What Are the Basics of a Good Road?

Soils

Vincent Drnevich, P.E., Professor
School of Civil Engineering,
Purdue University

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Topics

- Ten Commandments for Good Roads
- Types of Soils
- Permeability
- Capillarity
- Compaction
- Frost Action and Potholes
- Selection of Soils for Roads
- Improvement of Soils for Roads
  - Stabilization
  - Geotextiles
- Summary and Conclusion

Ten Commandments for Good Roads (from: Vermont Local Roads Program)

1. Get Water Away from the Road*
2. Build on a Firm Foundation*
3. Use the Best Soils Available*
4. Compact Soils Well*
5. Design for Winter Maintenance
6. Design for Traffic Loads and Volumes
7. Pave Only Those Roads That Are Ready*
8. Build From the Bottom Up*
9. Protect Your Investment
10. Keep Good Records

*6 of the 10 are related to soils

Types of Soils

- Boulders – Larger than 12-inches
- Cobbles – 3 to 12 inches
- Gravels – approx. ¼ to 3 inches
- Sands – 0.003 (#200 sieve) to ¼ inch
- Silts - smaller than #200 sieve but no strength (cohesion) when dried
- Clays - smaller than #200 sieve but significant strength (cohesion) when dried

Determine Soil Types (Sieving)

Put Soil in at top
Cobles - soil retained on 3” sieve
Gravel - soil retained on #4 sieve
Coarse Sand - soil retained on #10 sieve
Fine Sand - soil retained on #200 sieve
Silt and clay - soil passing the #200 sieve

Silts and Clays (referred to as “fines”) are Easily Identified by Behavior

- Silts – exhibit no plasticity; crumble when rolled into a thread; when dry, can easily broken by hand into a powdery form
- Clays – exhibit plasticity; can be rolled into a thread without crumbling; when dry forms hard lumps which cannot be readily broken by hand

From Das, B. (2002)
Classification of Soils (AASHTO)

- **Granular Soils** – Soils that have less than 35% silts and clays
  - Drain well – depends on amount of clay and silt
  - Good support for pavements

- **Silt-Clay Soils** – Soils that have more than 35% silts and clays
  - Generally prevent drainage
  - Behavior strongly determined by the amount of water in the soil (wet = mud; dry = very strong)
  - Generally not good for pavement support

Permeability

- **Ability of soil to allow water to flow through it.**

  - Gravel: ~ 10,000 ft/day (2 mi/day)
  - Sand: ~ 10 ft/day
  - Silt: ~ 0.01 ft/day (1/8"/day)
  - Clay: ~ 0.00001 ft/day (1/2"/year)

Gravels and sands allow water to be drained from beneath pavements assuming that there is a place for the water to drain.

Capillarity

- **How water is absorbed in a soil (analogous to how a sponge attracts water)**

  Height of Rise:
  - Small Gravel: 0.1-0.4 feet
  - Coarse sand: 0.5 feet
  - Fine sand: 1-3 feet
  - Silt: 3-30 feet
  - Clay: 30-90 feet

From Das, B. (2002)

Compaction

- **Increasing density of soil**
  - Increases strength of soil – reduced likelihood of failure
  - Increases stiffness of soil – reduces deformation and settlement

  - Depends on the water content of soil at the time of compaction
  - Some water in soil aids in compaction
  - Too much water in soil impedes compaction

Water Content at the Time of Compaction Obtainable Density

<table>
<thead>
<tr>
<th>Water Content at the Time of Compaction</th>
<th>Obtainable Density</th>
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<tbody>
<tr>
<td>Maximum Dry Unit Weight</td>
<td>Optimum Moisture Content</td>
</tr>
<tr>
<td>Saturated conditions</td>
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</tbody>
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The Maximum Dry Unit Weight and Optimum Moisture Content vary with soil type.

Compaction Specifications for Highway Embankments (Percent of Max. Density)

<table>
<thead>
<tr>
<th>Condition 1</th>
<th>Condition 2</th>
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<tbody>
<tr>
<td>(Wet Season for Foundation)</td>
<td>(Dried Season)</td>
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<tr>
<td>Height of Fill (ft)</td>
<td>Height of Fill (ft)</td>
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<tr>
<td>Date</td>
<td>Date</td>
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<tr>
<td>Weight of Fill</td>
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<td>(100)</td>
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<td>Sat.</td>
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<td>Low</td>
<td>Low</td>
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<td>High</td>
<td>High</td>
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</tbody>
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Effects of Water on Well Compacted Soils

Do you want this soil beneath your pavements?

Keeping Water from Soils Beneath Pavements

- Design road to minimize ground water access to the soils beneath the pavement
- Good pavement maintenance minimizes the water getting into the soils beneath the pavement
- Provide for removal of water from beneath pavements
  - Free draining base material
  - Place for water to drain – side ditches

Freeze-Thaw and Potholes

What causes potholes?
- Water
  - If water is not drained from beneath pavements, it freezes and expands
  - The depth of freezing could go well into the subgrade
  - Thawing occurs from the roadway downward
  - Upon thawing the frozen soil surrounds the thawing soil beneath the pavement
  - Loose saturated soil provides very little support for the pavement

Common Pavement Profile

Prolonged Freezing Temperatures in Water-Saturated Soils Form Ice Lenses and Cause Pavement Heave

Water drawn into the zone of freezing from groundwater by capillarity

Thawing Occurs from Top Down - Saturated Soil in Thawed Zone Cannot Drain Bathtub Effect = Little Support for Pavement
Selection of Soils for Roads

- Subgrade – natural soil at the site
  - If soft or loose soil, compact it or stabilize it
- Subbase – first layer above the natural soil
  - Should prevent clays and silts from penetrating into the base layer.
  - Dense-graded aggregate is frequently used (Indiana 33 s)
- Base – layer immediately below the pavement
  - Open graded, free draining material (# 8 or #9 aggregate)
  - Attention to removing water at edge of pavement into drainage ditches

Improvement of Soils for Roads

- Stabilization of Subgrades
  - Clayey soils, especially ones which are wet – use quicklime or lime kiln dust
  - Mix with soil
  - Compact to make dense
  - Granular soils – if cannot be compacted consider mixing in small amounts of cement and water before compacting

Use of Geotextiles

- Many types exist
  - Filter fabrics placed on subgrades prevent silts and clays from migrating into the base materials and contaminating them
  - Geogrids are geotextiles that act like reinforcing steel does in concrete

Summary and Conclusions; Basics of Good Roads - Soils

- Build roads on good soils; if soils are not good, compact and/or improve them
- Use a subbase to prevent subgrade soils of contaminating the pavement base
- Use a free-draining base material and make sure that water drains away from the pavement
- Maintain the road to:
  - Reduce water infiltration through the pavement
  - Allow base layer to drain

References

- Drnevich on Basics of Good Roads -- Soils 3/10/04
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- https://www.sacdot.com/services/Potholes.asp
- http://syllabus.syr.edu/CIE/SKBHATIA/Cie584/dave/index1.htm
- http://www.mtcsg.com/ (Mt. Carmel Sand and Gravel)