#16	99	
24	BH-01	3	8	8.45	SM	#30	95	
25	BH-01	3	8	8.45	SM	#40	89	
26	BH-01	3	8	8.45	SM	#50	75	
27	BH-01	3	8	8.45	SM	#80	60	
28	BH-01	3	8	8.45	SM	#100	43	
29	BH-01	3	8	8.45	SM	#200	18	
30	BH-02	1	1	1.45	SP-SM	1/4 IN	100	
31	BH-02	1	1	1.45	SP-SM	#4	99	
32	BH-02	1	1	1.45	SP-SM	#10	97	
33	BH-02	1	1	1.45	SP-SM	#16	96	
34	BH-02	1	1	1.45	SP-SM	#30	91	
35	BH-02	1	1	1.45	SP-SM	#40	86	
36	BH-02	1	1	1.45	SP-SM	#50	79	
37	BH-02	1	1	1.45	SP-SM	#80	70	
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AI IMPLEMENTATION EXAMPLE: LADOTD BORING LOG DIGITIZATION

Each page contains 3 boring logs, scanned copies, including typed and handwritten with varied scan quality:

sol Type Sol Type	description AR CL W/CONC Org=11% AR SI SA SR SI SA SR SI SA CL SR CL SI Org=12% V/IR OX R CL	depthTop depthBa 0 10 115 200 255 300 400 400 400 400 400 400 400 400 400 400 400 400 400	elevationTop elevationTop 5 G64.3 10 S9.3 15 G44.3 20 G49.3 30 G44.3 30 G44.3 31 G44.3 35 G44.3 40 G29.3 45 G44.3 50 G4.3 60 G4.3 61 G4.3 62 G4.3 63 G4.3 64 G4.3 7 G4.3	levationBase locationID 59.3 BORING NO. 4 54.3 BORING NO. 4 44.3 BORING NO. 4 34.3 BORING NO. 4 20.3 BORING NO. 4 21.3 BORING NO. 4 20.3 BORING NO. 4 21.3 BORING NO. 4 41.3 BORING NO. 4 21.3 BORING NO. 4 19.3 BORING NO. 4 41.9.3 BORING NO. 4 4.3 BORING NO. 4 -0.7 BORING NO. 4 -25.7 BORING NO. 4 -35.7 BORING NO. 4	2 17 4 3 30 4 4 30 4 4 30 4 4 30 4 5 30 4	A 1 wetDensit 2 12 3 12 4 12 5 12 6 12 7 12 8 12 9 10 10 13 11 12	B C D ty moistureContent LL PI 17 21 54 26 19 225 39 12 20 232 24 27 13 335 67 34 12 232 75 37 30 25 61 36 29 337 76 44 36 200 41 20	E F qu failureMo 0.88 S/S 0.53 YLD 0.63 MS 0.35 MS 0.74 S/S 1.09 S/S 0.42 S/S 1.18 S/S 1.12 MS 5.5 MS	G H SPT denth d - 2.5 - - 7.5 - - 12.5 - - 22.5 - - - 27.5 - - - - 27.5 - - - - 32.5 - - - - 37.5 - - - - - - - -	elevation loo 61.8 BORI 56.8 BORI 51.8 BORI 46.8 BORI 36.8 BORI 31.8 BORI 26.8 BORI 26.8 BORI 21.8 BORI	J cationID ING NO. 4 ING NO. 4
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	GR SA LEAN CL GR SI SA W/STR CL	100 1			28	12 12	22 20 0	1 94 MG	52.5	E 8 DOR	
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		105 1	10 -40.7	-45.7 BORING NO. 4		14			/ 62.5	1.8 BOR	ING NO. 4
18 GR	GR SA SI	110 1	15 -45.7	-50.7 BORING NO. 4	23	b 15			20 67.5	-3.2 BOR	ING NO. 4
	GR SA LEAN CL	115 1	20 -50.7	-55.7 BORING NO. 4		16			57 72.5	-8.2 BOR	ING NO. 4
	GR SI CL SA	120 1	25 -55.7	-60.7 BORING NO. 4		_ 17			50 77.5	-13.2 BOR	ING NO. 4
