7.0 PAVEMENT DATA

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7.0 PAVEMENT DATA

7.1 General Information

A brief description of the pavement charts following will be helpful in their use for airport planning. Each airplane configuration is depicted with a minimum range of four loads imposed on the main landing gear to aid in interpolation between the discrete values shown. All curves for any single chart represent data at a constant tire pressure which will produce a tire deflection of 32% at the maximum ramp weight shown.

Page 72 presents basic data on the landing gear footprint configuration, maximum ramp loads and tire sizes and pressures.

Maximum pavement loads for certain critical conditions at the tire-ground interfaces are shown on Page 73.

Pavement requirements for commercial aircraft are customarily derived from the static analysis of loads imposed on the main landing gear struts. The chart on Page 74 is provided in order to determine these loads throughout the stability limits of the aircraft at rest on the pavement. These main landing gear loads are used to enter the pavement design charts which follow, extrapolating load values where necessary.


Rigid pavement design curves (Page 80) have been prepared with the use of the Westergaard equation in general accordance with the procedures outlined in the 1955 edition of "Design of Concrete Airport Pavement" published by the Portland Cement Association, Old Orchard Rd. Skokie, Illinois, 60076 but modified to the
new format described in the 1968 Portland Cement Association publication

"Operating Instructions — Computer Program for Concrete Airport Pavement Design," (Program PDILB) by Robert G. Packard.

The following procedure is used to develop rigid pavement design curves such as those shown on Page 80:

1. Having established the scale for pavement thickness to the left and the scale for allowable working stress to the right, an arbitrary load line is drawn representing the main landing gear maximum weight to be shown.

2. All values of the subgrade modulus (k values) are then plotted as shown on Page 80.

3. Additional load lines for the incremental values of weight on the main landing gear are then established on the basis of the curve for k = 300, already established.


On the same charts showing LCN versus equivalent single-wheel load, there are load plots for the 720 and 720B showing equivalent single-wheel load versus pavement thickness (h) for flexible pavements and versus \( f \) (radius of relative stiffness) for rigid pavements.

Procedures and curves provided in the ICAO Aerodrome Manual, Part 2, Chapter 4, are used to determine equivalent single-wheel loads for use in making LCN conversion of rigid pavement requirements.

NOTE: Pavement requirements are presented for loads, tires, and tire pressures presently planned for certified commercial usage.

All curves represent data at a constant specified tire pressure.
### Landing Gear Footprint

#### Models 720, 720B

<table>
<thead>
<tr>
<th>Model</th>
<th>Maximum Ramp Weight</th>
<th>Percent of Weight on Main Gear</th>
<th>Nose Tire Size</th>
<th>Nose Tire Pressure</th>
<th>Main Gear Tire Size</th>
<th>Main Gear Tire Pressure</th>
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<td>720</td>
<td>230,000 LB</td>
<td>SEE PAGE (74)</td>
<td>(2)</td>
<td>34 X 9.9</td>
<td>7.04 KG/CM(^2)</td>
<td>100 PSI</td>
<td>50 FT 8 IN.</td>
<td>1 FT 10 IN.</td>
<td>2 FT 8 IN.</td>
<td>4 FT 1 IN.</td>
<td>21 FT 11 IN.</td>
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<td></td>
<td>104,400 KG</td>
<td></td>
<td>100 PSI</td>
<td>40 X 14</td>
<td>10.2 KG/CM(^2)</td>
<td>145 PSI</td>
<td>(15.44 M)</td>
<td>(0.56 M)</td>
<td>(0.81 M)</td>
<td>(1.24 M)</td>
<td>(6.68 M)</td>
</tr>
<tr>
<td>720 B</td>
<td>235,000 LB</td>
<td>SEE PAGE (74)</td>
<td>(2)</td>
<td>39 X 13</td>
<td>8.10 KG/CM(^2)</td>
<td>115 PSI</td>
<td>50 FT 8 IN.</td>
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<td>4 FT 1 IN.</td>
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<tr>
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<td>106,700 KG</td>
<td></td>
<td>115 PSI</td>
<td>40 X 14</td>
<td>10.2 KG/CM(^2)</td>
<td>145 PSI</td>
<td>(15.44 M)</td>
<td>(0.56 M)</td>
<td>(0.81 M)</td>
<td>(1.24 M)</td>
<td>(6.68 M)</td>
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7.3 MAXIMUM GROUND LOADS

MODEL 720, 720B

\[ V_{NG} = \text{MAXIMUM VERTICAL NOSE GEAR GROUND LOAD AT MOST FORWARD CG} \]

\[ V_{MG} = \text{MAXIMUM VERTICAL MAIN GEAR GROUND LOAD AT MOST AFT CG} \]

\[ H = \text{MAXIMUM HORIZONTAL GROUND LOAD FROM BRAKING} \]

