Practical Principles fo

by Alan Forsberg, Public Works Director and County Engineer, Blue Earth County, Minnesota

After many years of planning, designing and constructing roads and streets in Blue Earth County, Minnesota, county engineers have developed reliable, practical principles for building and maintaining low volume roads in cold climates.

Blue Earth is located in south central Minnesota and gets extremely cold in the winter. Temperatures of minus 20 to 30°F are common. The County has 720 miles of roadway consisting of minor and major collectors and minor arterials. Traffic ranges from as low as 100 vehicles per day to several thousand per day. About 400 miles are paved. The rest are surfaced with aggregate. Traffic in rural parts of the county is stable, but around the City of Mankato, it is steadily growing.

Decisions to pave roads in Blue Earth County are generally based on potential for economic development, maintenance cost, safety and environmental considerations such as dust and erosion. Limited resources balanced with demands for road improvements also influence decisions.

Pavement Drainage

The County recognizes the critical need for good drainage in designing and constructing pavements. Slotted, corrugated drain tile and open-graded drainage layers are economical and effective. The 4-inch thick clean rock drainage layer under the aggregate base provides drainage through the drain tile system. But the drainage layer under the shoulder is not necessary for proper drainage.

Base design that extends the aggregate base through and beyond the shoulder costs more and is unnecessary because the shoulders get little or no traffic. Its additional cost for drainage or load-carrying capacity is not warranted on many low volume roads.

Design Decisions

Because the climate is extremely cold in winter in central Minnesota and because traffic volume is low in parts of the County, Blue Earth pavement engineers have established that our road designs must consider the following factors:

or Low Volume Roads

- ▲ roads fail because of age, or oxidation and stripping of asphalt binder;
- ▲ additional asphalt provides increased durability and a reservoir to compensate for oxidation and stripping;
- ▲ infrequent but heavy loads may cause failures;
- ▲ emphasis solely on ESALs may result in short pavement life;
- ▲ design is often a compromise between the current most economic design and future needs;
- ▲ road designs should focus on a 15- to 20-year design life.

Because of these factors, Blue Earth County engineers have found that a relatively high asphalt content coupled with low air voids provides the elasticity needed for long pavement life with low traffic volumes and extreme weather conditions. The County requires an integrated design-construct method for asphalt pavements that controls air voids appropriate for the particular mix by varying gradation of aggregates and asphalt cement.

Studies, coupled with our own experience, show that high air voids promote pavement deterioration due to oxidation and stripping. Problems associated with low voids such as rutting and bleeding are not common on low volume roads.

Consequently, low volume roads, especially those with light traffic and light loads, should be designed toward the low end of the air voids spectrum.

Durable Aggregates

Hard, durable aggregates, which will resist the affects of loading and severe weather, are also essential. Critical aggregate qualities include gradation of material by size and hardness, shape and affinity for asphalt binder. They effectively transfer loads and reduce spalling. Crushed materials substantially increase stability and reduce rutting. The best gradations are developed by requiring two or more stockpiles graded by size. Coarser materials with increased crushed content are best. Limiting the use of soft, deleterious materials will prevent surface spalling and increase long-term stability.

When larger rock is not locally available, imported material is an alternative. The County requires an integrated design-construct method for asphalt pavements that controls air voids appropriate for the particular mix by varying gradation of aggregates and asphalt binder.

Maximum Density Line

A Colorado DOT study examined 101 mix designs for relationships between air voids and several alternative maximum density plots. The study found the maximum density line was a useful rule of thumb to determine how to adjust gradation to optimize the mixture's air voids. If a local agency wants higher air voids, they will adjust the gradation away from the maximum density line. If they want lower air voids, they will adjust the gradation toward the maximum density line.

Blue Earth specifications allow the local agency to adjust asphalt content and aggregate gradation upon request. This ability requires that the aggregate producer have multiple stockpiles, and also separate pay items for asphalt binder and aggregate.

Adjusting Binder and Gradation

Laboratory design is an essential but limited model of the field environment. The real need is to control air voids, aggregate and asphalt binder in the hot-mix asphalt produced at the plant. The following is an example.

Blue Earth County was paving a road in the summer of 1993. Loveall Construction was the contractor. Gradation and asphalt content tests showed the contractor was operating within the specifications, but samples showed that air voids at 5 percent were above the optimum 3 to 4 percent for the low volume road.

An asphalt content of 6.5 percent was appropriate based on past experience with the aggregate source. Production gradation was extremely close to trial mix gradation. The County elected to adjust the mix gradation since the asphalt content was appropriate.

After studying the maximum density curve, the County instructed the contractor to decrease the sand by 2 percent increments. This would move production gradation toward the maximum density line and reduce the air voids. A voids update was done after each increment until the contractor reached voids of 3.5 percent. Production then continued at 3.5 percent air voids and asphalt content at 6.5 percent.

Compaction

Behind the paver, the mat has 15 to 20 percent air voids. The rollers will reduce that void content to 8 percent or less of maximum theoretical specific gravity.

The County currently requires the contractor to construct a control strip to determine the best rolling pattern to reach maximum density. The contractor determines densities by means of a portable nuclear gauge. Compaction specifications require breakdown by steel-wheeled roller, intermediate rolling by rubber-tired roller, and finish rolling by a steel-wheeled roller.

Owner Responsibility

Planning, design, construction and maintenance of low volume asphalt roads is still an art, but is slowly advancing to a science. We have learned a lot since we began paving and maintaining roads in the county. We have made mistakes, and we have corrected them. We are trying to follow and improve upon the practical guidelines that we have developed over the years.

The owner, the County, must be willing to take responsibility for the quality of the work performed. We, myself and the Blue Earth engineering staff, represent the people in Blue Earth County, and we willingly take the responsibility for doing the job right. ▲

Blue Earth Goes Superpave

"Higher asphalt content and lower air voids generally provides the most durable low volume mix. We've been working on that premise for many years. Then, we began getting information from Focus, the Asphalt Institute, TRB and the Local Road Research Board (LRRB) about Superpave. The LRRB is a local advocacy group composed of State and local agencies dedicated to improving pavement throughout our State.

"After studying the information about Superpave and asking a lot of questions, I was ready to try a Superpave project on a low volume road. We did a 3.5-mile, 2-inch-thick overlay on County State Aid Highway (CSAH) 30 at Crystal Lake using Superpave mix design. The average daily traffic on the road is about 130.

"Minnesota DOT brought in its mobile pavement laboratory and designed the mix right at the aggregate pit. Because the Superpave mix used a higher quality aggregate, and coarser than local aggregates, we had to import aggregate. It cost a bit more, but only $1,000 to $2,000 more per mile than our conventional mix. LLRB paid the cost overrun.

"Another Superpave project, CSAH 8, included a 5-mile new road, composed of 12 inches of aggregate base and 3.5 inches of Superpave mix placed in two courses, one 2-inch course and one 1.5-inch course. We used a PG 52-34 binder. It cost just a little more than the standard MnDOT binder.

"On all these projects, we are building a base of knowledge. As we gain confidence, we'll shift completely to Superpave. We are convinced it has the potential for dramatically improved pavement performance at a reasonable cost."

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