CHAPTER 4. AIRPORT PAVEMENT OVERLAYS AND RECONSTRUCTION

400. GENERAL. Airport pavement overlays or reconstruction may be required for a variety of reasons. A pavement may require an overlay or reconstruction because the original pavement has served its design life and it is simply “worn out.” A pavement may also require an overlay or rehabilitation due to surface conditions or material-related distresses. A pavement may have been damaged by overloading in such a way that it cannot be economically maintained at a serviceable level. Similarly, a pavement in good condition may require strengthening to serve heavier airplanes than those for which the pavement was originally designed. Generally, airport pavement overlays consist of either Portland cement concrete or hot mix asphalt concrete. Techniques and equipment are now available to recycle old pavement materials into reconstructed sections. Pavements that are severely distressed in the center portions can sometimes be economically rehabilitated by reconstructing the keel section. The reconstruction method can consider using recycled materials.

401. CONDITION OF EXISTING PAVEMENT. Assessment of the condition of the existing pavement is one of the most important and difficult steps in design of a reconstruction or overlay project. Measurement of the properties of the existing pavement should include the thickness, condition, and strength of each layer; the subgrade soil classification; and some estimate of foundation strength (CBR or subgrade modulus). An assessment of the structural integrity of the existing pavement is necessary. The overlay design procedures in this AC assume that the overlay is to be placed on a base pavement with significant structural integrity. Problems such as alkali-silica reactivity in existing rigid pavements should be addressed, and if necessary mitigated, prior to overlay. Severely distressed areas in the existing pavement should be carefully studied to determine the cause of the distresses and to determine potential mitigation. Subsurface drainage conditions should be assessed carefully and corrected if found to be deficient. In some instances, subsurface drainage corrections are best performed through reconstruction. Overlaying an existing pavement without correcting poor subsurface drainage will usually result in poor overlay performance. A valuable technique for assessing the structural condition of the existing pavement is nondestructive pavement testing (NDT) (see AC 150/5370-11, Use of Nondestructive Testing Devices in the Evaluation of Airport Pavement, Appendix 4). NDT can be used to estimate foundation strength, measure joint load transfer, and possibly detect voids in existing pavements. NDT can also be used to determine structural capacity, to assist with calculating PCN, and to assess areas of localized weakness.

402. MATERIAL SELECTION CONSIDERATIONS. Criteria are presented in this circular for both hot mix asphalt and concrete reconstruction or overlays. The selection of the material type should be made after careful consideration of many factors. The designer should consider the total life cycle cost of the reconstructed or overlay pavement (see DOT-FAA-RD-81/078, Appendix 4). Life cycle costs should include initial construction and maintenance costs over the design life of the pavement. Other considerations such as allowable downtime of the pavement and availability of alternate pavements to use during construction will have a significant impact on the material selected.

403. OVERLAY DESIGN. The remainder of this chapter is devoted to the design of overlay pavements. As previously mentioned, the design of reconstructed pavements is essentially the same as for new construction.

a. Typical Overlay Cross Sections and Definitions. Typical overlay pavement cross sections are shown in figure 4-l. Definitions applicable to overlay pavements are as follows:

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

(2) Hot Mix Asphalt Overlay. Hot mix asphalt pavement placed on an existing pavement.

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

(4) Sandwich Pavement. Overlay pavement sections containing granular separation courses between the old and new impervious surfaces are called sandwich pavements.

b. Sandwich Pavements. Regardless of the type of overlay, FAA criteria do not permit the construction of sandwich overlay pavements. They are not allowed because the granular separation course usually becomes saturated with water and provides poor or, at best, 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. The trapped water drastically reduces the stability of the overlay. However, where an existing concrete surface layer over a stabilized subbase is rubblized prior to placement of a HMA or PCC overlay, the overlaid structure should not be considered sandwich construction.

