

Evaluation of Open-Graded Friction Courses: Construction, Maintenance, and Performance

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Introduction

The primary objective of this study was to identify methods to improve the design, performance, construction, and maintenance of open graded friction courses (OGFC) in South Carolina. To accomplish this objective, several tasks were completed to gain as much information about OGFCs. An extensive literature review on all facets of OGFCs was conducted to learn about the state-of-the-practice with respect to OGFC on a national and international scale. The performance of OGFC in South Carolina and other states and countries was surveyed to identify recurring problems with this type of pavement. A laboratory study was conducted to compare different OGFC mix design procedures employed by state DOTs in the US. The influence of aggregate gradation on OGFC properties was also evaluated in the laboratory where the performance properties of OGFC mixtures made using ten gradations representative of those in use throughout the US were evaluated. The study also surveyed best practices for the construction and maintenance of OGFC mixtures.

Conclusions

Performance

The primary performance concerns with OGFC mixtures include: Raveling, delamination, clogging, and draindown. Each of these issues are affected by either the mix design, the production and construction methods, the environment, or a combination of these factors.

Mix Design

Based on the evaluation of the different mix design procedures currently used in the US, it was evident that different methods yield different results for optimum binder content if all other variables were held constant. The most variability was found for the methods based on the properties of compacted specimens similar to conventional asphalt mix design procedures. The oil absorption and visual determination methods were more consistent and repeatable. Based on these findings, it is recommended that visual draindown methods (SC-T-91) be used to determine the optimum binder contents of OGFC mixtures. However, it is also recommended to measure the performance of the mix design. At a minimum, this evaluation would include measuring the porosity and permeability of specimens compacted using 50 gyrations of the Superpave gyratory compactor. More in-depth mixture analysis could also evaluate the raveling susceptibility of the mixture. Currently, the Cantabro abrasion test is the most common method adopted to assess the durability of OGFC mixtures.

The evaluation of the aggregate gradation indicated that the gradation specified by SCDOT ranked in the top half of

the gradations studied with respect to permeability, texture, abrasion loss, and rut resistance. It is recommended, however, that the gradation be designed, so that the percent passing the No. 4 (4.75 mm) sieve is less than 20%. This recommendation is based on the results of this study and others (Mallick et al. 2000). Additionally, this study revealed that a gradation containing a higher percentage of material retained on the $\frac{3}{8}$ -inch sieve exhibited the best all-around performance (permeability, clogging, abrasion resistance, indirect tensile strength) of the ten gradations evaluated.

It is possible to design OGFC mixtures that exhibit desired properties (draindown and durability) without the use of fibers. One study on the use of warm mix asphalt (WMA) technologies is presented in this report. In addition to WMA, there are other alternatives including crumb rubber modified binders and activated mineral binder stabilizers. Removal of fibers from these mixtures will improve the functional performance as porosity will increase, thus increasing the permeability of the mixtures. Additionally, this could potentially result in more consistent mix production and construction quality.

Thickness Design

Based on the assessment of the current performance of OGFC layers in South Carolina and a rational lift thickness design methodology based on rainfall intensity, pavement design parameters, and mix design properties, the thickness of OGFC lifts in South Carolina could be increased to potentially enhance the performance of the pavements. The recommended layer thickness should be a minimum of 1¼ inches and no less than 2 times the maximum aggregate size of the OGFC mixture. For pavements having a flow path greater than 14 feet (two lanes of traffic), the thickness should be increased to ensure water does not flow over the pavement surface. An equation to calculate the thickness of the OGFC lift can is presented in this report.

In addition to increasing the minimum lift thickness, the mixture permeability has a major influence on the ability of an OGFC layer to function as intended. This functionality is commonly reduced due to clogging of the voids in the OGFC. To compensate for this, a clogging factor can be applied to the permeability of the mixture. It is recommended that the clogging factor range from 1.2 to 1.4. Applying the clogging factor to the recommended design permeability of 164 in/hr results in a mix design permeability of 196 to 230 in/hr.

