What Are the Basics of a Good Road?
Soils

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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

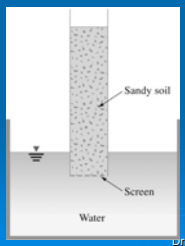
- Ability of soil to allow water to flow through it.

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)



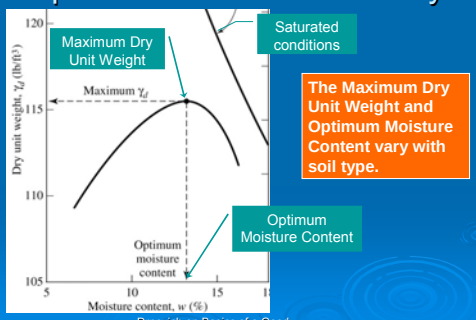
Height of Rise:
Small Gravel: 0.1-0.4 feet
Coarse sand: 0.5 feet
Fine sand: 1-3 feet
Silt: 3-30 feet
Clay: 30-90 feet

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



The Maximum Dry Unit Weight and Optimum Moisture Content vary with soil type.

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

TABLE 8.16 RECOMMENDED REQUIREMENTS FOR COMPACTION AND SLOPES OF HIGHWAY EMBANKMENTS.

		Condition of Exposure					
		Condition 1 (Not Subject to Inundation)			Condition 2 (Subject to Inundation)		
Revised Public Roads System	Approximate Equivalent, Unified System	Height of Fill, feet	Side Slope	Desired Compaction, % AASHO Maximum Density	Height of Fill, feet	Side Slope	Desired Compaction, % AASHO Maximum Density
A-1	GW, GP, SW, some GM or SM	Not critical	1½ to 1	95+	Not critical	2 to 1	95
A-3	SP	Not critical	1½ to 1	100+	Not critical	2 to 1	100+
A-2-4	Most GM and SM	Less than 50	2 to 1	95+	Less than 10	3 to 1	95
A-2-5					10 to 50	3 to 1	95–100
A-2-6 or 7	GC or SC	Less than 50	2 to 1	95+	Less than 50	3 to 1	95–100
A-4, A-5	ML, MH	Less than 50	2 to 1	95+	Less than 50	3 to 1	95–100
A-6, A-7	CL, CH	Less than 50	2 to 1	95–100	Less than 50	3 to 1	95–100

Notes:
(1) Under Condition 2, higher fills on the order of 35 to 50 ft should be compacted to 100 percent at least for portions subject to inundation. Major fills composed of unusual materials which have low shearing resistance should be analyzed by soil mechanics methods.
(2) For soils of the A-6 or A-7 groups, the lower compaction requirements shown obtain only for low fills (10 to 15 ft or less) not subject to inundation and not carrying large volumes of heavy traffic.
(3) Highly organic soils are not generally suitable for fill construction.

Ref.: Hilf, J.W., *Chapter 8 - Compacted Fill*, **Foundation Engineering**, Second Ed., Edited by Fang, H-Y, Van Nostrand Reinhold, New York, 1991, p. 313.

Effects of Water on Well Compacted Soils

Do you want this soil beneath your pavements?

Keeping Water from Soils Beneath Pavements

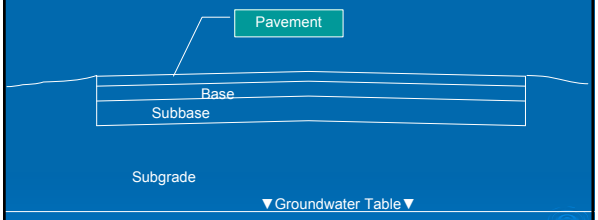
- Design road to minimize ground water access to the soils beneath the pavement
- Good pavement maintenance minimizes the water getting into the soils beneath the pavement
- Provide for removal of water from beneath pavements
  - Free draining base material
  - Place for water to drain – side ditches

Freeze-Thaw and Potholes

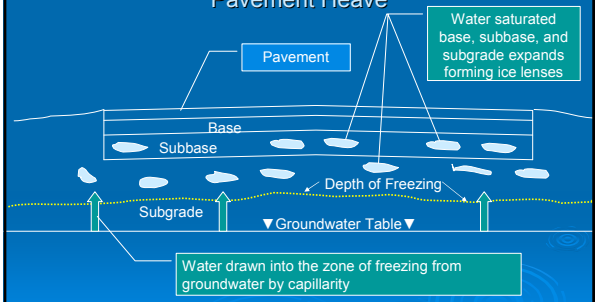
What causes potholes?

- 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

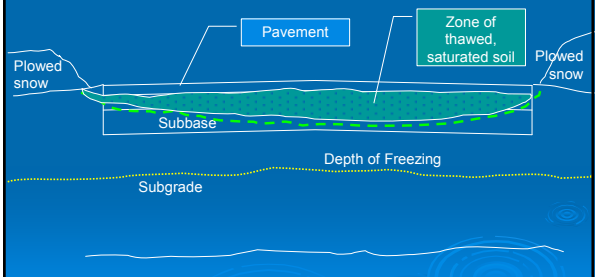
Common Pavement Profile



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



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

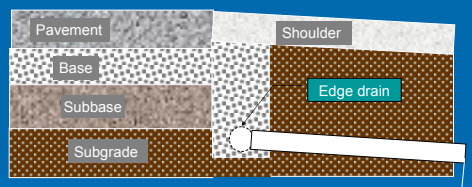


Selection of Soils for Roads

- 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 53'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

Details at Pavement Edges –

Collect water that gets beneath pavement and get rid of it



http://www.dot.state.ny.us/cmb/consult/cpdmfiles/CPDM_Chap_09.pdf

Transverse drains to drainage ditch or storm sewer

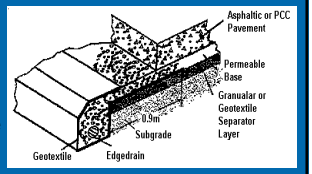
Improvement of Soils for Roads

- 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

http://www.mtcsg.com/

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



http://syllabus.syr.edu/CIE/SKBHATIA/Cie584/dave/index1.htm

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

- Das,B. (2002) *Principles of Geotechnical Engineering*, Brooks-Cole Publishers, 5th Ed., ISBN 0-534-38742-X
- http://personalweb.smcvt.edu/vermontlocalroads/FactSheet%20files/Basics_of_a_Good_Road_Fact_Sheet.htm
  http://www.dot.state.ny.us/cmb/consult/cpdmfiles/CPDM_Chap_09.pdf
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- http://syllabus.syr.edu/CIE/SKBHATIA/Cie584/dave/index1.htm
- http://www.mtcsg.com/ (Mt. Carmel Sand and Gravel)