FAA Pavement Design

Subgrade Soils & Granular Materials

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FAA Pavement Design

AC 150/5320-6E, Airport Pavement Design and Evaluation

• Completely revised in 2008
• New design methodologies for rigid and flexible pavements
• Design procedure requires the use of computer program, FAARFIELD
Design Methodology

• Flexible Pavement Design based on Layered Elastic design procedure
  – CBR method no longer used

• Rigid Pavement Design based on 3-Dimensional Finite Element model
  – Westergaard design procedure no longer used
Soil Investigations and Evaluation
Soil Investigations and Evaluation

- Very few significant changes
- Still uses Unified Soil Classification (USC) system
  - Reference to ASTM 2487
## Minimum Subsurface Boring Recommendations

<table>
<thead>
<tr>
<th>Area</th>
<th>Minimum spacing</th>
<th>Minimum depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>RWY/TWY</td>
<td>200 ft interval</td>
<td>10 ft</td>
</tr>
<tr>
<td>Other areas</td>
<td>1 per 10,000 sq ft</td>
<td>10 ft</td>
</tr>
<tr>
<td>Borrow areas</td>
<td>As necessary</td>
<td>As necessary</td>
</tr>
</tbody>
</table>

- Depth of materials
- Material Classification
- Water Table
- Standard Penetration Test (SPT)
Soil Testing Recommendations

- Particle size analysis
- Liquid Limit, Plastic Limit, Plasticity Index
- Moisture density relations of soil
- Strength test
  - CBR
  - k-value
- Other
  - Shrinkage factor
  - Permeability
  - Organic materials
Soil Compaction Requirements

Based on 60,000-lb gross weight airplane

Light Load Pavement

< 60,000 lbs  ASTM D 698  Standard Proctor

Heavy Load Pavement

> 60,000 lbs  ASTM D 1557  Modified Proctor
Methods of Obtaining Design Values

- Laboratory test
- Field test – CBR, DCP, VSS, etc.
- Borings – split-spoon, standard penetration test
- NDT data backcalculation
Sensitivity Analysis

• The subgrade CBR imparts the highest sensitivity of all material property inputs
• For airfield pavement design, the sensitivity can be as high as a factor of 12
  – For a 20% change in CBR subgrade, there is a 240% change in pavement life
• Only a proven correlative expression for determining CBR should be used

Paper presented by Moshe Livneh, Faculty of Civil and Environmental Engineering
Transportation Research Institute, Technion-Israel Institute of Technology
Technion City, Haifa 32000, Israel
2007 FAA Worldwide Airport Technology Transfer Conference
Atlantic City, New Jersey, April 2007
Sensitivity of Flexible Design to CBR

Random example – not indicative of all cases
Soil Strength Parameter for Flexible Pavement Design

CBR or Subgrade Modulus (E, psi)

CBR

• Design value – one standard deviation below the mean
• Minimum of three tests per soil type
• Lowest practical value: CBR = 3
  – Otherwise stabilize or replace
Soil Strength Parameter for Flexible Pavement Design

Laboratory CBR

- Penetration test at constant rate of strain
- Sample remolded to desired density
- Sample soaked for 4 days (to reach saturation)
  - In-place soils beneath pavements expected to be near saturation after 3 years
- Seasonal conditions dictate use of saturated test
  - Traffic must be supported during worst case
Soil Strength Parameter for Rigid Pavement Design

Resilient Modulus (E, psi) or Modulus of Subgrade Reaction (k-value, pci)

- Design value – “conservative selection”
- k-value can be estimated from CBR

\[
k = \left[ \frac{1500 \times \text{CBR}}{26} \right]^{0.7788} \quad (k \text{ in pci})
\]
Sensitivity of Rigid Design to k-value

• Sensitivity of k-value is increased with 3D finite element design procedure
• Errors in selection of k-value can generate noticeable changes in the required pavement thickness
Sensitivity of Rigid Design to k-value

Note: example not indicative of all situations
Seasonal Frost

- Freezing can cause heaving at the surface
- Thawing can weaken the subgrade support

