Skid-resistant Airport Pavement Surfaces

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CHAPTER 1. OVERVIEW

1-1. PURPOSE. This course provides guidelines for designing, constructing, and maintaining skid-resistant airport pavement surfaces and for conducting evaluations and surveys of runway friction for pavement maintenance purposes. It also contains performance specifications for friction measuring equipment. Guidance on pavement friction measurement for aircraft operational purposes during winter weather and performance standards for decelerometers are provided in this course and the reference documents.

1-2. BACKGROUND. Since the advent of turbojet aircraft with their greater weight and high landing speeds, braking performance on runway surfaces, particularly when wet, has become a significant safety consideration. A number of research programs by FAA, NASA, and USAF, as well as those performed by foreign governments, have been directed in two major areas: original pavement surface design to maximize skid-resistance with proper materials and construction techniques and effective evaluation and maintenance techniques to detect deterioration of skid-resistance and to restore it to acceptable levels.

1-3. PAVEMENT DESIGN RESEARCH. Pavement grooving was the first major step in achieving safer pavement surfaces for aircraft operations in wet weather conditions. These studies were completed by NASA at the Langley Research Center, Langley, Virginia, in 1968. The FAA, through its Technical Center in Atlantic City, New Jersey, directed a test program on pavement surface treatments at the Naval Air Engineering Center, Lakehurst, New Jersey. The study was completed in 1983. Both the NASA Langley and the FAA Technical Center studies showed that a high level of friction could be achieved on wet pavement by forming or cutting closely spaced transverse grooves on the runway surface, which would allow rain water to escape from beneath tires of landing aircraft. Other research conducted both in the United Kingdom and the United States determined that an open graded, thin hot-mix asphalt (HMA) surface course called "porous friction course" (PFC) also could achieve good results. This permits rain water to permeate through the course and drain off transversely to the side of the runway, preventing water buildup on the surface and creating a relatively dry pavement condition during rainfall. The FAA Technical Center study demonstrated that a high level of friction was maintained on PFC overlays for the entire runway length.

In addition, a number of studies were carried out, and are continuing, on basic skid-resistant behaviors of pavement surfaces, both HMA and Portland cement concrete (PCC). These have led to other noteworthy surface treatments that improve pavement surface texture such as asphaltic chip and aggregate slurry seals. For concrete pavements, wire combing the surface, while the concrete is still in the plastic condition, notably improves pavement surface texture.

1-4. PAVEMENT MAINTENANCE AND EVALUATION RESEARCH. Regardless of pavement type or surface treatment, runway friction characteristics will change over time depending on type and frequency of aircraft activity, weather, environmental issues, and other factors. In addition to ordinary mechanical wear and tear from aircraft tires, contaminants can collect on runway pavement surfaces to decrease their friction properties. Contaminants such as rubber deposits, dust particles, jet fuel, oil spillage, water, snow, ice, and slush all cause friction loss on runway pavement surfaces. Rubber deposits occur in the touchdown areas on runways and can be quite extensive. Heavy rubber deposits can completely cover the pavement surface texture thereby causing loss of aircraft braking capability and directional control when runways are wet.

In October 1978, the FAA embarked on a 2-year program to conduct friction and pavement evaluation surveys at 268 airports (491 runways) within the contiguous United States. The information obtained represented a very broad collection of data on the friction characteristics of runways at airports that have turbojet aircraft operations. Field observations of the runway pavement surface conditions and analysis of the friction test data identified those areas on the runway pavement which were below the minimum acceptable friction level. Test data and surface condition information obtained during this program were given to airport owners so that they could take proper corrective measures to eliminate runway pavement deficiencies.

1-5. FRICTION MEASURING EQUIPMENT RESEARCH. Beginning in the early 1970's, NASA, FAA, and USAF conducted runway traction studies to determine the correlation between various types of aircraft and friction measuring equipment. These studies showed a fair correlation between some of the friction measuring devices, but the tests on correlation between the friction devices and aircraft were inconclusive. The tests did show, however, that friction measuring devices were effective when used to evaluate pavement surface friction properties for engineering and maintenance purposes.