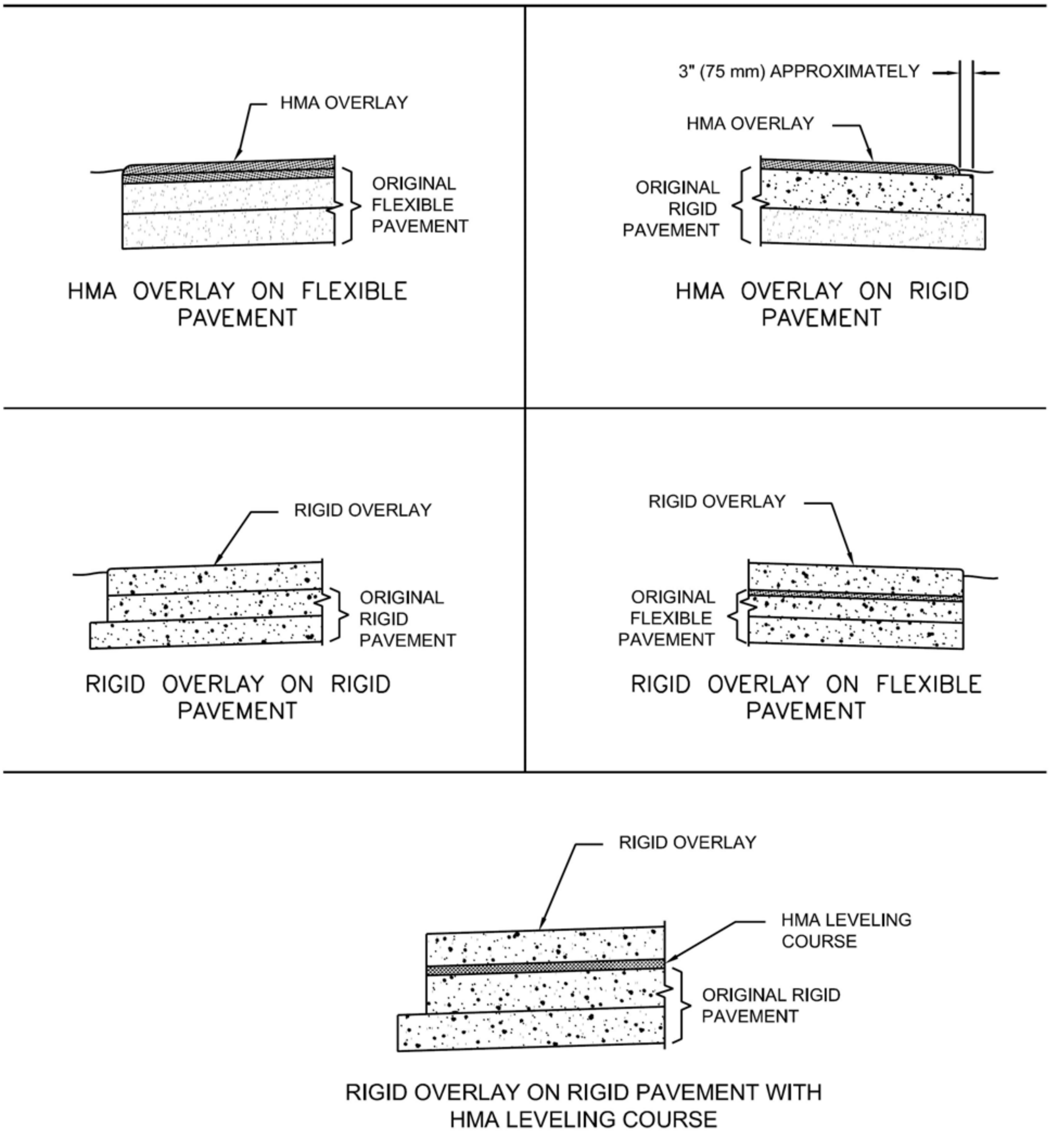


FIGURE 4-1. TYPICAL OVERLAY PAVEMENTS

c. FAARFIELD Overlay Design. The layered elastic and three-dimensional finite element methods as implemented in the FAARFIELD program allow a direct approach for overlay design. FAARFIELD calculates the thickness of overlay required to provide a 20-year life, which satisfies the layered elastic failure criteria for limiting stress or strain. The 20-year life thickness is defined as the design thickness. Report DOT-FAA-PM-87/19, Design of Overlays for Rigid Airport Pavements (see Appendix 4), describes the developed through an FAA-funded research effort design method for overlays of rigid pavement. Overlay pavements are grouped into four different types as follows:

