Subgrade Preparation

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CONNELL

Subgrade Preparation

- What is Subgrade
- Subgrade verses Subbase
- Poor Subgrade
- Types of Subgrade preparation
- Grading
- Compaction and Testing

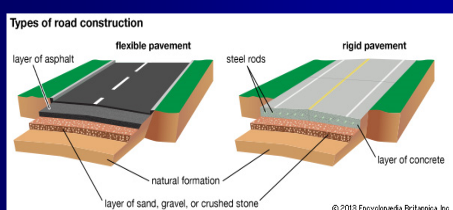
Subgrade

- The soil is prepared and compacted to support a structure or a pavement system
- The bed of ground on which the foundations of a road are built.

Subbase

- **Subbase** is the layer of aggregate material laid on the subgrade, on which the base course layer is located.
- Subbase is often the main load-bearing layer of the pavement.
- Its role is to spread the load evenly over the subgrade

Typical Road Section



Importance of Quality Subgrade

- Provide good support for placement and compaction of base section and pavement
- Limit pavement deflections to acceptable limits
- Minimize differential movement due to frost and Shrinking/swelling soils
- Promote uniformity of support (Key element for good long term pavement performance)

Poor Subgrade

- Will not support the pavement
- Does not distribute the load properly
- Asphalt will deteriorate quickly
- Costly repairs will be needed

Alligator Cracking

Alligator Cracking

- Alligator cracking is associated structural failure
- Can be due to weakness in the surface, base or sub grade; a surface or base that is too thin
- Can also be a result of poor drainage or a combination of all three

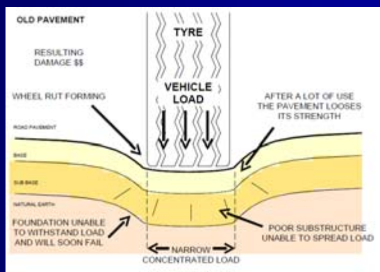
Asphalt Heaving

Asphalt Heaving

- The cause is the freezing and thawing that comes with above and below freezing temperatures that start the formation of ice lenses
- Poor drainage in subgrade or base
- Clay and silty soils are more susceptible to frost heave than better draining soil mixtures

Asphalt Rutting

Asphalt Rutting



Asphalt Rutting

- Rutting results from consolidation or lateral movement of any of the pavement layers or the subgrade under traffic
- It is caused by insufficient pavement thickness; lack of compaction of the asphalt, stone base or soil

Types of subgrade preparation

- Modification and Stabilization
- Removal and Replace
- Geosynthetic Reinforcement
- Moisture Conditioning
- Full Depth Reclamation

Modification and Stabilization

- Subgrade treatment that is intended to provide a stable working platform during construction.
  - Adding chemicals like fly ash or cement
  - Replacing existing soils with aggregates
  - Geosynthetic reinforcement with aggregates
  - Moisture conditioning

Adding chemicals like fly ash or cement

Chemical Stabilization

- This work consists of treating the subgrade by combining chemicals such as fly ash, lime, or cement and water with the pulverized soil material to the specified depth and compaction requirements

Soil Stabilization Benefits

- Lower material costs – reduces base and pavement thickness
- Lower construction costs – eliminates cost of material removal and replacement. 30% - 50% savings
- Increased Strength – a dramatic increase in the CBR can be achieved

Soil Stabilization Benefits

- Longer durability – stabilized soil is highly resistant to water and frost, which increases the lifespan of the subgrade
- Increased environmental responsibility – stabilizing the existing soil eliminates the need to export the poor undesirable soil and import new fill

Remove and Replace

- Simple Procedure that does not require specialized equipment

Removal and Replace

- This process will consist of removing the unsuitable soil and replacing it with aggregates such as base or sand
- Geosynthetics are often placed on the surface of the excavated subgrade prior to placement of aggregates

Geosynthetic reinforcement with aggregates

Geosynthetics

- Placed in pavement bases to preform following function
  - Reinforcement
  - Separation
  - Filtration

Geosynthetics

- The primary purpose of using geosynthetics in the pavement design is to reduce reflective cracking in the asphalt and resist moisture intrusion into the underlying pavement structure