NOTE:
- ALL LOADS CALCULATED USING AIRPLANE MAXIMUM GROSS WEIGHT

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<tr>
<th>MODEL</th>
<th>MAXIMUM GROSS WEIGHT</th>
<th>( V_{NG} )</th>
<th>( V_{MG} ) PER STRUT (2)</th>
<th>H (PER STRUT (2))</th>
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<tr>
<td></td>
<td>STATIC AT MOST FORWARD CG</td>
<td>STATIC + BRAKING AT 10 FT/SEC^2 DECELERATION</td>
<td>MAXIMUM LOAD OCCURRING AT STATIC AFT CG</td>
<td>AT STEADY BRAKING 10 FT/SEC^2 DECELERATION</td>
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<td>35,870 16,250</td>
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7.4 LANDING GEAR LOADING ON PAVEMENT MODELS 720, 720B

NOTE: UNSHADED AREAS REPRESENT OPERATIONAL LIMITS

WEIGHT ON MAIN LANDING GEAR (1,000 POUNDS)

GROSS WEIGHT (1,000 KILOGRAMS)

PERCENT OF WEIGHT ON MAIN GEAR
7.5 FLEXIBLE PAVEMENT REQUIREMENTS, SEFL 165A — U.S. CORPS OF ENGINEERS DESIGN METHOD
MODELS 720, 720B

D6-58323

75
7.6 Flexible Pavement Requirements, LCN Conversion

In order to determine the aircraft weight that can be accommodated on a particular flexible pavement, both the LCN of the pavement and the thickness (h) of the pavement must be known.

In the example for the 720 and 720B, shown on Page 77, the flexible pavement thickness is shown at 25 inches with an LCN of 43. For these conditions the apparent maximum allowable weight permissible on the main landing gear is 150,000 pounds.

NOTE: Provided that the resultant aircraft LCN is not more than 10% above the published pavement LCN, it is the United Kingdom view that the bearing strength of the pavement can be considered sufficient for unlimited use by the aircraft. The figure of 10% has been chosen as representing the lowest degree of variation in LCN which is significant. (Reference: ICAO Aerodrome Manual, Part 2, "Aerodrome Physical Characteristics," Chapter 4, Paragraph 4.1.5.7v.)
40 X 14 INCH TIRES---TIRE PRESSURE CONSTANT AT 145 PSI (10.2 KG/CM²)

NOTE: EQUIVALENT SINGLE-WHEEL LOADS ARE DERIVED BY METHODS SHOWN IN ICAO AERODROME MANUAL, PART 2, PAR. 4.1.3

WEIGHT ON MAIN LANDING GEAR (SEE PAGE 74)

POUNDS KILOGRAMS
218,000 99,000
200,000 90,800
175,000 79,500
150,000 68,100

MAXIMUM POSSIBLE MAIN GEAR LOAD AT MAXIMUM RAMP WEIGHT AND AFT CG

FLEXIBLE PAVEMENT THICKNESS (h) (INCHES)
INCHES X 2.54 = CENTIMETERS

LOAD CLASSIFICATION NUMBER (LCN)
7.7 Rigid Pavement Requirements, Portland Cement Association Design Method

Rigid pavement requirements, herein presented, are based upon two Portland Cement Association practices:


Higher stresses for equivalent pavement thicknesses are obtained by the computerized method. These occur because of the following:

1. **Increased Radius of Influence**

   The effect of influence from adjacent wheels by the manual method was limited to approximately 2 times \( l \) (the radius of relative stiffness). The computer utilizes the Westergaard equation directly and includes influence from all wheels within a radius of 3 times \( l \).

2. **Maximizing Process**

   It has been common practice when using the manual count method to align the landing gear footprint on the major axis of the influence chart with one wheel centered over the origin. While this practice does not necessarily produce the maximum possible moment, the values obtained have been considered practical since the procedure eliminates arduous repetitive manual summations of moment blocks.

   The computer determines the actual maximum stress values by a combination of shifting the footprint in relationship to the origin and by angular rotation of the footprint.
3. **Difference in Footprint Shape**

An elliptical contact area is used in the computerized version to represent a single-wheel footprint instead of a rectangle with rounded ends. The variance in moment attributed to this change is minor.

