CASE STUDY

Jackson County Detention Center
Kansas City, MO

Jackson County Detention Center – Kansas City, MO

Agenda

- Introduction to Surcharging and Wick Drains
- Project Overview
- Surcharge and Wick Drain Design Overview
- Wick Drain Installation
- Settlement Monitoring
- Closing Remarks

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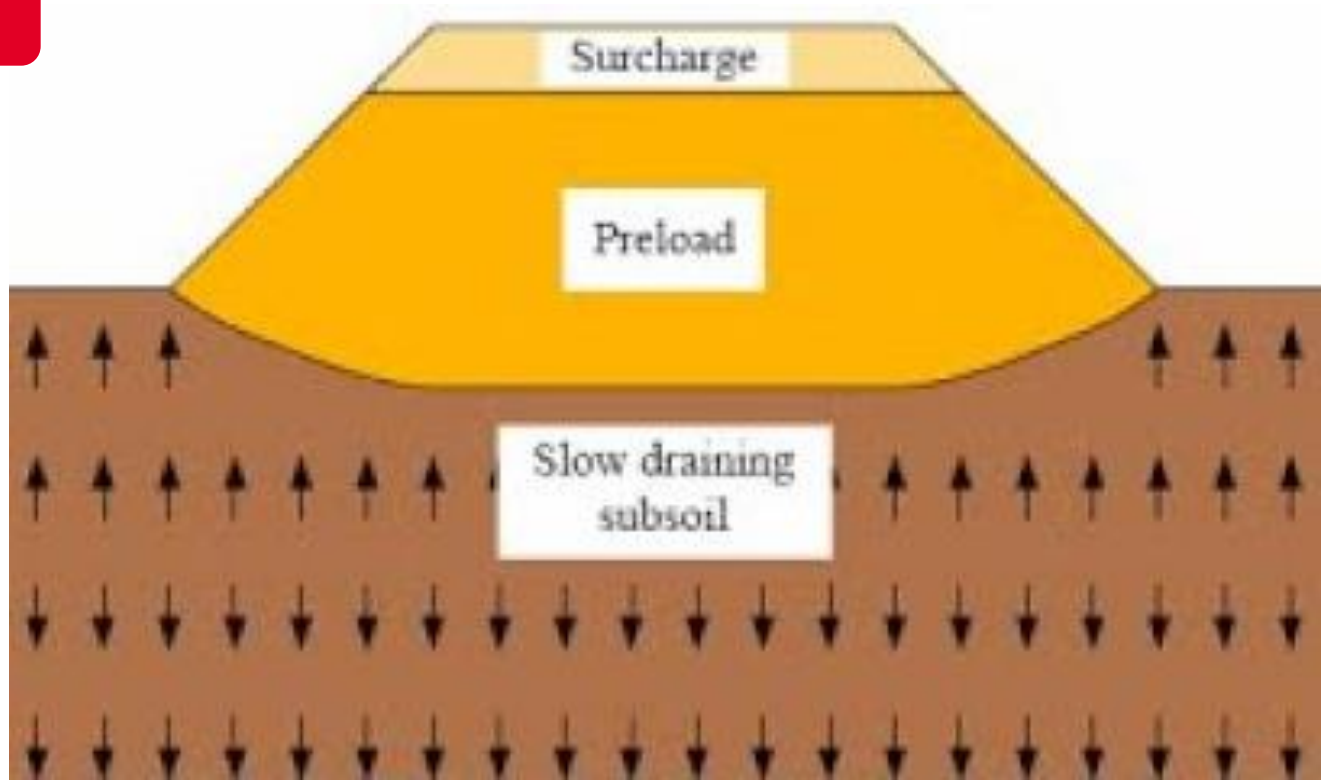
Preloading / Surcharging

- Objective: Minimize post-construction settlement by inducing settlement during construction
- Additional benefit: Moderate improvement of soil characteristics through over-consolidation
- Often low cost compared to deep foundations but the schedule delay risk can make it prohibitive
- Nomenclature can be confusing (what is a surcharge vs. preload?)



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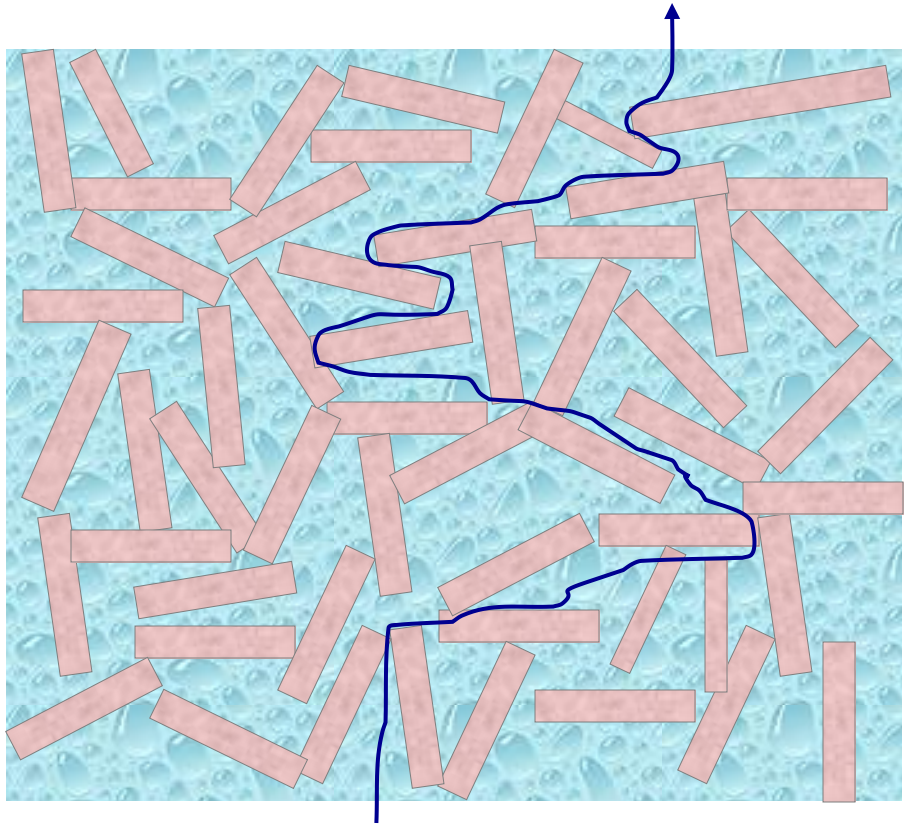
Fine Silts and Clay soils have a very small particles – Flat, plate like shape means a very high ratio of grain surface area per volume.