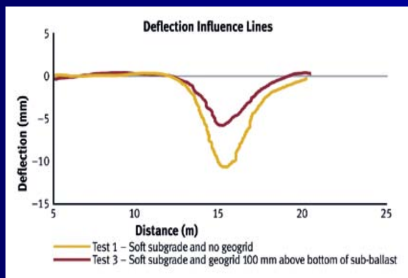
Geosynthetic Benefits

- Improves structural capability of soil
- Allows the use of poorer quality of soils to be used in construction
- Construction time can be reduced
- Drastically increases the durability of subgrade

Geosynthetic Benefits

- Reduced construction cost due to the optimization of pavement layer configuration
- Dramatic extension of pavement life
- Reduces asphalt and base quantities due to added subgrade strength

Benefit of Geogrid



Moisture Conditioning

Moisture Conditioning

- This work consists of blading, shaping, wetting, and compacting the subgrade with moisture and density control
- Moisture Conditioning reduces or increases the soil moisture content to be compacted to the required density
- Controls shrinking and swelling of soils

Moisture Conditioning Benefits

- Allows contractors to expedite work
- Reduction of construction costs
- Improved utilization of existing materials
- Greater environmental protection
- Increased short-term and long-term savings

Full Depth Reclamation

Full Depth Reclamation Process

- The total asphalt surface is pulverized plus a predetermined portion of the base
- The pulverized base is compacted and graded
- The new stabilized base is now ready for paving

FDR Benefits

- Cheaper – At least 50% less expensive than traditional road repair methods
- Faster – Get 2-3 times more repairs done in the same time period
- Easier – No excavating, no loading, no hauling off and dumping old asphalt

FDR Benefits

- Base is stabilized with pulverized road surface
- No reflective cracking!
- Permanent repair, not a temporary fix
- Environmentally friendly

Grading

Fine Grading

- Fine grade is required for the final trimming and checking of the cross section.

Equipment Maintenance

- Make sure to always inspect all equipment daily
- Always check cutting edges on equipment
- Cutting edges are wear parts and need to be replaced often
- This will save money in the long run

Checking grade

- A string line can be stretched across adjoining grade stakes
- The subgrade is checked by measuring down to the known offset distance from the string line to the dirt
- Straight edge – easiest way to check uniformity of subgrade

Importance of uniform subgrade

- Strength
  - Make sure you have full pavement section.
- Yield
  - Uniform subgrade will optimize yield.
- Cost
  - Asphalt is for more expensive than base
- Smoothness
  - HMA compacts differentially, thicker areas compact more than thinner areas which will affect pavement smoothness

Cost Comparison

- Proper grading has been done and checked
- 2,000’ long road
- 38’ in width
- 6” depth of asphalt
- 2,787 tons of asphalt required at $65/ton for material and placement

Cost of Material and Placement

- $181,155

Cost Comparison

- Poorly graded road that is ½” deep on average
- Same dimensions on road
- Depth is now 6 ½”
- 3,019 tons required at $65/ton for material and placement

Cost of Material and Placement

- $196,235
- ½” extra asphalt cost an additional $15,080
- 1” extra asphalt would cost $30,160

Compaction

- Compaction occurs when a force compresses the soil and pushes air and water out of it so that it becomes more dense. Compaction is more severe when the soil is wet and less able to withstand compression.

Why Compact?

- 5 reasons to compact
- - Increases load-bearing capacity
- - Prevents soil settlement and frost damage
- - Provides stability
- - Reduces water seepage, swelling and contraction
- - Reduces settling of soil

Types of compaction

- There are four types of compaction effort on soil or asphalt:
- Vibration
- Impact
- Kneading
- Pressure

Two types of compaction force

- *Static force*
- *Vibratory force*

Static Force

- *Static force* is the deadweight of the machine, applying downward force on the soil surface, compressing the soil.
- Static compaction is confined to upper soil layers.
- Kneading and pressure are two examples of static compaction.

Vibratory Force

- *Vibratory force* uses a mechanism, usually engine-driven, to create a downward force.
- The compactors deliver a rapid sequence of blows to the surface, affecting the top layers as well as deeper layers. Vibration moves through the material, setting particles in motion and moving them closer together for the highest density possible.
- Based on the materials being compacted, a certain amount of force must be used to overcome the cohesive nature of particular particles.

Compaction Equipment

- Choosing the right equipment for the job is vital to achieving proper compaction.