	GR SA LEAN CL W/TR ORG	125 1	30 -60.7	-65.7 BORING NO. 4	4 25	2 18			23 82.5	-18.2 BOR	ING NO.
BR LEAN CL W/TR ORG	SR LEAN CL W/SA	130 1	39 -65.7	-74.7 BORING NO. 4		19			33 87.5	-23.2 BOR	
		-0.5 5	.5 6/	57 BORING NO. 5	20	20	16 34 19	1	75 92 5	-28 2 BOR	
132 26 28 10 1.84 M.S. (77)		5	61.5	BORING NO. 5		20	10 54 15	,	100 07.5	22.2 DON	
D SAMPLE RETAINED		9.5 14	5 57	52 BORING NO. 5		_ 21	28 /		100 97.5	-55.2 DUR	ING NO. 4
n=7 (07)		14.5 24	30 42	42 BORING NO. 5		1 22	25 33 15		89 102.5	-38.2 BOR	ING NO. 4
R SA N P n=20 017		24.5	50 42 55 56 5	30.5 BORING NO. 5	25	23			100 107.5	-43.2 BOR	ING NO. 4
70 -5.7 WIR GRAV 20 CF		30 30	55 50.5			_ 24	24 29		100 112.5	-48.2 BOR	.ING NO. 4
N P n=57 603		20.5 4/	5 51.5	27 BORING NO. 5		25	24 38 19)	80 117.5	-53.2 BOR	ING NO. /
N P n=50 002 31 GP		445 44	1.5 27	17 BORING NO. 5		26	22 26		100 122.5	-58.2 BOR	ING NO.
1 0 00 00 157 00 00 157 00 00 00 00 00 00 00 00 00 00 00 00 00	BRIEAN CLW/TRORG	44.5 43	5 17	11 5 BORING NO. 5		- 27	22 42 23		88 127 5	-63 2 BOR	
N P n=23 00 33 BP	R SI SA	45.5	5 115	2 BORING NO. 5		20			CF 422.5	C0.2 DON	
Wigrav Wigrav				BR SA W/TR GRAV							
	С	D	E	F			G	Н	I.	J	
1 date locationID	longitude	stationingN	o locat	ion latitu	ıde	proje	ctName pr	ojectID_A p	rojectID_B	elevation	
2 7/14/2004 BORING NO. 4	92° 06' 35.02"W	486+36	35" RT A	dopt. CL 32° 11' 4	9.85"N					64.3	5
3 9/28/2004 BORING NO. 5	92° 06' 36.72"W	488+36	65' LT Ad	opt. CL 32° 11' 5	0.00"N					66.5	j
GEOSYNTEC CONSULTANTS 4 7/21/2004 BORING NO. 6	92° 06' 37.54"W	490+36	42' RT Ac	opt. CL 32° 11' 5	2.16"N					64.4	31

KEY TAKEAWAYS – PART II

- Using standardized digital data formats are important to leverage the power of big data.
- If you are <u>ready to change</u> your current data workflows in the era of big data, DIGGS is a great tool that allows geotechnical engineers to leverage the power of big data in Geotechnical Engineering:
 - ✓ Learn more about **DIGGS**: <u>https://github.com/DIGGSml</u>
 - ✓ Learn more about **DIGGS Implementation** using **pyDIGGS**: <u>https://pydiggs.readthedocs.io</u>
- If you are <u>NOT ready to change</u> your current data workflows with PDF boring logs and lab testing sheets in the big data age, AI can efficiently extract data from both typed and hand-written PDFs. This unlocks immense value from historical archives for any ongoing and future projects.



SPECIAL THANKS TO



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THANK YOU!

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