In March of 1990, FAA concluded a test program to evaluate the performance of different tires on approved friction measuring devices and to develop correlation data in order to ensure that devices of different manufacture and design would give comparable results in field use. Appendix 1 summarizes research on qualification and correlation of friction measuring equipment.

1-6. ADDITIONAL BACKGROUND AND INFORMATION. Appendix 2 contains a list of pertinent reading material on design and evaluation of skid-resistant pavements.

CHAPTER 2. DESIGN AND CONSTRUCTION OF SKID-RESISTANT PAVEMENT

Section 1. Basic Design Considerations

2-1. GENERAL. In building new runways, major reconstruction, or adding overlays, the design engineer must choose either HMA or PCC as the basic paving component. The selection is usually based on economics, local preference, and other design factors. These considerations, as well as basic pavement structural design, are covered in this course 150/5320-6, *Airport Pavement Design and Evaluation*. This chapter is limited to discussion only of the surface of the airport pavement, literally "where the rubber meets the runway." All of the techniques discussed in this chapter may be applied during original construction (or reconstruction), and some may be applied to existing pavement to restore or create good friction characteristics.

2-2. SURFACE TEXTURE AND DRAINAGE. In discussing the effects of pavement texture on friction and hydroplaning, two terms commonly used to describe the pavement surface are microtexture and macrotexture. Microtexture refers to the fine scale roughness contributed by small individual aggregate particles on pavement surfaces which are not readily discernible to the eye but are apparent to the touch, i.e., the feel of fine sandpaper. Macrotexture refers to visible roughness of the pavement surface as a whole. Microtexture provides frictional properties for aircraft operating at low speeds and macrotexture provides frictional properties for aircraft operating at high speeds. Together they provide adequate frictional properties for aircraft throughout their landing/takeoff speed range.

The primary function of macrotexture is to provide paths for water to escape from beneath the aircraft tires. This drainage property becomes more important as the aircraft speed increases, tire tread depth decreases, and water depth increases. All three of these factors contribute to hydroplaning. Good microtexture provides a degree of "sharpness" necessary for the tire to break through the residual water film that remains after the bulk water has run off. Both properties are essential in providing skid-resistant pavement surfaces.

Textural appearances, however, can be deceiving. A rough looking surface could provide adequate drainage channels for the water to escape, but the fine aggregate in the pavement may consist of rounded or uncrushed mineral grains that are subject to polishing by traffic, thereby causing the pavement surface to become slippery when wet. Likewise, a less rough looking surface, that may even have a shiny appearance when wet, will not necessarily be slippery if it has good microtextural properties.

All paving should, of course, be constructed with appropriate transverse slope for basic drainage and must have adequate provision for prompt removal of storm runoff.

2-3. PAINTED AREAS ON PAVEMENT SURFACES. Painted areas of wet runway pavement surfaces can be very slippery. In addition, an aircraft with one main gear on a painted surface, and the other on an unpainted surface, may experience differential braking. It is important to keep the skid-resistance properties of painted surfaces as close to that of unpainted surfaces as possible. Usually this means adding a small amount of silica sand to the paint mix to increase the friction properties of the painted surface. Glass beads, while used primarily to increase conspicuity of markings, have been shown to increase friction levels, also.

Section 2. Hot-Mix Asphalt (HMA) Pavement

2-4. CONSTRUCTION TECHNIQUES FOR HMA PAVEMENT. The surface texture of newly constructed HMA pavements is usually quite smooth. This is due to the rolling done during construction to achieve the required compaction and density. Nevertheless, several methods are available to improve surface texture and friction in HMA pavements. These include proper mix design and the use of PFCs, chip seals, and aggregate slurry seals. Saw cut grooves made after final compaction are highly effective. This chapter gives guidance for providing these surface treatments. The construction specification for HMA pavement is contained in AC 150/5370-10, *Standards for Specifying Construction of Airports*.