Deciding Factors

- Soil type
  - **Cohesive**
  - **Granular**
- Thickness of Lift and Machine Performance
- Compaction Specifications

Cohesive soils

- Machine with high impact force is required to ram the soil and force the air out to achieve compaction.
- Pad Foot or Sheep Foot Roller with vibratory option
- Jumping Jack

Granular soils

- Require vibratory action to move them or Kneading
- Smooth Drum Roller
- Plate Compacter
- Wheel Rolling

Thickness of Lift and Machine Performance

- The thicker the lift the heavier piece of equipment needs to be.

Materials					
		Vibrating Sheep foot Rammer	Static Sheep foot Grid Roller Scraper	Vibrating Plate Compactor Vibrating Roller Vibrating Sheep foot	Scraper Rubber-tired Roller Loader Grid Roller
	Lift Thickness	**Impact**	**Pressure (with kneading)**	**Vibration**	**Kneading (with pressure)**
Gravel	12+	Poor	No	Good	Very Good
Sand	10+/-	Poor	No	Excellent	Good
Silt	6+/-	Good	Good	Poor	Excellent
Clay	6+/-	Excellent	Very Good	No	Good

Compaction Specifications

- Method Specification
  - Detailed instructions specify machine type, lift depths, number of passes, machine speed and moisture content.
- End-result Specification
  - Engineers indicate final compaction requirements, allowing the contractor to choose what is the best method to achieve compaction.

Compaction Equipment

Rollers

- Smooth drum
- Padded drum Sheep Foot
- Rubber-tired
- Static and vibratory sub-categories
- Walk-behind and ride-on

Smooth Drum Roller

Smooth Drum

- Smooth-drum machines are ideal for both soil and asphalt

Sheep Foot Roller

Padded Drum / Sheep Foot

- Appropriate for cohesive soils.
- The drum pads provide a kneading action on soil.

Rubber Tire Roller

- 7 to 11 tires that have an overlapping pattern
- Typically a static roller
- Compaction effort is pressure and kneading

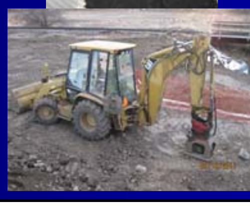
Wheel Rolling

Jumping Jack

Rammers / Jumping Jack

- Deliver a high impact force making them an excellent choice for cohesive and semi-cohesive soils
- Three types of compaction: impact, vibration and kneading.

Plate Compacter



Vibratory Plates

- Low amplitude and high frequency, designed to compact granular soils and asphalt.
- Type of compaction: vibration

Walk Behind

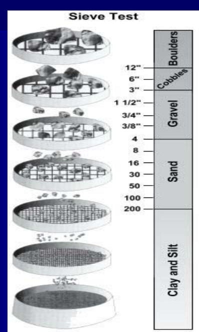
- Appropriate for cohesive soils
- Ideal for small areas

Soil types

- Soil types are classified by grain size, determined by passing the soil through sieves to screen or separate the different grain sizes.
- A *well-graded* soil consists of a wide range of particle sizes with the smaller particles filling voids between larger particles.
- The are three basic soil groups:

Three Soil Groups

- Cohesive
- Granular
- Organic (this soil is not suitable for compaction)



Cohesive

- Cohesive soils have the smallest particles. Clays range from .00004" to .002".
- Cohesive soils are dense and tightly bound together. They are plastic when wet and can be molded, but become very hard when dry.
- Proper water is essential for proper compaction.
- Cohesive soils usually require a force such as impact or pressure.
- Silt has a noticeably lower cohesion than clay. However, silt is still heavily reliant on water content.

Granular

- Granular soils range from .003" to .08" (sand) and .08" to 1.0" (fine to medium gravel).
- Granular soils are known for their water-draining properties.
- Sand and gravel obtain maximum density in either a fully dry or saturated state.
- Testing curves are relatively flat so density can be obtained regardless of water content.

Guide to Soil Types

What to look for	Appearance/Feel	Water Movement	When Moist	When Dry
Granular soils, fine sands and silts	Coarse grains can be seen. Feels gritty when rubbed between fingers	When water and soil are shaken in palm of hand, they mix. When shaking is stopped they separate	Very little or no plasticity	Little or no cohesive strength when dry. Soil sample will crumble easily.
Cohesive soils, mixes and clays	Grains cannot be seen by naked eye. Feels smooth and greasy when rubbed between fingers	When water and soil are shaken in palm of hand, they will not mix	Plastic and sticky. Can be rolled	Has high strength when dry. Crumbles with difficulty. Slow saturation in water.