- Water needs to take very complicated & long path to get out of the soil matrix
- Excess pore water slow to escape
- Consolidation time is long (few inch to few ft per year)
- Permeability is low
- Adsorption (H_2O dipole and negatively charged particles) further slows down water

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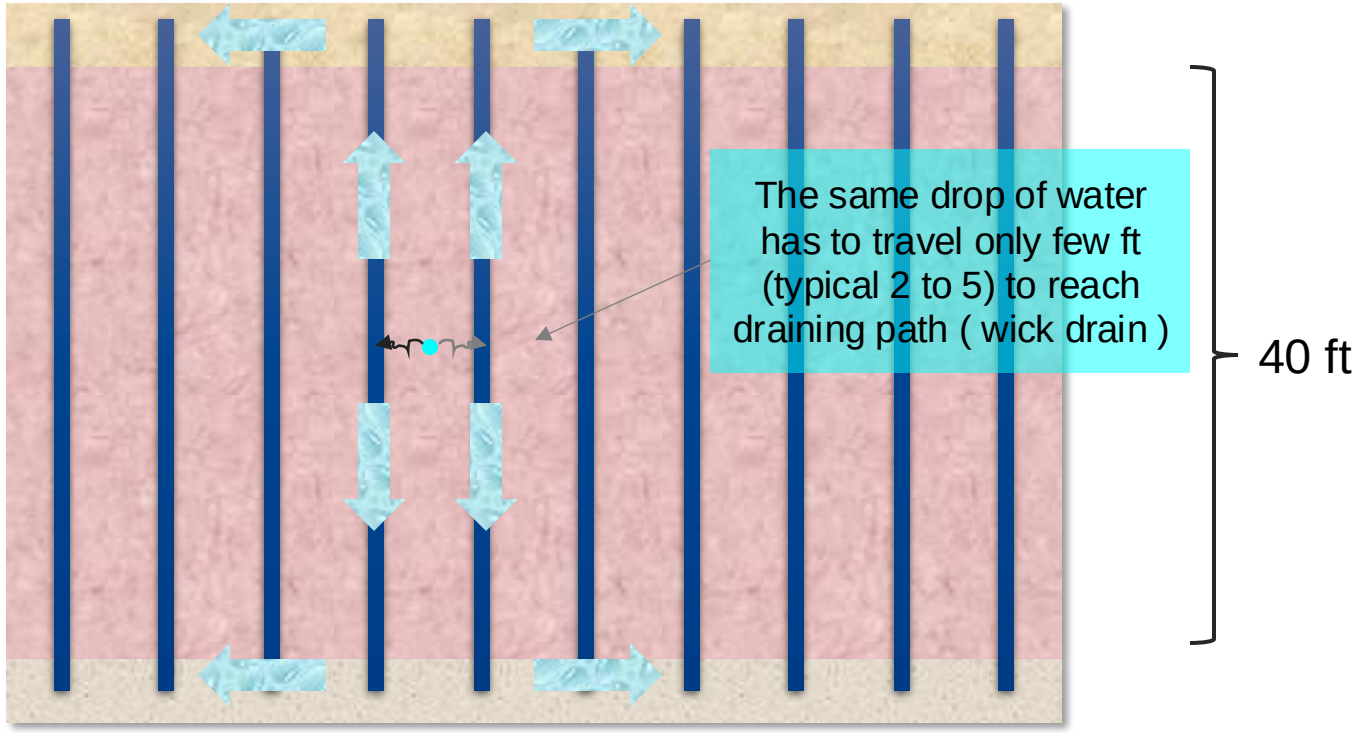
Wick drains reduce the length of the path the excess water has to travel to reach a draining layer – the water travels radially instead of vertically



