Design Procedures for Flexible And Bituminous Overlays

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I. Federal Aviation Agency Procedures

•THIS design procedure is for bituminous overlays rather than composite pavements; however, it is pertinent to the design of composite pavements.

The design of airport pavement overlays currently in use by the Federal Aviation Agency is well illustrated in their brochure on "Airport Paving." This brochure, published in November 1962, is a reprint of the Civil Aeronautics Administration's design procedure for airport paving. The following comments relative to overlay design have been extracted for inclusion in this summary report. Design procedures are suggested for flexible, bituminous, and concrete overlays in the FAA manual, however, the concrete overlays are not herein discussed due to their limited use. The manual contains several design examples. Figure 1 contains typical sections of overlay pavements.

Preliminary design information is required before the actual design can be made, including the following:

1. Determination of the soil group and subgrade class of soil underlying the existing pavement based on the FAA classification procedure.
2. Determination of the actual thickness of each layer of the existing pavement.
3. Based on the type overlay contemplated, a determination must be made of the pavement thickness required for the wheel loading and subgrade class under consideration.

After the above information has been assembled, the design may take one of several forms depending on the conditions under consideration. If it is a flexible or bituminous overlay to be applied to either a flexible or rigid pavement, certain general criteria must be followed.

1. Subbase courses will not be used in pavement overlays.
2. Nonbituminous base courses shall consist of crushed material.
3. A portion of the thickness of a bituminous overlay may consist of penetration macadam.
4. Bituminous overlays shall have a minimum thickness of 3 in.
5. Bituminous overlays greater than 3 in. thick may be planned for stage construction.
6. All materials must comply with FAA's "Standard Specifications for Construction of Airports" for base course of surface course.

With a foreknowledge of the above six criteria, the design may be made by one of two procedures.

FLEXIBLE AND BITUMINOUS OVERLAYS ON EXISTING FLEXIBLE PAVEMENTS

To use the design procedure involving flexible and bituminous overlays on flexible pavements, the basic curves shown in Figures 2 and 3 are used to determine a total pavement thickness to accommodate the desired wheel load. The difference between the existing total pavement thickness and the required total pavement represents the unadjusted thickness of overlay. Adjustment to the overlay thickness is made on the basis of the character and condition of the existing surface and the type of overlay base, as follows:

