Subgrade Challenges in a Railroad Environment

BCR2A Workshop
June 29, 2009
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BNSF Network

Route Miles: 32,000
Number of Employees: 40,000
Locomotives: Approx. 6,400
Average Freight Cars on System: 200,000
About BNSF

• BNSF is a privately owned and publicly traded freight railroad

• Unlike other forms of freight transportation, our trains operate on an infrastructure built and financed almost entirely by the railroad

• Every day, we deliver trainloads of consumer goods, agricultural products, industrial products, and coal to customers across our 32,000-mile rail network
BNSF: Size and Scope

- 32,000 route miles in 28 states and two provinces
- Approximately 6,400 locomotives and 200,000 freight cars
- Employs approximately 40,000 people
- Operates an average of 1,400 freight trains per day
- Moves one fourth of the nation’s rail freight
- Serves all major ports on the West Coast and Gulf of Mexico
- If stacked end-to-end, all the intermodal loads shipped with BNSF in one year would reach from Los Angeles to Shanghai 6 times.
- Leads rail industry in technological innovation
- Has one of the largest computer systems in the world to manage our network operations 24 hours a day
Transcon Capital Expansion – 2007

- Belen - West End Expansion
  3rd Main Track

- Abo Canyon
  2nd Main Track

- Daggett to Barstow
  3rd Main Track

- Crossover Plants
  10 Locations

- Vaughn to Carnero
  2nd Main Track

- Ft. Sumner to Agudo
  2nd Main Track

- Congo to Eton
  3rd Main Track

- Hazleton to Brink
  2nd Main Track

- Brink to Avard
  2nd Main Track

- CREATE Projects
  McCook, Corwith, Panhandle
Southeast Initiative Capital – 2007

Projects:
- Eldridge, AL: Extend Siding
- Racine, MO: Extend Siding
- Shirk, OK: New Siding
- Gatman, MS: Extend Siding
- Reese, MS: Extend Siding
Coal Capital Expansion – 2007

- Hettinger Subdv.
- Signals
- Cassa to Fisher 2nd Main Track
- Thornton to Kara 2nd Main Track
- Moorcraft to E. Rozet 2nd Main Track
- Lakeside to Antioch 2nd Main Track
- Orin Sub. – MP 0.0 to 39.0 3rd Main Track
- Orin Sub. - Logan Hill 4th Main Track
- Cassa to Fisher 2nd Main Track
- Bingham to Ellsworth 2nd Main Track
- Wendover, WY Siding Upgrade
- Seneca to Mullen 2nd Main Track
- Enterprise to Stuart 2nd Main Track
- Seneca to Mullen 2nd Main Track
- Anselmo to Linscott 2nd Main Track
- Ashland to South Bend 2nd Main Track
- Clark to MP 11.8 2nd Main Track
- Mason to Berwyn 2nd Main Track
- Seward to Tamora 2nd Main Track
## Unified Soil Classification System

### Unified Soil Classification and Symbol Chart

#### Coarse-Grained Soils
- **Clean Gravels (Less than 5% fines)**
  - **GW**: Well-graded gravels, gravel-sand mixtures, little or no fines
  - **GP**: Poorly-graded gravels, gravel-sand mixtures, little or no fines

- **Gravels with fines (More than 12% fines)**
  - **GM**: Silty gravels, gravel-sand-silt mixtures
  - **GC**: Clayey gravels, gravel-sand-clay mixtures

#### Sands
- **Clean Sands (Less than 5% fines)**
  - **SW**: Well-graded sands, gravelly sands, little or no fines
  - **SP**: Poorly graded sands, gravelly sands, little or no fines

- **Sands with fines (More than 12% fines)**
  - **SM**: Silty sands, sand-silt mixtures
  - **SC**: Clayey sands, sand-silt-clay mixtures

#### Fine-Grained Soils
- **Silt and Clays**
  - **Liquid limit less than 50%**
    - **ML**: Inorganic silts and very fine sands, rock flour, silty clayey fine sands or clayey silts with slight plasticity
  - **CL**: Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
  - **OL**: Organic silts and organic silty clays of low plasticity