With Wick Drains

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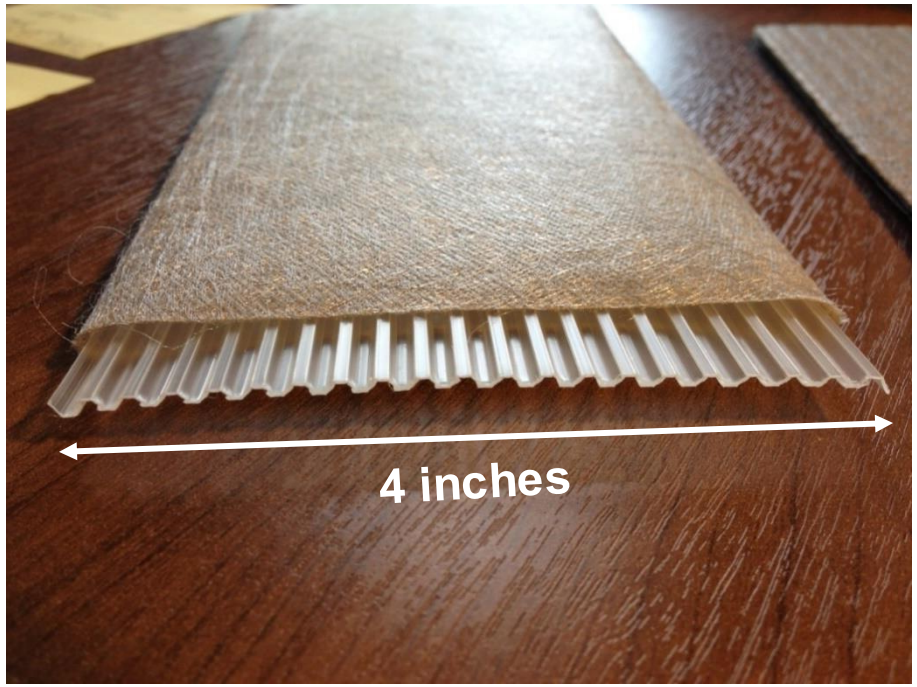
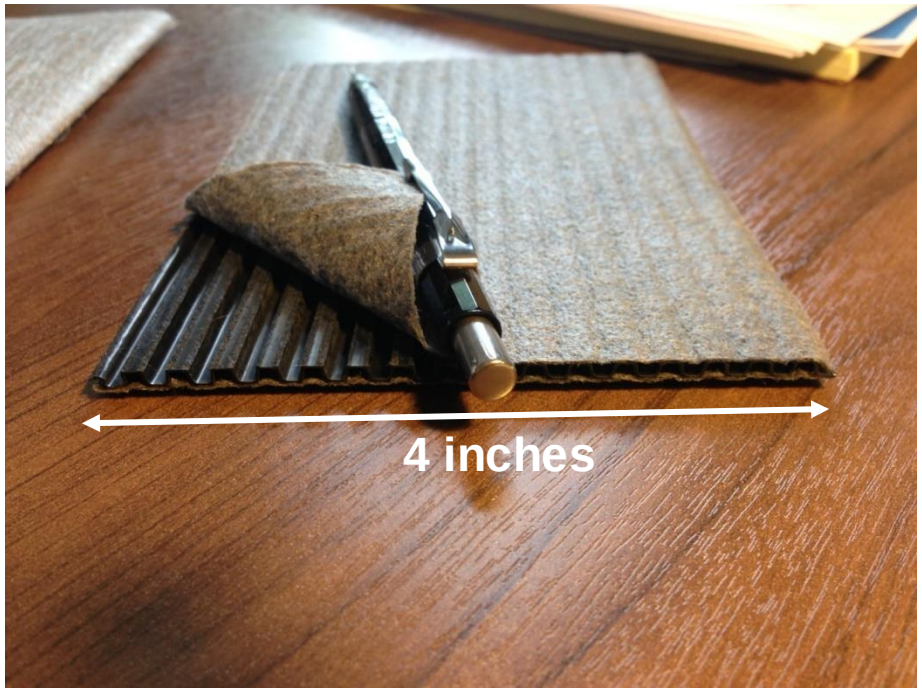


2 PARTS : Filter is wrapped around core



Composite: Filter is glued to core

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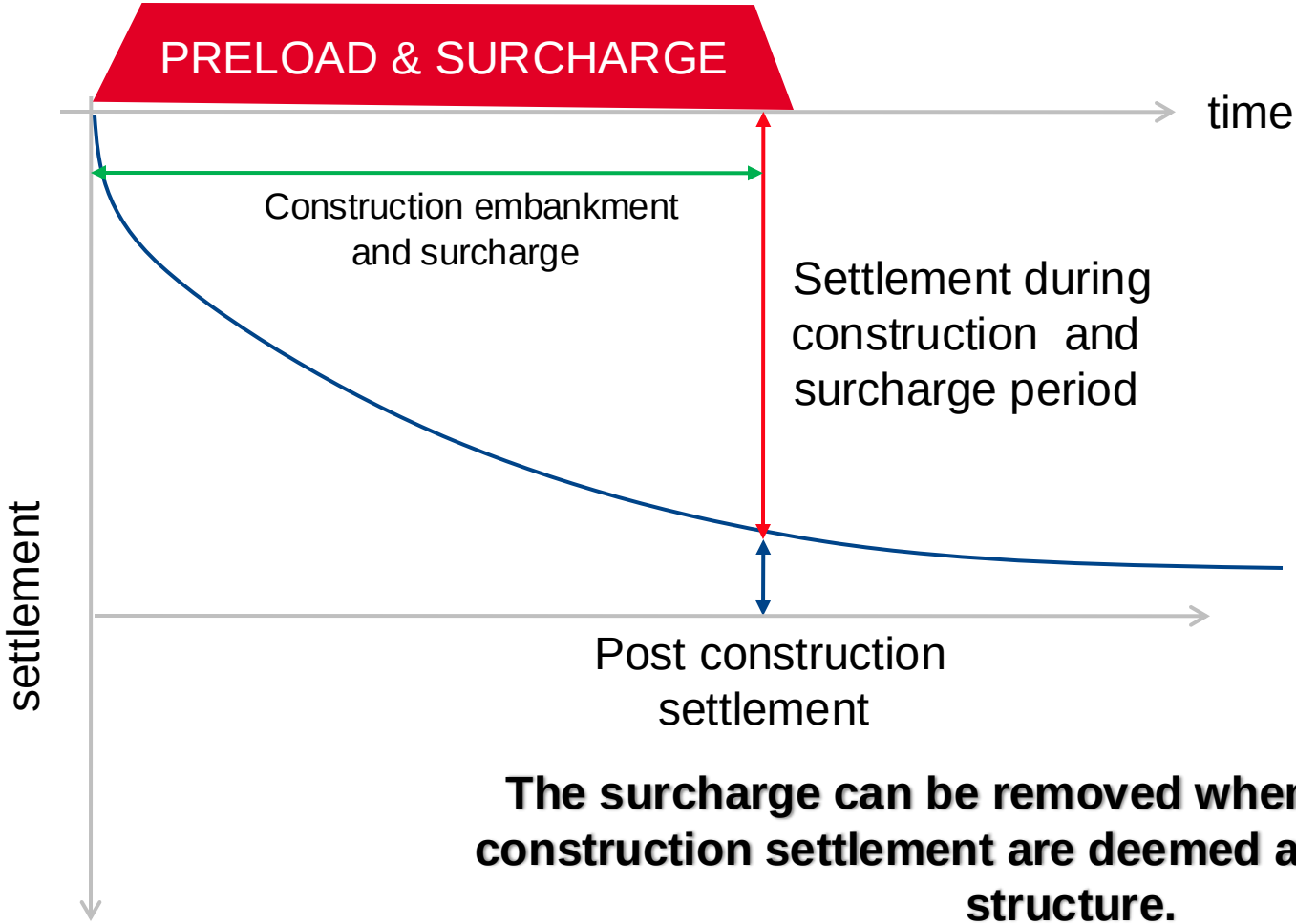

