BLOCK 3.0

RESURFACING

Can you explain this result???

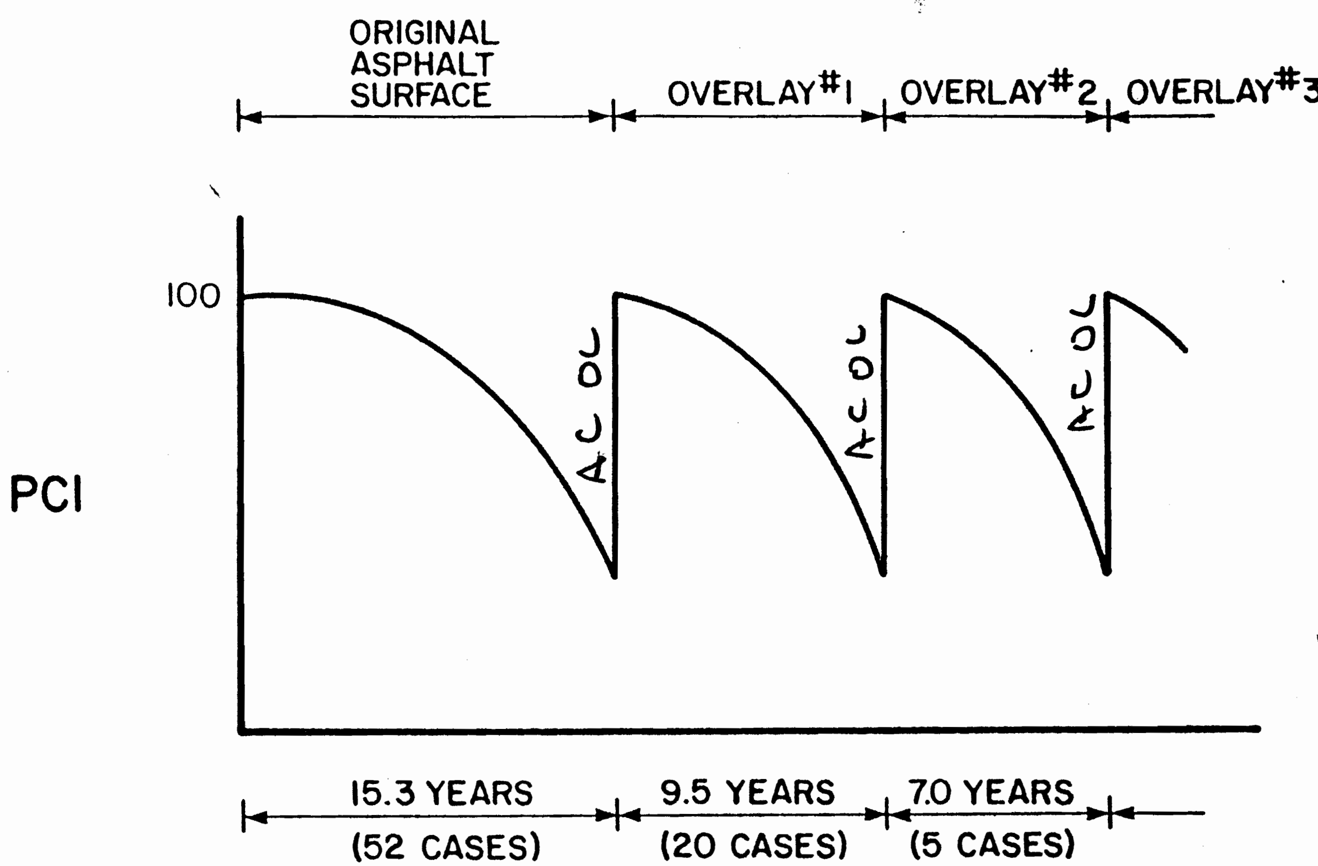


Figure 2. Average Age of an Asphalt Surface Before Overlay.

Airfield Pvts.

Overlay

AC OL life < original life

We didn't overlay pavement until things have to be done

FAA PROCEDURE

CHAPTER 4. AIRPORT PAVEMENT OVERLAYS.

62. GENERAL.

a. Airport pavement overlays may be required for a variety of reasons. A pavement may have been damaged by overloading in such a way that it cannot be maintained satisfactorily at a serviceable level. Similarly, a pavement in good condition may require strengthening to serve heavier aircraft than those for which the pavement was originally designed. A pavement may also require an overlay simply because the original pavement has served its design life and is "worn out." Generally, airport pavement overlays consist of either portland cement concrete or bituminous concrete.

b. Definitions applicable to overlay pavements are as follows:

(1) Overlay pavement. Pavement which is constructed on top of an existing pavement.

(2) Bituminous overlay. Bituminous concrete pavement placed on an existing pavement.

(3) Concrete overlay. Portland cement concrete pavement placed on an existing pavement.

(4) Sandwich Pavement. An overlay pavement containing a granular separation course.

Typical overlay pavement cross sections are shown in Figure 4-1.

63. PRELIMINARY DESIGN DATA. Regardless of the type of overlay to be employed, several determinations should be made prior to the actual design. The following items will provide this essential information:

a. Determine the foundation conditions under the existing pavement. This determination should include the soil classification, drainage conditions, and some estimate of foundation strength (CBR or subgrade modulus).

b. Determine the actual thickness of each layer of the existing pavement, its condition and strength.

c. In accordance with the requirements for the particular type of overlay, determine the pavement thickness required for the loading under consideration by using the appropriate basic pavement design curves included in Chapter 3.

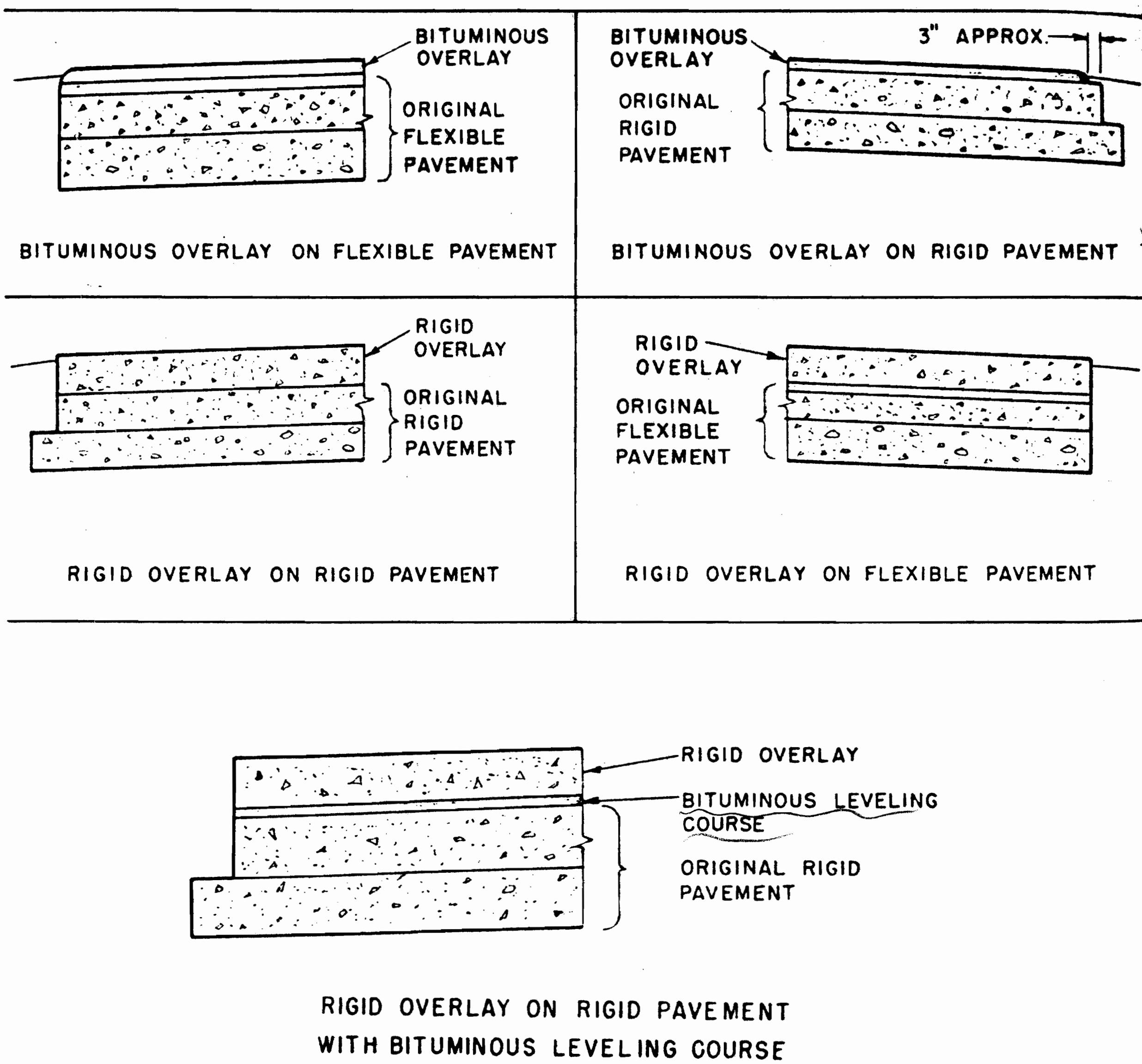


FIGURE 4-1. TYPICAL OVERLAY PAVEMENTS

d. Failed areas in the existing pavement should be carefully studied to determine the probable cause of failure.In some instances reconstruction or subsurface drainage is needed.

e. Techniques and equipment are now available to recycle old pavement materials and incorporate the material in a reconstructed section. Pavements which are severely distressed in the center portions can sometimes be economically reconstructed by building a keel section using recycled materials. Use of this method of reconstruction is essentially the same as building a new pavement.

MATERIAL SELECTION CONSIDERATIONS. Criteria are presented in this chapter for both bituminous and concrete overlay pavements. The selection of the overlay type should be made after careful consideration of many factors. The designer should consider the total life cycle cost of the overlay pavement. Life cycle costs should include initial construction and maintenance costs over the design life of the pavement. Other considerations such as allowable down time of the pavement and availability of alternate pavements to use during construction will have a significant impact on the overlay type selected.

DESIGN OF BITUMINOUS OVERLAYS. Bituminous overlays can be applied to either flexible or rigid pavements. Certain criteria are applicable to the design of bituminous overlays whether they are to be placed over existing rigid or flexible pavements.

a. Overlay pavements which use a granular separation course between the old and new surfaces are not allowed. Overlay pavements containing granular separation courses are referred to as sandwich pavements. Sandwich pavements are not allowed because the separation course is likely to become saturated with water and provide rather unpredictable performance. Saturation of the separation course can be caused by the infiltration of surface water, ingress of ground or capillary water, or the condensation of water from the atmosphere. In any event, the water in the separation course usually cannot be adequately drained and drastically reduces the stability of the overlay.

b. Bituminous overlays for increasing strength should have a minimum thickness of 3 inches (7.5 cm).

