



Open-Graded Friction Courses (OGFC)

An Online Continuing Education Course for Engineers

Course Number: T-1004

Credit: 1 Hour / 1 PDH / 1 CPD

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Gregory J. Taylor, P.E.

INTRODUCTION

An “**open-graded friction course**” is defined as a thin, permeable layer of asphalt that integrates a skeleton of uniform aggregate size with a minimum of fines. These mixes contain a small percentage of fine aggregate which produces a large number of air voids. The pavement consists primarily of single size coarse aggregate with a high asphalt content. The aggregate skeleton is responsible for the pavement's ability to resist trucks and carry the loads without undergoing permanent deformation. The load is carried by the stone while the asphalt keeps everything in place.

Open graded voids and its stone-on-stone skeleton give this type of mix many positive attributes. The porous nature allows immediate drainage of water from the pavement surface. Much like the recent European stone matrix asphalt (SMA) mixes, the stone-on-stone structure can hold up better to heavy traffic than other mixes. The texture of the larger aggregate without fines provides better traction (i.e. 1970s "popcorn" and porous asphalt mixes). The voids also absorb sound energy as tires roll over the pavement to reduce surface noise.

Open-Graded Friction Course



(Steve Muench; hawaiiasphalt.org)

Open-graded friction courses (OGFC) have been used across the U.S. since the 1950's to improve the surface frictional resistance of asphalt pavements. In 1974, the Federal Highway Administration (FHWA) developed an OGFC mix design procedure to be used by state departments of transportation (DOTs). At first, many DOTs reported good performance using OGFC but others stopped using these mixes due to unacceptable performance. Since then, many significant improvements have been made in the areas of OGFC gradation and binder type.

Although DOTs experiences with open graded mixes has been varied, half of the states surveyed in a recent National Center for Asphalt Technology (NCAT) study indicated good performances with OGFC. Over 70 percent of the states reported an OGFC service life of eight or more years - plus approximately 80% of the states have standard specifications for open-graded mix design and construction.

Since water is the greatest enemy of pavements, roadways benefit from the quick drainage of water that OGFC mixes allow. Their "open" aggregate structure allows runoff to drain right through the driving or friction course to an impervious intermediate course below, and out into roadside ditches. This eliminates tire spray and hydroplaning, improves wet pavement friction, increases surface reflectivity, and reduces traffic noise which produces a safer pavement.

Research has shown that OGFCs provide instant noise reduction by as much as 5 decibels (dBA). This immediate reduction is due to the diminishing effect that the open-graded structure of the asphalt layer has on the sound energy generated at the road surface.

OGFCs offer state DOTs a better-performing, driver-friendly pavement - but at a 30 to 40% cost premium over conventional asphalt mixes. However, open-graded paving is lighter in weight than conventional mixes, and is able to cover more pavement surface area. This OGFC cost disadvantage is outweighed when long-term life-cycle costing is used, both in terms of reducing maintenance and delay costs to highway users during maintenance operations.

