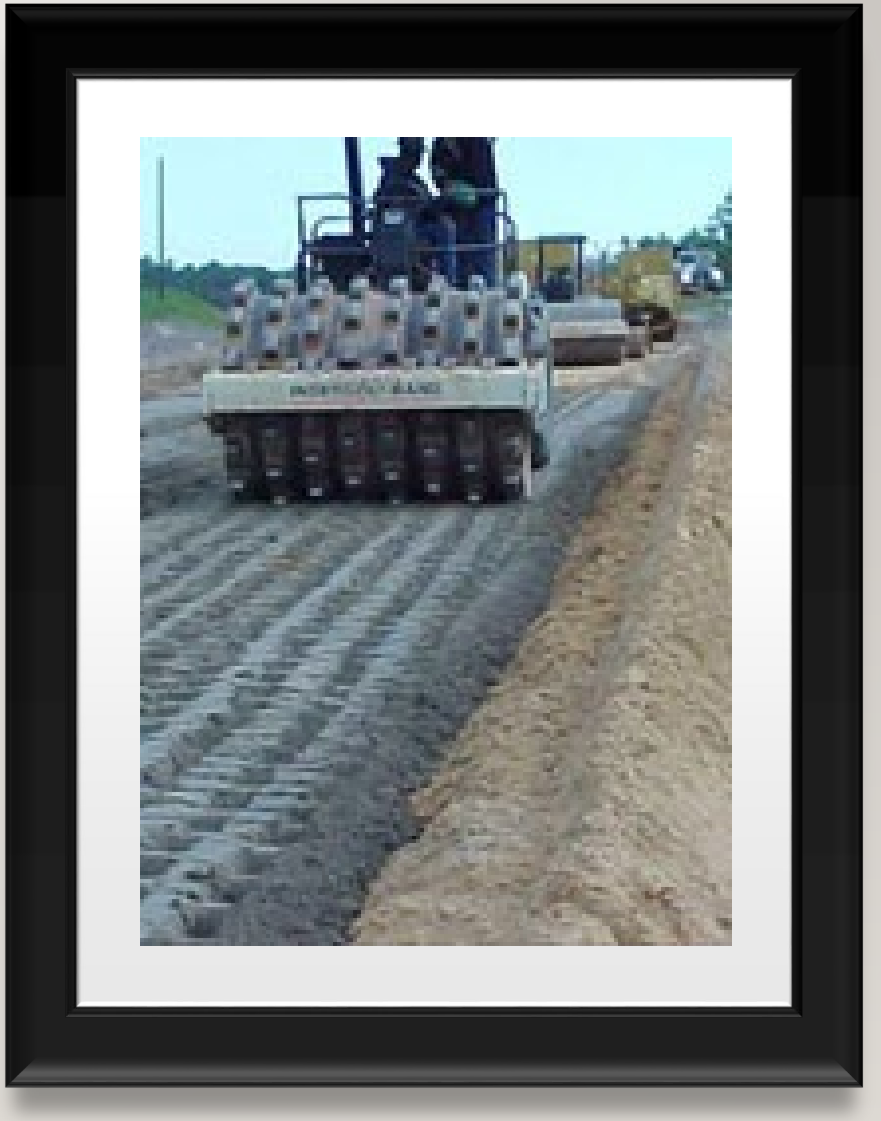
SOIL CEMENT STABILIZATION

BETTER CONCRETE CONFERENCE

FALL 2018



TYPES OF SCS

- Cement Modified Soils (CMS)
- Cement Stabilized Subgrades (CSS)
- Cement Treated Base (CTB)
- Full Depth Reclamation (FDR)

- Updated Guide to Cement Modified Soil ~ PCA Publication 2008
- http://secement.org/wp-content/uploads/2017/04/EB242.pdf

DEFINITION OF…

- Cement Modified Soil (CMS): A mixture of pulverized in-situ soil, water and small proportion of Portland cement resulting in an unbound or slightly bound material, similar to a soil, but with improved engineering properties.
- Cement Stabilized Soil (CSS): An engineered mixture of pulverized in-situ soil, water and moderate proportion of Portland cement, resulting in a semi bound to bound material, with engineering properties similar to an granular material. Will still provide improved soil shear and compressive strength.

