LOW TRAFFIC PORTLAND CEMENT CONCRETE PAVEMENT ON THE TURTLE MOUNTAIN INDIAN RESERVATION NORTH DAKOTA

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The Turtle Mountain Indian Reservation is situated at Belcourt, North Dakota, area near the Canadian border. The population density averages 55 people per mile of road. This presented problems in maintaining a gravel road, and we therefore began looking for hard all weather surfacing. We had two things to consider when we evaluated surface types. (1) We must utilize local aggregate which consisted of 65% fine aggregate and 35% coarse aggregate and also meet the quality requirements for surfacing aggregate. (2) The maintenance cost over the life of the surfacing would have to be low due to rising labor and material costs. The final decision was a 140 mm (5½ inch) non-reinforced, slip formed concrete pavement, 6.7 m (22 feet) wide. The present gravel surfaced roads were trimmed a depth of 102 mm (4 inches) by an autograder. The grade line was checked so excess trim would be avoided and yet fill areas could be avoided. This trimming resulted in the concrete being placed directly on the clay subgrade material. The trim material was used for shoulder material against the concrete pavement. The joint spacing varied from 4.27 m (14 feet) to 5.48 m (18 feet) on an 24.38 m (80 foot) cycle. The 24.38 m (80 foot) joint was formed with a premolded joint material with all intermediate joints being sawed. In three years we have completed concrete pavement on 56.3 kilometer (35 miles) of road and the maintenance costs have been only for snow removal and shoulder repairs.

By 1975 the population in the rural portions of the Turtle Mountain Indian Reservation was averaging 55 people per mile of road. Traffic consisted mainly of cars, some farm to market trucks and school buses. These had caused problems in maintenance and dust control on the gravel surfaced roads. In evaluating hard all weather surfacing we took the following two items into consideration.

(1) We must utilize local aggregate, which, when crushed consisted of 65% fine aggregate and 35% coarse aggregate.

(2) The maintenance cost over the life of the surfacing must be kept low to produce the lowest annual cost to the user in view of increasing costs for labor and materials.

The final decision was for a 140 mm (5½ inch) non-reinforced, slip formed concrete pavement 6.7 m (22 feet) wide with a 0.9 m (3 foot) unpaved shoulder on each side.

The aggregate to be used in the concrete mix came from a glacial deposit. The specifications called for crushing all material under 254 mm (10 inches) in diameter which resulted in a gradation of 65% passing the 9.5 mm (3/8 inch) sieve. Therefore our design mix consisted of about two-thirds fine aggregate and one-third coarse aggregate which was just about the opposite of our normal requirements.

The local aggregate also had shale and this problem in the coarse aggregate had to be watched closely. Our specifications for the coarse aggregate was modified to increase the maximum shale content from 0.7% to 1.5%. Excess shale was removed after crushing by washing in a sand screw and passing through a jig. We found that after crushing if the coarse aggregate was spread out in a shallow layer, rather than placed in a conical stockpile, the shale would breakdown faster and could be separated more readily during the washing operation. The shale content of the fine aggregate was not a problem.

The aggregate specifications were as follows:

Fine Aggregate

Sieve Size	Percent passing
9.5 mm (3/8 inch)	100
4.75 mm (No. 4)	95-100
1.19 mm (No. 16)	45-80
0.29 mm (No. 50)	10-30
0.15 mm (No. 100	2-5

Coarse Aggregate

Sieve Size	Percent passing
38 mm (1½ inch)	100
25.4 mm (1 inch)	50-95
19 mm (3/4 inch)	35-80
9.5 mm (3/8 inch)	10-40
4.75 mm (No. 4)	0-15
0.074 mm (No. 200)	0-3

The Physical Properties of the fine aggregate conformed to the requirements of AASHTO M6 with the following modification:

Physical Properties	Max. % by wt.
1. Clay lumps, not more than	0.5

2. Coal, Lignite and Scoria not more than	1.00
3. Material passing 0.074 mm (No. 200) sieve not more than	3.00
4. Other deleterious substances (such as shale, alkali, mica, coat grains, soft and flaky particles.) not more than	3.00
Sum of materials listed 1, 2 and 4, not more than	4.00

The physical properties of the coarse aggregate conformed to the requirements of AASHTO M80 with the following modifications:

