

Design of Continuously Reinforced Concrete Pavement for Airports

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A design procedure for continuously reinforced concrete pavement for airports is reported. A method is presented to compute slab thickness and reinforcing requirements. Reinforcement detailing and special treatments for pavement ends are discussed.

Keywords: airports; concrete pavements; concrete slabs; continuously reinforced pavements; detailing; reinforcing steels; structural design; thickness.

CONTENTS

Chapter 1—Introduction, p. 325.5R-1

Chapter 2—Purpose, p. 325.5R-2

Chapter 3—Material specifications, p. 325.5R-2

- 3.1—Deformed reinforcement
- 3.2—Concrete

Chapter 4—Pavement thickness design, p. 325.5R-3

- 4.1—Example method

Chapter 5—Reinforcement design, p. 325.5R-6

- 5.1—CRCP design equation
- 5.2—Reinforcement to resist temperature effects
- 5.3—Strength ratio
- 5.4—Transverse reinforcement
- 5.5—Crack width and spacing
- 5.6—Reinforcement detailing

Chapter 6—Pavement jointing, p. 325.5R-9

Chapter 7—Terminal treatments, p. 325.5R-10

Chapter 8—Design example, p. 325.5R-10

- 8.1—Slab thickness
- 8.2—Reinforcement design
- 8.3—Final design

Chapter 9—References, p. 325.5R-12

- 9.1—Specified and/or recommended references
- 9.2—Cited and other references

CHAPTER 1—INTRODUCTION

A continuously reinforced concrete pavement (CRCP) is a portland cement concrete pavement with continuous longitudinal reinforcement and no intermediate transverse expansion or contraction joints. Transverse reinforcement may also be included. Transverse reinforcement normally is used in continuously reinforced concrete pavements for airports since the applied loads are not as directional as highway-type loadings. Continuously reinforced concrete pavements for airports normally contain from 0.5 to 1.0 percent longitudinal reinforcement and about 0.05 to 0.1 percent transverse reinforcement.

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Although use of CRCP is widespread in highway applications, its use for airports has been relatively limited. The largest airport application of CRCP to date is at an U.S. Air Force facility in Palmdale, Calif. Other airport CRCP applications include O'Hare International Airport and Midway Airport, Chicago, Ill.; Richmond International Airport in Richmond, Va.; John F. Kennedy International Airport in Jamaica, N.Y.; Wold-Chamberlain International Airport in St. Paul, Minn.; Glenview Naval Air Station, Glenview, Ill.; and Patuxent Naval Air Station in Patuxent, Md.

Some of the earlier applications of CRCP on airports were not successful. Premature failures occurred due to insufficient slab thickness or keyed joint deficiencies. While these failures were the result of inadequate design, they resulted in relatively slow acceptance of CRCP for airport applications; however, valuable lessons were learned.

The performance of CRCP on airports where adequate slab thicknesses and properly designed joints were provided has been good. The main advantage of continuously reinforced concrete pavement is the elimination of transverse contraction joints, which are costly to construct and maintain. CRCP usually provides a very smooth riding surface. A properly designed CRCP typically develops regularly spaced, hair-line transverse cracks at 3 to 10 ft (1 to 3 m) intervals. The resultant pavement is composed of a series of short slabs held tightly together by the longitudinal reinforcement. A high degree of shear transfer across the cracks is assured because the cracks are held tightly closed.

To provide cost-effective CRCP for airports, the cost of providing continuous reinforcement must be less than or equal to the cost of constructing and maintaining joints in conventional jointed concrete pavements, given equal usable lives.

CHAPTER 2—PURPOSE

The purpose of this report is to present a design procedure for CRCP for airports. The design procedure consists of: (a) determining CRCP thickness, (b) determining longitudinal reinforcement, (c) determining transverse reinforcement, and (d) designing terminal treatment. The thickness design procedure is based on the stipulation that the same slab thickness be used for CRCP as would be determined for plain jointed concrete pavement. The performance of earlier CRCP designed for airport use indicates that reduced thicknesses are not adequate. CRCP performance at airports has been quite good where the thickness of the CRCP was comparable to the thickness of plain jointed concrete pavement.

CHAPTER 3—MATERIAL SPECIFICATIONS

Materials used in the construction of CRCP should conform to accepted standards as outlined in this chapter.

3.1—Deformed reinforcement

Reinforcement should be specified on the basis of yield strength. The recommended minimum yield strength of longitudinal reinforcement is 60,000 psi (414 MPa). The recommended minimum yield strength of transverse reinforcement is 40,000 psi (276 MPa). All reinforcement should be deformed, and deformed bars should conform to ASTM A 615, A 616, A 617, or A 706. Deformed welded wire fabric should conform to ASTM A 497.