(1) Hot Mix Asphalt Overlay of Existing Flexible Pavement
(2) Concrete Overlay of Existing Flexible Pavement
(3) Hot Mix Asphalt Overlay of Existing Rigid Pavement
(4) Concrete Overlay of Existing Rigid Pavement

404. OVERLAYS OF EXISTING FLEXIBLE PAVEMENTS. The design of an overlay for an existing flexible pavement is essentially the same as designing a new pavement. The existing flexible pavement is characterized by assigning the appropriate thicknesses and moduli of the existing layers. A qualified engineer should be consulted to characterize the existing pavement layers.

a. Hot Mix Overlay of an Existing Flexible Pavement. A trial thickness of overlay is selected and the program iterates until a CDF of 1.0 is reached. The overlay thickness required to achieve a CDF of 1.0 is the design thickness. However, the minimum hot mix overlay of an existing flexible pavement is 2 inches (50 mm).

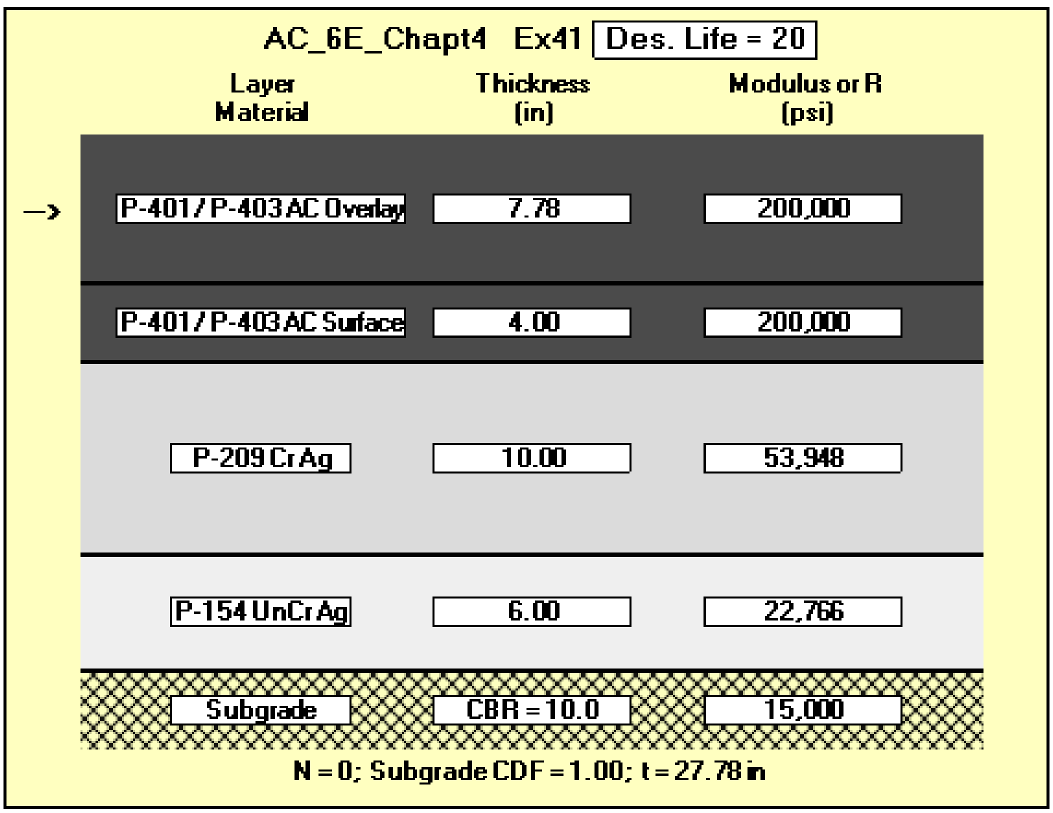


FIGURE 4-2. DESIGN EXAMPLE OF FLEXIBLE OVERLAY ON EXISTING FLEXIBLE PAVEMENT

(1) Example. To illustrate the procedure of designing HMA overlay, assume an existing taxiway pavement composed of the following section: the subgrade CBR is 10, (*E* is 15,000 psi (103.42 MPa)), the HMA surface course is 4 inches (102 mm) thick, the standard base course (P-209) is 10 inches (254 mm) thick, and the subbase (P-154) is 6 inches (152 mm) thick. Frost action is negligible. Assume the existing pavement is to be strengthened to accommodate the following airplane mix: DC10-10 weighing 458,000 pounds (207 745 kg) at an annual departure level of 2,263, B747-200B Combi Mixed weighing 873,000 pounds (395 986 kg) at an annual departure level of 832, a B777-200 ER weighing 634,500 pounds (287 804 kg) at an annual departure level of 425. The flexible pavement thickness required based on FAARFIELD for these conditions is—

P-401 asphalt overlay	7.78 inches (198 mm)
P-401 asphalt surface	4.00 inches (102 mm)
P-209 standard base	10.00 inches (254 mm)
P-154 standard subbase	6.00 inches (152 mm)
Total pavement thickness	27.78 inches (706 mm)

The required overlay thickness of 7.78 inches (198 mm) will be rounded up to 8 inches (203 mm) as shown in figure 4-2. In this example the existing pavement structure does not require a stabilized base to accommodate airplanes weighting more than 100,000 pounds. The lack of stabilized base is compensated by designing thicker asphalt overlay than it would be required in case of stabilized base in place.