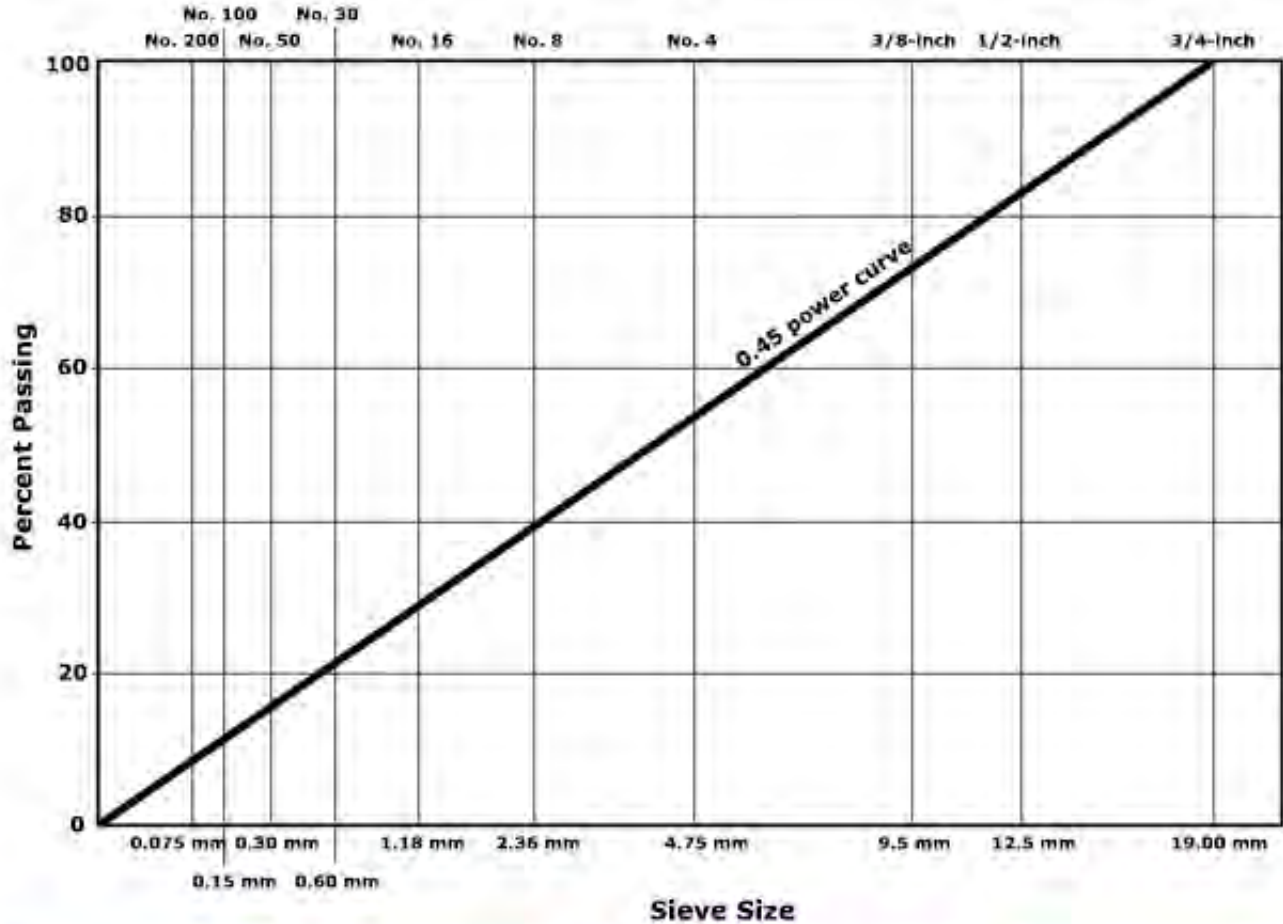
Job Mix Formulas and Design Limits for Open-Graded Friction Course (OGFC) and Porous European Mix (PEM)

Mix Control Typical Tolerance	Asphaltic Concrete	FHWA Guidelines	Georgia OGFC	PEM	12.5 mm Paving
Gradation Requirements					
±0.0	% Passing 19 mm Sieve	-	100	100	100
±6.1	% Passing 12.5 mm Sieve	100	85-100	90-100	95-100
±5.6	% Passing 9.5 mm Sieve	95-100	55-75	35-60	80-93
±5.7	% Passing 4.75 mm Sieve	30-50	15-25	10-25	54-76
±4.6	% Passing 2.36 Sieve	5-15	5-10	5-10	35-57
±2.0	% Passing 75 µm Sieve	2-5	2-4	1-4	0-7
Design Requirements					
±0.4	Range for % AC	-	-	5.5-7.0	5.3-7.0

(FHWA, Georgia DOT & Tennessee DOT)

Recent open-graded friction-course pavements built in the U.S. and Europe have considerably higher air void contents than before (17 to 22%). The void content for hot mix asphalt (HMA) paving used in Tennessee is normally 4 to 7 percent. Newer OGFC mixes are much more open with more voids.