The surcharge can be removed when expected post-construction settlement are deemed acceptable for the structure.

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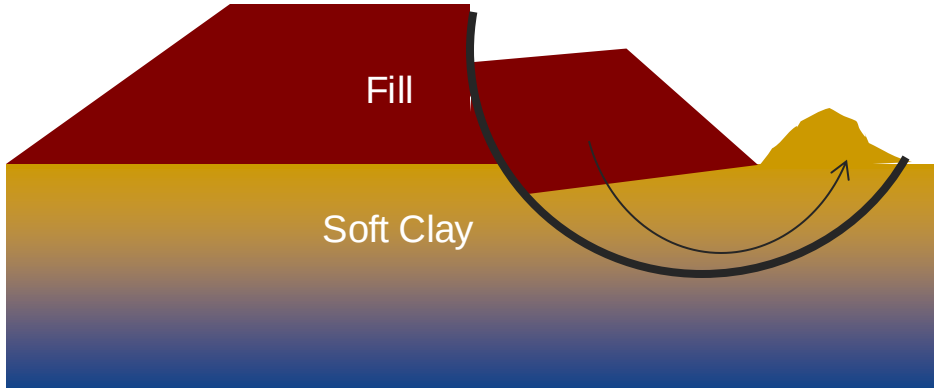
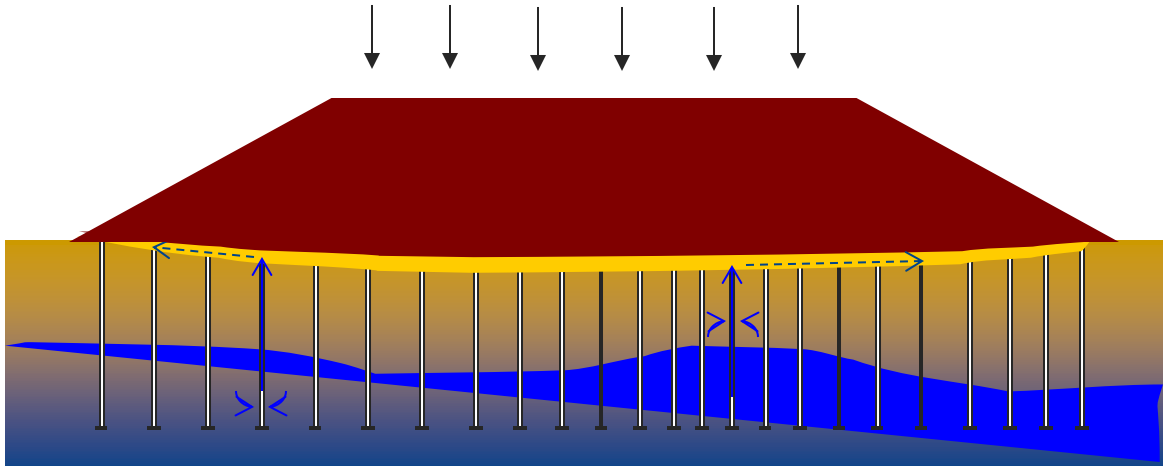


No Wicks – Immediate Fill

- Undrained condition in clay
- High effective stresses…
- And increased shear stresses ultimately may lead to failure



With Wicks – Staged Fill

- Positive drainage reduces excess pore pressure and minimizes effective stresses
- Allows surcharge operation to proceed much more quickly