The reasons for recommending a lower minimum yield strength for transverse reinforcement are as follows. First, transverse reinforcement must sometimes be field bent and later straightened during construction of multiple lanes. Lower yield strength reinforcement is less likely to break during field bending. Second, lower yield strength reinforcement usually is less costly. Galvanized or epoxy-coated reinforcing bars normally are not required for airport pavement applications. Corrosive deicing chemicals normally are not used on airport pavements because they will attack certain metallic components of aircraft.

3.2—Concrete

Paving-quality concrete should be specified for CRCP for airports. For detailed guidance on concrete materials, proportioning, placement, curing, etc., of paving-quality concrete, see ACI 316R. The Federal Aviation Administration specification for paving quality concrete can be found in Advisory Circular 150/5370-10, Standards for Specifying Construction of Airports, Item P-501, Portland Cement Concrete Pavement.¹ Detailed information on concrete mixtures can be found in Design and Control of Concrete Mixtures, EB001T, Portland Cement Association, 1988.² These publications contain sufficient information to permit the development of specifications and mix designs for concrete for airport CRCP.

Concrete strength should be specified in terms of the flexural strength and tested in accordance with ASTM C 78. Flexural strength is specified since the primary action of a loaded concrete pavement slab is flexure, and failure is caused by flexural action. Wide variations are encountered in correlating flexural and compressive strengths, thus it is impractical to specify a compressive strength for design.

The 90-day flexural strength often is used for design; however, the specified age selected depends on the individual project and the anticipated start of traffic. Mix proportions may be based on an earlier age, such as 14 or 28 days, to avoid long curing times for laboratory specimens. A general rule of thumb often used is that concrete usually will achieve a 10 percent increase in flexural strength between 28 and 90 days.¹ An airport pavement normally requires considerable associated work such as marking, lighting, shoulder construction, etc., prior to opening to traffic. Concrete flexural strengths on the order of 600 to 750 psi (4.1 to 5.2 MPa) at 90 days typically are used for design.

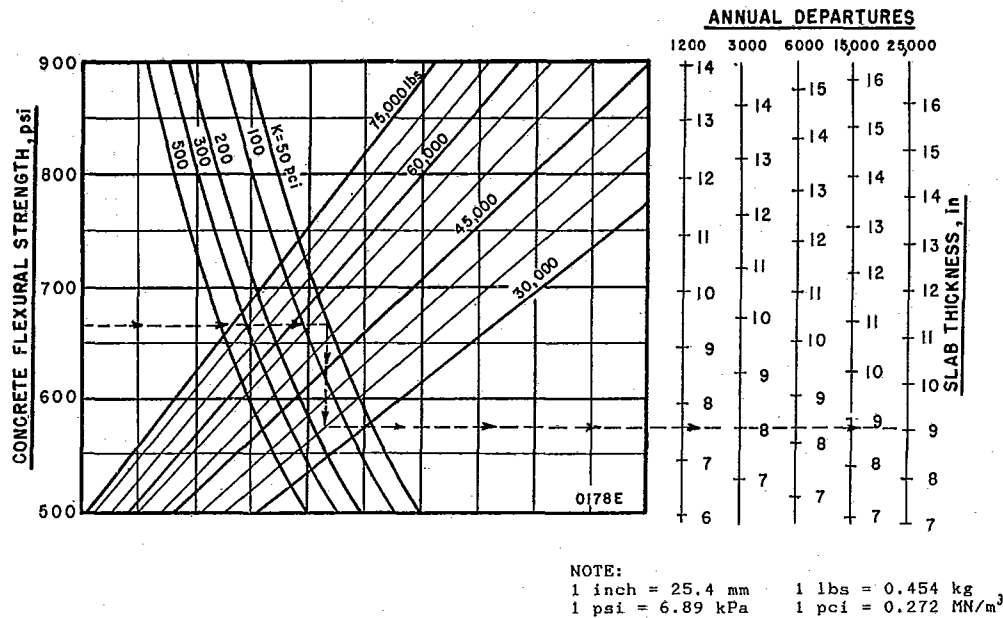


Fig. 1—CRC design curve, single wheel gear

CHAPTER 4—PAVEMENT THICKNESS DESIGN

Several different airport pavement thickness design procedures are available, such as those developed by the Federal Aviation Administration,³ the Portland Cement Association,⁴ and the military services.^{5,6} All of these procedures rely on some version of the Westergaard analysis as their basis. All yield reasonable results, although some small differences in thickness will be observed due to different basic assumptions and operational requirements.

4.1—Example method

The Federal Aviation Administration thickness design method is used in this report.³ Other suitable design procedures are available.⁴⁻⁶ Design curves are shown in Fig. 1 through 9 for single-wheel, dual-wheel, dual-tandem, and wide-body aircraft. These design curves were extracted directly from FAA Advisory Circular 150/5320-6C.³ Schematic drawings of various gear configurations are shown in Fig. 10.