66. BITUMINOUS OVERLAYS ON EXISTING FLEXIBLE PAVEMENT.

a. Use the appropriate basic flexible pavement curves (Figures 3-3 through 3-11) to determine the thickness requirements for a flexible pavement for the desired load and number of equivalent design departures. A CBR value is required for the subgrade material and subbase. Thicknesses of all pavement layers must be determined. The thickness of pavement required over the subgrade and subbase and the minimum base course requirements must be compared with the existing pavement to determine the overlay requirements.

b. Adjustments to the various layers of the existing pavement may be necessary to complete the design. Bituminous surfacing may have to be converted to base, and base to subbase conversion may be required. A high quality material may be converted to a lower quality material, such as surfacing to base. A material may not be converted to a higher quality material. For example excess subbase cannot be converted to base. The equivalency factors shown in Tables 3-2 and 3-3 may be used as guidance in the conversion of layers. It must be recognized that the values shown in Tables 3-2 and 3-3 are for new materials and the assignment of factors for existing pavements must be based on judgment and experience. Surface cracking, high degree of oxidation, evidence of low stability, etc., are only a few of the considerations which would tend to reduce the equivalency factor. Any bituminous layer located between granular courses in the existing pavement should be evaluated inch for inch as granular base or subbase course.

c. To illustrate the procedure of designing a bituminous overlay, assume an existing taxiway pavement composed of the following section. The subgrade CBR is 7, the bituminous surface course is 4 inches (10 cm) thick, the base course is 6 inches (15 cm) thick, the subbase is 10 inches (25 cm) thick, and the subbase CBR is 15. Frost action is negligible. Assume the existing pavement is to be strengthened to accommodate a dual wheel aircraft weighing 100,000 pounds (45 000 kg) and an annual departure level of 3,000. The flexible pavement required (referring to Figure 3-4) for these conditions is·

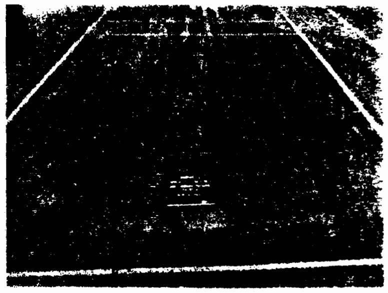
Bituminous Surface	4 inches	(10 cm)
Base	9 inches	(23 cm)
Subbase	10 inches	(25 cm)
Total pavement thickness	23 inches	(58 cm)

The total pavement thickness must be 23 inches (58 cm) in order to protect the CBR 7 subgrade. The combined thicknesses of surfacing and base must be 13 inches (33 cm) to protect the CBR 15 subbase. The existing pavement is thus 3 inches (7.5 cm) deficient in total pavement thickness, all of which is due to base course. For the sake of illustration, assume the existing bituminous surface is in such a condition that surfacing can be substituted for base at an equivalency ratio of 1.3 to 1. Converting 2.5 inches (6 cm) of surfacing to base yields a base course thickness of 9.2 inches (23 cm) leaving 1.5 inches (4 cm) of unconverted surfacing. A 2.5 inch (6 cm) overlay would be required to achieve a 4 inch (10 cm) thick surface. In this instance the minimum 3-inch (7.5 cm) overlay thickness would control. A 3-inch (7.5 cm) overlay thickness would be required.

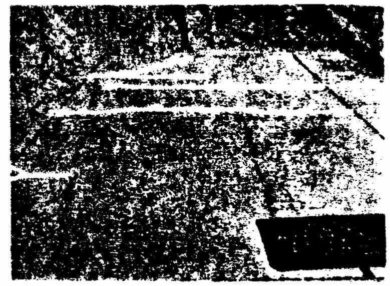
d. The most difficult part of designing bituminous overlays for flexible pavements is the determination of the CBR values for the subgrade and subbase and conversion of layers. Subgrade and subbase CBR values can best be determined by conducting field in-place CBR tests. Field CBR tests should be performed in accordance with the procedures given in Manual Series No. 10 (MS-10) by The Asphalt Institute. See Appendix 4. The subgrade and subbase must be at the equilibrium moisture content when field CBR tests are conducted. Normally a pavement which has been in place for at least 3 years will be in equilibrium. Layer conversions, i.e., converting base to subbase, etc., are largely a matter of engineering judgment. When performing the conversions, it is recommended that any converted thicknesses never be rounded off. To illustrate, if a converted thickness yields a value of 2.6 inches (7 cm), this value should not be rounded off to 3 inches (7.5 cm).

67. BITUMINOUS OVERLAY ON EXISTING RIGID PAVEMENT. To establish the required thickness of bituminous overlay for an existing rigid pavement, it is first necessary to determine the single thickness of rigid pavement required to satisfy the design conditions. This thickness is then modified by a factor "F" which controls the degree of cracking which will occur in the existing rigid pavement. The effective thickness of the existing rigid pavement is also adjusted by a condition factor "C_b." The "F" and "C_b" factors perform two different functions in the bituminous overlay determination as discussed below:

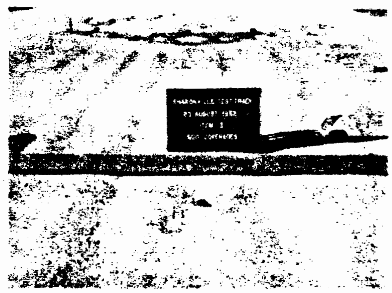
a. The factor "F" which controls the degree of cracking which will occur in the base pavement is a function of the amount of traffic and the subgrade strength. The "F" factor selected will dictate the final condition of the overlay and base pavement. The "F" factor in effect is indicating that the entire concrete single slab thickness determined from the design curves is not needed because a bituminous overlay pavement is allowed to crack and deflect more than a conventional rigid pavement. More cracking and deflection is allowable as the bituminous surfacing will not spall and can conform to greater deflections than a totally rigid pavement. Photographs of various overlay and base pavements shown in Figure 4-2 illustrate the meaning of the "F" factor. Figures 4-2a, b, and c show how the overlay and base pavements fail as more traffic is applied to a bituminous overlay on an existing rigid pavement. In



SURFACE OF OVERLAY

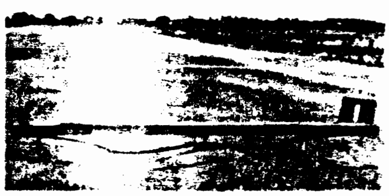


BASE PAVEMENT

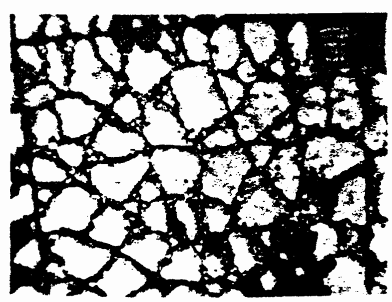


SURFACE OF OVERLAY

BASE PAVEMENT



SURFACE OF OVERLAY



BASE PAVEMENT

FIGURE 4-2. ILLUSTRATION OF VARIOUS "F" FACTORS FOR BITUMINOUS OVERLAY DESIGN the design of a bituminous overlay, the condition of the overlay and base pavement after the design life should be close to that shown in Figure 4-2b. Figure 4-3 is a graph enabling the designer to select the appropriate "F" value to yield a final condition close to that shown in Figure 4-2b.

b. The condition factor "C_b" applies to the existing rigid pavement. The "C_b" factor is an assessment of the structural integrity of the existing pavement. The determination of the proper "C_b" value is a judgment decision for which only general guidelines can be provided. A "C_b" value of 1.0 should be used when the existing slabs contain nominal initial cracking and 0.75 when the slabs contain multiple cracking. The designer is cautioned that the range of "C_b" values used in bituminous overlay designs is different from the "C_r" values used in rigid overlay pavement design. The minimum "C_b" value is 0.75. A single "C_b" should be established for an entire area. The "C_b" value should not be varied along a pavement feature. Figures 4-4 and 4-5 illustrate "C_b" values of 1.0 and 0.75, respectively.

c. After the "F" factor, condition factor "C_b," and single thickness of rigid pavement have been established, the thickness of the bituminous overlay is computed from the following formula:

$$t = 2.5\,(Fh - C_b h_e)$$

where t = thickness of bituminous overlay, inches

F = factor which controls the degree of cracking in the base pavement

h = single thickness of rigid pavement required for design conditions, inches. Use the exact value of h; do not round off.

C_b = condition factor for base pavement ranging from 1.0 to 0.75

h_e = thickness of existing rigid pavement, inches

Calculation of bituminous overlay thickness in metric units should be performed using the formula below:

$$t = 6.3\,(Fh - C_b h_e)$$

where:

