Michigan Department of Transportation - M•DOT

Mates

Issue No. 71 January 1993

EUROPEAN PAVEMENT INSPECTION TOUR

Seven engineers, including Randy VanPortfliet and myself from the United States returned from a 12-day tour of Europe on October 22, 1992. The purpose of the trip was to gain insight into European pavement design and construction practices for possible application in the U. S. and Michigan.

Funding levels for transportation in Germany are higher than in the U. S. Gas prices are about 1.5 marks/liter, which includes a tax of about 0.6 marks, or about 40 percent of the fuel price. Equivalent cost in the U. S. would be $4.00/gallon, with a $1.60/gallon gas tax. A vehicle tax based on engine size is paid on a yearly basis. These funds are spent for both highway and railroad construction.

Truck axle load characteristics in Germany are much different than in the U. S. Single axle loads are allowed to be 25.3 kips and will be increased to 28.6 kips in 1993. [**Note:** the measurements used in this article have been converted from the metric system.] Single, super tires (inflated to 125 psi) are permitted on the single axle. The new axle weights will be uniform throughout the European Community.

Vehicular volume on their freeways is normally 40,000 to 60,000 per day with 25 to 40 percent being trucks. This volume of truck traffic, use of super tires, and relatively high single-axle loads permitted there requires the pavement design thickness to be greater than that in the U. S.

Austria

Design

An unusual feature of the Austrian design is that three layers of asphalt and subbase are placed for a new roadway. After completion, these three layers carry traffic for five to seven years to allow settlement to occur. The ruts and bumps created in the asphalt are then milled, weak spots in the subbase revealed by traffic are replaced, and a concrete pavement is placed on top of these layers. There are no problems with the concrete bonding to the asphalt subbase layer because the five to seven years of traffic wears the surface to an irregular, open pattern. This procedure is used to accommodate the mountainous terrain, which requires widespread use of embankments on the sides of the mountains to accommodate the roadway.

The concrete pavement consists of a two-layer monolithic (wet on wet) construction. That is, fresh concrete of the top layer is placed on the fresh concrete of the bottom layer in one continuous operation. This pavement is typically 8.7 in. total thickness, 7.1 in. (the bottom layer) is made from their standard concrete and the top 1.6 in. consists of a premium concrete with an exposed aggregate surface treatment. Transverse joints are spaced at 16.4-ft intervals, and the concrete pavement is not reinforced. Dowel bars in transverse joints are variably spaced, with a closer dowel bar spacing used in the wheel paths.

The exposed aggregate treatment used in Austria since 1989 is a patented process, and is performed only on the traveled roadway, with a burlap drag treatment used on the shoulder. Because of the random pattern of the exposed coarse aggregate, tire noise level generated by traveling vehicles is decreased. The friction characteristics are comparable to a transverse tined surface due to the aggregate surface roughness and high resistance to polishing.

The process of exposing the aggregate consists of spraying a retarder on the top surface immediately after finishing, then covering immediately with 2-mil plastic sheeting. The joints are saw cut through the plastic sheeting within 24 hours. The plastic sheeting is removed within 24 to 72 hours and the retarded concrete surface is dry wire brushed to remove the surface mortar and expose the coarse aggregate particles.

Materials

Concrete - The top layer of premium concrete normally contains 759 lb of cement/cu yd with a water/cement ratio of less than 0.40. It is superplasticized and contains about 4 percent entrained air. Compressive strength from the top cores tested at 28 days is typically about 8700 psi. The bottom layer, consisting of their standard concrete, contains 590 lb of cement/cu yd. The water/cement ratio is 0.42 and a retarder is normally used. Entrained air of 5 percent is used for this bottom layer, and the 28-day compressisve strength from testing the second layer cores is typically about 5075 psi. The mix is very stiff, with essentially zero slump.

Coarse Aggregate - Coarse aggregate in the top layer is a basalt consisting of sizes from 0.16 to 0.32 in. The bottom layer coarse aggregate is typically a high quality natural gravel. Both top and bottom layer coarse aggregates have high resistance to freeze-thaw damage.