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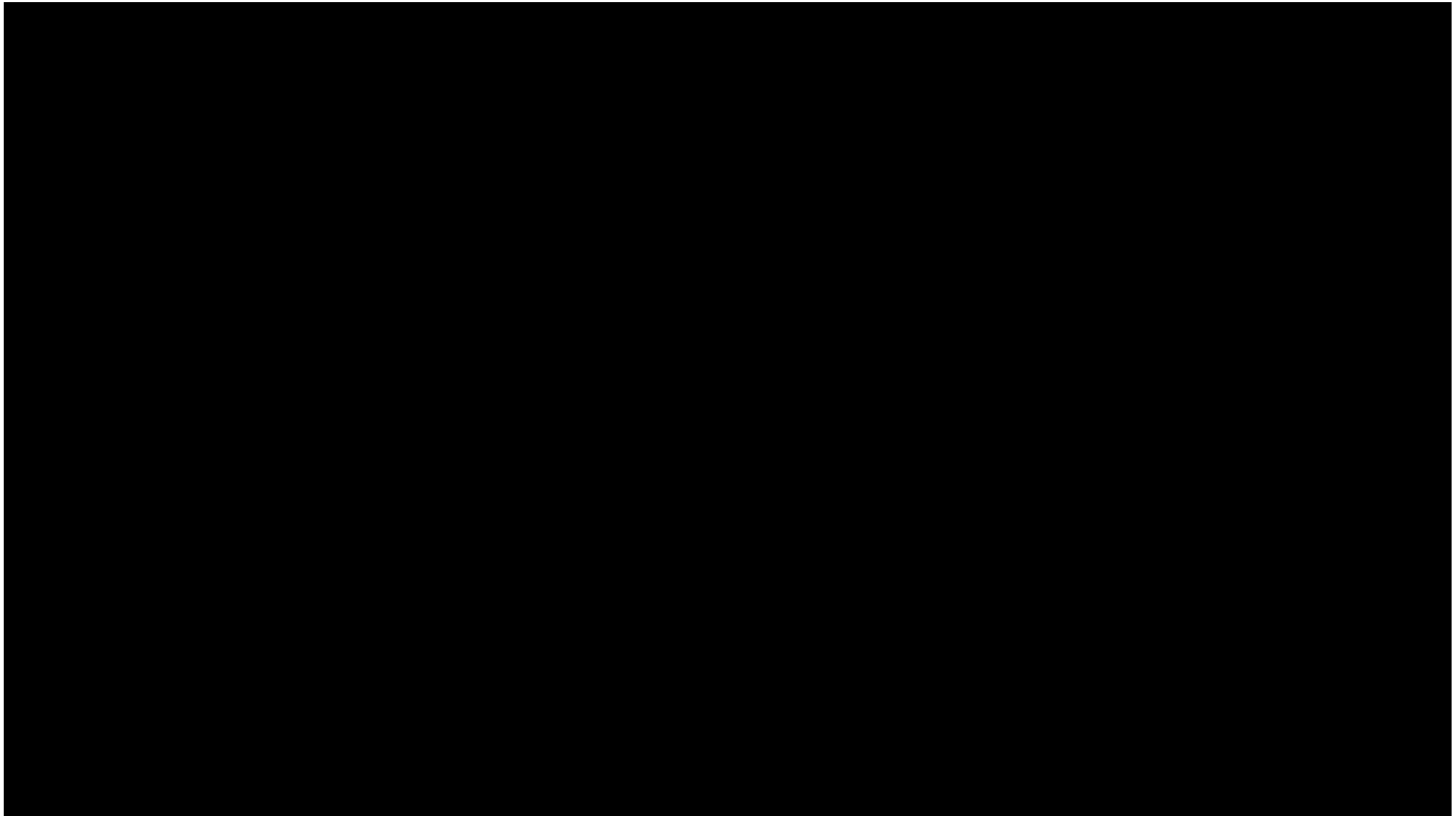

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Project Overview

- Project located in Southeast Kansas City, near Stadium District
- Located just east of Blue River
- Residential/trailer area since early 1960's
- Project Design began in 2020
- Grounbreaking in September 2022
- Wick Drains Installed in Summer 2023

Project Team

- General Contractor: J.E. Dunn
- Earthwork Contractor: Kissick Construction
- Engineer: Taliaferro & Browne
- Geotechnical Engineers: CFS & Olsson
- Wick Drain Installer: Menard

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Project Details

- Approximately 400,000 square foot structure
- Approximately 100 acre site
- One-to-two story facility
- Maximum building column load of 400 kips
- Up to 8.5 feet of fill required to reach finished grade