(2) Summary. Structurally, an 8 inch (203 mm) thick overlay should satisfy the design conditions. The overlay thickness calculated from structural considerations should be compared with that required to satisfy geometric requirements. Geometric requirements include, for example, provision of drainage, correcting crown and grade, meeting grade of other adjacent pavements and structures, etc. The most difficult part of designing hot mix asphalt overlays for flexible pavements is the determination of the properties of the existing pavement. Subgrade and subbase properties can be measured by conducting NDT. The subgrade and subbase must be at the equilibrium moisture content when field tests are conducted. Normally, a pavement that has been in place for at least 3 years will be in equilibrium. Procedures for calculating properties from nondestructive tests are contained in AC 150/5370-11.

b. Nonstructural Hot Mix Asphalt Overlays. In some instances overlays are required to correct nonstructural problems such as restoration of crown, improve rideability, etc. Thickness calculations are not required in these situations, as thickness is controlled by other design considerations or minimum practical overlay thickness. Although the overlay in this case is not necessary for structural requirements it may be included when computing pavement strength (PCN). 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).

c. Concrete Overlay of an Existing Flexible Pavement. The design of a concrete overlay on an existing flexible pavement is essentially the same as designing a new rigid pavement. The existing flexible pavement is characterized by assigning the appropriate thicknesses and moduli of the existing layers. A trial thickness of overlay is selected and the program iterates until a CDF of 1.0 is reached. The overlay thickness required to achieve a CDF of 1.0 is the design thickness. The design process is relatively simple; however, the characterization of the existing pavement layers requires judgment by a qualified engineer. The program assumes the interface between the concrete overlay and the existing flexible surface is frictionless. When frost conditions require additional thickness, the use of nonstabilized material below the rigid pavement overlay is not allowed, as this would result in a sandwich pavement. Frost protection must be provided by stabilized material. The minimum thickness for a concrete overlay of an existing flexible pavement should be 5 inches (130 mm).