Exposed Aggregate Surface Treatment - The retarder that is used in the exposed aggregate process can be either a sugar-based admixture (red color tint), which provides about 0.04 in. of exposed aggregate when completed, or a citric acid chemical-based admixture (green color tint), which provides about 0.08 in. of exposed aggregate. These retarders are color-tinted in order to visually check for uniform application rates. The citric acid chemical-based retarder also acts as a curing compound; however, the sugar-based does not.

Sample Analysis - A thin wafer of pavement section and a sample of the coarse aggregate contained in the top layer of the pavement were brought back from Austria for a petrographic examination. It appears that sources for the high quality coarse aggregate required in both the top and bottom layers are available in the State of Michigan for use in a trial pavement.

Construction

The Austrian construction methods are similar to those employed in Michigan. The major difference was the paving operation. A short paver was used for both the bottom and top layers of concrete pavement. These pavers ran in tandem with concrete being delivered to the second paver by a conveyor. Line and grade control were established for each paver. The first paver had a dowel bar inserter, mounted on a beam, which allowed variable spacing of the dowel bars. Both pavers contained an auger and a screed. The process is not labor or equipment intensive.

Germany

Design

The current concrete pavement design in Germany consists of a 10.2-in. concrete pavement without steel reinforcement. The pavement is constructed in two layers, wet on wet, using a burlap drag surface finish. This is placed over a 5.9-in. lean concrete base. These two sections of concrete are placed over a 11.4 to 19.3 in. thick layer of granular material that is not frost susceptible. Climate and soil

MATES is a news bulletin authorized by the transportation director to disseminate technical information to MDOT personnel, and is published by the Materials & Technology Division. The cost of publishing 800 issues at $0.05 per issue is $40.00 and it is printed in accordance with Executive Directive 1991-6.

conditions dictate the thickness that will be used. This layer serves as structural support for the pavement and is drainable.

A 16.4-ft transverse joint spacing is used with variably spaced, plastic coated dowel bars. The dowel bars are spaced closer together in the wheel paths. The lane ties are epoxy coated in the middle one-third of the bar only, and three to four ties are inserted in each slab. Transverse and longitudinal joints are saw cut in the concrete pavement, and are either saw cut or vibrated into the lean concrete base. Joints that occur in the lean concrete base will have a joint directly above them in the concrete pavement. Elastomeric seals are used for both the longitudinal and transverse joints.

It is anticipated that the bond between the concrete pavement and the lean concrete base will last about five years. Initially, the debonding starts at the joint and works its way toward the center of the slab. Subsurface drainage is required because this bond of the pavement to the base is not permanent. This entails an enclosed drainage system (using edge drains and sewers) in order to evacuate the water from the subbase.

Traffic lanes are 12.3 ft wide and the edges of the concrete pavement extend 1.6 ft beyond the traffic lane edge in order to provide good edge support for the wheel loads. Shoulders are paved with the full-depth concrete sections (pavement and lean concrete base) and are 8.2 ft wide. The lean concrete base extends beyond the shoulder by about 1.6 ft. and provides good edge support.

The transverse and longitudinal joint operations are similar to Michigan's. The main difference is that the transverse joints are cut approximately one-third of the pavement depth, and a plastic cord is inserted to keep the saw cut clean. The notch for the elastomeric seal is then made. Elastomeric joint seals are used for the longitudinal joints as well. It was interesting to note that expansion joints are used only at bridges. It is the German's belief that there is enough concrete shrinkage in their 16.4-ft long slabs to accommodate the expansion that occurs in the summer months.

Materials

Concrete - The top layer of the concrete pavement contains 574 to 590 lb of cement/cu yd with a water/cement ratio of 0.4 to 0.45 and an air content of about 5 percent. The compressive strength at 28 days, measured using a 7.8-in. cube is typically about 5075 psi. The bottom layer of the concrete pavement has a mix design similar to the top. The lean concrete base mix design has a water/cement ratio of about 0.8 and an air content of 5 percent. The compressive strength of this lean concrete base, based on using a 7.8-in. cube is about 2175 psi.