DEFINITION OF…

- Cement Treated Base (CTB): Fully bound engineered mixture of soil/aggregate, water and sufficient Portland cement to meet the project specified minimum durability and strength requirements. CTB can be mixed-in-place using on-site soils or mixed in a central plant using selected aggregate.

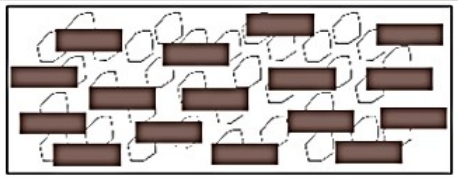
  - Usually FAA projects
  - Typical 7-day unconfined compressive strengths range from 300 – 800 psi.

DEFINITION OF…

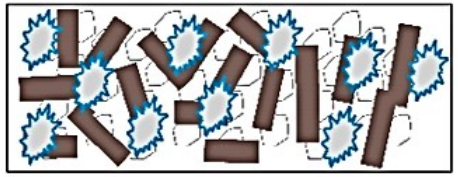
- Full Depth Reclamation(FDR): Full-depth reclamation (FDR) rebuilds worn out pavements by recycling the existing roadway in-situ. The old pavement section and base materials are pulverized, mixed with cement and water, and compacted to produce a strong, durable base for a new pavement surface. ~PCA

DIFFERENCES IN SCS

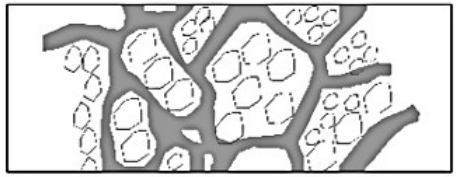
- Cement Modified Soils (CMS)
  - Intended to improve / modify subgrade
  - Uses low dosages of cement
- Cement Stabilized Subgrades (CSS)
  - Intended to improve / modify subgrade
  - Uses higher dosages of cement
- Cement Treated Base (CTB)
  - Intended to create a structural base
  - Uses higher dosages of cement
  - Typically used for FAA Projects
- Full Depth Reclamation (FDR)
  - Intended to create a structural base
  - Used widely to address existing pavement complete structural failures
  - Uses higher dosages of cement



Virgin Soil



CMS / CSS



CTB

DIFFERENCES IN SCS TREATMENTS

- Cement Modified Soils (CMS)
  - Typical Dosage – 3 – 5 %
- Cement Stabilized Subgrades (CSS)
  - Typical Dosage – Greater than 5 %
- Cement Treated Base (CTB)
  - Typical Dosage – Varies based on project requirements / design
    - PCA recommends 3 – 10%
- Full Depth Reclamation (FDR)
  - Typical Dosage –3-10% (could be up to 15%)

IS SCS FOR MY PROJECT?

- What type of pavement support are you trying to achieve?
- What type of problematic soils are you trying to overcome?
  - Wet, expansive, low strength, etc.
- How are the soils behaving on your project?
  - Will they allow for the desired outcome?
  - Are they hindering construction progress?
- What if I'm in the construction phase and the soils deteriorate on the project?

- At this point in the process, you should call a *geotechnical* engineer

WHICH SCS IS RIGHT FOR MY PROJECT?

- SCS will improve soil subgrade properties
  - Strength
  - Chemical composition (expansive soils)
  - Freeze/thaw durability
  - Shrink/swell characteristics
  - Drying of soils

- Use the above list to determine which SCS process you need.

