Guidance Development for Use of Flocculants in Construction Stormwater Management
ALDOT USES FLOCCULANTS TO IMPROVE BMP EFFICIENCY

BUT...THERE ARE CHALLENGES

FLOCCULANTS ARE SOIL SPECIFIC

SOILS VARY ACROSS A SINGLE PROJECT

A VARIETY OF PRODUCTS ARE AVAILABLE

WHAT ARE MIXING AND AGITATION REQUIREMENTS?
**Guidance Development for Use of Flocculants in Construction Stormwater Management**

**REAPPLICATION & MAINTENANCE INTERVALS?**

**ARE THERE ENVIRONMENTAL RISKS?**

**SEVERAL APPLICATION TECHNIQUES**

- DITCH CHECK - POWDER
- DITCH CHECK - SOCK
- SEDIMENT BASIN
- SLOPE DRAIN

**DO CURRENT TECHNIQUES WORK?**

**RESEARCH GOAL: DEVELOP GUIDANCE**

- Longevity?
- Application Intervals?
- Flocculant Type?
- Maintenance Frequency?
- Soil Analysis?
- Product Selection?
- Optimum Dosage?
- Residuals?
- Application Technique?

**WHAT ARE OTHER STATE DOTS DOING?**

- 39% of DOTs use flocculants
- Main concern: unknown risks posed to receiving waters
Guidance Development for Use of Flocculants in Construction Stormwater Management

States Do Not Have Guidance...

- 7 DOTs rely on manufacturer guidance for dosage and application rates
- 2 DOTs have their own standard guidance for dosage and application rates
- 3 DOTs do not use any guidance for dosage and application rates
- 1 DOT has toxicology limits

Soil Sample Locations

- North: SR-25 Roadway Relocation Etowah Cty, RAEDAA-0025(556)
- West Central: Bridge Replacement on SR-6 Bibb Cty. BR-0004(573)
- East Central: Roadway Improvement and Bridge Widening on I-65 Shelby Cty. NHF-MIF-I065 (364)
- Southwest: U.S. 98 / SR-158 Extension Mobile Cty. NHF 0158 (502)&(508)
- Southeast: Bridge Replacement on SR-6 at Jenkins Creek Montgomery Cty. BR-0004(563)

Collected Soils

- Soil Sample Collection
- Tested using USDA Web Soil Survey, Sieve Analysis, Atterberg Limits Analysis, Hydrometer Analysis, and CEC Analysis

Analyzed Soils

- Laboratory Tests
- Soil Sample USDA Web Soil Survey
- CEC (meq / 100 g)
- Clay Content (%)
- CEC / Clay Content (meq / %)

Compared Samples Against Web Soil Survey

- Analyzed Cationic Exchange Capacity
- Measure of cations that can be retained on soil particle surfaces
- Can CEC be used to determine flocculant selection?
BENCH-SCALE EXPERIMENTS

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Research Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Match Tests</td>
<td>Which products / flocculant types work with which soils?</td>
</tr>
<tr>
<td>2 – Dosage Tests</td>
<td>What is the optimal flocculant dosage?</td>
</tr>
<tr>
<td>3 – Residual Tests</td>
<td>How can we measure concentrations being discharged?</td>
</tr>
</tbody>
</table>

1 - FLOCCULANT MATCH TESTS

- **Purpose:** Identify best matches for each soil
- 12 soils x 14 products
- 180 tests
- Flash mix - 1 min. (~120 rpm)
- Slow mix - 20 min. (~60 rpm)
- Settling - 15 min.
- Observations: Color, Floc Formation, Floc Size, Settling Velocity
- Point system based on observations

