Abridgment

Field Performance of Porous Friction Surface Courses

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Aircraft hydroplaning occurs when a film of water separates a high-speed aircraft tire from the pavement and causes a loss of directional control and braking. A porous friction course (PFC) is an open-graded bituminous pavement surfacing course designed with a high percentage of internal voids and a coarse macrosurface texture. The high porosity permits the surface water to drain laterally, internally as well as on the surface, and thus reduces the water-film thickness and the hydroplaning potential. The rough surface texture provides tire-to-aggregate contact above the water film, and thus increases the skid resistance.

PURPOSE

The purpose of this study was to develop laboratory mix design procedures for PFC mixes and to prepare PFC construction specifications.

SCOPE

The first phase of the study was a three-element program to determine the applicability of PFCs for airport surfacings. The first element was a literature survey to establish a state of the art for PFC mixes. The second was the observation of the construction and performance of PFCs at a number of airports and airfields to determine the construction procedures and pavement characteristics that result in the best performance. The third was a laboratory study to identify the material characteristics of aggregates and bituminous materials that correlate with field performance and to establish procedures for designing PFCs. The second phase consisted of additional performance studies and laboratory testing to improve the mix design procedures and construction specifications.

SUMMARY OF WORK ACCOMPLISHED

Literature Survey

The literature survey reviewed the state of the art in the use of PFCs, the design procedures that have been used, and the agencies that have been interested in such pavements. It was found that the aggregate gradations for PFCs have been fairly well established through experience. Therefore, one of these gradations was selected for use in the laboratory studies. In addition, the experience of others was used in planning the laboratory and field phases of this study and for guidance in evaluating the laboratory results and field observations.

Laboratory Studies

A series of tests was outlined to establish the material and mixture requirements for PFCs. Included were determinations of density, shear strength, bitumen drainage, aggregate degradation, permeability, and surface area, as well as selection of an acceptable compaction method for the PFC specimens. Three types of aggregate (a limestone, a chert gravel, and a slag) and three penetration grades of asphalt cement having two viscosities [60-70, AC-20; 85-100, AC-20; and 200-300, AC-5, low on viscosity at 60°C (140°F)] were selected for preparing PFC specimens to encompass a range of aggregate-asphalt combinations.

Two methods of compacting the PFC specimens were investigated: impact compaction, which is applied according to the Marshall procedure, and gyratory compaction, which is applied by using a gyratory compaction machine. The standard impact compaction procedure selected consisted of 10 blows of the Marshall hand hammer on one side of the specimen. The standard gyratory compaction procedure selected consisted of 10 revolutions at a 1° angle of gyration and a 1380-kPa (200-lbf/in^2) ram pressure.

An acceptable means of measuring the densities of PFC mixtures was found to be a physical measuring technique that used the specimen mass in air and its measured dimensions. This method was adopted because of the consistency of data obtained with it.

Studies were conducted to determine whether a relation between direct shear strength and asphalt content could be used in establishing an acceptable PFC mix design. These data indicated that the maximum shear strengths developed by the specimens did not vary greatly over the range of asphalt contents used in the mixtures.

A testing program was conducted to evaluate the effectiveness and reproducibility of bitumen drainage tests for use in specifying the optimum amount of asphalt in a PFC mix. Generally, these tests indicated a range of several percentage points in asphalt content for a given drainage condition over which an acceptable asphalt content could be chosen.

Because toughness and abrasion resistance are important characteristics of the materials used in PFCs, Los Angeles abrasion tests and special gyratory degradation tests were used to evaluate the aggregates. These tests produced a relative comparison of aggregate quality through an accelerated test method.

Permeability tests were used to develop a limiting value of asphalt content to achieve acceptable drainage. Analyses of the permeability of laboratory PFC specimens and field PFC installations were used to evaluate laboratory compaction efforts. The results of these tests led to the adoption of the standard laboratory compaction effort. Observations and experience gained during the tests led to the selection of a standard size for laboratory specimens to be used for the permeability test.

California centrifuge kerosene equivalency (CKE) tests were investigated as one means of determining an optimum asphalt content. This test involves relating an aggregate surface-area constant to the required amount of asphalt. Estimates of asphalt content found by using this method were within acceptable limits for observed satisfactory field performance.