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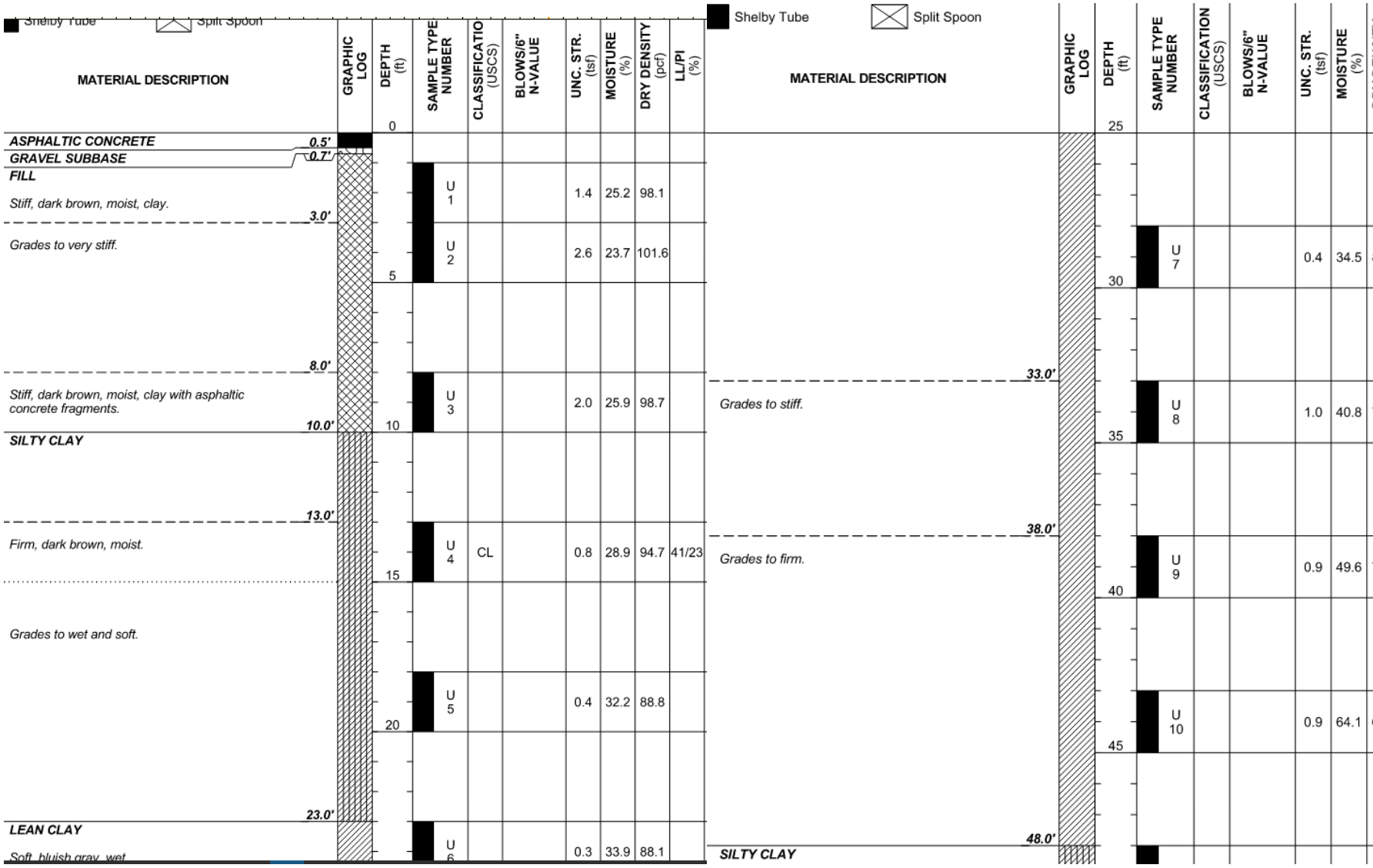
Geotechnical Overview

- Upper Lean Clay Crust
  - ~10’ thick
  - UCS >2 tsf
  - Assumed to be over-consolidated – design recompression index = 0.06
- Lower Soft Lean Clay
  - ~40’ to 50’ thick
  - Often silty, sometimes sandy
  - Sometimes transitioned to a fat clay
  - UCS <1 tsf
  - MC generally b/w 30% and 50%
  - C_c b/w 0.27 and 1.09 – design = 0.4
  - Conservatively assumed to be normally consolidated – consolidation tests did not show consistent OCR
- Silty Sand Bearing Layer
  - With gravel
  - Sometimes dense right away, sometimes loose at the top then dense below



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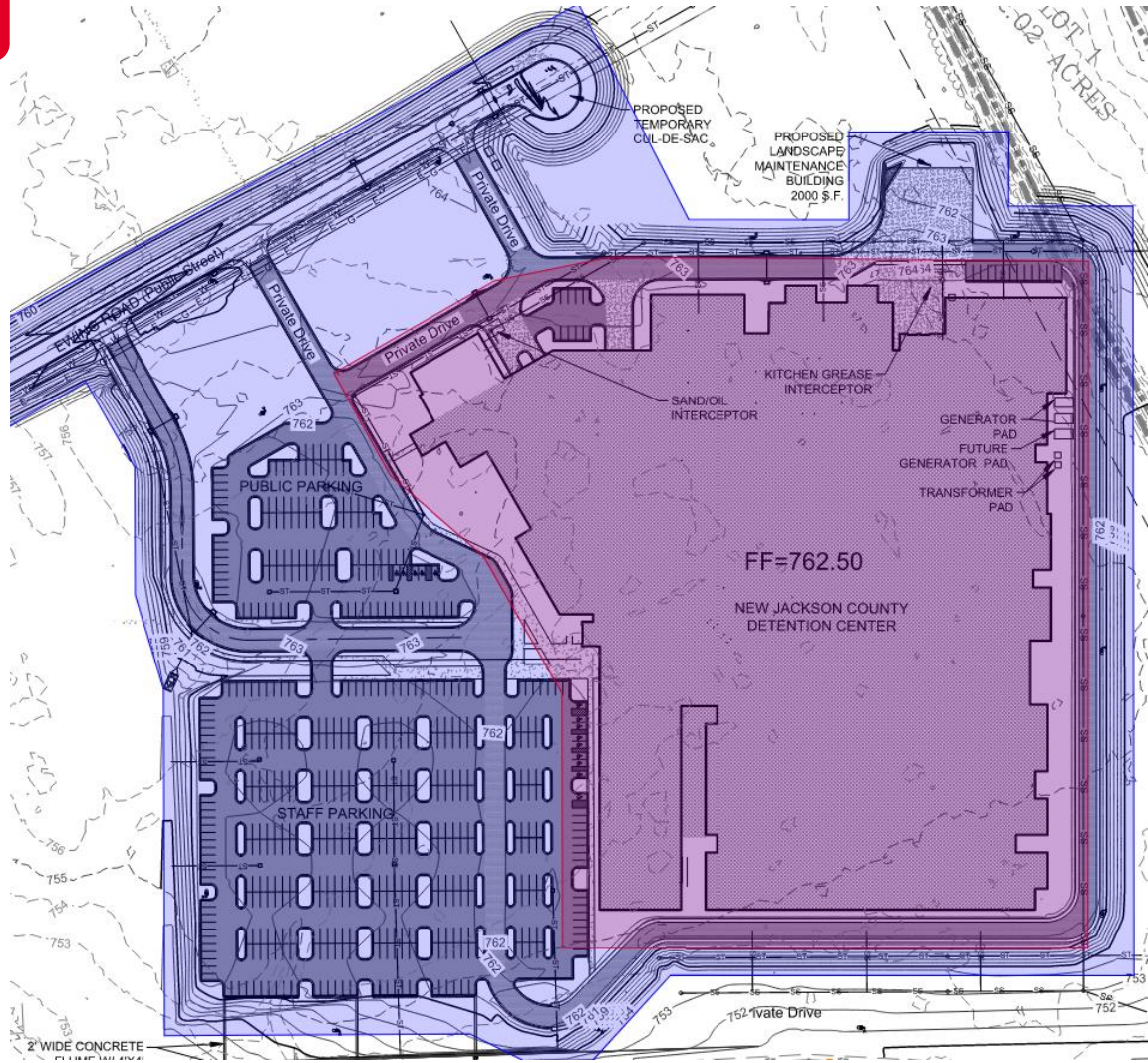
General Design Concept