### MATCH TEST POINT SYSTEM

<table>
<thead>
<tr>
<th>Category</th>
<th>Color</th>
<th>Point</th>
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<tbody>
<tr>
<td>1 - Clear</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>2 - Light Yellow</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>3 - Dark Yellow</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>4 - Brown</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5 - Dark Brown</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>6 - Black Brown</td>
<td>0</td>
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<table>
<thead>
<tr>
<th>Category</th>
<th>Floc Formation (sec)</th>
<th>Point</th>
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<tbody>
<tr>
<td>1 - &lt;10</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>2 - 10-20</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>3 - 20-40</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>4 - 50-60</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>5 - 60-80</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>6 - 80-100</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>7 - 100-120</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>8 - 120-140</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>9 - &gt;140</td>
<td>2</td>
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<table>
<thead>
<tr>
<th>Category</th>
<th>Size Floc (mm)</th>
<th>Point</th>
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<tbody>
<tr>
<td>1 - &lt;3.5</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>2 - 3.5-3.0</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>3 - 3.0-2.5</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>4 - 2.5-2.0</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>5 - 2.0-1.5</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>6 - 1.5-1.0</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>7 - 1.0-0.8</td>
<td>4</td>
<td></td>
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<tr>
<td>8 - 0.8-0.6</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>9 - 0.6-0.4</td>
<td>2</td>
<td></td>
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<tr>
<td>10 - 0.4-0.2</td>
<td>1</td>
<td></td>
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<tr>
<td>11 - &gt;0.2</td>
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<table>
<thead>
<tr>
<th>Category</th>
<th>Settling Rate (x103 in./hr)</th>
<th>Point</th>
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<tbody>
<tr>
<td>1 - A</td>
<td>(0.3 - 0.5)</td>
<td>10</td>
</tr>
<tr>
<td>2 - B</td>
<td>(0.5 - 0.75)</td>
<td>9</td>
</tr>
<tr>
<td>3 - C</td>
<td>(0.75 - 1.0)</td>
<td>8</td>
</tr>
<tr>
<td>4 - D</td>
<td>(1.0 - 1.5)</td>
<td>7</td>
</tr>
<tr>
<td>5 - E</td>
<td>(1.5 - 2.25)</td>
<td>6</td>
</tr>
<tr>
<td>6 - F</td>
<td>(2.25 - 3.0)</td>
<td>5</td>
</tr>
<tr>
<td>7 - G</td>
<td>(3.0 - 4.5)</td>
<td>4</td>
</tr>
<tr>
<td>8 - N/A</td>
<td>(0.0)</td>
<td>3</td>
</tr>
</tbody>
</table>

Selection of top 3 performing product for each soil

2 - DOSAGE TRIALS

- **Purpose:** Identify optimum flocculant dosage rate
- 12 soils x top 3 best performing products per soil x 3 replicates
- 112 tests
- Flash mix - 1 min. (120 rpm)
- Slow mix - 20 min. (~40 rpm)
- Settling - 15 min.
- Observations: Turbidity, pH, Color, Temperature

Dosage ranges between 0% to 200% of the manufacturer recommendation

Guidance Development for Use of Flocculants in Construction Stormwater Management
2 - DOSAGE TEST METHODOLOGY

- Turbid water samples: ~1,500 (+/- 300) NTU
- Air dried soils
- Sieve through #200 sieve
- 1,000 mL tap water
- Set soil concentration based on initial turbidity readings

2 - DOSAGE TEST – FLASH MIX (120 RPM) 1 MIN.

2 - DOSAGE TEST – SLOW MIX (~60 RPM) 20 MIN.

2 - DOSAGE TEST – SUPERNATANT

3 - RESIDUAL TESTING METHOD – SETTLING VELOCITY
3 - SETTLING VELOCITY OBSERVATIONS

<table>
<thead>
<tr>
<th>Product</th>
<th>Equation</th>
<th>R²</th>
</tr>
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<tbody>
<tr>
<td>B1</td>
<td>y = 0.0147x - 0.1385</td>
<td>0.9983</td>
</tr>
<tr>
<td>B1</td>
<td>y = 0.0201x - 0.1607</td>
<td>0.9986</td>
</tr>
<tr>
<td>B1</td>
<td>y = 0.0223x - 0.0582</td>
<td>0.9992</td>
</tr>
<tr>
<td>B1</td>
<td>y = 0.0265x + 0.0206</td>
<td>0.9976</td>
</tr>
<tr>
<td>B1</td>
<td>y = 0.0331x - 0.1267</td>
<td>0.9992</td>
</tr>
<tr>
<td>B1</td>
<td>y = 0.0622x - 0.5252</td>
<td>0.9918</td>
</tr>
</tbody>
</table>

3 - RESIDUAL TESTING METHOD – SETTLING VELOCITY

- Dosage target: 50 mg/L
- Residual: 35 mg/L
- Residual of application dosage: 70%

FLUME EXPERIMENTS

Research Questions

- Is proper mixing and agitation being achieved?
- Is the target concentration being introduced?
- What is the degradation of delivery mechanism?