Typical Gradations



Dense Gradation

Uniform Gradation

Open Gradation

Gap Gradation

Open graded: refers to a gradation that contains only a small percentage of aggregate particles in the small range. This results in more air voids because there are not enough small particles to fill in the voids between the larger particles. The curve is near-horizontal and near-zero in the small-size range. (Steve Muench; hawaiiiasphalt.org)

Today's OGFCs are polymer-modified and include spun mineral or cellulose fibers. Polymer modifiers and fibers complement each other in the liquid asphalt. The polymer stiffens the asphalt binder and adds flexibility in order to resist raveling. The fibers disperse, overlap and form a mat, which keeps the liquid asphalt from draining to the bottom of the layer before cooling.

ANALYSIS

POSSIBLE APPLICATIONS

Open-graded courses are best utilized when tailored to specific project areas with any of the following characteristics:

Noise Sensitive Areas

Residential areas or similar settings suited for quiet pavements

High Friction Needs

Sites where high surface friction can increase safety and prevent accidents

Heavy Rainfall

Open pavement structure reduces vehicle hydroplaning in areas with drainage issues. Stormwater runoff is typically cleaner than that from other pavements.

High Volume/High Speed Traffic

These sites help keep the pavement pores clear. Noise reduction strategies are also beneficial at these locations.

OGFCs should be used where the benefits represent a priority – and adverse conditions that pose a threat are not present. These mixes produce the best results in warm southern climates since they can help mitigate heavy rainfall without being impacted by snow or ice.

BENEFITS

Advantages of using open graded friction courses include the following:

- **Mitigating noise, often providing a 3 to 5 decibel reduction in tire noise**
- **Increasing pavement life and decreasing long term costs**
- **Providing and maintaining good high speed and friction qualities**
- **Reducing potential hydroplaning**
- **Decreasing splash and spray**
- **Improving the visibility of painted pavement markings**

SAFETY

Open-graded mixes are very safe due to their rapid drainage surfaces and excellent skid resistance. Chances of hydroplaning after heavy rainfalls are greatly reduced by the OGFC's void structure. The aggregate structure creates a higher degree of friction and permeability for

the pavement surface. This permeability improves friction during inclement weather and reduces splash/spray or hydroplaning due to increased surface drainage. Water can quickly enter and drain through the structure due to its 15 to 25 percent void range.

NOISE REDUCTION

Tire pavement noise is only one source of vehicle noise. Engines, exhaust noise, and wind shear can also contribute to the overall roadside noise. For roadways with high speed vehicles, **tire noise** is the dominant noise source.

Open-graded friction courses are typically quieter than regular paving. Research has shown that OGFCs reduce road noise levels for drivers as well as those who live or work near the roadway. The void structure within the open graded mix dissipates tire noise and causes the riding surface to absorb other noises instead of deflecting them.

In their paper, *Comparative Field Measurements of Tire Pavement Noise of Selected Texas Pavements*, McNerney, Landsbeger, Turen, and Pandelides presented field test data that showed open graded friction courses as the quietest surfaces tested. The top five quietest pavement types were HMA-based - as were seven of the top nine.

The quietest roadways were the result of road surfaces used in conjunction with noise structures, effective buffers and speed control. The perception of the reduction of noise, and its measurement in decibels (dBA), is a subjective matter. For example, a 10 dB increase represents a tenfold increase in energy from the unit below it. A 10 dB increase is perceived as a doubling of loudness in human response in which a sound is perceived as twice as loud as the preceding sound. Three dBA is recognized as the minimum change in sound level that has a significant impact on most people.

Any noise reduction measures implemented by local governments and road agencies since noise abatement structures were once considered an extravagance are now standard practice. Open graded friction courses are one of the mixes to mitigate noise. Noise abatement structures are barriers that are placed along the roadway. Barriers generally cost \$15 to \$20 per linear foot. **Therefore, a cost-effective noise abatement structure is the use of open graded friction courses (OGFCs) rather than noise barriers.**

New research from the University of Texas at Dallas indicates immediate noise reductions of 3 to 5 dB. This noise reduction can be achieved by the use of OGFCs. This is compared to conventional dense HMA mixes. The use of OGFCs can reduce noise levels by 22 to 23 percent. This is compared to a 10 percent increase in noise levels for conventional dense HMA mixes.

Open graded pavements produce noise at different frequencies versus those produced by conventional dense HMA mixes - this causes bystanders to assume that noise levels have