Use of these design curves requires input of concrete flexural strength, gross weight of design aircraft, modulus of subgrade reaction (k -value), and annual departure level. Each of the design parameters is discussed in the following.

4.1.1 Concrete flexural strength—As mentioned previously, concrete strength is determined by flexural testing in accordance with ASTM C 78. Normally, the 90-day strength is used for design; however, a different age may be necessary depending on the particular situation.

4.1.2 Modulus of subgrade reaction (k -value)—The modulus of subgrade reaction (k -value) is a measure of the stiffness of the foundation supporting the concrete pavement. The design k -value should be assigned to the top of the layer immediately below the concrete pavement. The k -value is indicated in units of lb/in³

(MN/m³) and ideally is measured by a plate-loading test (see AASHTO T222). Often, it will have to be estimated since data are not available at the design stage. Several methods of estimating a k -value are available.^{3,4}

Although the longitudinal reinforcement provides continuity of load transfer, uniform foundation support should be provided preferably by a noneroding stabilized subbase. A stabilized subbase provides the uniform support needed for all weather conditions, minimizes the effects of frost action, provides a stable working platform for construction operations, and reduces the susceptibility of the foundation to erosion or weakening from moisture effects.

4.1.3 Design load—Airport traffic usually is comprised of a mixture of several aircraft having different gear types, wheel loads, and wheel spacings. Most airport pavement design procedures are based on a single design aircraft. The effects of mixed traffic are taken into account by converting all traffic to a single design aircraft. The effects of mixed traffic on CRCP are the same as for jointed concrete pavements. The analysis of mixed traffic presented in either Reference 3 or 4 is recommended.

The thickness design method presented in this report uses the gross weight of the design aircraft as the load parameter. Aircraft transmit loads to pavements through their landing-gear assemblies. The usual gear configuration consists of a nose gear and two main gear assemblies. The nose gear assembly normally supports 3 to 10 percent of the gross weight depending on the aircraft type and the location of the center of gravity.

Since it is impossible to predict precisely what percentages of the load will be supported by the nose gear and main gears, the FAA uses the following simplifying assumptions. The nose gear assembly is assumed to carry 5 percent of the gross weight of the aircraft and the main landing gears support the remaining 95 per-