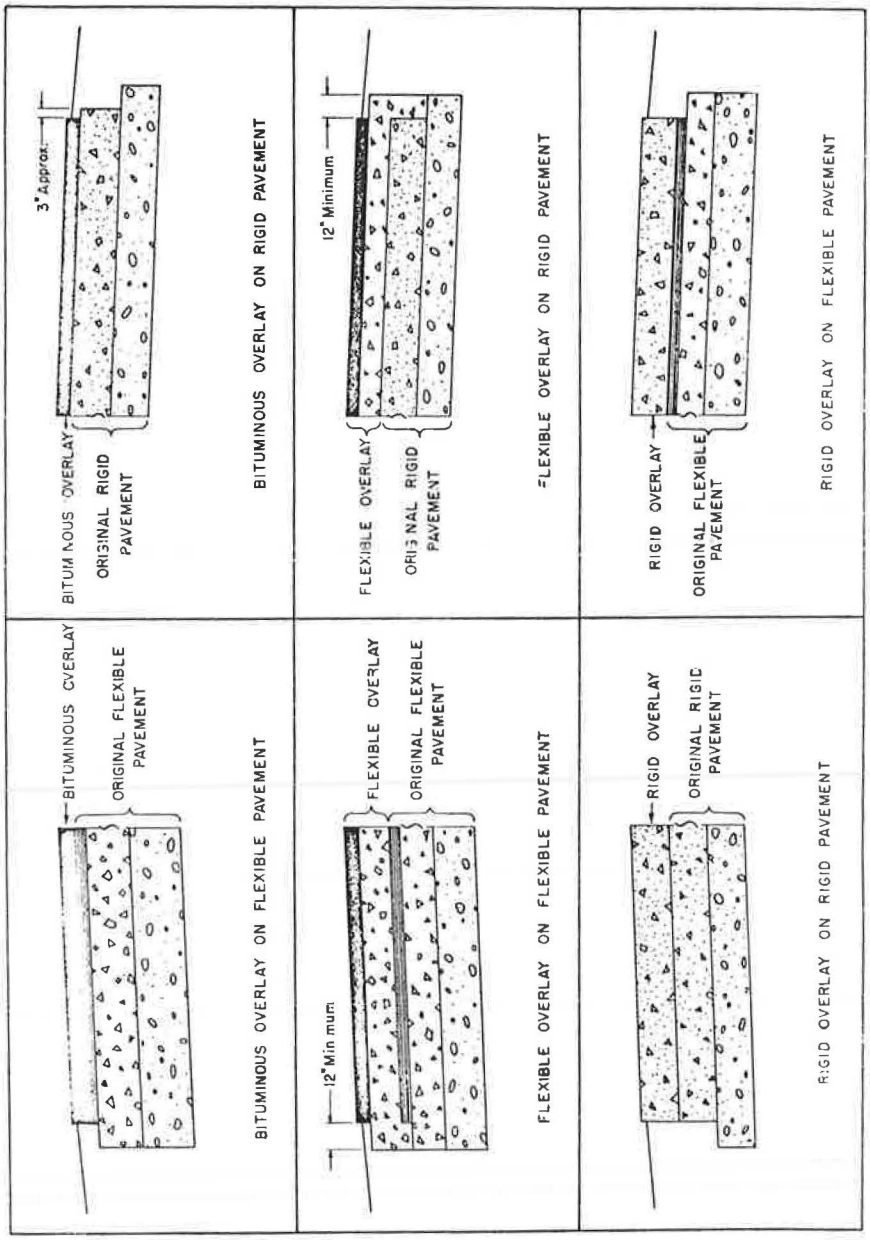


Figure 1. Typical sections of overlay pavements (FAA).