Coarse Aggregate - In the concrete pavement, the top layer coarse aggregate consists of crushed basalt and high quality natural gravel. The bottom layer coarse aggregate consists of high quality natural gravel or recycled concrete. In the lean concrete base, natural gravel or recycled concrete is used.

Frost Inhibiting Layer - The granular material that is used for this layer is different than that used in Michigan because not more than about 15 percent is permitted to pass the No. 100 sieve. The intent of this layer is to provide structural support and allow water in the subbase to escape. This is accomplished by allowing very few fines in the granular material.

Edge Drains - The edge drains that were being placed were smooth-lined corrugated plastic pipe with an inner diameter of 4.7 in. These drains are slotted and the slots are placed facing up in the trench. The drains were not wrapped with a geotextile fabric even though crushed rock was being placed in the trench for backfill.

Sample Analysis - Samples of aggregate used for the top layer of the concrete pavement and samples of crushed concrete used for the bottom layer of the concrete pavement were brought back from Germany for a petrographic analysis. The results of this analysis indicate that similar sources of the coarse aggregate are available here for use in trial sections.

Construction

The lean concrete base is placed with a typical concrete paver. Longitudinal and transverse joints are cut or vibrated into the lean concrete base when wet. The lean concrete base is paved outside the concrete pavement width. This provides a level, solid base for the paver, which results in a smoother concrete pavement surface and a better ride. The lean concrete base is mixed in a typical concrete plant, and no special equipment is required for its construction.

The two-layer, monolithic (wet on wet), concrete pavement is slightly different from typical Michigan concrete paving. The German paver has two augers and two screeds. The paver resembles two pavers in one. Concrete is dumped in front of the paver for the first auger and screed. Approximately two-thirds of the pavement thickness (bottom layer) is placed in this operation. A dowel bar and lane tie inserter then installs the bars in the fresh concrete before the second auger and screed places the top layer of pavement. Concrete for the second auger and screed is delivered by a conveyor after dowel bar and lane tie insertion.

In Germany, the contractor is responsible for line and grade of the pavement, the concrete mix design, and quality control testing. A four-year warranty from the contractor is required. No cracks in the pavement is the condition required by this warranty and a portion of the contract price to cover repair cost is withheld by the owner until the end of the warranty period.

Trial Project

A trial section using a combination of German and Austrian designs has been selected for a 1993 demonstration project by the Michigan Department of Transportation. The trial section is on northbound I 75 and will be approximately one mile long located between I 94 and I 375 in downtown Detroit. The entire project is 2.1 miles long and includes replacing both the northbound and southbound concrete pavements. Our conventional concrete pavement design will be used on the remaining portion of the project to serve as a control section. The selection of this section was, in part, based on review of the weather data of Munich, Germany as compared to that of the Detroit City Airport. The average high and low temperatures of these two cities compare very closely.

The trial section pavement structure will have transverse joints spaced at 15 ft and will consist of a 10-in. concrete pavement, over a 6-in. concrete base, over a 16-in. non-frost-susceptible layer. Expansion joints will not be used in the concrete pavement. The pavement will be constructed using a two-layer type construction with an exposed aggregate surface treatment. The concrete pavement will not contain steel reinforcement. Durability requirements for the aggregates will be similar to those specified in Germany and Austria. An enclosed drainage system will be incorporated into the trial section and our standard section. Slight modification of the German and Austrian designs were necessary because of project constraints (ramps and structures present). This project will be let in early 1993 for construction during that season.

Participation in this overseas trip, and the demonstration project, are further steps in the Michigan Department of Transportation's quest for providing the best quality, most cost-effective pavements.

-Roger Till

This issue of MATES will be the last one edited by Jim Alfredson. He will retire January 28 after 26 years of service to the Materials and Technology Division. Jim was in charge of the Technology Transfer Unit and, among other things, was responsible for editing and publishing MATES, as well as research reports, and special Division publications. His expertise and efforts added professionalism, and creditability to our work and will be missed. We wish Jim a long and happy retirement.

-The Team

Technology Transfer Unit
Materials and Technology Division
Michigan DOT
P.O. Box 30049
Lansing, Michigan 48909
Telephone (517) 322-1637