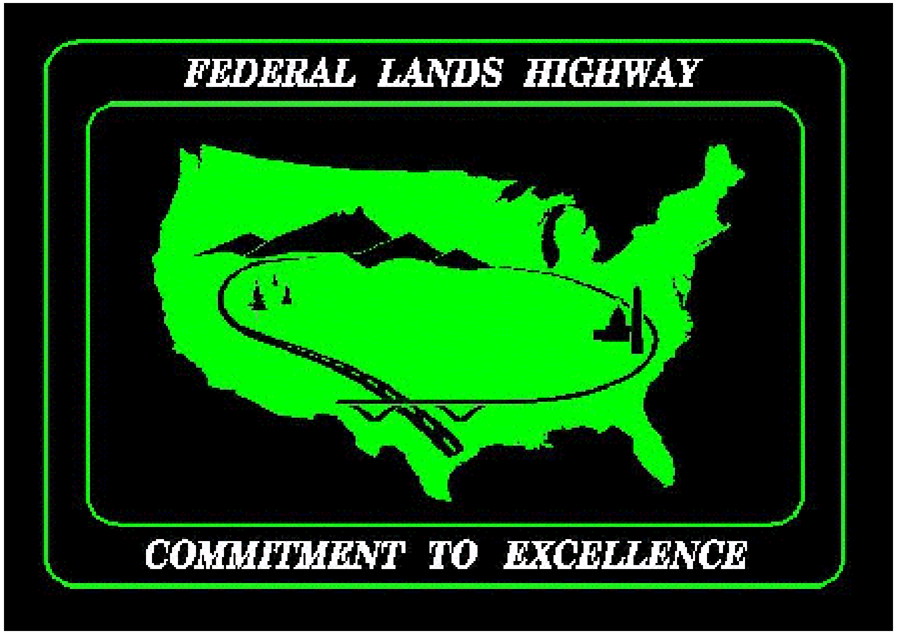
Yellowstone National Park

Cold Regions Engineering

DEPARTMENT OF TRANSPORTATION · UNITED STATES OF AMERICA



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UNESCO

WORLD HERITAGE SITE

Picture1

Picture2

Yellowstone National Park Road Program

- 20-year program to upgrade roads
- $12 million per year budget
- Both reconstruction and 3R
- Original road system built in 1930's
- 230 km long Grand Loop Road
- 175 km of additional primary highways

Climate on the Park's West Side

- Roads are between 1600 m and 2700 m elevation
- 560 mm average annual precipitation
- 3630 mm average annual snow accumulation
- July average maximum temperature is 26°C
- January average minimum temperature is -18°C
- Mean annual air temperature is 1.6 °C
- Average 268 days/year with lows below freezing
- Air thawing index is 3423 degree-days
- Air freezing index is 5478 degree-days

Soils and Pavement Design

- Primarily colluvial and glacio-fluvial soils derived from tuff and rhyolite
- Generally granular—silty sand and gravel, SP, SM, GP, and GM
- Don’t provide Corps of Engineers’ frost design throughout the project
- Instead, subexcavate frost-susceptible soils in known frost heave areas

Road Management

- Roads are plowed and open to the public from April through October
- Park manages overweight vehicles during spring thaw period
- Roads are groomed for snowmobiles from November through March
- Snow over the center of the roadway is compacted and has poor insulation properties compared to snow over the road shoulders

North Rim Drive

- Two photos of typical spring frost heave conditions

Picture3

Picture4

Northeast Entrance Road

- Two photos of road condition prior to 3R project

Picture5

Picture6

Typical Subexcavation Treatments in Frost Heave Areas

- Experience over several projects indicates depth has to be at least one meter to prevent future pavement cracking
- Use separation geotextile on the floor of the subexcavation
- Select borrow is free draining with less than 5% passing the 75-micron sieve
- Provide underdrains in wet areas

Type 1 Subexcavation

- Used in areas with high water table
- *In situ* soils are wasted because they are too moist to be workable
- Creates relatively large quantities of waste and requires large quantities of select borrow

Picture7

Type 2 Subexcavation

- “Sandwich” treatment used in moderately wet areas
- *In situ* soils are reused if they are at a workable moisture content
- Advantages: lower cost because quantities of waste material and select borrow material are reduced

Picture8

Type 3 Subexcavation

- Used over cross culverts where frost heave is a problem

Picture9

Type 4 Subexcavation

- Experimental treatment used in moderately wet areas
- Geocomposite sheet drain replaces geotextile and select borrow
- *In situ* soils are reused if they are at a workable moisture content
- Advantages: lower cost because quantity of waste material is reduced and no need for select borrow material
- Four years of use shows it to be as effective in preventing frost heave as Type 1 and 2 treatments

Picture10

Construction of Type 2 Subexcavation

- Photo shows top layer of geotextile placed over select borrow layer
- Contractor used half-width construction so traffic could pass

Picture11

Nez Perce Ford Frost Heave Area

- Historically one of most severe heave areas in the Park—up to 350 mm of differential heave
- 160 meters long
- High water table
- Profile: 0.7 m of sand (SP-SM) over lacustrine silt (ML)
- Sand layer contains prehistoric artifacts (obsidian arrowheads and shards)

Picture12
Picture13

Nez Perce Ford Proposed Design

- Minimize impact to artifact-bearing sand layer from subexcavation and drains
- Profile allows only a small grade raise
- Use 75 mm of polystyrene insulation board to reduce frost penetration

Picture14

Gibbon Meadows Reconstruction

- Another historically severe heave area with a lot of differential heave
- 1340 meters long
- Meadow has interbedded layers of fine sand (SP-SM) and diatomaceous earth (ML)
- Existing road fill (600 to 800 mm of sand, SP-SM) was constructed over several time periods
- Some borings encountered corduroy (logs) and other borings encountered rocky embankment layers
- Four roadway cross sections follow two photographs:

Picture15

Picture16

Picture17

Picture18

Gibbon Meadows Design

- Widened roadway all on one side
- Subexcavated a portion of the native soils to limit differential settlement under the new embankment
- Backfilled subexcavated area with existing embankment material to maintain uniformity of embankment material
- Placed a uniaxial geogrid (10 kN/m allowable wide width strength) transversely across the roadway to limit crack propagation up through the embankment
- Raised overall grade by 300 mm to reduce frost penetration into frost-susceptible layers

Picture19

Gibbon Meadows Performance

- Roadbed was constructed up to subgrade last fall
- 300-mm-thick pavement structure is yet to be placed
- Last winter was a moderate year for frost heaves
- No visible distortion of the roadbed surface this spring
- A few isolated hairline cracks appeared to be visible in the roadbed surface this spring

Warm Ground Design

- Primary purpose is to prevent snow from melting from the roadway in warm areas so that snowmobiles can run on the snow (Insulation board)
- Avoids expense of maintenance crews placing wood chips on the roadway each fall and removing them in the spring
- Secondary purpose is to prevent hydrothermal gases from deteriorating the asphalt concrete pavement (geomembrane)
- To minimize impact on hydrothermal features and caverns, no vibratory compaction is allowed during construction in these areas

Picture20

Picture21

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