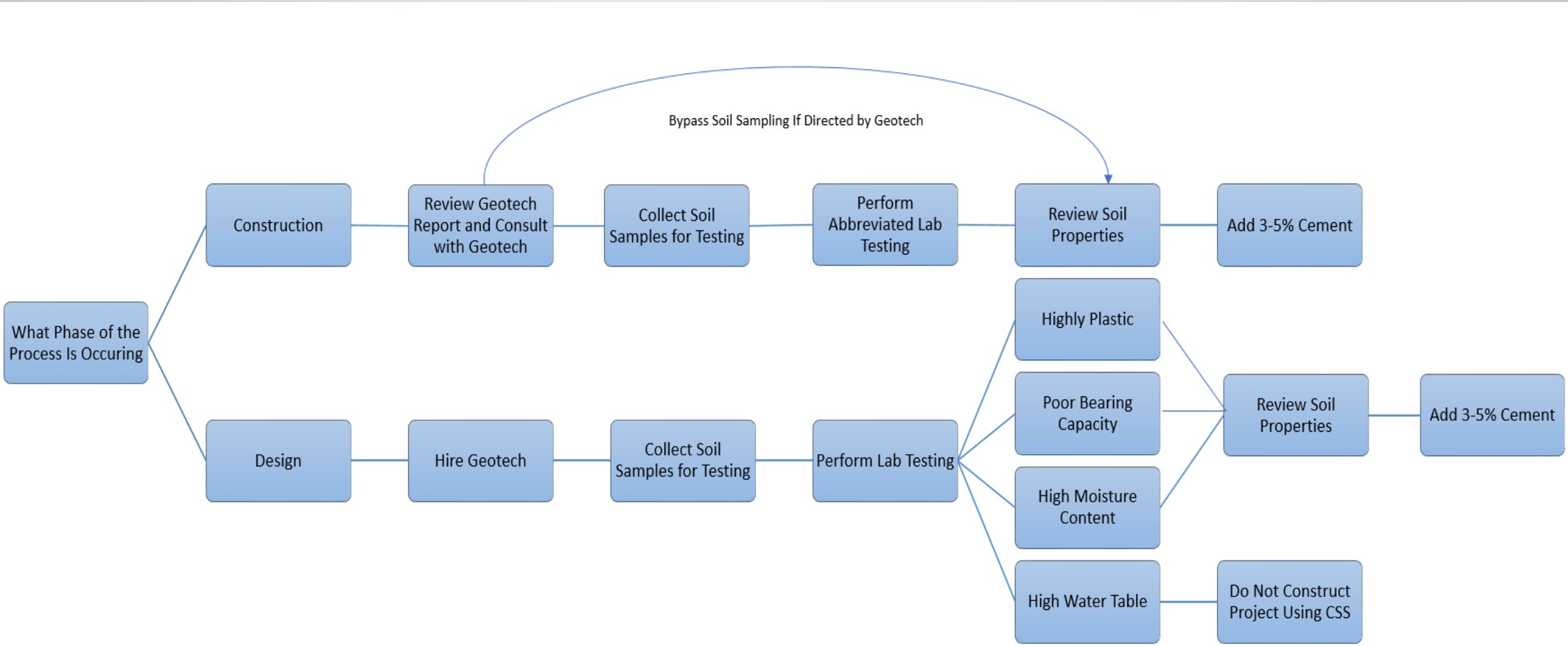
WHICH SCS IS RIGHT FOR MY PROJECT?

SCS Type	Definition	Cement %	Application
CMS	Soil , Water, Cement	3% - 5%	Soft subgrades
CSS	Engineered Soil , Water, Cement, Unbound	>5%	Soft subgrades or subgrade requiring increase in strength
CTB	Engineered Soil , Water, Cement, Bound	3% - 10%	to achieve project specified strength requirements
FDR	Engineered Soil , Water, Cement, Full Pavement Reconstruction	5% - 8%	Improve bituminous surfaced roadway

STEPS FOR USING SCS

- Identify the need for improving soil conditions
- Identify the types of soils present
- Implement the mix design process
- Apply to construction methods

DECISION TREE



IDENTIFY THE IN-SITU SOIL CONDITIONS

- Wet, expansive, unstable?
- Obtain soil samples and classify them to understand where the problems are.
  - Every soil is unique!
- At this point in the process, you should call a *geotechnical* engineer

IMPLEMENT A DESIGN PROCESS

- Soil samples should be tested to determine virgin soil properties.
- Design SCS depending on desired outcome and virgin soil properties.
  - Which SCS does your project need?
  - Select a range of cement dosages to verify.

