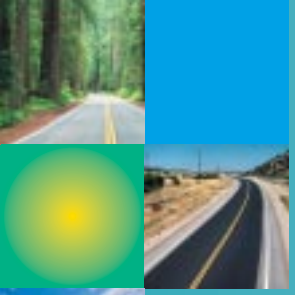



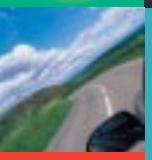

# OPEN GRADED FRICTION COURSES:

## SMOOTH, QUIET, AND MORE DURABLE THAN EVER

Recent years have seen a turnaround in the performance and use of porous asphalt surface courses, better known as Open Graded Friction Courses (OGFCs). New mixture designs offer reduced splash and spray in wet weather, improved wet-pavement skid resistance, better visibility of pavement markings and reduced noise levels.

In the early to mid-1980s, some states discontinued the use of an earlier version of OGFC because of premature failures. Today, a new generation of Open Graded Friction Courses is prompting a number of states, including some in northern climates, to take a renewed interest in these porous asphalt surfacings. These new mixtures have higher air voids, typically 18 to 22 percent, than earlier mixtures at 15 percent. Recent evidence shows that better

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performances and longer durability result from porous asphalt that uses polymer-modified binders. And fibers are being added to these new mixes to control draindown of the binder, which was a problem with the older mixtures.

As evidence of the surge in popularity of porous asphalt, consider that:

- Since 2001, Georgia has been using a Porous European Mixture (PEM) to resurface all its Interstate highways. The mix has 20 to 24 percent air voids, a 12.5-mm nominal maximum aggregate size, and an asphalt cement content of 6 to 6.2 percent. It's typically placed in a 30-mm-thick surface course.
- Departments of Transportation (DOTs) in thirteen states have contributed to a pooled-funds research project on porous asphalt being performed by the National Center for Asphalt Technology (NCAT).
- To see whether OGFCs maintain their acoustic qualities over time, the California Department of Transportation has a study under way in which noise measurements are taken on a test section three times a year. The OGFC has maintained a reduction of 4 to 6 dB(A), as compared to a dense-graded surface.
- In Texas, the state DOT recently has placed about 15 projects using its version of OGFC, which it calls Permeable Friction Course (PFC). "We're seeing a lot more PFC projects let now," says Dale Rand, the Texas DOT's director of the flexible pavements branch, construction division. "And we've got quite a few more projects now in various stages. We recommend it for any high-speed pavement on which we have a posted speed limit above 45 miles per hour."

- The Arizona DOT received favorable public comment on the reduction in noise when they resurfaced an urban concrete highway, Superstition Freeway in Tempe and Mesa, with OGFC asphalt rubber. In late 2002, ADOT announced a new three-year program to resurface 115 miles of existing concrete freeways in the Valley of the Sun (the Phoenix metropolitan area) with the same material. George Way, chief pavement design engineer for ADOT, said, "This is a way we can enhance the quality of life in our neighborhoods."

## Improved drainage

Porous asphalt is designed with interconnected voids that give a pavement surface high permeability. As a result, water easily enters the pavement and is removed from the surface, which dramatically improves wet weather visibility, writes Gerald A. Huber in "Performance Survey on Open-Graded Friction Course Mixes," a synthesis of highway practice.

"By draining the water quickly, you reduce splash and spray and thereby improve safety and visibility," says Peter Wu, state bituminous construction engineer with the Georgia DOT. Since the early 1990s, Georgia has surfaced highways with 1.5 million tons of OGFC and Porous European Mixture (PEM). Because PEM is designed with coarser aggregates than OGFC, PEM drains water across multiple pavement lanes faster than conventional OGFC can. "You do not see big splashes and sprays behind the trucks on six- to eight-lane interstates," says Wu.

## Reduces noise pollution

"Also, it's quieter," adds Wu. "The noise is absorbed into the air voids. You can hear the difference and you can feel the difference."

Here's why. Tires rolling on the road cause air to be forced away in front of, and sucked in behind, the area of contact between the tire and the road, according to a document titled "Design, Construction, and Maintenance of Open-Graded Asphalt Friction Courses" published by the National Asphalt Pavement Association (NAPA). This air pumping generates high-frequency noise. With OGFC, the pumping, and therefore noise generated, is reduced because the air is pumped down into the porous pavement, says the NAPA document, which was written by Prithvi S. Kandhal, associate director at NCAT.