t is in centimeters
h is in centimeters
h_e is in centimeters

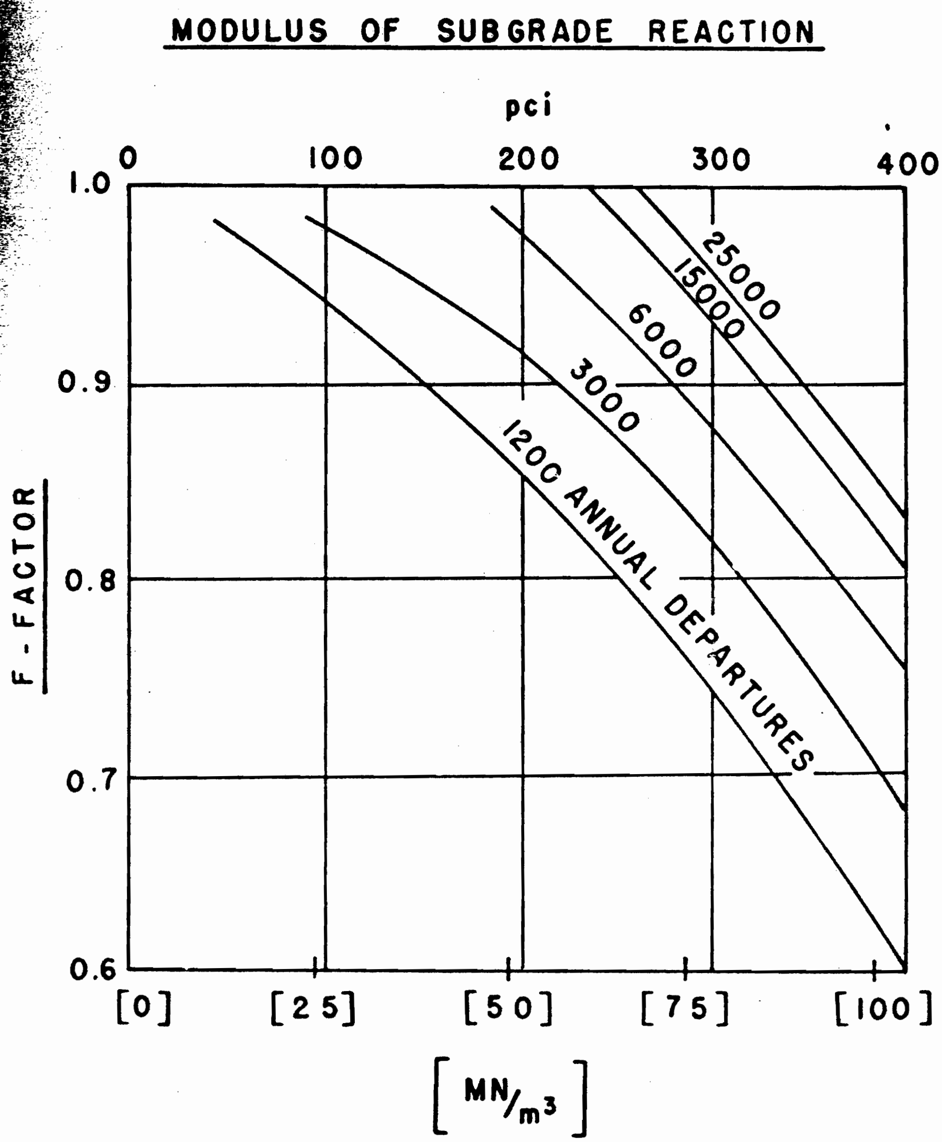


FIGURE 4-3. GRAPH OF "F" FACTOR VS. MODULUS OF SUBGRADE REACTION FOR DIFFERENT TRAFFIC LEVELS

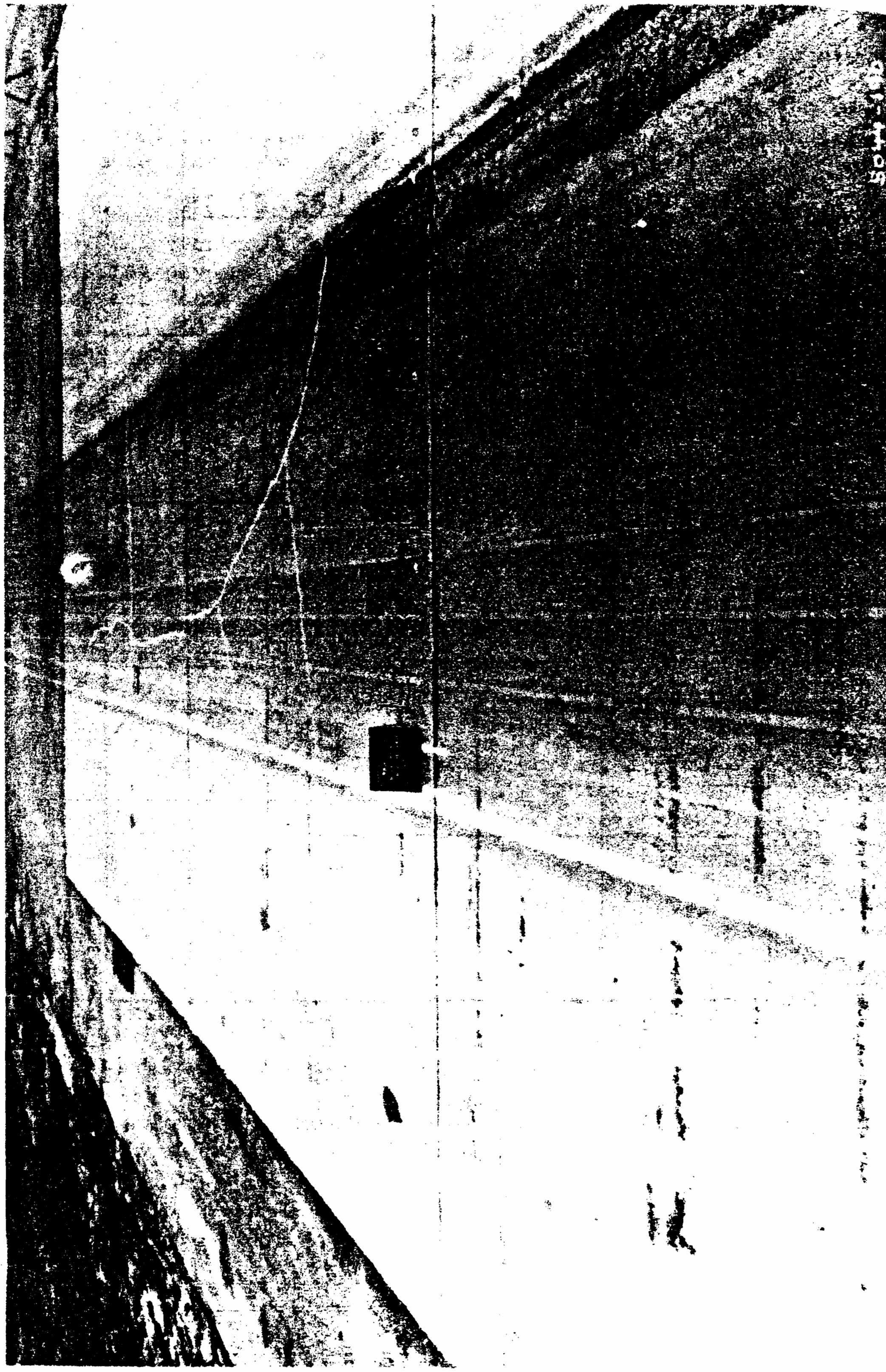


FIGURE 4-4. EXAMPLE OF A "C_b" FACTOR OF 1.0 FOR BITUMINOUS OVERLAY DESIGN

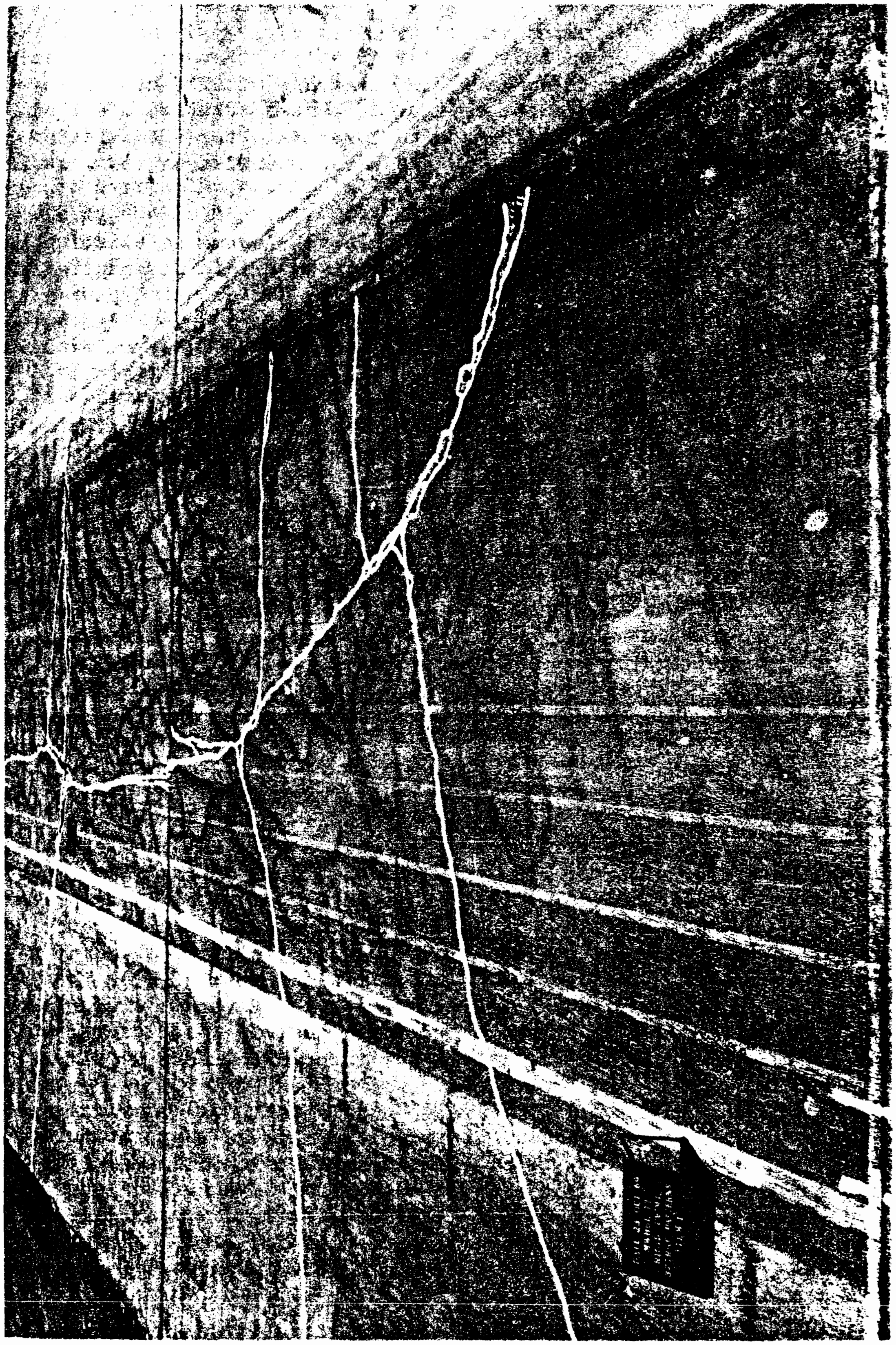


FIGURE 4-5. EXAMPLE OF A "C_b" FACTOR OF 0.75 FOR BITUMINOUS OVERLAY DESIGN

d. The design of a bituminous overlay for a rigid pavement which has an existing bituminous overlay is slightly different. The designer should treat the problem as if the existing bituminous overlay were not present, calculate the overlay thickness required, and then adjust the calculated thickness to compensate for the existing overlay. If this procedure is not used, inconsistent results will often be produced.

(1) An example of the procedure follows. Assume an existing pavement consists of a 10-inch (25 cm) rigid pavement with a 3-inch (7.5 cm) bituminous overlay. The existing pavement is to be strengthened to be equivalent to a single rigid pavement thickness of 14 inches (36 cm). Assume an "F" factor of 0.9 and "C_b" of 0.9 are appropriate for the existing conditions.

(2) Calculate the required thickness of bituminous overlay as if the existing 3-inch (7.5 cm) overlay were not present.

$$t = 2.5\ (0.9 \times 14 - 0.9 \times 10)$$

$$t = 9 \text{ inches } (23 \text{ cm})$$

(3) An allowance is then made for the existing bituminous overlay. In this example assume the existing overlay is in such a condition that its effective thickness is only 2.5 inches (6 cm). The required overlay thickness would then be 9 - 2.5 = 6.5 inches (17 cm). The determination of the effective thickness of the existing overlay is a matter of engineering judgment.

e. The formula for calculating the thickness of bituminous overlays on rigid pavements is limited in application to overlay thicknesses which are equal to or less than the thickness of the base rigid pavement. If the overlay thickness exceeds the thickness of the base pavement, the designer should consider designing the overlay as a flexible pavement and treating the existing rigid pavement as a high quality base material. This limitation is based on the fact that the formula assumes the existing rigid pavement will support considerable load by flexural action. However, the flexural contribution becomes negligible for thick bituminous overlays.

68. NONSTRUCTURAL BITUMINOUS OVERLAYS. In some instances overlays are required to correct nonstructural problems such as restoration of crown, improve ridability, etc. Thickness calculations are not required in these situations, as thickness is controlled by other design considerations or minimum practical overlay thickness. Information concerning runway roughness correction can be found in FAA Report No. FAA-RD-75-110, Methodology for Determining, Isolating and Correcting Runway Roughness. See Appendix 4.

REFLECTION CRACKING IN BITUMINOUS OVERLAYS. Reflection cracking in bituminous overlays has been and continues to be a problem which has not been completely solved. Numerous materials and techniques have been tried in attempts to solve the problem with varying degrees of success. Large numbers of research studies have been conducted which often have produced contradictory findings. At the present time the use of particular materials or techniques to prevent reflection cracking should be done on a case-by-case basis.

DESIGN OF CONCRETE OVERLAYS. Concrete overlays can be constructed on existing rigid or flexible pavements. The minimum allowable thickness for concrete overlays is 5 inches (13 cm) when placed on a flexible pavement, directly on a rigid pavement, or on a leveling course. The minimum thickness of a concrete overlay which is bonded to an existing rigid pavement is 3 inches (7.5 cm). The design of concrete overlays is predicated on equating the base and overlay section to a single slab thickness. The formulas presented were developed from research on test track pavements and observations of in-service pavements.

CONCRETE OVERLAY ON FLEXIBLE PAVEMENT. The design of concrete overlays on existing flexible pavements is based on the design curves in Figures 3-14 through 3-29. The existing flexible pavement is considered a foundation for the overlay slab.

a. For design of the rigid pavement, the existing flexible pavement shall be assigned a k value using Figure 2-5 or 3-13 or by conducting a plate bearing test on the existing flexible pavement. In either case the k value assigned should not exceed 500.

b. When frost conditions require additional thickness, the use of nonstabilized material is not allowed as this would result in a sandwich pavement. The frost protection must be provided by stabilized material.

72. CONCRETE OVERLAY ON RIGID PAVEMENT. The design of concrete overlays on existing rigid pavements is also predicated on the rigid pavement design curves, Figures 3-14 through 3-29. The rigid pavement design curves indicate the thickness of concrete required to satisfy the design conditions for a single thickness of concrete pavement. Use of this method requires the designer to assign a k value to the existing foundation. The k value may be determined by field bearing tests conducted in test pits cut through the existing rigid pavement, or may be estimated from construction records for the existing pavement. The design of a concrete overlay on a rigid pavement requires an assessment of the structural integrity of the existing rigid pavement. The condition factor should be selected after a pavement condition survey. The selection of a condition factor is a matter of engineering

judgment. The use of nondestructive testing (NDT) can be of considerable value in assessing the condition of an existing pavement. NDT can also be used to determine sites for test pits. NDT procedures are given in Advisory Circular 150/5370-11, Use of Nondestructive Testing Devices in the Evaluation of Airport Pavements. See Appendix 4. In order to provide a more uniform assessment of condition factors, the following values are defined:

C_r = 1.0 for existing pavement in good condition -- some minor cracking evident but no structural defects.

C_r = 0.75 for existing pavement containing initial corner cracks due to loading but no progressive cracking or joint faulting.

C_r = 0.35 for existing pavement in poor structural condition - badly cracked or crushed and faulted joints.