- At this point in the process, you should have called a *geotechnical* engineer

REMEMBER…

COMMUNICATION WITH A GEOTECHNICAL ENGINEER IS IMPERATIVE THROUGHOUT THIS PROCESS.

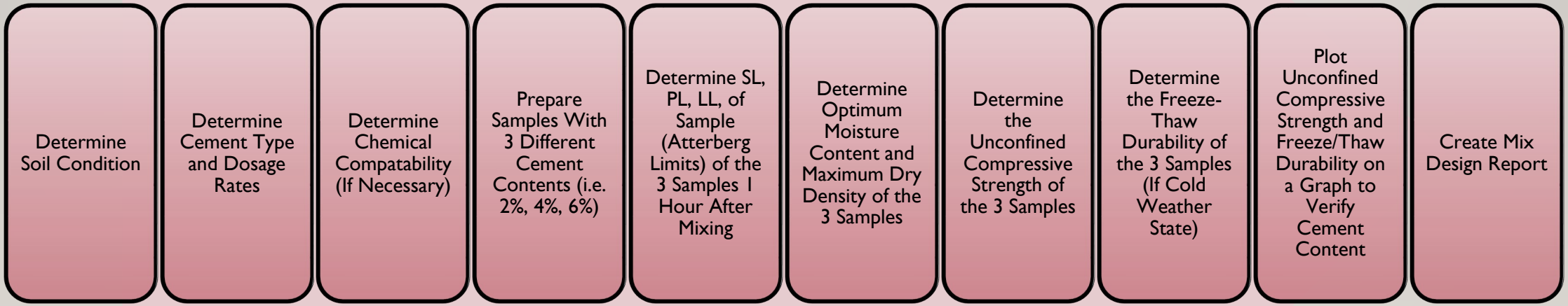
SOIL SAMPLING FOR MIX DESIGN

- Sample Frequency
  - Common to obtain every 400 ft.
  - Usually to a depth of 10 ft below grade.
- Obtain soil samples and run laboratory testing
  - General soil classification tests
    - Proctors
    - Atterbergs (Liquid Limit, Plastic Limit, Plastic Index)
    - Grain Size Analysis (Hydrometers)
  - AASHTO classifications
    - Most Iowa soils are A4, A6 or A7 (Silty or Clayey Soils) classification

MIX DESIGN PROCESS

- The amount of cement the soil will need is dependent on
  - Grain size / particle distribution
  - Desired support from subbase
  - Type of SCS selected
- Determine which cement type to use.
  - Soil sulfate content will dictate.
- Should test 3 to 4 dosage points to determine optimum value.