Physical Properties	Max. % by wt.
(a) Shale	1.5
(b) Soft Iron Oxide Particles (paint rock and ochre)	2.0
(c) Coal and Lignite	0.3
(d) Total Spall Materials (includes items a, b and c above, plus other iron oxide particles, unsound cherts, clayey, limestone particles, and other materials having similar characteristics	3.7
(e) Soft Particles (exclusive of items a, b, c and d above)	1.3
(f) Clay Balls and Lumps	0.3
(g) Sum of Materials listed under items d, e and f above (For item d, use % in total sample retained on the 4.75 mm (No. 4) sieve)	4.0
(h) Slate	3.0
(i) Thin or Elongated Pieces (maximum thickness less than 1/4 the maximum width, or maximum length more than 3 times the maximum width)	15.0
(j) Material Passing 0.074 mm (No. 200) sieve	1.0

The final concrete mix contained 234.5 Kg. (517 lbs) of type II cement per cubic yard with 0.25 Kg. (0.55 lbs) of water per pound of cement, 884.5 Kg. (1950 lbs) of fine aggregate, 442.3 Kg. (975 lbs) of coarse aggregate, 0.16 Kg. (5.5 ounces) of protex. The 28 day cylinder breaks were generally 20.68 MPa (3000 psi) or better and the beam breaks produced flexure strength of 3.10 MPa (450 psi) or better. Slump was kept at 38 mm to 51 mm (1½-2 inches).

The transverse contraction joint spacing was randomized at 4.27 m (14 feet), 4.57 m (15 feet), 4.87 m (16 feet), 5.18 m (17 feet), and 5.48 m (18 feet) with an 24.38 m (80 feet) cycle. Every fifth joint was formed with a premolded strip to induce initial cracking. In order to better control the cracking during hot weather, additional joints were formed with a premolded strip. The premolded strips had to be placed with care so that they were vertical and even with the top of the surface to prevent spalling at the joint. Transverse joints were sawed 6.4 mm (1/4 inch) wide, 28.6 mm (1-1/8 inch) deep and filled with hot poured rubber asphalt sealer. The centerline longitudinal joint had 762 mm (30 inch), 13 mm (½ inch) diameter deformed bars on 762 mm (30 inch) centers and sawed 9.5 mm (3/8 inch) wide, 34.9 mm (1-3/8 inch) deep and filled with hot poured rubber asphalt sealer.

Costs

The cost per square yard for the 140 mm (5½ inch) slab was as follows:

Year	Square Meters	Cost Per Square Meter
1975	91,445(112,895 sq yd)	7.28 (5.90 per sq yd)
1976	99,702(123,039 sq yd)	6.74 (5.46 per sq yd)
1977&78	184,441(227,705 sq yd)	7.89 (6.39 per sq yd)

Procedure

The roads to be paved on the reservation had been graded several years previously. A centerline profile was taken and a new grade line laid, which required trimming an average of 102 mm (4 inches) from the present surface. The new grade line was checked during the trimming operation so excess trim could be avoided and not allow new fill areas. The trimming was accomplished with an Autofine grader which deposited the material along both sides of the road. This material was placed along the finished slab and compacted to form 0.9 m (3 foot) wide shoulder.

Trimming an average of 102 mm (4 inches) from the roadway surface resulted in the concrete being placed directly on the clay subgrade.

The trimmed subgrade without new fill area provided a very uniformly compacted roadbed upon which the concrete surfacing was placed.

The concrete was mixed at a central plant and hauled in tandem axle, end dump trucks and dumped on the roadbed in front of the slip form paver. The vibrators on the slip form paver were slowed as much as possible to reduce the floating of shale particles to the surface.

The slip form paver was followed by the finishing cart equipped with an astro grass drag to produce a rough driving surface. The finishing cart also carried the angle iron template which cut the fresh concrete for inserting the premolded strip. The cure cart followed the finishing cart and sprayed white membrane curing compound.

In a good days operation the contractor could achieve up to 1.6 kilometers (1.0 miles).

Results

We now have 56.3 kilometers (35 miles) of concrete pavement in place on rural roads constructed from 1975 through 1978. The riding quality of the slab is good to excellent. The transverse joint spacing has controlled the cracking and we have very little random cracking other than what occurred during construction. The joints formed with the premolded strips are being watched and if spalling occurs they will be sawed and resealed.

We have not had a popout problem due to the shale content. We attribute this to the light use of the vibrators and not floating the shale particles to the surface.

The 6.7 m (22 foot) wide slab seemed narrow at first, but we now feel this may have some merit in keeping the speed down and the drivers more alert. As of this date we have not had a head on collision or other accident which could be attributed to the slab being too narrow. The 0.9 m (3 foot) unpaved shoulder provides additional width in case of emergencies and adds to the safety of the road.

The maintenance costs to date have been only for snow plowing and shoulder repair.

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