The three conditions discussed above are used to illustrate the condition factor rather than establish the only values available to the designer. Conditions at a particular location may require the use of an intermediate value of C_r within the recommended range. Photographs of three different values of C_r are shown in Figures 4-6, 4-7, and 4-8.

a. Concrete Overlay Without Leveling Course. The thickness of the concrete overlay slab applied directly over the existing rigid pavement is computed by the following formula:

$$h_c = \sqrt[1.4]{h^{1.4} - C_r h_e^{1.4}}$$

h_c = required thickness of concrete overlay

h = required single slab thickness determined from design curves

h_e = thickness of existing rigid pavement

C_r = condition factor

Due to the inconvenient exponents in the above formula, graphic displays of the solution of the formula are given in Figures 4-9 and 4-10. These graphs were prepared for only two different condition factors, C_r = 1.0 and 0.75. The use of a concrete overlay pavement directly on an existing rigid pavement with a condition factor of less than 0.75 is not recommended because of the likelihood of reflection cracking.

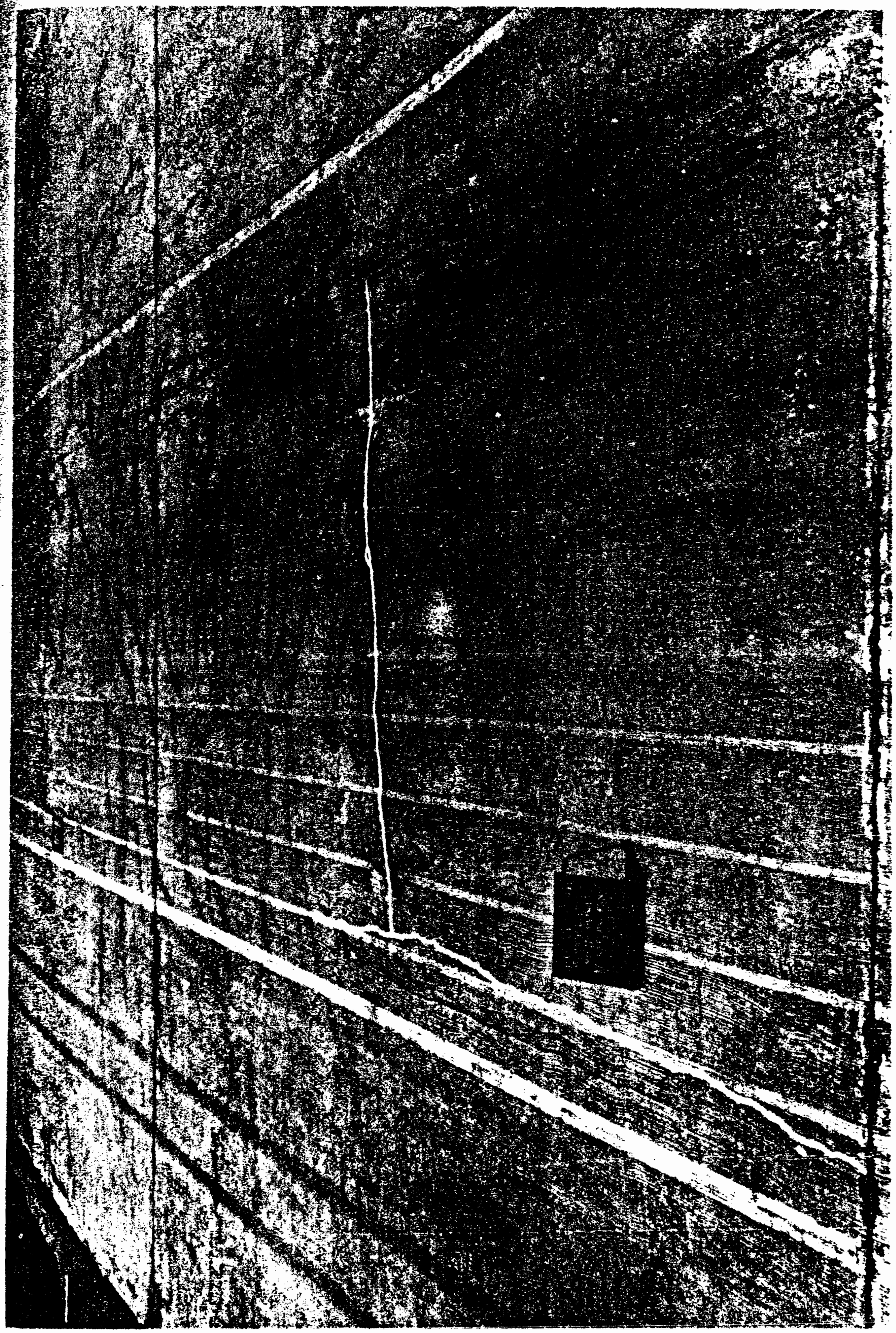


FIGURE 4-6. EXAMPLE OF A CONDITION FACTOR, "C_r" OF 0.85 USED FOR CONCRETE OVERLAY DESIGN PURPOSES

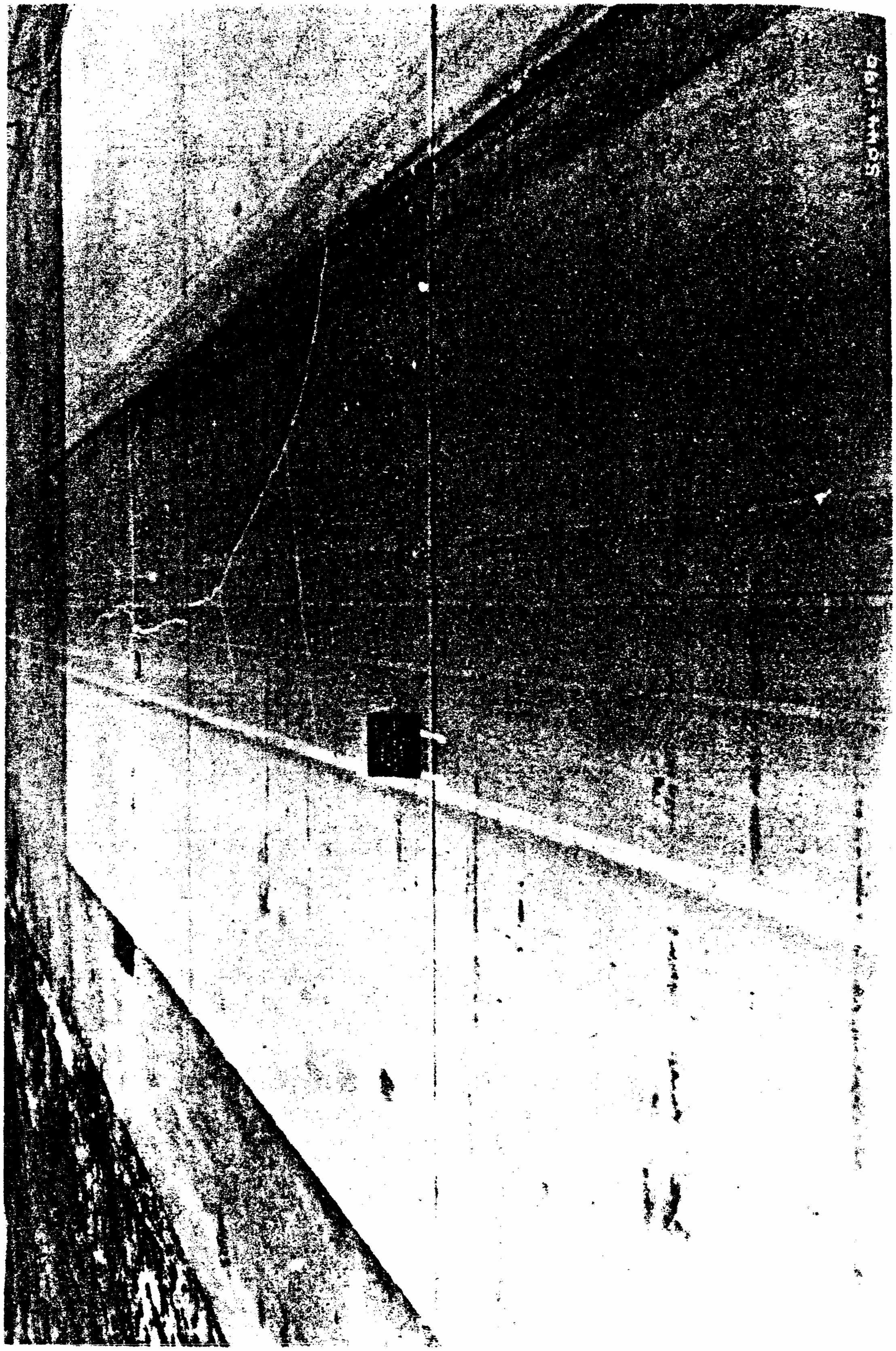


FIGURE 4-7. EXAMPLE OF A CONDITION FACTOR, "C_r" OF 0.5 USED FOR CONCRETE OVERLAY DESIGN PURPOSES

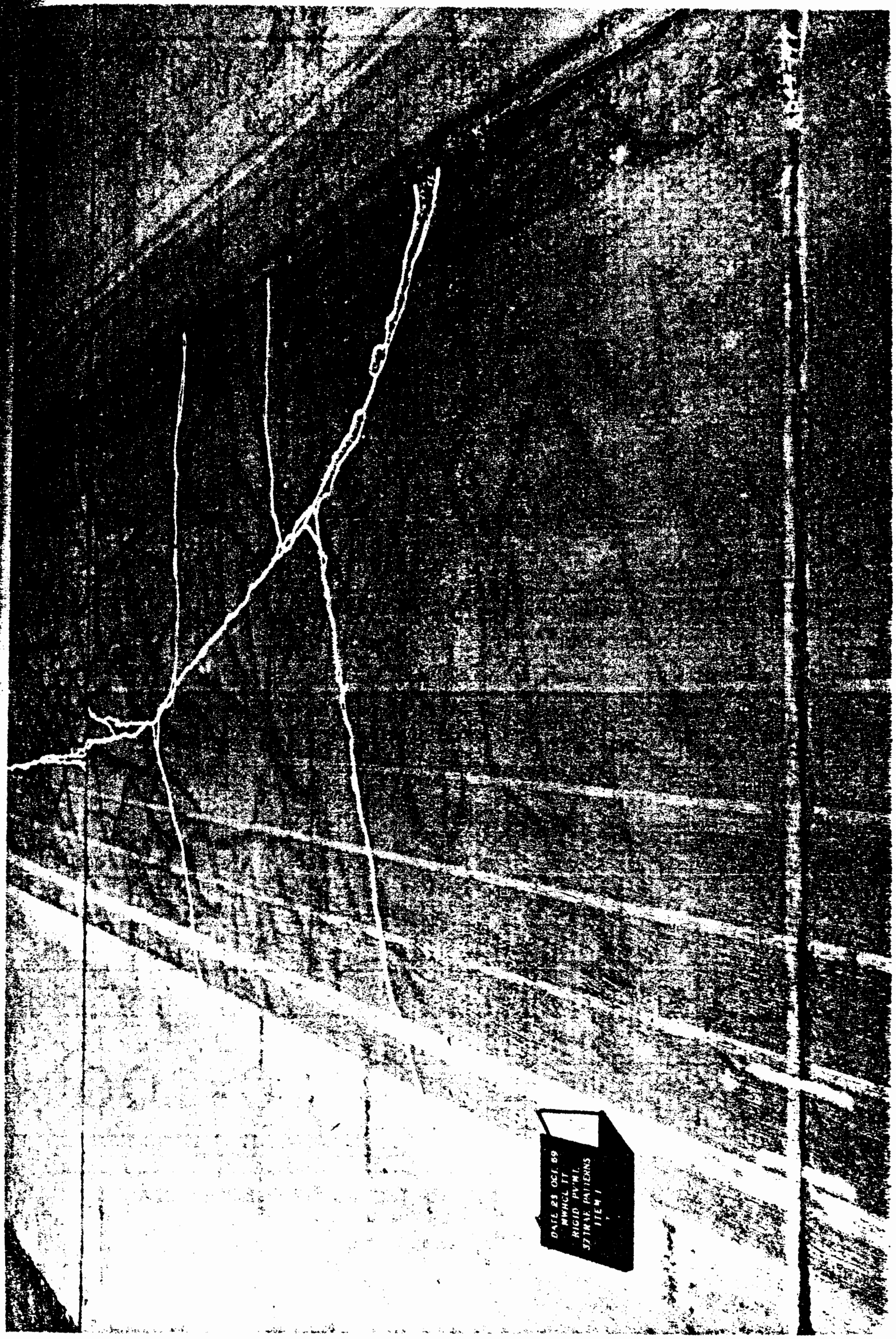


FIGURE 4-8. EXAMPLE OF A CONDITION FACTOR, "C_r" OF 0.35, USED FOR CONCRETE OVERLAY DESIGN PURPOSES

b. Concrete Overlay With Leveling Course. In some instances it may be necessary to apply a leveling course of bituminous concrete to an existing rigid pavement prior to the application of the concrete overlay. Under these conditions a different formula for the computation of the overlay thickness is required. When the existing pavement and overlay pavement are separated, the slabs act more independently than when the slabs are in contact with each other. The formula for the thickness of an overlay slab when a leveling course is used is as follows:

$$h_c = \sqrt{h^2 - C_r h_e^2}$$

no bond !?

h_c = required thickness of concrete overlay

h = required single slab thickness determined from design curves

h_e = thickness of existing rigid pavement

C_r = condition factor

The leveling course must be constructed of highly stable bituminous concrete. A granular separation course is not allowed as this would constitute sandwich construction. Graphic solutions of the above equation are shown in Figures 4-11 and 4-12. These graphs were prepared for condition factors of 0.75 and 0.35. Other condition factors between these values can normally be computed to sufficient accuracy by interpolation.