- **Building Footprint**
  - Use a 5-foot soil surcharge above FFE to achieve settlement and bearing capacity targets
  - 2000 psf bearing capacity for footings
  - Use wick drains on tight spacing to accelerate settlement

- **Exterior Paved Areas**
  - Fill to pavement subgrade early in construction process
  - Use wick drains on wider spacing to accelerate settlement (paving not on critical path)
  - No surcharge beyond finished grade required

- Settlement monitoring across the site to confirm appropriate level of consolidation is reached



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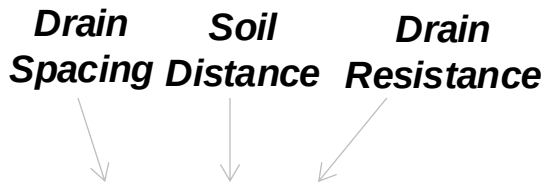
DESIGN EQUATION

Consolidation time:



$$t = (D^2/8c_h)\,(F(n) + Fs + Fr)\,(\ln(1/1-U_h))$$

Where:

- ***t*** *= time required to achieve consolidation*
- ***Uh*** *= average degree of consolidation*
- ***D*** *= diameter of zone of influence of the wick drain*
- ***Ch*** *= coefficient of consolidation for horizontal drainage*
- ***F(n)*** *= drain spacing factor = ln(D/dw) -3/4*
- ***dw*** *= equivalent diameter = 2(a+b)/p, where a = width of drain and b = thickness of* drain
- ***Fs*** *= soil distance factor = ((kh/k s) - 1) ln(ds/dw)*
- ***kh*** *= coefficient of horizontal permeability in the undisturbed soil*
- ***ks*** *= coefficient of permeability in the disturbed soil zone*
- ***ds*** *= diameter of the idealized disturbed zone around the drain*
- ***Fr*** *= factor for drain resistance = p z (L-z) (kh/qw)*
- ***z*** *= distance below the top surface of the compressible layer*
- ***L*** *= effective drain length (full length 1 side drainage, ½ length for double sided drainage*
- ***qw*** *= discharge capacity of the wick drain at a gradient of 1*

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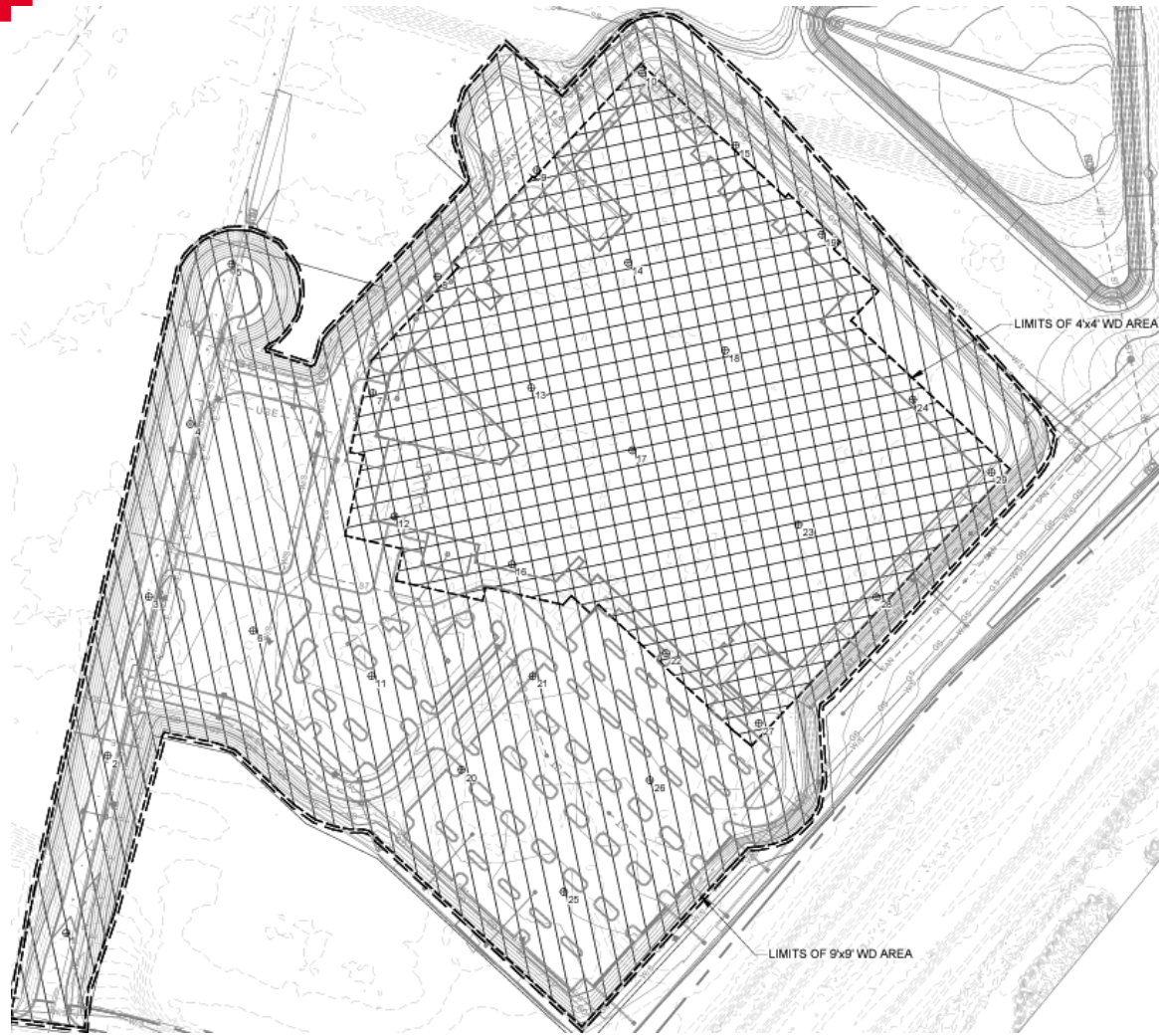
Wick Drain Design