2-5. HMA PAVEMENT MIXTURES. Several factors concern the pavement designer in selecting the appropriate design mix. These factors include the blending of aggregate sources, aggregate size and gradation, the relationship between aggregates and binder, and the construction methods to obtain the required surface properties which meet all other requirements.

a. Blending Aggregates. When superior quality aggregates are in limited supply or processing costs are prohibitive, natural aggregates can be combined with synthetic aggregates.

b. Aggregate Size and Gradation. The maximum size aggregate, as well as the mix gradation, may be varied by the pavement designer to produce the desired surface texture and strength. For HMA pavement, the size and properties of the coarse aggregate are critical for good macrotexture. Generally, the larger size aggregates in HMA pavement mixtures provide greater skid-resistance than the smaller ones.

c. Aggregate Characteristics. After size and gradation, the most frequently considered characteristics for skid-resistant aggregates are resistance to polish and wear, texture, and shape of particles.

(1) Resistance to Polish and Wear. The ability of an aggregate to resist the polish and wear action of aircraft traffic has long been recognized as the most important characteristic. Certain aggregates in pavements are more susceptible to wear and polish effects than others, becoming extremely slippery when wet. The presence of coarse grain sizes and gross differences in grain hardness appear to combine and lead to differential wear and breaking off of grains resulting in a constantly renewed abrasive surface. Rocks high in silica content are the most satisfactory performers. Generally, high carbonate rocks are poor performers. Rocks that are generally acceptable are unweathered crushed quartzite, quartz diorite, granodiorite, and granite.

(2) **Texture.** The surface textures of individual aggregates are governed by the size of the individual mineral grains and the matrix in which they are cemented. For an aggregate to exhibit satisfactory skid-resistant properties, it should contain at least two mineral constituents of different hardness cemented in a matrix that will wear differentially, thus continually exposing new surfaces.

(3) **Shape.** The shape of an aggregate particle, which is determined by crushing, significantly affects its skid-resistant properties. Aggregate shape depends on many of the same factors that influence texture. The angularity of an aggregate contributes to its skid-resistant quality. Flat, elongated particles are poor performers.

d. Asphalt Cement. The characteristics and percentages of the asphalt cement used should be in accordance with standard HMA pavement design practice.

2-6. PFC. One method used to improve runway pavement skid-resistance and mitigate hydroplaning is a thin HMA surface course overlay that ranges from 3/4 inch to 1-1/2 inches (25 mm to 40 mm) thick, characterized by its open graded matrix.

a. Pavement Suitability for PFC. Prior to constructing this type of surface course, the existing pavement surface should be evaluated to determine its structural integrity. Strengthening of the existing pavement, if needed, should be accomplished before laying the PFC. Also, the pavement should be in good condition; that is, it should have proper longitudinal and transverse grades and a watertight surface that is free of major cracks, significant depressions, or any other surface irregularities. For minor cracks, normal maintenance procedures should be followed as given in AC 150/5380-6, *Guidelines and Procedures for Maintenance of Airport Pavements*. If there are rubber deposits on the runway pavement surface, these areas should be cleaned prior to constructing the PFC overlay. The PFC should be constructed only on HMA pavements. It has been shown that a longer life, as well as better adhesion and bond, can be achieved by adding rubber particles during the preparation of the mix. The specification for the PFC is given in AC 150/5370-10. Figure 2-1 shows an edge view of a typical PFC overlay.

b. Restrictions to PFC Construction. On PFC constructed runway surfaces that have high aircraft traffic operations, rubber accumulation can become a serious problem if not closely monitored. If the rubber deposits are not removed before they completely cover the pavement surface and plug up the void spaces in the matrix of the overlay, water can no longer drain internally through the structure of the overlay. When this condition occurs, it is impossible to remove the rubber deposits without causing serious damage to the structural integrity of the overlay. Therefore, the FAA

Purchase this course to see the remainder of the technical materials.