Sound measurements made on dry pavements in the Netherlands have shown an approximate reduction in noise level of 3 dB(A) when OGFC is substituted for dense-graded hot mix asphalt (HMA), says the NAPA document. That 3 dB(A) is equivalent to a 50 percent reduction in noise level. In wet weather, the effects of noise reduction are more pronounced and can range up to 8 dB(A). Measurements were made at speeds of more than 50 miles per hour because the noise produced at the tires tends to increase at higher speeds.

The Federal Highway Administration conducted a comparative noise level study of OGFC, dense-graded HMA, portand cement concrete pavement, and chip seal in Arizona, California and Nevada, says the NAPA document. In fact, the study found that OGFC had the lowest noise level compared to all other pavement surfaces.

## Looks good, functions well, an easy mix to use

Texas's PFC mixture is designed with 18 percent air voids, a 12.5 mm nominal maximum aggregate size, and 6 percent minimum asphalt cement content. "It's a copy of Georgia's Permeable European Mix," says Rand.

"People like it," says Rand. "It's an easy mix to use. It looks good and functions well. We like the spray reduction and safety aspects of it. It reduces hydroplaning, and you get much better visibility without the spray. The visibility difference in rainy conditions is like night and day." In terms of improved visibility and spray reduction, Rand says that conventional asphalt pavement is better than concrete, but PFC is better than either of them. "You drive on regular pavement and then you hit this (PFC) pavement and you say, 'Man, this is nice,'" he says.

"And the way it's constructed, you don't have to compact it much," says Rand. "It doesn't require multiple passes with the roller. With a couple of passes using a steel-wheeled roller in static mode, you're finished." As well, says Rand, Texas's porous asphalt is quieter than concrete and quieter than the state's chip seal surfaces.

What is more, "These PFC mixes have produced some of the smoothest pavements we've placed. I look at the ride quality statistics from various states," says Rand. "The states that use PFC mixes – Georgia, Florida, and Arizona – have the smoothest pavements. Georgia arguably has the best projects in terms of smoothness, and they put this mixture on all their Interstates.

"When we went to Georgia, it rained for three days," says Rand. "In driving their porous asphalt pavements, we didn't see any cracking, rutting or segregation, and no potholes. Their pavements were smooth, and the spray reduction was dramatic. And we saw pavements that had been down for 10 years."

After OGFC was developed in the U.S. in the early 1970s, it has been used increasingly in many European countries, says the NAPA document. Today, OGFC-style mixes are used frequently in Austria, Belgium, France, Germany, Italy, the Netherlands, Spain, Switzerland, and the United Kingdom. In 1992, for example, there were some 400,000 square meters on German federal roads. These OGFC pavements were still in excellent condition after eight years under traffic, according to the NAPA document.

## Long life

Oregon has been using OGFC since 1979. The earliest-placed project lasted for some 20 years, and "wasn't in bad shape even at that point," says Jim Huddleston, now executive director of the Asphalt Pavement Association of Oregon and former pavements engineer for the state's DOT. "We made our mix out of 19-mm rock and put it down 50 mm thick," recalls Huddleston. "About 1985 we began ramping up and doing more and more open-graded jobs until it was the primary wearing course in the state," says Huddleston.

"We get more life out of the 50-mm layer with a 19-mm top-size aggregate," says Huddleston; such surfaces last 15 or more years. "We've not had a problem with the 19-mm mix raveling," says Huddleston. "We've got hundreds of lane miles of the 19-mm open-graded surface course and we never really had one unzip on us.

"For heavy-duty pavements we use polymer-modified binders and fibers in the mix," Huddleston says. "We use open-graded surface courses on all roads from local roads up through our Interstates. If it's a rural Interstate we use 19-mm open-graded for sure. If it's an urban Interstate we use Stone Matrix Asphalt to get an even longer life. (Stone Matrix Asphalt, or SMA, is a premium Hot Mix Asphalt surface mix that relies on stone-on-stone contact to provide strength.)

"People love them," says Huddleston of open-graded surface courses. "We get really good feedback on them. Coming home on a rainy night in Oregon, when you go from dense-graded pavement to open-graded asphalt, the difference is substantial. The open-graded courses are safer in wet weather."

## The motorist gets the benefits.

Whether they are called OGFCs, PEMs, or PFCs, open-graded asphalt pavements are finding more and more acceptance all over the country. Georgia's Wu points out that the polymer modifiers and fibers push the cost higher, but the benefits make the price tag well worth while. He concludes, "When people come to Atlanta, they will see the benefits. We're paying for safety, and it's a smooth and comfortable pavement."

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