- Pavement Surface
- Ice Crystals in Frost-Susceptible Layer
- Upward Water Movement by Capillary Action
# Seasonal Frost – Frost Groups

<table>
<thead>
<tr>
<th>FROST GROUP</th>
<th>KIND OF SOIL</th>
<th>PERCENTAGE FINER THAN 0.02 mm BY WEIGHT</th>
<th>SOIL CLASSIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>FG-1</td>
<td>Gravelly Soils</td>
<td>3 to 10</td>
<td>GW, GP, GW-GM, GP-GM</td>
</tr>
<tr>
<td>FG-2</td>
<td>Gravelly Soils</td>
<td>10 to 20</td>
<td>GM, GW-GM, GP-GM, SW, SP, SM, SW-SM, SP-SM</td>
</tr>
<tr>
<td></td>
<td>Sands</td>
<td>3 to 5</td>
<td></td>
</tr>
<tr>
<td>FG-3</td>
<td>Gravelly Soils</td>
<td>Over 20</td>
<td>GM, GC</td>
</tr>
<tr>
<td></td>
<td>Sands, except very fine silty sands</td>
<td>Over 15</td>
<td>SM, SC</td>
</tr>
<tr>
<td></td>
<td>Clays, PI above 12</td>
<td>--</td>
<td>CL, CH</td>
</tr>
<tr>
<td>FG-4</td>
<td>Very fine silty sands, All Silts</td>
<td>Over 15</td>
<td>SM</td>
</tr>
<tr>
<td></td>
<td>Clays, PI = 12 or less</td>
<td>--</td>
<td>ML, MH</td>
</tr>
<tr>
<td></td>
<td>Varved Clays /other fine grained banded sediments.</td>
<td>--</td>
<td>CL, CL-ML</td>
</tr>
</tbody>
</table>

**Notes:**
- **FG-1**
  - 3 to 10 percentage finer than 0.02 mm by weight
  - Soil classification: GW, GP, GW-GM, GP-GM

- **FG-2**
  - 10 to 20 percentage finer than 0.02 mm by weight

- **FG-3**
  - Over 20 percentage finer than 0.02 mm by weight
  - Soil classification: GM, GC

- **FG-4**
  - Over 15 percentage finer than 0.02 mm by weight
Depth of Frost Penetration

• Based on engineering experience (local construction practice, building codes, etc.)
• No nomographs or programs provided
Frost Design

• Complete Frost Protection
  – Remove frost susceptible materials to below frost depth

• Limited Frost Protection
  – Remove frost-susceptible material to 65% of frost depth
  – Limits frost heave to tolerable level

• Reduced Subgrade Strength
  – Reduce subgrade support value
  – Design adequate load carrying capacity for weakened condition
  – Not allowed for FG-4 soils
### TABLE 3-3. REDUCED SUBGRADE STRENGTH RATINGS

<table>
<thead>
<tr>
<th>Frost Group</th>
<th>Flexible Pavement CBR Value</th>
<th>Rigid Pavement k-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FG-1</td>
<td>9</td>
<td>50</td>
</tr>
<tr>
<td>FG-2</td>
<td>7</td>
<td>40</td>
</tr>
<tr>
<td>FG-3</td>
<td>4</td>
<td>25</td>
</tr>
<tr>
<td>FG-4</td>
<td>Reduced Subgrade Strength Method Does Not Apply</td>
<td></td>
</tr>
</tbody>
</table>
Swelling Soils

• Greater than 3% swell from CBR test
• Treatment:
  – Low (3-5%): compact wet of optimum to not greater than 90% of maximum density
  – Medium (6-10%): stabilize soil to 12 inches
  – High (>10%): remove & replace; deep stabilization; provide depth of new soil cover
Soil Stabilization

• Consider when:
  – Weak soils
  – Poor drainage
  – Adverse surface drainage
  – Frost
  – Need working platform
Soil Stabilization

• Chemical
  – Lime
  – Portland cement
  – Emulsion

• Mechanical
  – Bridging
  – Geotextiles/geogrids
Questions?

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