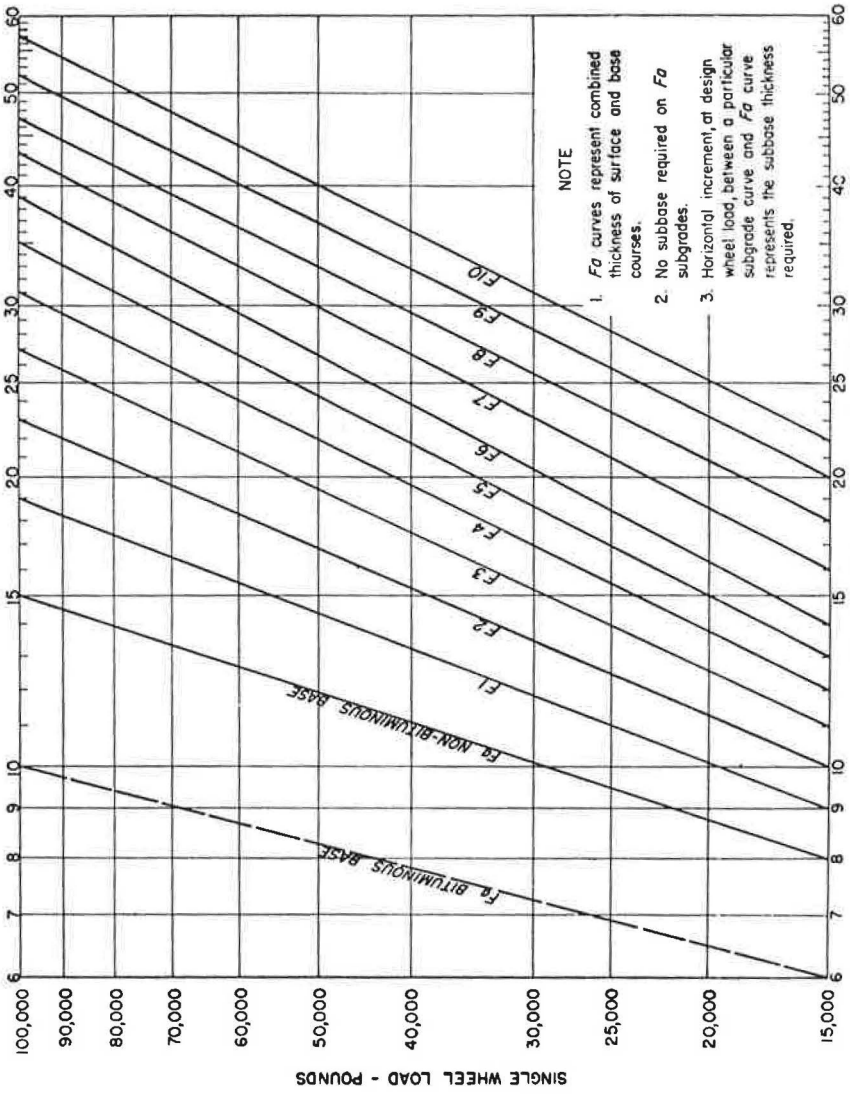


Figure 2. Design curves for flexible pavements, taxiways, aprons, and runway ends(FAA).

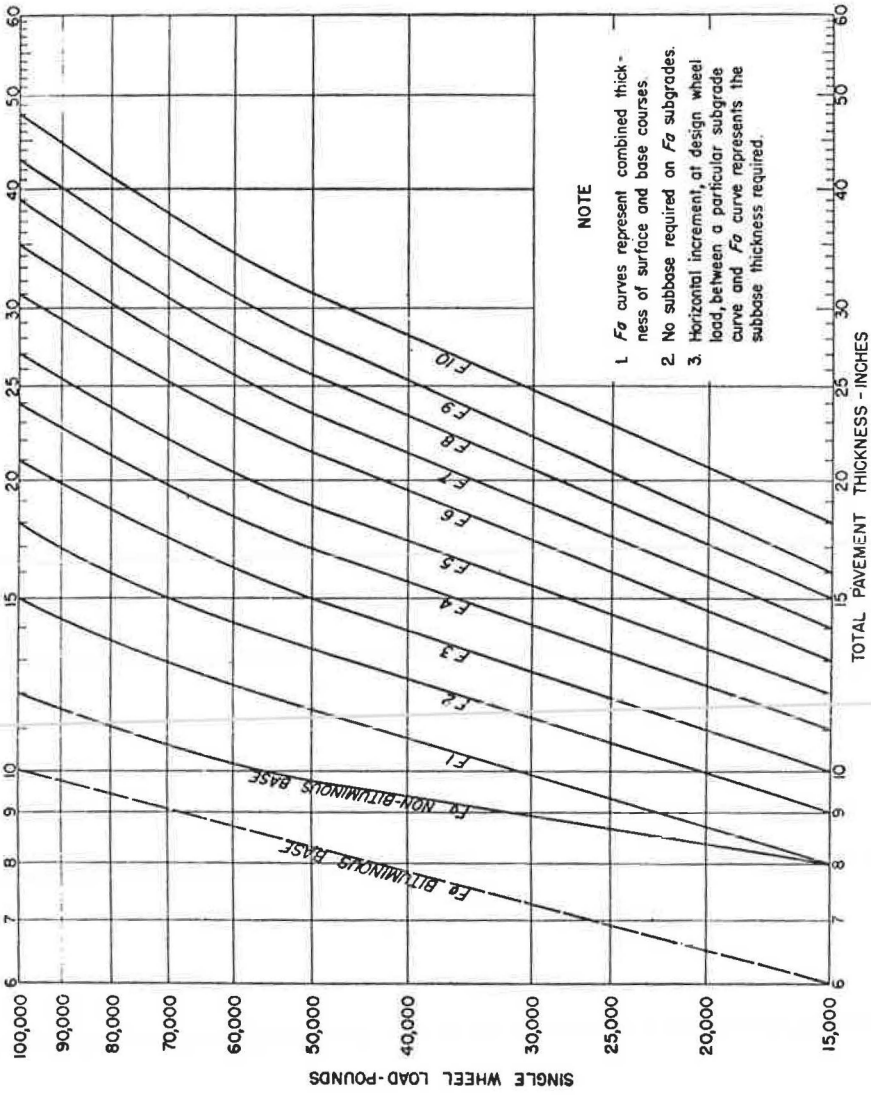


Figure 3. Design curves for flexible pavements—noncritical runway areas (FAA).

1. An existing dense-graded plant-mix bituminous surface, in sound condition, may be evaluated for base course purposes on the basis that each inch of such surface is equivalent to $1\frac{1}{2}$ in. of base course provided the entire overlay will consist of bituminous concrete.