73. BONDED CONCRETE OVERLAYS. Concrete overlays which are bonded to existing rigid pavements are sometimes used under certain conditions. By bonding the concrete overlay to the existing rigid pavement the new section behaves as a monolithic slab. The thickness of bonded overlay required is computed by subtracting the thickness of the existing pavement from the thickness of the required slab thickness determined from design curves.

$$h_c = h - h_e$$

where:

h_c = required thickness of concrete overlay

h = required single slab thickness determined from design curves

h_e = thickness of existing rigid pavement

Bonded overlays should be used only when the existing rigid pavement is in good condition. Defects in the existing pavement are more likely to reflect through a bonded overlay than other types of concrete overlays. The major problem likely to be encountered with bonded concrete overlays is achieving adequate bond. Elaborate surface preparation and exacting construction techniques are required to insure bond.

JOINTING OF CONCRETE OVERLAYS. Where a rigid pavement is to receive the overlay, some modification to jointing criteria may be necessary because of the design and joint arrangement of the existing pavement. The following points may be used as guides in connection with the design and layout of joints in concrete overlays.

a. Joints need not be of the same type as in the old pavement.

b. It is not necessary to provide an expansion joint for each expansion joint in the old pavement; however, a saw cut or plane of weakness should be provided within 1 foot (0.3 m) of the existing expansion joint.

c. Contraction joints may be placed directly over or within 1 foot (0.3 m) of existing expansion, construction, or contraction joints. Should spacing result in slabs too long to control cracking, additional intermediate contraction joints may be necessary.

d. If a concrete overlay with a leveling course is used, the joint pattern in the overlay does not have to match the joint pattern in the existing pavement.

e. If slabs longer than 20 feet (6.1 m) are desired, distributed steel reinforcement should be provided regardless of overlay thickness.

75. PREPARATION OF THE EXISTING SURFACE FOR THE OVERLAY. Before proceeding with construction of the overlay, steps should be taken to correct all defective areas in the existing surface, base, subbase, and subgrade. Careful execution of this part of an overlay project is essential as a poorly prepared base pavement will result in an unsatisfactory overlay. Deficiencies in the base pavement will often be reflected in the overlay.

a. Failures in flexible pavements can take the form of pavement breakups, potholes and surface irregularities, and depressions.

(1) Localized areas of broken pavement will have to be removed and replaced with new pavement. This type of failure is usually encountered where the pavement is deficient in thickness, the subgrade consists of unstable material, or poor drainage has reduced the supporting power of the subgrade. To correct this condition, the subgrade material should be replaced with a

select subgrade soil or by installation of proper drainage facilities; this is the first operation to be undertaken in repairing this type of failure. Following the correction of the subgrade condition, the subbase, base, and surface courses of the required thickness should be placed. Each layer comprising the total repair should be thoroughly compacted before the next layer is placed.

(2) Surface irregularities and depressions, such as shoving, rutting, scattered areas of settlement, and occasional "birdbaths" should be leveled by rolling, where practical, or by filling with suitable bituminous mixtures. If the "birdbaths" and settlements are found to exist over extensive areas, a bituminous leveling course may be required as part of the overlay. The leveling course should consist of a high-quality bituminous concrete. Scattered areas requiring leveling or patching may be repaired with bituminous patch mixtures.

(3) A bleeding surface may detrimentally affect the stability of the overlay and for this reason any excess bituminous material accumulated on the surface should be bladed off if possible. In some instances, a light application of fine aggregates may blot up the excess material, or a combination of the two processes may be necessary.

(4) Cracks, and joints, 1/2 inch (1 cm) or more in width, should be filled with a lean mixture of sand and liquid bituminous material. This mixture should be well tamped in place, leveled with the pavement surface and any excess removed.

(5) Potholes should be thoroughly cleaned and filled with a suitable bituminous mixture and tamped in place.

b. In rigid pavements, narrow transverse, longitudinal, and corner cracks will need no special attention unless there is an appreciable amount of displacement and faulting of the separate slabs. If the subgrade is stable and no pumping has occurred, the low areas can be taken care of as part of the overlay and no other corrective measures are needed. On the other hand, if pumping has occurred at the slab ends or the slabs are subject to rocking under the movement of aircraft, subgrade support should be improved by pumping cement grout under the pavement to fill the voids that have developed. Pressure grouting requires considerable skill to avoid cracking slabs or providing uneven support for the overlay.

(1) If the pavement slabs are badly broken and subject to rocking because of uneven bearing on the subgrade, the rocking slabs can be broken into smaller slabs to obtain a more firm seating. Badly broken slabs that do not rock will not require repairs since the criteria make adjustments for such a condition in the pavement thickness. In some cases, it may be desirable to replace certain badly broken slabs with new slabs before starting construction of the overlay. The decision in such cases will have to be made according to the merits of the individual project.

(2) Where the existing pavement is rough due to slab distortion, faulting, or settlement, a provision should be made for a leveling course of bituminous concrete before the overlay is commenced.

(3) Cracks, and joints, 1/2 inch (1 cm) or more in width, should be filled with a lean mixture of sand and liquid bituminous material. This mixture should be tamped firmly in place, leveled with the pavement surface and any excess removed.

(4) After all repairs have been completed and prior to the placing of the overlay, the surface should be swept clean of all dirt, dust, and foreign material that may tend to break the bond between the overlay and the existing pavement. Any extruding joint-sealing material should be trimmed from rigid pavements.

(5) Bonded concrete overlays will require special attention to insure bond with the existing pavement. Acid etching or mechanical texturing is sometimes used to provide a surface which will allow bonding. A cement grout placed immediately ahead of the concrete overlay is recommended to promote bonding.

76. MATERIALS AND METHODS. With regard to quality of materials and mixes, control tests, methods of construction, and workmanship, the overlay pavement components are governed by AC 150/5370-10, Standards for Specifying Construction of Airports.

a. If a bituminous overlay is specified, the existing pavement should receive a light tack coat or fog coat immediately after cleaning. The overlay should not extend to the edges of the pavement but should be cut off approximately 3 inches (7.5 cm) from each edge.

b. After cleaning, existing concrete surfaces should be wetted prior to depositing the plastic concrete of a rigid overlay to insure as good a bond as possible.

c. Should the existing pavement require drilling to provide [illegible] for the overlay pavement forms, the size and number of holes [illegible] be the minimum necessary to accomplish that purpose. Holes [illegible] not be located close to joints or cracks. Location of holes [illegible] form anchors should be such as to avoid causing additional [illegible] or spalling.

77. NEW OVERLAY MATERIALS. In recent years, some new pavement overlay materials have been used with varying degrees of success. These materials include fibrous concrete, asbestos asphalt, and rubberized asphalt. Use of materials other than conventional portland cement concrete or asphaltic concrete should be subject to case-by-case approval.

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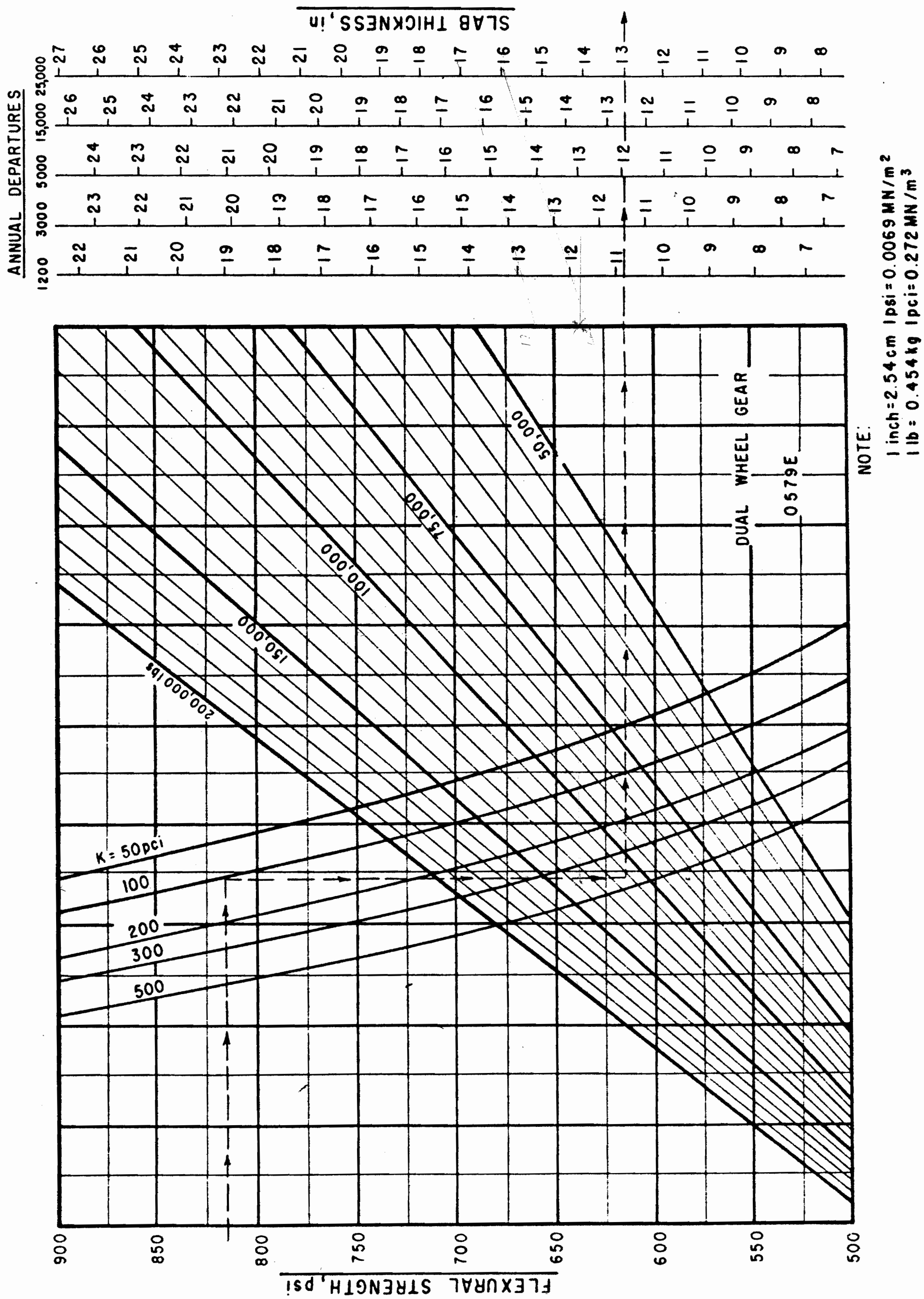