OPTIMUM DOSAGE FLUME EXPERIMENTS

- 40 ft long flume
- Adjustable Legs
- 5% Slope
- 18 in. diameter HDPE double wall smooth pipe

FLUME TESTING

- Flocculant Form
  - Block
  - Sock
  - Granular
  - Aqueous Solution
- Soil
  - Control (Clean water)
  - AU-SRF Soil
- Sampling
  - Upstream (Control)
  - Mid-section (Low Agitation)
  - Downstream (High Agitation)
- Measurements
  - Turbidity
  - Settling Velocity
  - Residuals

FLOCCULANT INTRODUCTION

- Aqueous
- Powder
FLOCCULANT INTRODUCTION

Block
Sock

FLUME TESTING

FLUME TESTING - PRELIMINARY RESULTS

Sampling Time (min) | Residual Concentration (mg/L) | Upstream | DC-2 | DC-4 | Downstream
---|---|---|---|---|---
20 | 2.6 | 9.5 | 25.2
40 | 2.3 | 11.1 | 23.1
60 | 2.9 | 8.9 | 20.9
80 | 3.5 | 11.0 | 21.2
100 | 3.4 | 7.6 | 17.2
200 | 14.2
300 | 10.1
400 | 10.4
500 | 5.6
600 | 6.4

\[ y = 0.0076x - 1.5694 \]

\[ R^2 = 0.8946 \]

CURRENT FINDINGS & OBSERVATIONS

- Web Soil Survey does not accurately identify soil characteristics
- Match testing is necessary to select appropriate products
- Optimum dosage varies with soil
- Dosage testing showing low concentrations of flocculant are highly effective
- Overdosing may sometimes increase turbidity
- Some products may cause undesirable (and significant) pH swings
- Ditch checks (flume scale) provide adequate mixing and agitation
- Granular application dissolves quickly, requires reapplication
- Socks appear to be least effective in dissolving
- Blocks provides steady dosage delivery
- Aqueous solution provides adequate delivery

FUTURE TESTING: LARGE-SCALE APPLICATION

Floc Bae: Billur Kazaz
Salt Bae
Guidance Development for Use of Flocculants in Construction Stormwater Management

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This research is sponsored by ALDOT. The support provided is gratefully acknowledged.

### Summary of evaluated flocculant products

<table>
<thead>
<tr>
<th>Product</th>
<th>Manufacturer</th>
<th>Flocculant Type</th>
<th>Form</th>
<th>Dosage (mg/L)</th>
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</thead>
<tbody>
<tr>
<td>H30</td>
<td>Carolina Hydrologic</td>
<td>Synthetic</td>
<td>Granular</td>
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<tr>
<td>APS 702</td>
<td>Applied Polymer Systems</td>
<td>PAM Synthetic</td>
<td>Stock solution</td>
<td>50</td>
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<tr>
<td>APS 705</td>
<td>Applied Polymer Systems</td>
<td>PAM Synthetic</td>
<td>Stock solution</td>
<td>50</td>
</tr>
<tr>
<td>APS 707</td>
<td>Applied Polymer Systems</td>
<td>PAM Synthetic</td>
<td>Stock solution</td>
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<td>Stock solution</td>
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<td>APS 712</td>
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<td>Granular</td>
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<td>APS 718</td>
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<td>Stock solution</td>
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<td>APS 720</td>
<td>Applied Polymer Systems</td>
<td>PAM Synthetic</td>
<td>Granular</td>
<td>50</td>
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<td>T3: BENCH SCALE TESTING</td>
<td>Innovative Turf Solutions</td>
<td>Bentonite-based</td>
<td>Inorganic Stock solution</td>
<td>180</td>
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<tr>
<td>FLOC</td>
<td>Innovative Turf Solutions</td>
<td>Bentonite based</td>
<td>Inorganic Stock solution</td>
<td>100</td>
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<tr>
<td>Tigerfloc</td>
<td>Floc Systems Inc.</td>
<td>Sodium Montmorillonite</td>
<td>Inorganic Stock solution</td>
<td>2,000</td>
</tr>
<tr>
<td>Tigerfloc</td>
<td>Floc Systems Inc.</td>
<td>Sodium Montmorillonite</td>
<td>Inorganic Stock solution</td>
<td>2,000</td>
</tr>
</tbody>
</table>

Note: Included in ALDOT Approved Product List
RESEARCH PLAN

- Task 1 - Literature Review and Survey
- Task 2 - Soil Assessment
- Task 3 - Bench-Scale Experiments
- Task 4 - Optimum Dosage Flume Experiments
- Task 5 - Large Scale Application Evaluation