Construction

Based on the performance of OGFC mixtures in South Carolina, a main concern is raveling at transverse joints and bridge tie-ins. In these areas, raveling can be severe, but isolated. While more observations are needed, it is speculated that the cause of the isolated raveling in these specific areas is

the result of inadequate compaction due to lower mixture temperatures. This may be more of an issue when paving is done at cooler ambient temperatures compared to hot summer months, but should be studied further. Potential strategies to minimize this type of distress include:

- ✓ Carefully monitor the mat temperature to ensure that compaction occurs within the proper compaction range.
- ✓ Use the first load, or portion of the first load of mix to warm up the material transfer vehicle and possibly the paver and then dispose of the mix. This will prevent the mixture that will actually be placed on the pavement from coming in contact with cold equipment that would consequently cool the mixture.
- ✓ Provide additional compaction effort (more roller passes) near these joints to ensure proper mix cohesion. However, care should be taken not to close the pore structure of the mix or cause aggregate breakdown.
- ✓ Some have proposed that the first load or two of mix be produced at significantly higher temperatures, so when it exits the cold MTV and paver, the temperature is in the ideal compaction range. While this may produce satisfactory results, caution should be exercised as excessive mix temperatures can result in premature aging and increased draindown. Both of these consequences can lead to reduced durability resulting in raveling.

Additional attention should also be given to the tack coat below an OGFC. The tack coat should provide full coverage of the pavement lane and be thick enough to promote adhesion of the OGFC layer to the underlying pavement layer. This could potentially be addressed with the use of non-tracking tacks that reduce the amount of the tack coat that is picked up by haul trucks or paving equipment during the paving operation. Another potential solution is spray-applied ultra-thin bonded wearing courses, or ultra-thin asphalt concrete surfacings (UTACS).

In addition to construction practices, methods should be developed to monitor the quality of OGFC pavement during construction. While it is difficult to monitor pavement density using a nuclear density gauge due to the high void content and thin lifts, there are other potential methods that could be adopted. One such method is to measure the in-situ infiltration rate of the OGFC layer. This is a simple, non-destructive test that can be conducted as soon as the mat cools. The OGFC layer should have a minimum infiltration value to be functional, so this could be used for quality control and quality assurance.

Maintenance

As with any type of pavement, maintenance is important for OGFCs. Often times, DOTs take a “do nothing” approach to OGFC maintenance because distresses are typically isolated and the layers are thin enough that they do not present a safety hazard when there is raveling or delamination. Additionally, if a section of OGFC were to be patched with conventional HMA, then the lateral flow of water through the pavement layer would not occur. As for clogging, it is difficult to prevent clogging, aside from employing

appropriate erosion and sediment control measures. It is also costly to restore permeability once clogging occurs.

Based on findings of this research, the following recommendations pertaining to OGFC maintenance are in order:

- ✓ When patching must be done, it can be performed with conventional mix as long as a lateral flow path exists for water to exit the pavement from the area surrounding the patch. Attention must be paid to the location of the patch with respect to grade and cross-slope with the pavement to ensure an adequate drainage path for the water within the OGFC layer. Alternatively, patches can be angled such that the water can flow around them. However, this could be difficult depending on the available milling equipment.
- ✓ The SCDOT *Supplemental Specification for Maintenance OGFC* can be used to design and construct patches using OGFC mixtures. These mixtures performed well with respect to permeability and durability. As with any OGFC mix, care should be taken to select a binder content that will not result in excessive draindown, or exhibit durability issues.
- ✓ Surface applications, such as fog seals have been used by DOTs on OGFCs in the past to minimize oxidation in an effort to prevent raveling. While such surface treatments can be beneficial, one must be cautious with respect to permeability.
- ✓ While clogging may not be a significant issue on the high speed travel lane of an interstate pavement, the shoulder could potentially become clogged due to the minimal traffic action. If the shoulders become clogged, water flowing within the OGFC layer in the travel lanes will not be able to completely drain out of the pavement, which could potentially lead to stripping or freezing depending on the temperature.

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