FIGURE 3-15. RIGID PAVEMENT DESIGN CURVES - DUAL WHEEL GEAR

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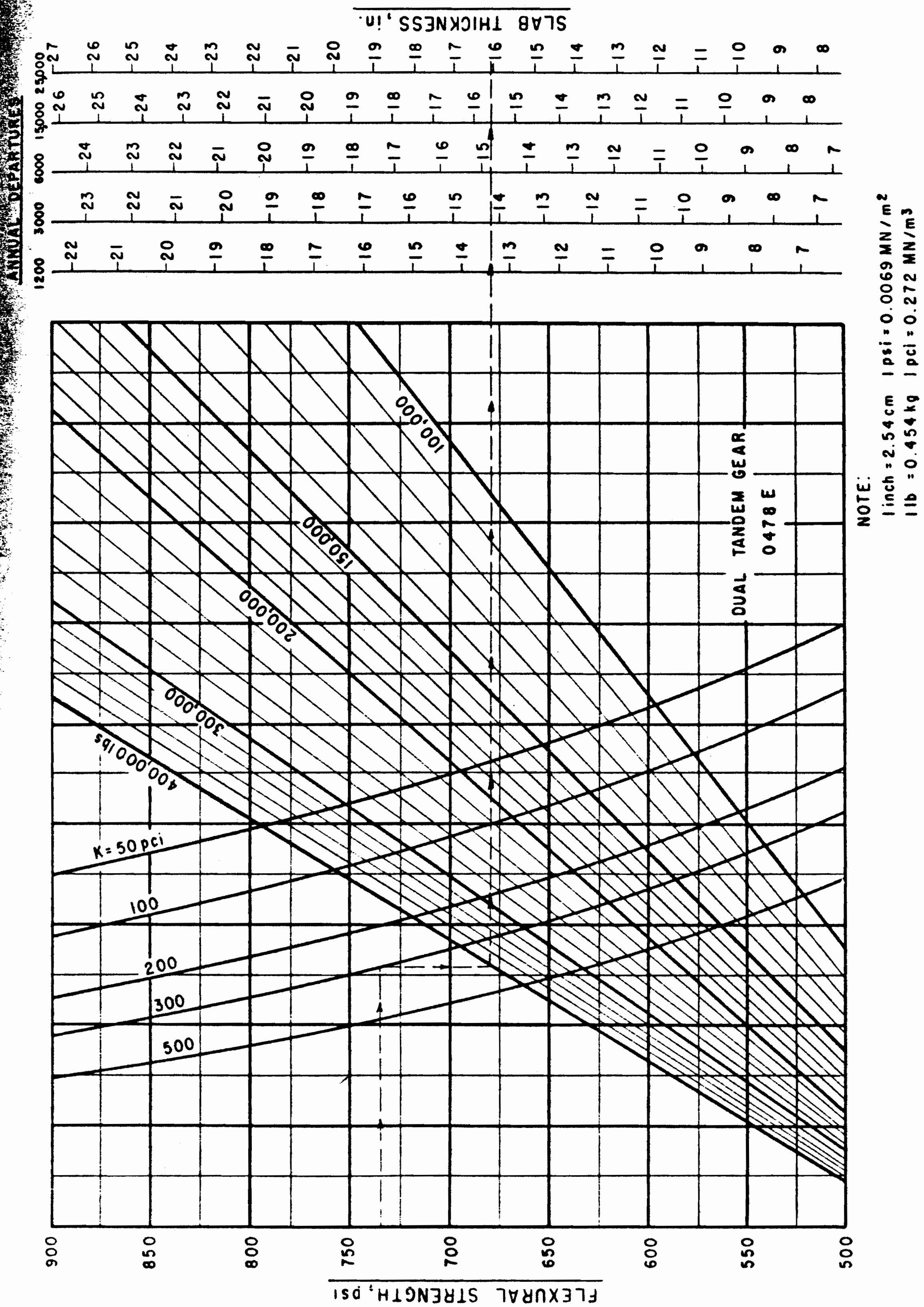


FIGURE 3-16. RIGID PAVEMENT DESIGN CURVES - DUAL TANDEM GEAR

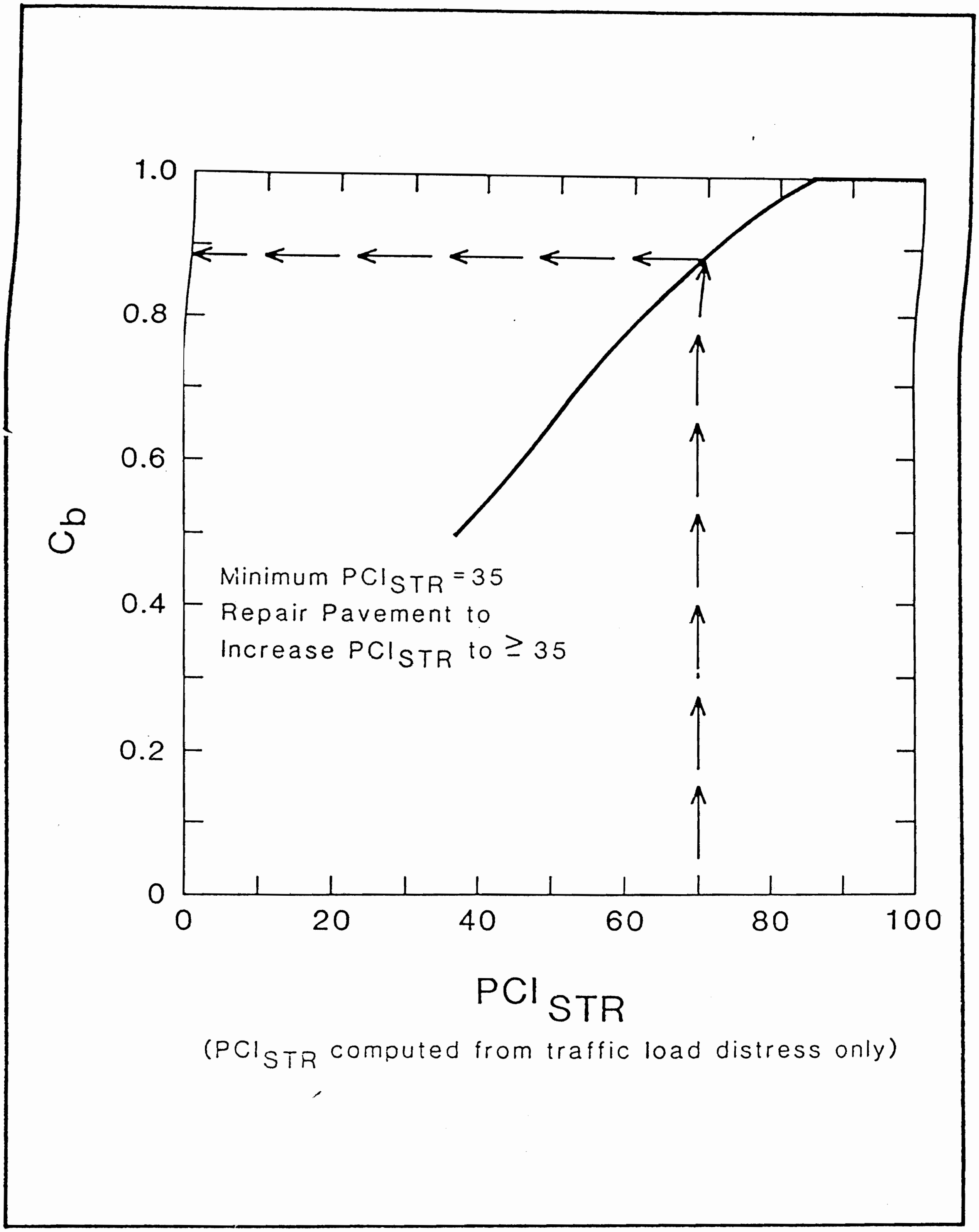
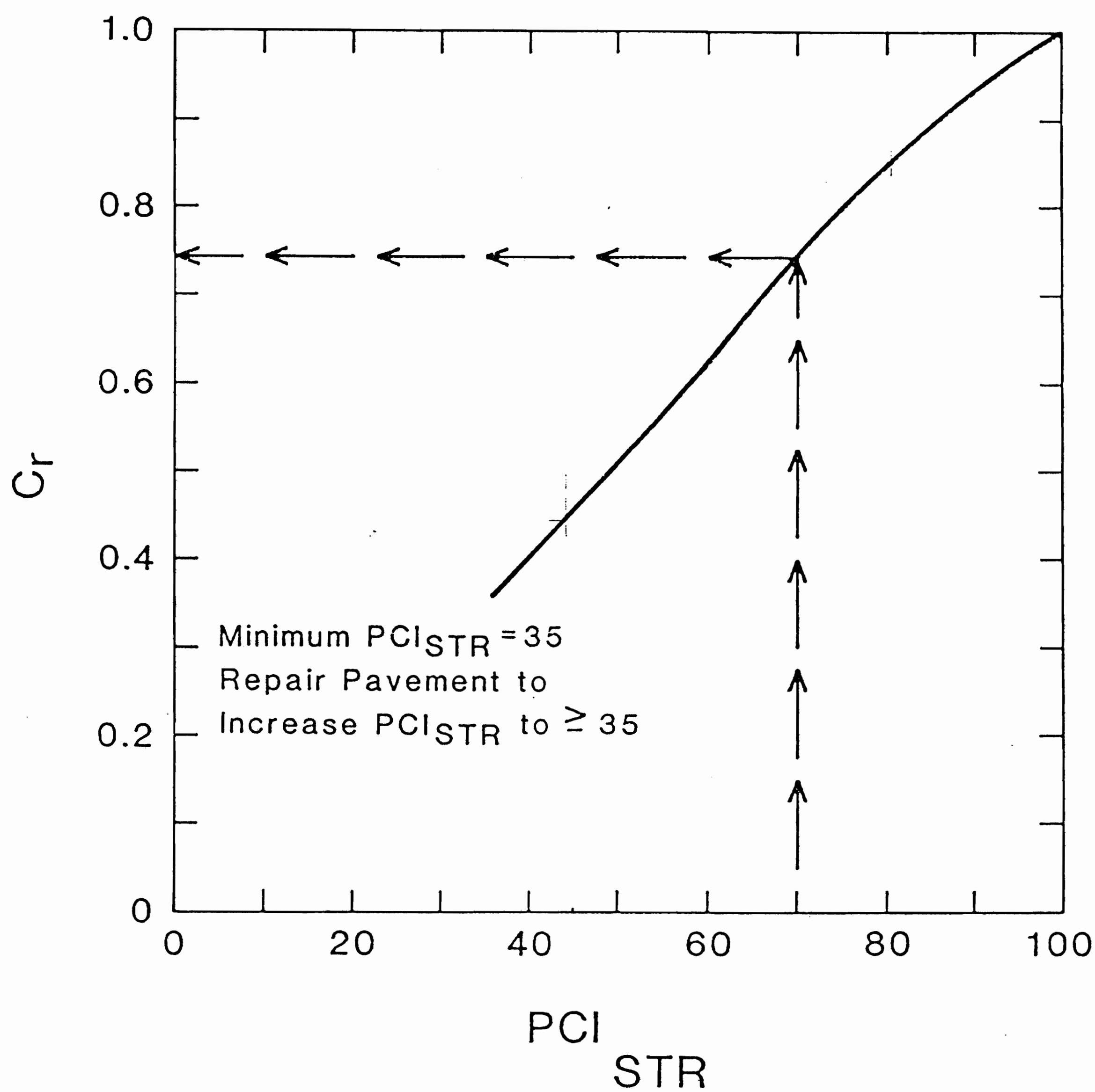


FIGURE 26

Chart for Determining C_b (for Flexible Overlays)

NAVY DM 21.04
1986



REFERENCE: Shahin, M. Y. and Darter, M. I., "Rehabilitation Design For Airfield PCC Pavements," 2nd International Conference on Concrete Pavement Design, 1981.

FIGURE 25
Chart for Determining C_r (for Rigid Overlays)

NAVY DM 21.04
1986

h_e = 10 in. $\qquad$ h = 14 in. $\qquad$ $h_c = \sqrt[n]{h^n - C_r h_e^n}$

DC-10-10 (450,000)
6000 Ann. Dep.