  - **Liquid limit 50% or greater**
    - **MH**: Inorganic silts, micaceous or diatomaceous fine sands or silty clays, elastic clays
    - **OH**: Inorganic clays of high plasticity, fat clays
    - **OD**: Organic clays of medium to high plasticity, organic clays

- **Highly Organic Soils**
  - **PT**: Peat and other highly organic soils

### Laboratory Classification Criteria

- **GW**
  \[ C_u = \frac{D_{60}}{D_{10}} \]  greater than 4; \[ C_c = \frac{D_{30}}{D_{10} \times D_{60}} \]  between 1 and 3

- **GP**
  Not meeting all gradation requirements for GW

- **GM**
  Afterberg limits below "A" line or P.I. less than 4
  Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols

- **GC**
  Afterberg limits above "A" line with P.I. greater than 7

- **SW**
  \[ C_u = \frac{D_{60}}{D_{10}} \]  greater than 4; \[ C_c = \frac{D_{30}}{D_{10} \times D_{60}} \]  between 1 and 3

- **SP**
  Not meeting all gradation requirements for GW

- **SM**
  Afterberg limits below "A" line or P.I. less than 4
  Limits plotting in shaded zone with P.I. between 4 and 7 are borderline cases requiring use of dual symbols

- **SC**
  Afterberg limits above "A" line with P.I. greater than 7

Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows:

- Less than 5 percent: GW, GP, SW, SP
- More than 12 percent: GM, GC, SC
- 5 to 12 percent: Borderline cases requiring dual symbols

### Plasticity Chart

![Plasticity Chart](chart.png)

- **CH**: A line: \( P_i = 0.75(\text{LL} - 20) \)
- **ML-SOL**: Shaded area for organic soils
<table>
<thead>
<tr>
<th>Silts and Clays</th>
<th>Liquid Limit - not dried</th>
<th>Organic silt KLMO</th>
</tr>
</thead>
<tbody>
<tr>
<td>inorganic</td>
<td>Pl plots on or above &quot;A&quot; line</td>
<td>CH Fat clay KLM</td>
</tr>
<tr>
<td></td>
<td>Pl plots below &quot;A&quot; line</td>
<td>MH Elastic silt KLM</td>
</tr>
<tr>
<td>organic</td>
<td>Liquid Limit - oven dried</td>
<td>OH Organic clay KLMOP</td>
</tr>
<tr>
<td></td>
<td>Liquid Limit - not dried</td>
<td>Organic silt KLMO</td>
</tr>
</tbody>
</table>

| HIGHLY ORGANIC SOILS | Primarily organic matter, dark in color, and organic odor | PT Peat |

A Based on the material passing the 3-in. (75-mm) sieve.
B If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
C Gravels with 5 to 12% fines require dual symbols:
GW-GM well-graded gravel with silt
GW-GC well-graded gravel with clay
GP-GM poorly graded gravel with silt
GP-GC poorly graded gravel with clay

D Sands with 5 to 12% fines require dual symbols:
SW-SM well-graded sand with silt
SW-SC well-graded sand with clay

SP-SM poorly graded sand with silt
SP-SC poorly graded sand with clay

E $C_\text{u} = \frac{D_{60}}{D_{10}} \quad C_\text{c} = \frac{(D_{60})^2}{D_{10} \times D_{60}}$

F If soil contains $\geq 15\%$ sand, add "with sand" to group name.
G If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
H If fines are organic, add "with organic fines" to group name.
I If soil contains $\geq 15\%$ gravel, add "with gravel" to group name.
J If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.
K If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel, whichever is predominant.
L If soil contains $\geq 30\%$ plus No. 200, predominantly sand, add "sandy" to group name.
M If soil contains $\geq 30\%$ plus No. 200, predominantly gravel, add "gravelly" to group name.
N Pl $\geq 4$ and plots on or above "A" line.
O Pl $< 4$ or plots below "A" line.
P Pl plots on or above "A" line.
Q Pl plots below "A" line.
DOUBLE TRACK TANGENT WITH DITCH
W/ 6" ASPHALT
NOT TO SCALE
San Bernardino
Thanks for your attention.