Field Surveys

A number of airports and airfields were visited to observe the construction and performance of PFCs. Visual inspections were made at each site, field tests were conducted where possible, and core specimens were taken for laboratory evaluation. The visual inspections involved observing the PFCs for surface appearance, cracking, raveling, damage caused by snow removal equipment, and loose aggregate particles. In addition, comments from airport personnel were solicited on PFC

performance. Permeability and skid-resistance measurements were made on pavements that were accessible.

From construction data collected in the field surveys, the relation between the binder temperature and the viscosity was identified as a primary factor in obtaining satisfactory construction and maintaining the permeability characteristics of PFCs. With a reasonable given volume of binder and a uniform gradation, excessive binder drainage is eliminated and adequate permeability of the PFC maintained.

Field evaluations conducted in 1973, 1974, and 1975 provided significant data by which to evaluate longer term performance of PFC. The field evaluations determined skid resistance, permeability, density, voids, binder content, binder penetration, binder viscosity, aggregate gradation, and pavement condition at the time of the evaluation. These data were used to validate a PFC design method and recommended specifications. As a result, a PFC mixing viscosity and a modified 1.25-cm (0.5-in) maximum-size aggregate gradation were adopted.

SUMMARY OF FINDINGS AND CONCLUSIONS

PFCs should be considered for use only on structurally sound flexible pavements because cracks in base pavements will reflect through the PFC in a short period of time and subsequently ravel.

Although there is a tendency for the harder penetration-grade asphalt cement (i.e., the 60-70) used as a binder material to stabilize sooner than the softer penetration-grade asphalt cement (i.e., the 200-300), the harder penetration-grade asphalt cement generally has lower values of wet skid resistance. An 85-100 penetration-grade asphalt cement could be used to counteract these effects. The best performances will probably be obtained from PFC mixes designed by using the same types of aggregate and asphalt as used in construction of the base pavement.

Neither laboratory test results nor field observations of PFC mixes showed any correlation between performance and Los Angeles abrasion values that could be used as a basis for changing the Los Angeles abrasion criteria used in the specification. The lack of differences in the performance of PFC pavements that is attributed to aggregate quality could also be a result of using high-quality aggregate in all the PFCs studied.

A recommended gradation for PFCs is shown below (1 mm = 0.039 in).

Sieve Size (mm)	Percent Passing by Weight
12.5	100
9.5	80 to 100
4.75	25 to 40
2.36	12 to 20
0.75	3 to 5

Based on this gradation of aggregate, the permeability of PFC mixes, and the field performances, it was determined that the minimum thickness of PFCs should be 19 mm (0.75 in) and the maximum should be 25.4 mm (1 in). This thickness of properly designed PFC will provide the necessary porosity, but the thickness should be kept to a minimum to reduce any tendency of the PFC to densify under traffic.

The design procedure for PFC mixes is based on meeting various material requirements of the asphalt and aggregate. The asphalt content can be estimated by using the relation $2K_c + 4.0$, where K_c is determined from the CKE test. The temperature of mixing should be established by using a viscosity-temperature relation for the job asphalt. Validation of the mix design can include the permeability test. The design procedure for PFC mixes should consist of the following:

1. Determine K_c, and estimate the asphalt content by using the relation $2K_c + 4.0$.
2. Develop the viscosity versus temperature relation for the job asphalt for use in establishing the field mixing temperature and select the mixing temperature at a viscosity of 0.000 275 ± 0.000 025 m^2/s (275 ± 25 centistokes).
3. If desired, conduct a laboratory permeability test to establish that the PFC mix design will have acceptable permeability.

NEEDED STUDIES

It has been proposed that a 19-mm (0.75-in) maximum-size aggregate gradation be used for PFCs. However, some problems with raveling have been observed with this gradation, and it is suggested that a more detailed study be made. Elastomeric-modified asphalt in the form of neoprene-modified asphalt has performed very well, and the use of other elastomers as asphalt modifiers should be studied.

ACKNOWLEDGMENT

This paper is a summary of a report to the Federal Aviation Administration (1).

REFERENCE

1. T. D. White. Field Performance of Porous Friction Surface Course. Federal Aviation Administration, Rept. FAA-RD-74-38, April 1976; NTIS, Springfield, VA, ADA-009-012.

Effectiveness, Skid Resistance, and Antihydroplaning Potential of Porous Friction Courses

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The Airport Operators Council International survey has provided an operational assessment of the effectiveness of the porous friction course as an alternative to grooving to reduce hydroplaning at airport facilities. Airport operators that have applied porous friction courses are pleased with their performances, both as to friction characteristics and wearability. The Federal Aviation Administration has evaluated these courses for