Bond / C_r	n = 1.0 Full	n = 1.4 Partial	n = 2.0 None
1.00	4 σ_B = 290	σ_B = 224 (full) to 345 (none) 7 σ_0 = 242	σ_B = σ_0 = 261 10
0.75	-	9	11
0.35	-	-	13

Table 2. Concrete Overlay Thickness.

h_e = 10 in. $\qquad$ h = 14 in. $\qquad$ $t = 2.5\ (Fh - C_b\ h_e)$

F / C_b	1.0	0.92	0.85
1.00	10 σ_B = 288	7	σ_B = 371 5
0.90	12.5	10	7
0.75	16 σ_B = 202	13.5	11

Table 3. Asphalt Overlay Thickness.

	Overlay Type	Overlay Thickness	Bond Type	Critical Base Slab Stress	Critical Overlay Stress
n = 1.0	Concrete	4 in.	Full Bond	290 psi	-
n = 2.0	Concrete	10 in.	None Unbonded	261 psi	261 psi
	Asphalt	10 in.	Full Bond	288 psi	-
partial	Concrete	7 in	None Full	345 224	242 —

Table 4. Calculated Critical Stress For Overlays.

PCI RATING	TYPE OF OVERLAY			
	BONDED CONCRETE	PARTIALLY BONDED CONCRETE	UNBONDED CONCRETE	ASPHALT CONCRETE
EXCELLENT	YES	NO (costly)	NO (costly)	NO (not normally required)
VERY GOOD	YES	YES	NO (costly)	NO (not normally required)
GOOD	YES (w/repair)	YES	NO (costly)	YES
FAIR	NO	YES (w/ repair)	YES	YES (w/repair)
POOR	NO	NO	YES	YES (w/repair)
VERY POOR	NO	NO	YES	NO
FAILED	NO	NO	YES (w/repair)	NO

Figure 23
General Guide for Type of Overlay Selection

NAVY DM 21.04
1986.

ASPHALT INSTITUTE METHOD

The Asphalt Institute's overlay design procedures are contained in the Asphalt Institute Manual Series 17 (MS-17) (13).

Overlay Design by Deflection Analysis

This method is used for designing AC overlays for asphalt pavements. It is based on elastic-layered theory and engineering experience with the use of deflections. The method requires an evaluation of the existing pavement to determine its strength and the traffic expected to use the facility. The assumptions associated with the procedure are: (a) the higher the level of pavement deflection is, the shorter the time will be until the pavement requires an overlay, (b) tolerable deflection is a function of traffic, and (c) the additional thickness of AC on an existing pavement will reduce the deflection to an acceptable level. In this procedure pavement deflection is measured with a Benkelman beam and the representative rebound deflection is determined. By using this value and the design traffic number (DTN), the AC overlay thickness is determined from Fig. 16. By entering the deflection on the abscissa of the chart and moving vertically to the design DTN curve (interpolate if necessary), the overlay thickness is read on the ordinate.

The rebound test procedure, using an 18-kip single axle load, is used with the Benkelman beam to measure deflections. The measured deflections are reduced to a representative rebound deflection, which is defined as the mean of the adjusted measured rebound deflections plus two standard deviations. Measured rebound deflections should be adjusted for temperature and the most critical period of the year for pavement performance. The representative rebound deflection equals $(\bar{X} + 2s)fc$ where $\bar{X}$ = arithmetic mean, s = standard deviation, f = temperature adjustment factor, and c = critical period adjustment factor (c = 1 for most critical period). Detailed procedures for arriving at each of these values are given in MS-17.

DTN, as used by the Asphalt Institute, is defined as the average daily number of equivalent 18-kip single axle load applications expected for the design lane during the design period. For overlay design, the design period is the number of years until the overlay is resurfaced. Methods of determining DTN are given in Asphalt Institute publications MS-17 and MS-1 (14). Kingham (15), in his derivation of the overlay design, has stated three principles inherent in the procedure. The first is that, for a given material, the higher the level of pavement deflection is, the shorter the pavement life will be. The second states that a tolerable deflection is a function of traffic and the third that additional thicknesses of asphalt concrete placed on the existing pavement will reduce the deflection, and, if sufficient thickness is added, the deflection will be reduced to a tolerable level. These principles suggest that a design method can be based on two relationships. The first relates tolerable deflection level to traffic while the second relates reduction in deflection to a thickness increase.

The traffic deflection relationship was established by examining a great deal of experience from various agencies. It involved looking at the WASHO and AASHO Road Test data, Benkelman's results, and experience in California, Canada, and several foreign countries. The experience of the various agencies is shown in Fig. 17. The Asphalt Institute adopted the heavy dark line in the figure as its design line. This is a conservative approach and, with it, the probability of an unsatisfactory design is very low. It should be noted that there is a gray area in the use of deflection criteria and judgment should be used in the selection of the design criteria. Furthermore, it should be stated that many different deflection measuring devices are used by the various agencies, ranging from light to heavy loadings, which may be either statically or dynamically applied. Users of these systems should be aware that the basic empirical cures for converting deflection to thickness of overlay are only valid when the measurements used are compatible with the curves.

Kingham states, "The assumption of a tolerable deflection related to future traffic use is not a wholly satisfactory failure criterion in terms of engineering mechanics. It is obvious that a traffic-deflection relationship will be different for different materials. However, considerable experience has been gained with pavement deflection on pavements having asphalt surfaces and granular bases, and this suggests that for this type of construction there is a relationship that can be put to practical use. Deflection is admittedly a crude parameter compared to more sophisticated parameters such as strain and stress, but it appeals to engineers because it is easily measured."

In establishing the thickness deflection relationship, the Asphalt Institute uses one of the major findings published at the 1967 Ann Arbor conference that elastic layered theory can be used to predict deflections (16).

An assumption used in the procedure is that the existing pavement and subgrade can be represented by an effective modulus, E_s. This modulus represents the foundation support to the overlay and is derived from the representative deflection by use of the Boussinesq equation:

$$d_s = \frac{1.5\ pa}{E_s}$$

where

d_s = representative pavement deflection (inches),
p = constant pressure, 70 psi,
a = radius of single plate, 6.4 inches, and
E_s = effective modulus.

This assumption has been made by numerous investigators and has been found to give a reasonable approximation to multilayer elastic theory.

The thickness of overlay required to reduce the representative deflection to a tolerable deflection can then be calculated from elastic layer theory. The Asphalt Institute used the two-layer relationship developed by Kirk (17) given below:

$$d_t = \frac{1.5\ pa}{E_s} \left[\left(1 - \frac{1}{\sqrt{1 + 0.8\left(\frac{t}{a}\right)^2}} \right) \frac{E_s}{E_p} + \frac{1}{\sqrt{1 + \left(0.8\ \frac{t}{a} \sqrt[3]{\frac{E_p}{E_s}}\right)^2}} \right]$$

where

d_t = tolerable pavement deflection (inches),
t = overlay thickness (inches), and
E_p = overlay modulus.

The design curves in Fig. 16 were determined by solving this equation for t using various values of d_t and E_s, which relate to design traffic and representative deflection as previously stated. The modulus of the AC overlay was assumed to be 500,000 psi, which Kingham states is typical for asphalt concrete tested at 1 cps on a cylindrical specimen at 70 F.

/

3.5 Overlay Design — Mechanistic Procedure
AC and PC Overlays

The need for pavement strengthening was evaluated for the 1-A apron for the B-747 and DC-10-30 aircrafts separately as required under this contract. The overlay must be designed to carry the following aircraft passes:

B-747: 1000 annual passes for 10 years = 10,000 total passes

DC-10-30: 1000 total passes

Since the overlay is to be designed for only one aircraft, a simplification of the normal ERES procedures can be made. If more than one heavy aircraft was to use the pavement, a different analysis would be conducted to analyze the need for strengthening the pavement (using the Miner's cummulative damage law).

The existing pavement does not show any sign of past load damage (e.g., broken slabs, corner breaks, pumping). If past load damage was evident, the Minor cummulative damage law would be employed as follows:

$$\text{Total Damage} = \underbrace{\sum \frac{n_p}{N_p}}_{\text{past damage}} + \underbrace{\sum \frac{n_f}{N_f}}_{\text{future damage}} \qquad \text{(Eq. 3.3)}$$

The past damage can be estimated two different ways, depending on the availability of past traffic loading data. If adequate data is available, then a summation of load damage can be made using the Minor damage law. However, if as is normally the case (as it is here), there is inadequate past traffic data (volume, weights, types), then the amount of past damage can be estimated using existing load associated slab cracking. ERES

Consultants, Inc. has procedures to accomplish this estimation. Since the Apron 1-A has no broken slabs from load, the past damage is neglected and assumed to be zero. This is one reason that a distress survey is critical to the evaluation.

The procedure used in this situation is as follows:

The pavement is characterized as described in Section 3.3 and each of the aircrafts are "loaded" onto the ILLISLAB finite element program at the critical joint position as described in Section 3.4. A series of stress calculations are made using the ILLISLAB finite element program over a range of overlay thicknesses as illustrated in Figure 3.21 for a given pavement and aircraft. The critical stress is still in the same location at the bottom of the slab parallel to the joint for the AC and the bonded PCC overlays. The critical stress for the unbonded PCC overlay is either at the bottom of the existing slab, or at the bottom of the new PCC overlay at the joint. The moduli and Poisson's ratio used for the AC and PCC overlays are as follows:

AC Overlay: E = 350,000 psi, u = 0.35

PCC Overlay: E = 4,000,000 psi, u = 0.20

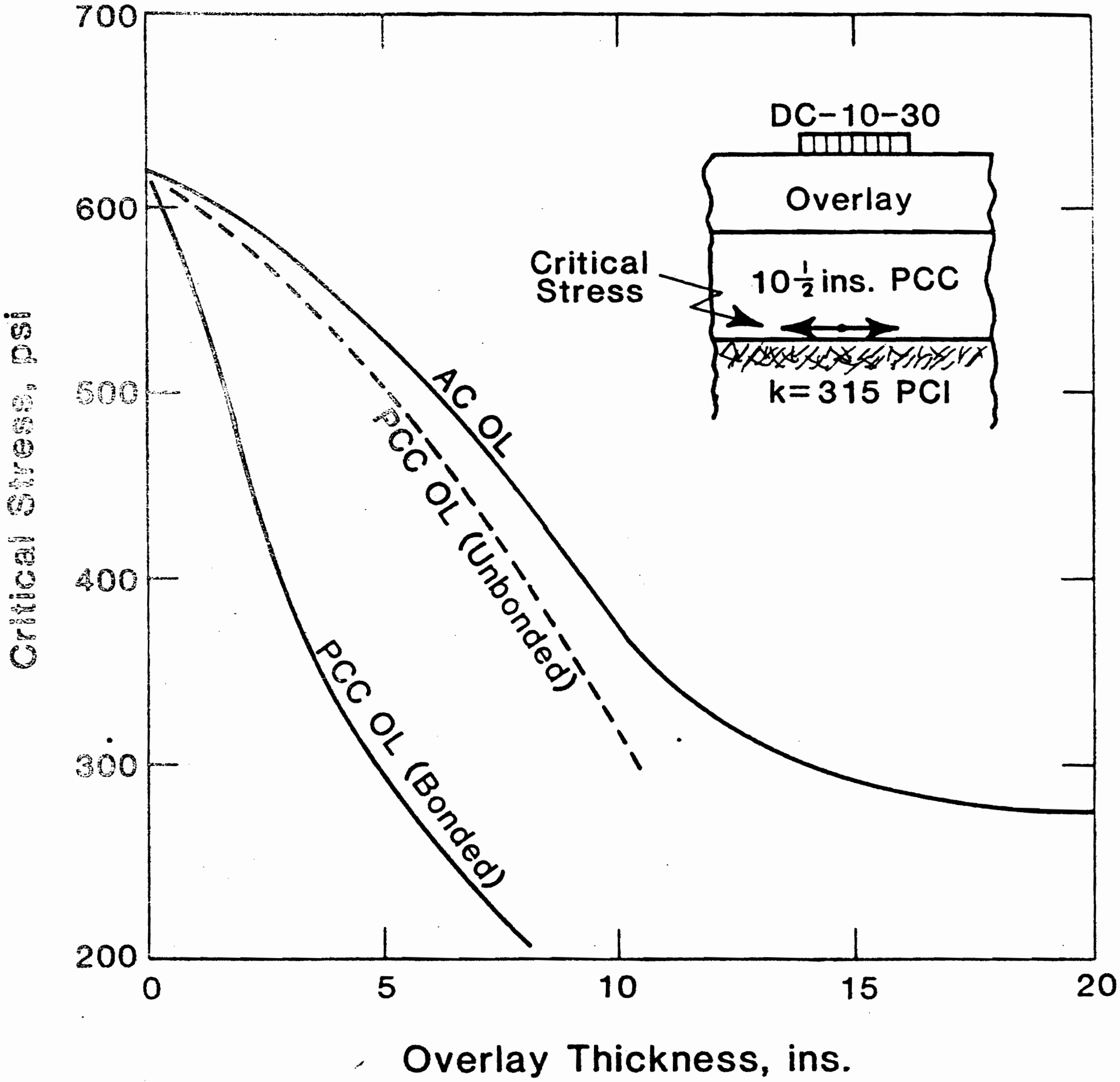


Figure 3.21: Illustration of Overlay Thickness and Type on Critical Slab Stress for DC-10-30 Aircraft and Apron 1-A

The same load transfer that exists in the base slab was used for the AC and PCC bonded overlay since they will not increase the load transfer at the joint (42 percent). The load transfer for the unbonded PCC overlay was increased to that normally used in new design for joints with mechanical load transfer or tied keyways (75 percent).