2. Under all other conditions, the existing pavement will be considered, inch for inch, as base course.

3. If a bituminous base of the type specified by FAA as Item P-201 is to be used, a thickness adjusted may be made on the basis of 1 in. of such base being equivalent to $1\frac{1}{2}$ in. of nonbituminous base.

With regard to flexible overlays, the thickness of the nonbituminous base shall not be less than 4 in. unless the existing bituminous surface is broken to such an extent that it can be blended with the new base course material.

FLEXIBLE AND BITUMINOUS OVERLAYS ON RIGID PAVEMENTS

When a flexible or bituminous overlay is to be placed over an existing rigid pavement, the thickness of surface course is determined by the appropriate design curve. In all instances, the minimum thickness of base course is 6 in. To establish the required thickness of overlay, it is first necessary to determine the basic rigid pavement design thickness from the curves in Figure 4. This thickness is then modified by a factor F which represents the subgrade and subbase conditions under the existing concrete. Table 1 shows values for the factor F as related to the FAA subgrade classification system.

TABLE 1

FLEXIBLE AND BITUMINOUS OVERLAYS ON RIGID PAVEMENTS

Existing Subgrade Class	Value of F when Subbase Conforms to Requirements for Class of Subgrade:				
	Ra[1]	Rb	Rc	Rd	Re
Ra	0.80	—	—	—	—
Rb	0.90	0.80	—	—	—
Rc	0.94	0.90	0.80	—	—
Rd	0.98	0.94	0.90	0.80	—
Re	1.00	0.98	0.94	0.90	0.80

[1] Apply when no subbase has been provided.

The appropriate value for F is found in the column in Table 1 that represents the subgrade class that would have to prevail for the existing thickness of subbase to be adequate for the design wheel load. Having determined the value of F, the overlay thickness can be computed from one of the following formulas.

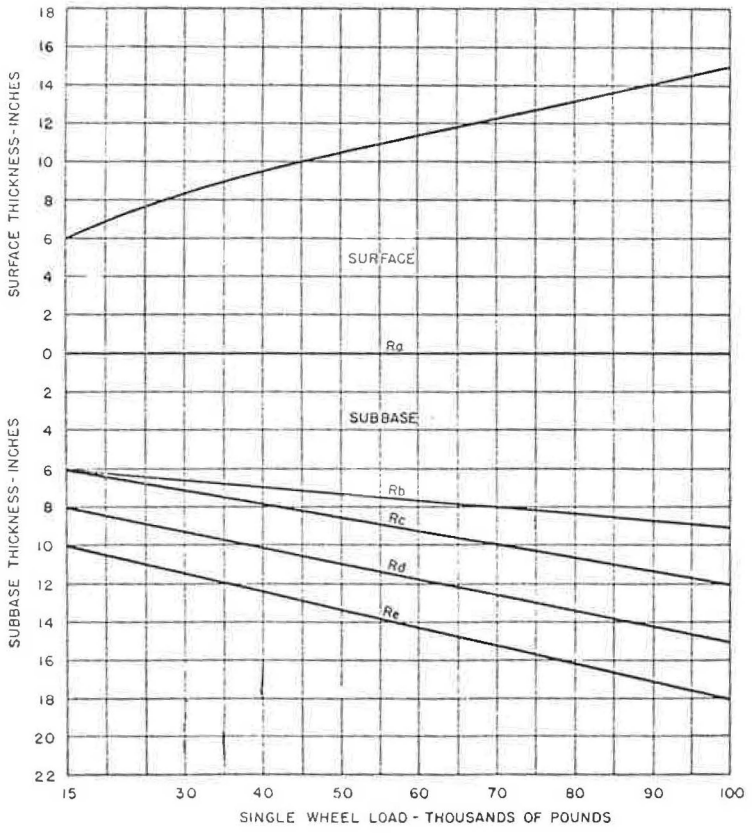


Figure 4. Design curves for rigid pavements, taxiways, aprons, and runway ends (FAA).

For flexible overlays:

$$t_f = 2.5\,(Fh - h_e) \tag{1}$$

in which

t_f = required thickness of flexible overlay;
F = factor which varies with subgrade class;
h = required thickness of an equivalent single slab placed on the subgrade or subbase; and
h_e = thickness of existing slab.