Actual pavement stress for any given model of airplane has not increased. The state of the art in calculation of pavement stress has advanced to permit prediction of stress values to a higher degree of certainty. This permits a proportionate decrease in design stress safety factor.
MAXIMUM POSSIBLE MAIN GEAR LOAD AT MAXIMUM RAMP WEIGHT AND AFT CG

- NEW COMPUTER CALCULATION ($k$)
- FORMER MANUAL CALCULATION ($k$)

**NOTE:** THE VALUES OBTAINED BY USING THE MAXIMUM LOAD REFERENCE LINE AND ANY VALUE OF $k$ ARE EXACT. FOR LOADS LESS THAN MAXIMUM, THE CURVES ARE EXACT FOR $k = 300$, BUT DEVIATE SLIGHTLY FOR OTHER VALUES OF $k$.

**REFERENCES:** "DESIGN OF CONCRETE AIRPORT PAVEMENT" AND "COMPUTER PROGRAM FOR AIRPORT PAVEMENT DESIGN" PROGRAM - PDILB PORTLAND CEMENT ASSN

**NOTICE:** DUE TO CHANGES PER NEW COMPUTER METHOD, VALUES OF STRESS ARE HIGHER THAN OBTAINED BY FORMER STANDARD MANUAL METHOD. (SEE PAGE 78)

RIGID PAVEMENT REQUIREMENTS — PORTLAND CEMENT ASSOCIATION DESIGN METHOD MODELS 720, 720B

D6-58323
RADIUS OF RELATIVE STIFFNESS ($\lambda$)

VALUES OF $\lambda$ IN INCHES

FOR $E = 4,000,000$ PSI AND $\mu = 0.15$

$$\text{RADIUS OF RELATIVE STIFFNESS } \lambda = \frac{4E}{12(1-v^2)k} \sqrt{\frac{d^3}{k}} = 24.1652$$

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</table>
7.8 Rigid Pavement Requirements, LCN Conversion

In order to determine the aircraft weight that can be accommodated on a particular rigid pavement, both the LCN of the pavement and the radius of relative stiffness \( (f) \) of the pavement must be known.

In the example for the 720 and 720B, shown on Page 83, the rigid pavement radius of relative stiffness \( (f) \) is shown at 35 with an LCN of 35. For these conditions, the apparent maximum allowable weight permissible on the main landing gear is 150,000 pounds.

NOTE: Provided that the resultant aircraft LCN is not more than 10% above the published pavement LCN it is the United Kingdom view that the bearing strength of the pavement can be considered sufficient for unlimited use by the aircraft. The figure of 10% has been chosen as representing the lowest degree of variation in LCN which is significant. (Reference: ICAO Aerodrome Manual, Part 2, "Aerodrome Physical Characteristics," Chapter 4, Paragraph 4.1.5.7v.)
40 X 14 INCH TIRES---TIRE PRESSURE CONSTANT AT 145 PSI (10.2 KG/CM²)

WEIGHT ON MAIN LANDING GEAR

NOTE: EQUIVALENT SINGLE-WHEEL LOADS ARE DERIVED BY METHODS SHOWN IN ICAO AERODROME MANUAL, PART 2, PAR. 4.1.3

POUNDS - KILOGRAMS

218,000 99,000

200,000 90,800

175,000 79,500

150,000 68,100

MAXIMUM POSSIBLE MAIN GEAR LOAD AT MAXIMUM RAMP WEIGHT AND AFT CG

RADIUS OF RELATIVE STIFFNESS (ξ)  LOAD CLASSIFICATION NUMBER (LCN)

20  30  40  50  60  70  80  90  100

10  20  30  40  50  60  70  80  90  100

EQUIVALENT SINGLE-WHEEL LOAD (1,000 POUNDS)

EQUIVALENT SINGLE-WHEEL LOAD (1,000 KILOGRAMS)

D-58323

MODELS 720, 720B

RIGID PAVEMENT REQUIREMENTS, LCN CONVERSION
7.9 Flexible and Rigid Pavement Requirements, FAA Method

The charts on Pages 85 and 86 are developed directly from pages in FAA Advisory Circular AC 150/5320-6A, May 9, 1967.

Pavement thicknesses are shown for gross aircraft weight irrespective of landing gear configuration and tire pressure. The following general assumptions were made by the FAA in preparing the charts:

1. Ninety-five percent of the gross aircraft weight is assumed to be supported by the main gear.

2. Dual-tandem wheel spacings are not given specifically, but certain design compromises are made as described in the Advisory Circular Appendix 1 in order to develop the curves shown.

The subgrade ratings for pavements are shown as standard FAA designations. These ratings and their derivation are fully described in the Advisory Circular mentioned above.
NOTE: Ra, Rb, Rc, Rd, and Re ARE FAA PAVEMENT SUBGRADE RATINGS


RIGID PAVEMENT REQUIREMENTS, FAA METHOD MODELS 720, 720B