Washington State Department of Transportation

Materials Laboratory
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tech notes

"tech notes" are a product of the State Materials Laboratory to share design and construction technology gained from projects done through WSDOT. This issue is from the Pavements Branch discussing The Use of Rock Cap Material As a Capillary Break.

Use of Rock Cap Material As a Capillary Break

The traditional approach to frost mitigation by the Washington State Department of Transportation (WSDOT) has been to provide a pavement structure made up of non-frost susceptible material equal to at least half the design depth of the frost penetration. This approach has worked for many roadways, but in northeast Washington, where both frost related and drainage problems become extensive, other means of mitigation have been sought. To mitigate high groundwater, capillary rise during frost heaving, thaw weakening during thawing temperatures and substantial run off from snow melt, WSDOT turned to correcting problems by isolating the flow of water from the pavement structure through the use of free-draining aggregate or a "rock cap" layer.

Photo 1. Example of the extent of damge caused by freezing and thawing on SR 20.

On SR 20, from Colville to Tiger Junction, WSDOT recognized the need for an "all-season roadway," that is, a roadway not subject to road restrictions or closures. Load restrictions on SR 20 were yearly occurrences due to a weak pavement structure. As with many roads built in the 1930's and 40's, a minimal thickness of crushed stone base was placed on frost susceptible soils prior to a bituminous surface treatment (BST). Over time, the placement of additional layers of BST has resulted in a bituminous layer that is adequate for low volume roadways during dry seasons. However, this structure does not adequately support truck traffic during the spring thaw, consequently resulting in substantial fatigue cracking and rutting (Photo 1) due to the amount of thawed moisture in the base and subgrade.

Photo 2. Open graded nature of the rock cap aggregate provides a positive drainage blanke allows excess water to be eliminated.

To reduce the amount moisture allowed to enter the base layers, a capillary break using free draining rock cap material was constructed. Photo 2 shows the open graded nature of the rock cap aggregate and the positive drainage blanket provided.

WSDOT's design of the rock cap structure has been based on the practices used by the Idaho Department of Transportation (Idaho DOT). The structure used by WSDOT consists of an 18-inch of aggregate (2 ½ to 3 inch maximum size) with 0 to 15 percent passing the ½ inch sieve. Above the rock cap layer, 4 inches of crushed stone base was placed and compacted, followed by an 4 to 5 inch asphalt wearing surface.

Photo 3. Watering and compcating rock cap aggregate.

Construction of the rock cap roadway consisted of placing the rock cap aggregate directly onto the existing BST roadway. However, where placement occurred in areas of natural subgrade or embankment widening, a geotextile fabric is placed as a separator to prevent the intrusion of fine particles into the rock cap layer.

The construction sequence for the rock cap structure consists of the placement of the rock cap aggregate in 6 inch maximum lifts, followed by grading, and

Photo 4. Vehicle traffic driving on the compacted rock cap surface.

Table 1. Rock cap costs.

SR 20 Roadway Section	Rock Cap (Tons)	Cost ($/Ton)
Spruce Canyon to Mill Road	127,800	7
Mill Road to Tiger Junction	271,900	7.45
Colville High School to MP 363	157,000	8.09

Table 2. SR 20 performance data.

Pavement Structural Condition[1]	Ride IRI (inches/mile)	Rut (inch)
86 to 100	59 to 75	0.12

Note 1 - WSDOT considers a Pavement Structural Condition of 50 equal to 10 percent alligator cracking in the wheel paths.

Photo 5. Final asphalt overlay on SR 20 with rock cap material in place.

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compaction (Photo 3). Typically, a 300 to 500 foot long section is completed to full depth before the entire operation progresses along the roadway.

The rock cap is compacted by using a 10-ton vibratory roller. The use of water during compaction is essential to reduce the inter-particle friction when compaction energy is applied. Idaho DOT had previously described rock cap material, while under traffic, as acting like an arrestor bed on a truck escape ramp. Nevertheless, the projects constructed on SR 20 from 1998 to 2002 exceeded all expectations, and the stability of the roadway for automobiles and construction vehicles was excellent.

WSDOT found that the 2 ½ to 3 inch rock cap material was normally very stable and only experienced two problems: trucks hauling rock cap material occasionally got stuck while dumping and car tires sometimes being punctured by sharp rocks. WSDOT was able to reduce the number of punctured car tires by compacting the material with at least three passes before allowing vehicles on the rock cap surface.

Following the placement of the rock cap layer, a 2-inch layer of crushed stone aggregate was placed on the roadway. The layer of crushed stone base tightened the rock cap surface by filling voids thus providing a temporary driving surface until the final thickness of crushed base material (4 inches) and asphalt surfacing (4.5 inches) can be placed.

Following the construction of a section of the rock cap and crushed stone base layers, WSDOT then applied a BST surface to eliminate maintenance concerns. The BST maintained the roadway cross slope and profile while providing a driving surface acceptable to the public until the final ACP wearing surface was placed.

The cost for the rock cap aggregate was lower than the cost for WSDOT's crushed surfacing base course (CSBC) used for normal surfacing projects. WSDOT contractors estimated that had CSBC been used on the SR 20 projects, the cost would have been approximately $0.50 to $1.00 more per ton for the quantities used. Table 1 summarizes the rock cap costs and quantities used on SR 20.

Rock cap construction has been successfully used to isolate the flow of water from the pavement structure while providing the drainage and the insulation needed to help protect the subgrade from freezing. Since the construction of the rock cap roadway on SR 20, there have been no road restrictions due to thawing or freeze/thaw related distress in the pavement structure. Table 2 summarizes the performance data for the 35 lane miles completed in 1998 and 1999. The PSC of below 100 is the result of alligator cracking related to isolated mix problems rather than the rock cap structural section. A ride of 59 to 75 inches per mile is considered excellent.

It has been WSDOT's experience that with the use of the rock cap construction, a structural section resistant to the damaging effects of frost heaving, thawing and excess moisture from drainage is provided, therefore achieving an all-season roadway. WSDOT will continue to monitor the performance of the rock cap roadway constructed on SR 20.