- Target consolidation: 95%, based on settlement/surcharge design by Geotech EOR
- Wick drains on 4-ft triangular spacing within building footprint
  - Expected time to 95% consol = 4-5 weeks
- Wick drains on 9-ft triangular spacing outside of building footprint
  - Expected time to 95% consol = 9 months
- 18-inch sand drainage blanket to transmit water evacuated by vertical drains
- Drainage blanket designed to gently slope one direction across site (<1%)
- 30 settlement plates across the site, both inside and outside the building footprint



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Wick Drain Installation

- Menard mobilized three wick drain installation rigs in July 2023
- Final estimated quantity of 2,727,000 LF of wick drains
- Average length of approximately 55 feet
- Drainage blanket doubled as working platform
- Main operational site challenge was clay/mud sticking to equipment and causing delays
- Also, had to replace two rental excavators early in the project due to mixup regarding capabilities of new models
- De-mobilized in mid-September 2023

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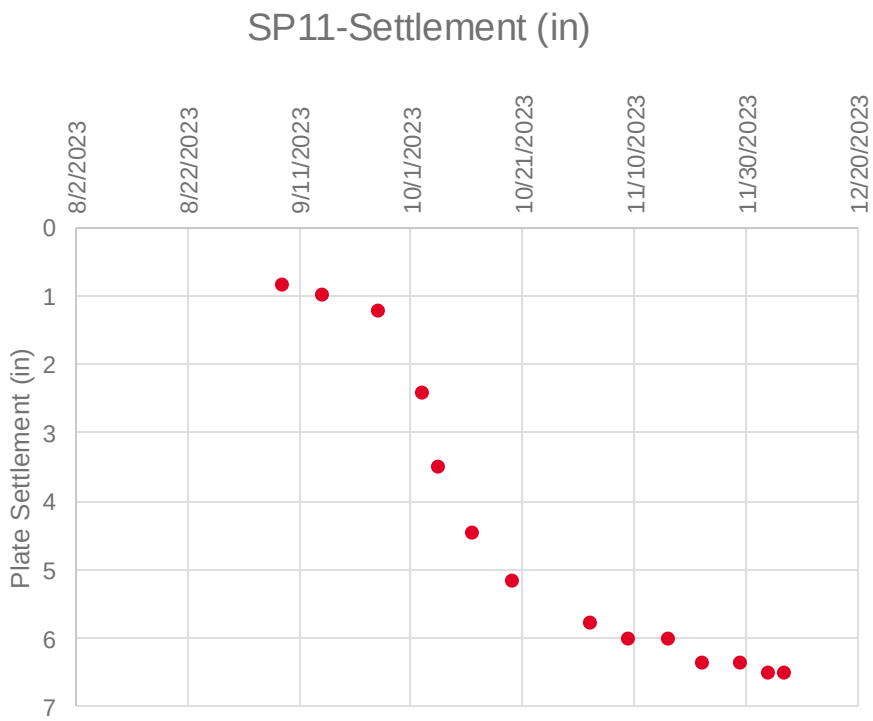
Settlement Monitoring Results

- Settlement monitoring installation and fill placement immediately followed wick drain installation in September 2023.
- Building plates were monitored weekly. Observed settlement under surcharge loads was up to 7 inches, but generally less than 5 inches.
- Menard provided staggered sign-off on settlement plates that leveled off. Final sign-off in early December to enable building construction. Time to reach 95% consolidation was generally in line with 4-to-5 week prediction.
- Exterior plates were baselined in October and not monitored over the winter. Regular monitoring restarted in February 2024 to confirm that settlement leveled off. Exterior fill placement gradually took place from October until late February.
- Last of remaining settlement plates leveled off in early June 2024, resulting in authorization to proceed with site paving.
- Exterior settlement due to fill placement without surcharge was also within the expected time frame of 9 months or less.



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Closing Thoughts

- Wick drains and surcharging provided a cost-saving alternative to deep foundations for the detention center structure.
- Wick drains accelerated the waiting period for the exterior fill placement.
- The design spacing for the wick drains was adjusted based on the available project schedule
- Observed settlement durations were generally in line with design predictions

MenardTalks Q&A Time