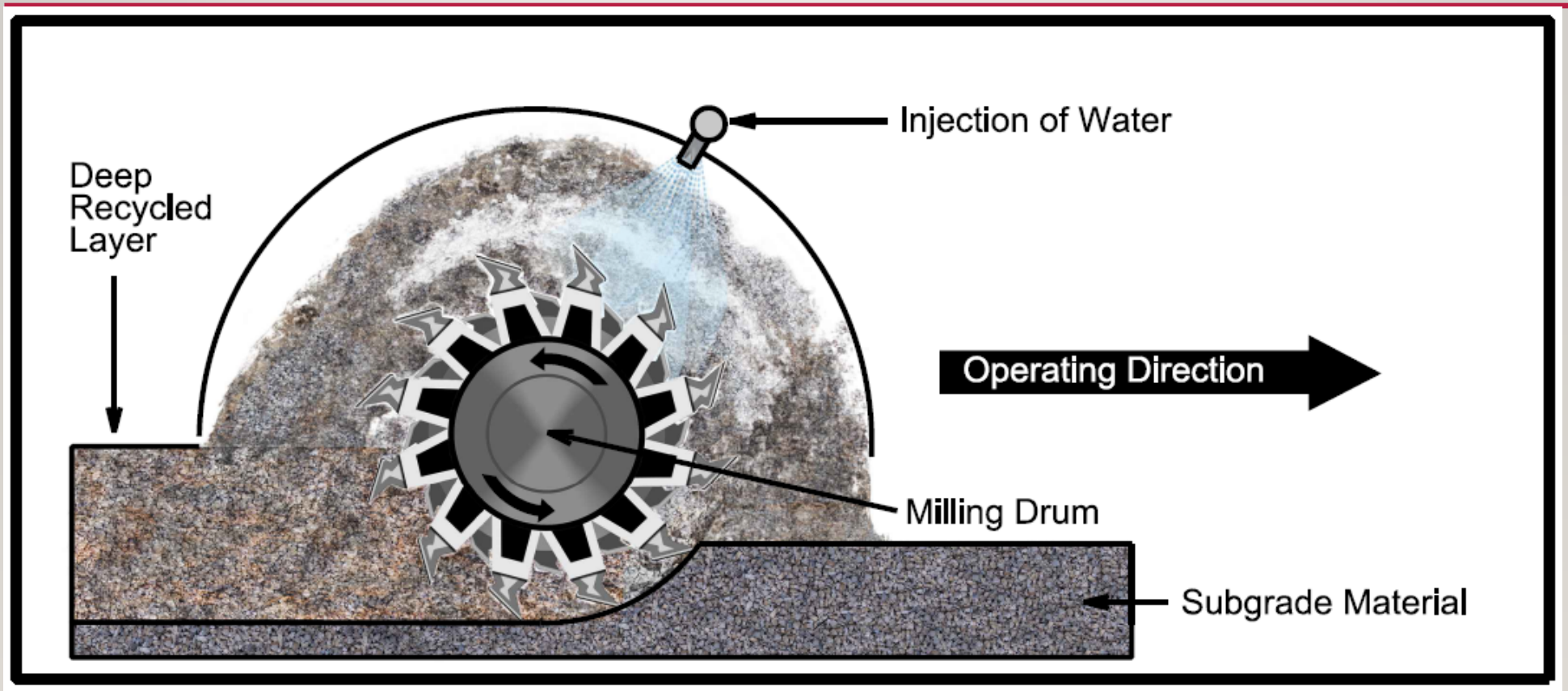
MIX DESIGN PROCESS



APPLY TO CONSTRUCTION METHODS

- Communicate the intended outcome and design with earthwork contractor.
- Cement should be incorporated using appropriate equipment.
    - Reclaimer/Mixer
    - Grader
    - Cement Spreader
    - Water Truck
    - Tamping/Sheepsfoot/Pad Foot Roller (Clayey and Silty Material)
    - Smooth Drum Roller (Granular Soils) / Pneumatic Tire Roller (Optional)

APPLY TO CONSTRUCTION METHODS



APPLY TO CONSTRUCTION METHODS

- SCS should be compacted in place, prior to cement hydrating.
  - Sometimes you might have to add water!

- Have your geotechnical engineer / representative assist with incorporation.
  - Monitoring dosage applications.
  - Monitoring compaction efforts.

APPLY TO CONSTRUCTION METHODS

- QC/QC during incorporation should included at a minimum
  - Proof roll the virgin subgrade first
    - Need to stabilize deeper?
  - Contractor should verify equipment in good working order
    - Water hose not clogged
    - Teeth on reclaimer not missing
    - Confirm application rate
  - Conduct a test strip
    - Identify if lab scenario can be applied to field
  - Verify stabilization efforts with moisture/density testing
    - Frequency of every 5,000 sq. ft.
  - Curing time (?)