For bituminous overlays:

$$t_b = \frac{t_f}{1.5} \tag{2}$$

in which

t_b = required thickness of bituminous overlay; and
t_f = required thickness of flexible overlay.

In both the flexible and bituminous overlays, a minimum thickness of 6 in. is required for a nonbituminous base course and 3 in. for a bituminous overlay.

II. The Asphalt Institute Procedure

•THIS design procedure is for overlay pavements rather than composite pavements; however, it is pertinent to the design of composite pavements.

The following excerpts are from the manual on "Thickness Design of Asphalt Pavement Structures for Highways and Streets," as published by the Asphalt Institute in 1962.

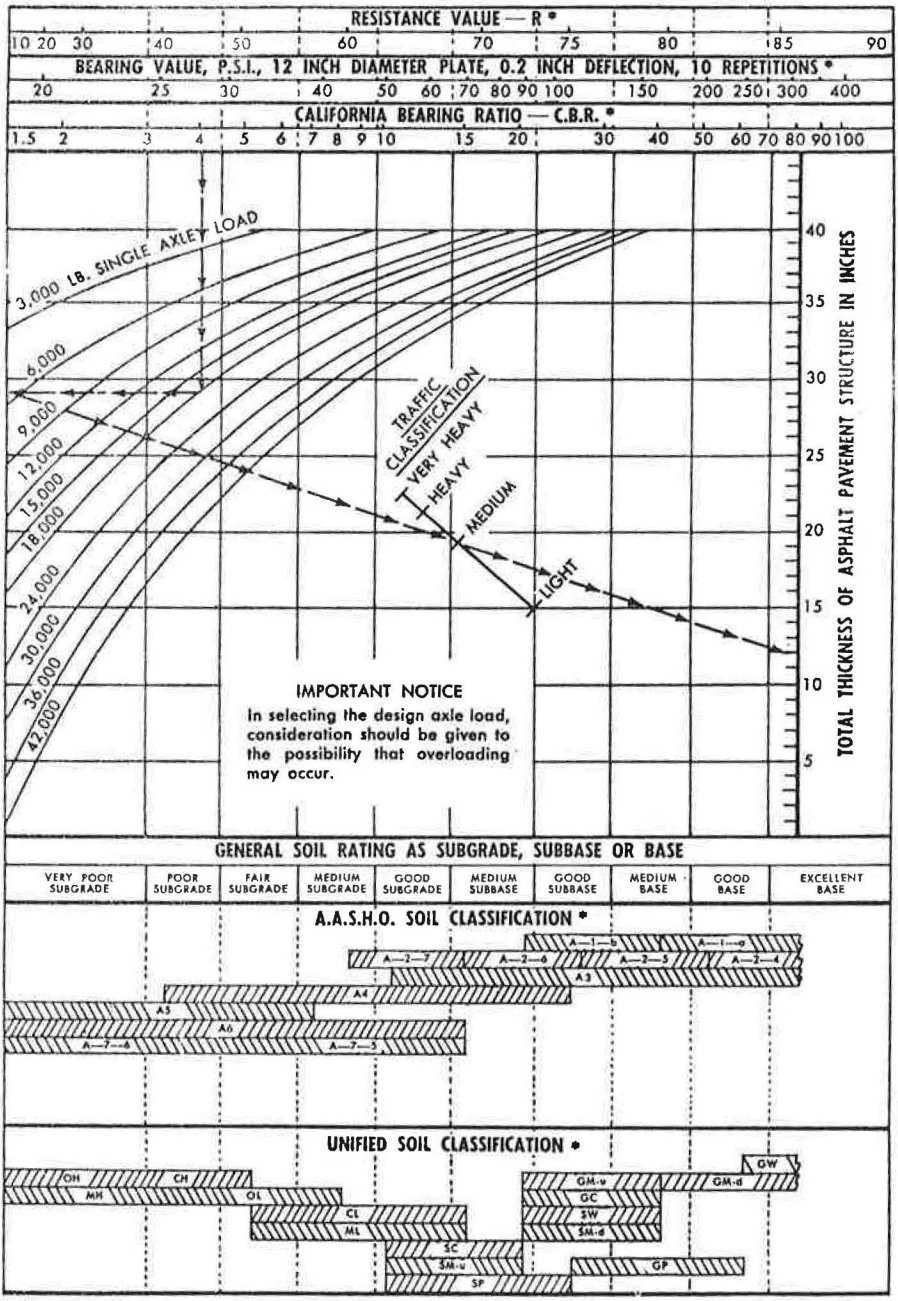
In this design procedure, existing pavements may be improved by overlaying with asphalt pavement or with a combination of asphalt pavement and asphalt base. Under certain conditions a high-quality, non-asphalt base may be included in the overlay. Such overlays may be considered in two categories:

1. Overlays to provide smooth, skid and water-resistant surfaces or to accomplish improvements in grade and cross-section.
2. Overlays to strengthen existing pavements to accommodate heavier loads or increased traffic.

In the first category, the overlay is usually constructed entirely of asphalt concrete, and the design thickness is determined by factors other than a required increase in pavement strength. When pavement strengthening is required, a thickness design procedure is warranted.

STRENGTHENING EXISTING ASPHALT PAVEMENTS

If an existing asphalt pavement structure requires strengthening to support heavier loads and higher volumes of traffic, the needed thickness of asphalt overlay may be arrived at by first establishing classification and strength characteristics of the existing pavement layers along with their thicknesses. After this information has been obtained, the new requirements of load and traffic are used to enter the design chart (Fig. 5) for the determination of required total thickness. The difference between existing thickness and required total thickness is the required thickness of overlay. In using the design chart, 1 in. of asphalt pavement surface is to be included in the total thickness. For any high-quality asphalt layer in the existing pavement, it may be considered that 1 in. of the asphalt layer is equivalent to 2 in. of non-asphalt base material.



In this chart the "R-Value" is only a part of the full "R-Value" design method as originated and used in California. The latter integrates an elaborate traffic census and analysis with the R-Value bearing test for materials proper, in which a traffic growth factor as well as types of vehicles and frequency is incorporated. It also includes a "cohesiometer" factor for the bituminous layer or layers, which is essentially a beam or panel action factor. For use in other areas as an integrated design method, the traffic growth factor should be modified to fit local conditions. For soils, an "exudation pressure" measurement and an "expansion pressure" measurement are used in the analysis of thickness requirements.*

Figure 5. Thickness requirements for asphalt pavement structures (Asphalt Institute).

STRENGTHENING EXISTING RIGID PAVEMENTS

The Asphalt Institute recognizes the design procedures established by the Corps of Engineers for strengthening rigid airfield pavements with asphalt overlays, but expresses caution for such use for highway pavements; that is, until the extent to which the design procedures are applicable to highways has been established. As an interim procedure, the design method currently in use by the Institute for the design of asphalt pavement structures is recommended.

To use the interim design procedure, it is necessary to assign certain equivalency factors (n) for evaluating the strength contribution of the existing rigid pavement. Based on Corps of Engineers tests, n factors have been selected as follows:

1. n = 1.5 to 2.0 for stable, non-pumping rigid pavement with some cracks but with no pieces smaller than about 1 sq yd in area.
2. n = 2.0 for nonreinforced, stable, non-pumping rigid pavements.
3. n = 2.5 for reinforced, stable, non-pumping rigid pavements.

Preliminary to the design, the following factors pertinent to the existing rigid pavement must be evaluated:

1. Strength of subgrade in terms of one of the systems shown on the design chart (Fig. 4).
2. Depth and strength of in-place granular base, if any.
3. Condition and construction features of existing rigid pavement for establishment of n factor.

With the preliminary design information, including the new loading and traffic volume for which the overlay is to be designed, an equivalent thickness of asphalt pavement structure may be determined from Figure 4. If a granular base is beneath the existing rigid pavement, its strength characteristics will determine if it is suitable to function as a subbase. The strength equivalency of the existing rigid pavement is then computed, and the required thickness of asphalt overlay may be established.

In case of an asphalt overlay over an existing rigid pavement having rocking or unstable slabs, slab support should be restored by undersealing.

In either of the above design procedures an overlay thickness of 6 in. or less should be constructed entirely of asphalt base and surface. If overlay thicknesses greater than 6 in. are required, a non-asphalt granular base course may be included provided it can be adequately drained. When drainage of the layer is questionable, the full depth of overlay should be asphalt construction.