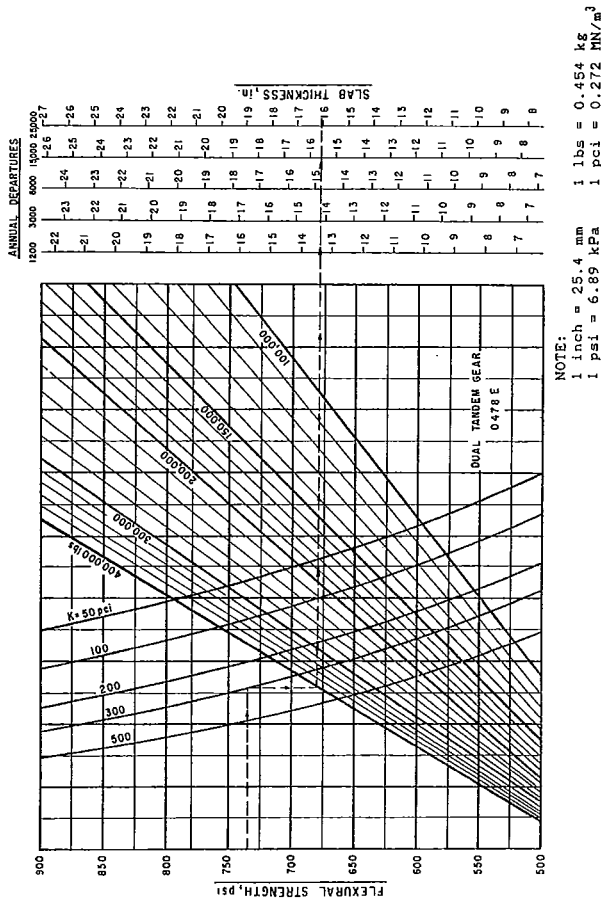


Fig. 3—CRC design curve, dual-tandem gear

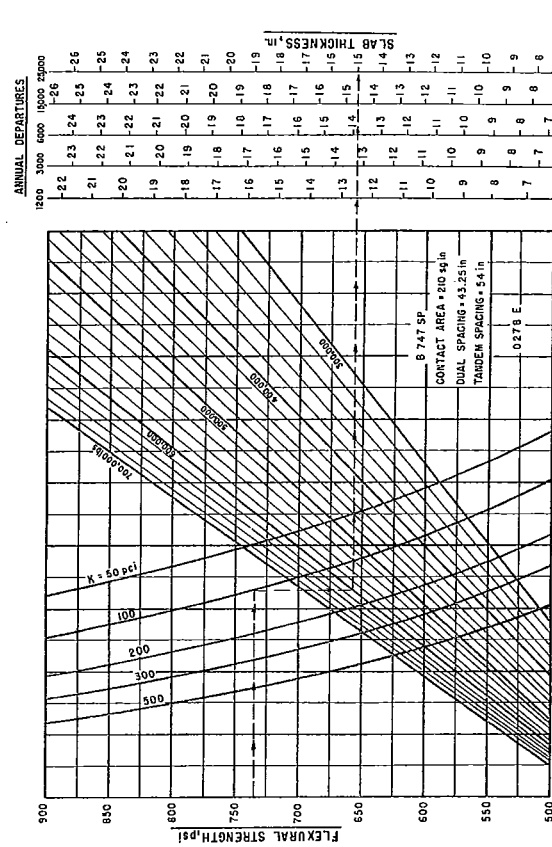


Fig. 5—CRC design curve, B 747-SP

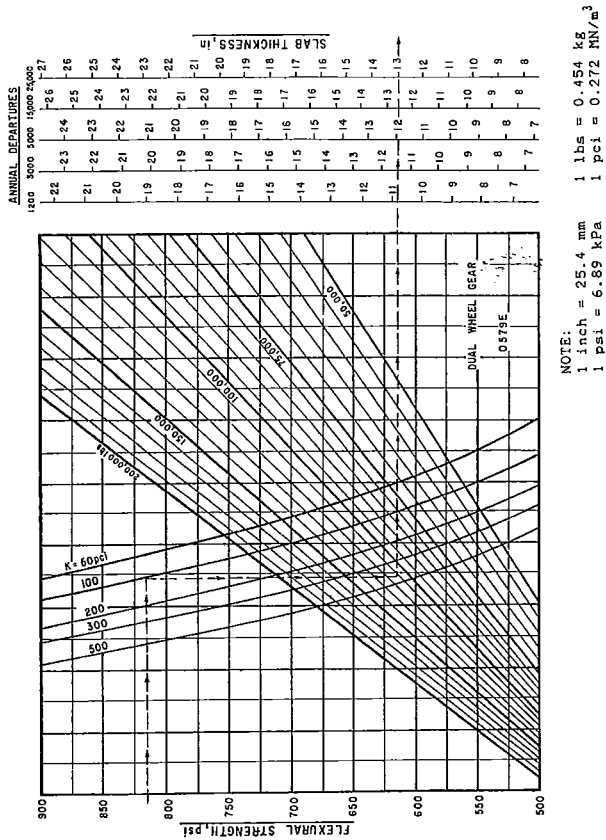


Fig. 2—CRC design curve, dual-wheel gear

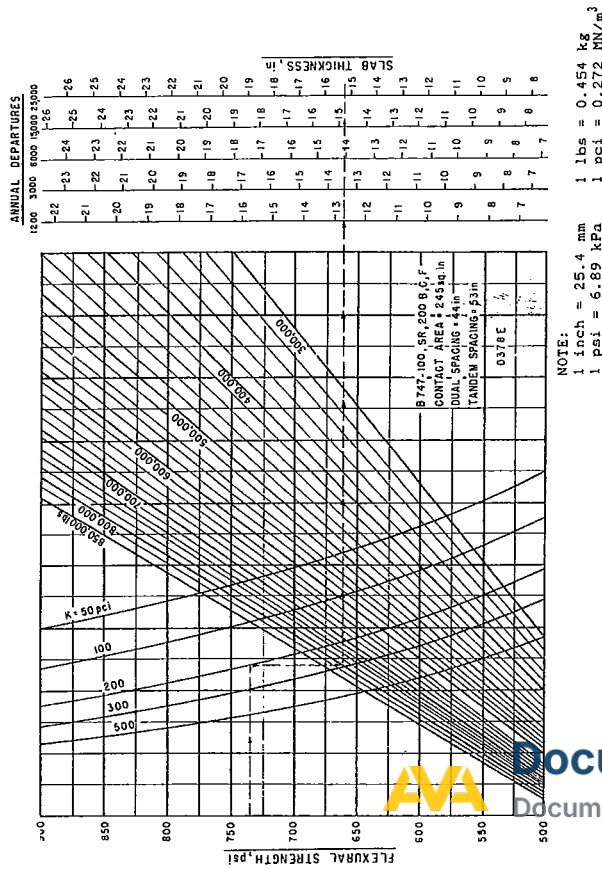


Fig. 4—CRC design curve, B 747, SR, 200B, C, F