Materials

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Clay	6+/-	Excellent	Very Good	No	Good

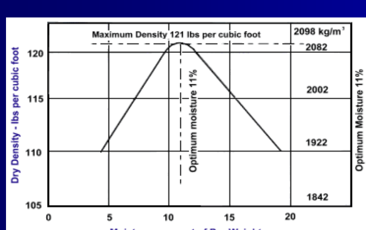
Fill Materials

	Permeability	Foundation Support	Pavement Sub grade	Expansive	Compaction Difficulty
Gravel	Very High	Excellent	Excellent	No	Very Easy
Sand	Medium	Good	Good	No	Easy
Silt	Medium Low	Poor	Poor	Some	Some
Clay	None+	Moderate	Poor	Difficult	Very Difficult
Organic	Low	Very Poor	Not Acceptable	Some	Very Difficult

Moisture vs. Soil Density

- Moisture or water content is key to achieving density in compaction. Water allows the particles of material to move together and decrees voids.
- Not enough water particles can not slide past each other.
- Too much water and water voids are created.
- The optimum moisture content is when compaction will be achieved the easiest.

Density Curve



Testing

Why Should We Test?

- Measures density of soil for comparing the degree of compaction vs. specs
- Measures the effect of moisture on soil density vs. specs
- Provides a moisture density curve identifying optimum moisture
- Save Money

Types of Tests

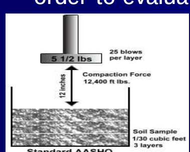
- Proctor Test
- Modified Proctor Test
- Hand Test

Proctor Test

- Determines the maximum density of a specific soil.
- Tests the effects of moisture on soil density
- Standard Proctor
- Modified Proctor

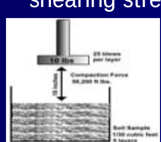
Standard Proctor

- A small soil sample is taken from the jobsite. A standard weight is dropped several times on the soil. The material weighed and then oven dried for 12 hours in order to evaluate water content



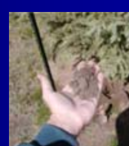
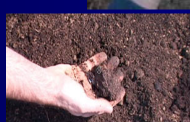
Modified Proctor

- This is similar to the Proctor Test except a hammer is used to compact material for greater impact, The test is normally preferred in testing materials for higher shearing strength.



Field Testing


Hand Test

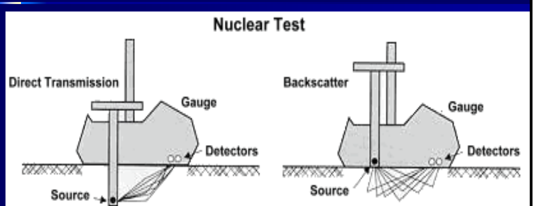





Hand Test

- Pick up a handful of soil.
- Squeeze it in your hand.
- If the soil is powdery and will not retain the shape made by your hand, it is too dry.
- If it shatters when dropped, it is too dry.
- If the soil is moldable and breaks into only a couple of pieces when dropped, it has the right amount of moisture for proper compaction.
- If the soil is plastic in your hand, leaves traces of moisture on your fingers and stays in one piece when dropped, it has too much moisture for compaction.

Nuclear Density (ASTM D2292-91)

- Nuclear Density meters are a quick and fairly accurate way of determining density and moisture content. The meter uses a radioactive isotope source (Cesium 137) at the soil surface (backscatter) or from a probe placed into the soil (direct transmission). The isotope source gives off photons (usually Gamma rays) which radiate back to the mater's detectors on the bottom of the unit. Dense soil absorbs more radiation than loose soil and the readings reflect overall density. Water content (ASTM D3017) can also be read, all within a few minutes. A relative Proctor density with the compaction results from the test.



Proof Rolling

Why Proof Rolling

- Point out soft or pumping subgrades
- Test anticipated stress levels under repeated load traffic
- Identify areas where density levels are acceptable, however the material is still not stable.
- Simple and Cheap form of testing

Lets Review

Questions ?