The number of aircraft coverages until slab cracking for each overlay thickness was then calculated using Equation 3.2 and the results are summarized in Figure 3.22 for both aircrafts. The allowable coverages were converted to passes.

Figures 3.23 and 3.24 give the plots for Apron 1-A showing overlay thickness versus the number of passes to 25 percent cracked slabs. Of course, any other failure criteria could of been used (e.g., 10 percent). A failure criteria of 25 percent is believed to be reasonable for major rehabilitation purposes.

Thus, the required overlay thicknesses can be determined from Figures 3.23 and 3.24 as:

B-747: 13.7 inches of AC for 10,000 passes
10.7 inches of unbonded PCC for 10,000 passes
5.8 inches of bonded PCC for 10,000 passes

Figure 3.22: Critical Stresses and Aircraft Passes for Apron 1A

Aircraft	OL Type	OL Thick (Ins.)	Critical Stress(S) (psi)	MR (psi)	MR/S	COV_{50}^{***}	COV_{25}^{x}	$Passes_{25}^{xx}$
DC-10-30*	AC	0	620	632	1.02	235	89	301
		4	550	632	1.15	464	177	598
		8	435	632	1.45	2226	849	2870
		12	322	632	1.96	32004	12210	41270
		20	174	632	3.63	$2x10^8$	$75x10^6$	$254x10^6$
	PCC (Bonded)	0	620	632	1.02	235	89	301
		1.6	478	632	1.32	1141	435	1471
		3.2	376	632	1.68	7439	2838	9593
		4.8	301	632	2.10	66412	25336	85637
		8	205	632	3.08	$11x10^6$	$4x10^6$	$15x10^6$
B-747**	AC	0	751	632	0.84	92	35	130
		4	683	632	0.93	147	56	207
		8	563	632	1.12	397	151	559
		12	437	632	1.45	2226	849	3142
		20	257	632	2.46	436717	166610	616455
	PCC (Bonded)	0	751	632	0.84	92	35	130
		1.6	615	632	1.03	244	93	346
		3.2	507	632	1.25	769	293	1085
		4.8	422	632	1.50	2855	1089	4030
		8	303	632	2.09	61771	23566	87194

*Gross Load = 590,000 lbf
**Gross Load = 820,000 lbf

***Eq. 3.2
$^{x}\log(COV_{50})-(.62x.675)$
COV to 25% slab crack

xx P/C DC-10 = 3.38
P/C 747 = 3.70

ERES

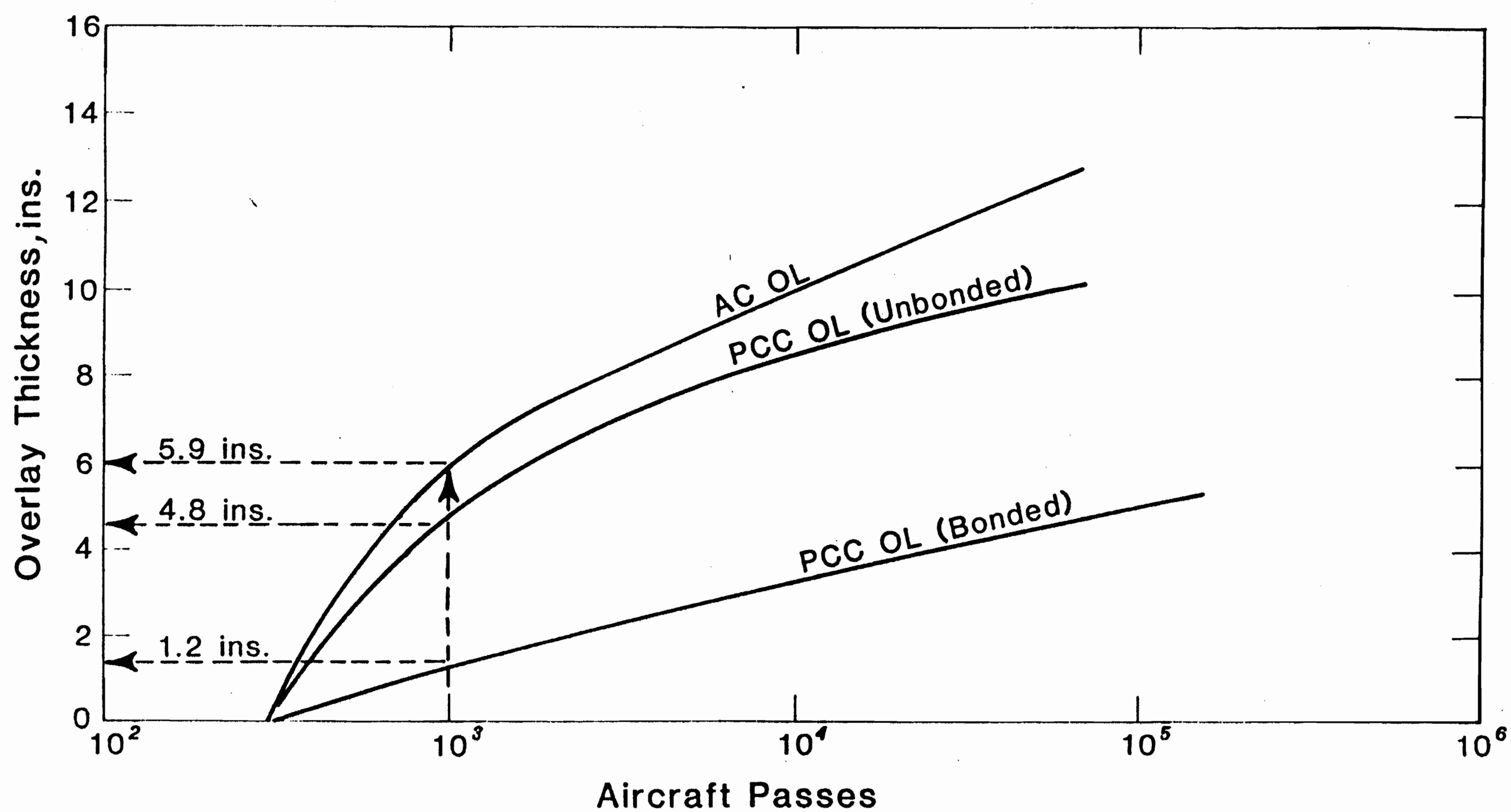


Figure 3.23: Overlay Thickness vs. Aircraft Passes (DC-10-30) for Apron 1-A (10.5 ins. PCC)

ERES

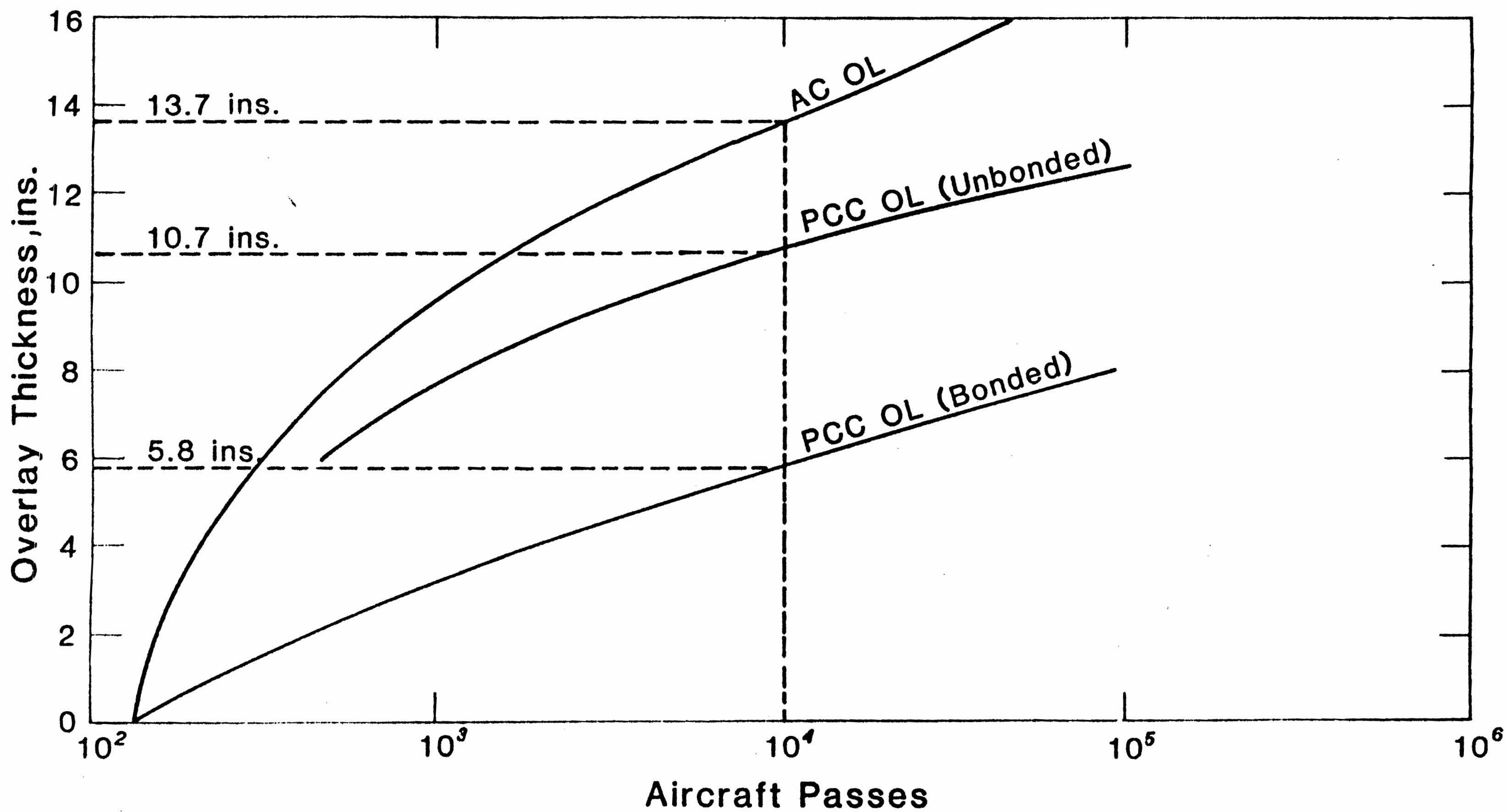


Figure 3.24: Overlay Thickness vs. Aircraft Passes (B-747) for Apron 1-A (10.5 ins. PCC)

ERES

DC-10-30: 5.9 inches of AC for 1,000 passes

4.9 inches of unbonded PCC for 1,000 passes
Use 6 inches for construction

1.2 inches of bonded PCC for 1,000 passes
Use 3 inches for construction