PCA Photo

APPLICATION TECHNIQUES

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TYPICAL APPLICATION RATES

Percent Cement By Weight		Percent Cement By Volume %	Cement Spread Requirements in Pounds Per Square Yard (kg/m3) for Compacted Thicknesses				
100 pcf (1602 kg/m³)	110 pcf (1762 kg/m³)		5 inches (125 mm)	6 inches (150 mm)	7 inches (175 mm)	8 inches (200 mm)	9 inches (225 mm)
1.9	1.7	2.0	7.1 (3.8)	8.5 (4.6)	9.9 (5.4)	11.3 (6.1)	12.7 (6.9)
2.4	2.1	2.5	8.8 (4.8)	10.6 (5.7)	12.3 (6.7)	14.1 (7.6)	15.9 (8.6)
2.8	2.6	3.0	10.6 (5.7)	12.7 (6.9)	14.8 (8.0)	16.9 (9.2)	19.0 (10.3)
3.3	3.0	3.5	12.3 (6.7)	14.8 (8.0)	17.3 (9.4)	19.7 (10.7)	22.2 (12.0)
3.8	3.4	4.0	14.1 (7.6)	16.9 (9.2)	19.7 (10.7)	22.6 (12.2)	25.4 (13.8)
4.2	3.8	4.5	15.9 (8.6)	19.0 (10.3)	22.2 (12.0)	25.4 (13.8)	28.6 (15.5)
4.7	4.3	5.0	17.6 (9.6)	21.2 (11.5)	24.7 (13.4)	28.2 (15.3)	31.7 (17.2)
5.2	4.7	5.5	19.4 (10.5)	23.3 (12.6)	27.1 (14.7)	31.0 (16.8)	34.9 (18.9)
5.6	5.1	6.0	21.1 (11.5)	25.4 (13.8)	29.6 (16.1)	33.8 (18.4)	38.1 (20.7)
6.1	5.6	6.5	22.9 (12.4)	27.5 (14.9)	32.1 (17.4)	36.7 (19.9)	41.2 (22.4)
6.6	6.0	7.0	24.7 (13.4)	29.6 (16.1)	34.5 (18.7)	39.5 (21.4)	44.4 (24.1)

~ CSS Guide Book

CASE STUDY - DM INTERNATIONAL AIRPORT

Year Constructed	**2018**
Case Type	Design
Facility Location	Des Moines International Airport Des Moines, Iowa
Existing Soil Conditions	Brown Silty Clay (CL, A-6)
Civil Firm	Foth Infrastructure & Environment, LLC
Construction Contractor	Flynn Company, Inc
Construction Subcontractor	Manatt's, Inc.

CASE STUDY - DM INTERNATIONAL AIRPORT

- Reconstruct 2,500 ft of Runway 13/31
- FAA required minimum 125 psi compressive strength (P-157)
- CMT obtained samples every 300 ft to test for design
  - Virgin soil was A6, CL
  - Used 2, 3 and 4% cement for design (Continental Type I/II)
  - Each dosage increased compressive strength 100-300%
- 4% dosage rate was elected
  - Approximately 38 lbs per sq. yard

CASE STUDY - DM INTERNATIONAL AIRPORT

CASE STUDY - DM INTERNATIONAL AIRPORT

- The final outcome was determined by…..
  - MOTHER NATURE
  - FAA approved to bump to 6%, then bumped to 8% for final design

WHY SCS WORKS

- SCS works to modify the soil particles by
  - Changing cohesion
  - Changing capillary and pore structures
  - Changing chemical composition of the soil

- The most important factor of these three is altering the chemical composition of the soil

WHY CHOOSE SCS

Cost effective solution

- Less expensive than remove and replace.
- Less expensive than granular subbase.
- Improved soil bearing strength
- Promotes soil drying, rather than farming the soils

Time saving

- No remove and replace time.
- No mellowing period required (minimal if any)

Long term performance

- Soil alterations are permanent.
- Future rehab options are less expensive.
- Reduces soil susceptibility to moisture

CHALLENGES WITH SCS

- Can be a dust nuisance for neighbors
- Can be ineffective in heavy freeze/thaw areas
- Can be ineffective in high groundwater areas

QUESTIONS?

Sybil K. Ferrier, P.E.

Construction Materials Testing

sybil@cmtdsm.com

515-263-0794

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