(1) Example. To illustrate the procedure of designing a concrete overlay, assume an existing taxiway pavement composed of the following section: the subgrade CBR = 10 (equivalent to E = 15,000 psi (103.4 MPa) or k = 141 pci (38.4 MN/m^3) using the conversion formulas from paragraph 326), the HMA surface course is 4 inches (102 mm) thick, and the base course is 12 inches (305 mm) thick. Frost action is negligible. Assume the existing pavement is to be strengthened to accommodate the following airplane mix: DC10-10 weighing 458,000 pounds (207 745 kg) at an annual departure level of 2,263, B747-200B Combi Mixed weighing 873,000 pounds (395 986 kg) at an annual departure level of 832, and B777-200 ER weighing 634,500 pounds (207 804 kg) at an annual departure level of 425. The concrete overlay required based on FAARFIELD for these conditions is:

PCC overlay on flexible	15.41 inches (392 mm)
P-401 asphalt surface	4.00 inches (102 mm)
P-209 base	12.00 inches (305 mm)
Total pavement thickness	31.41 inches (789 mm)

Figure 4-3 shows the required concrete overlay thickness is 15.41 inches (392 mm), which is rounded up to the nearest 0.5 inch, or 15.5 inches (381 mm).

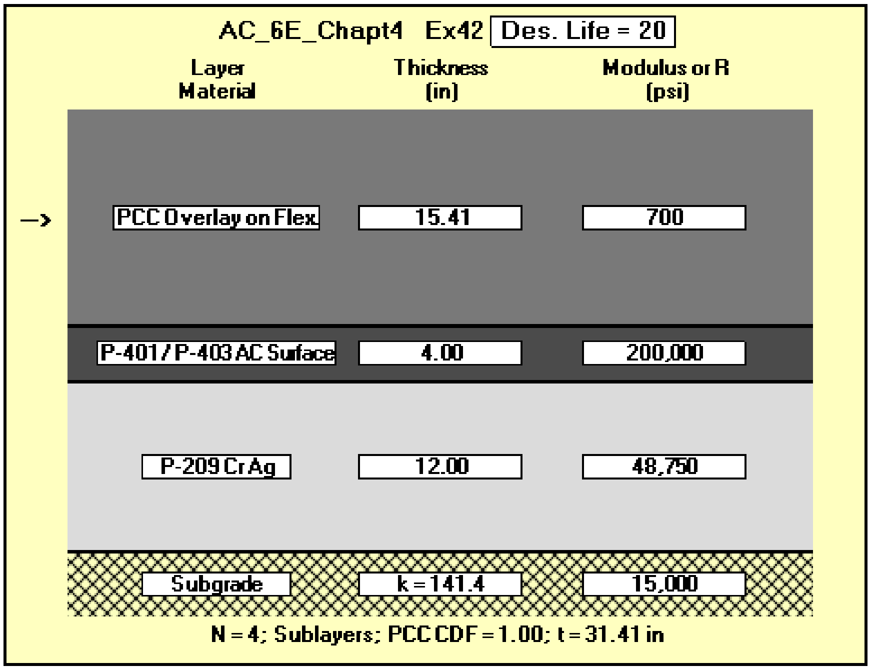


FIGURE 4-3. DESIGN EXAMPLE OF RIGID OVERLAY ON EXISTING FLEXIBLE PAVEMENT

405. OVERLAYS OF EXISTING RIGID PAVEMENTS. The design of overlays for an existing rigid pavement is complex because deterioration of the underlying pavement as well as deterioration of the overlay must be considered. The flexural strength of the existing rigid pavement can be determined using non-destructive testing (NDT), destructive methods or engineering judgment. The condition of the existing rigid pavement prior to overlay is important and is expressed in terms of the structural condition index (SCI) (see DOT-FAA-PM-87/19, Appendix 4).

a. Structural Condition Index (SCI). The SCI is derived from the pavement condition index (PCI) and it is the summation of structural components from PCI. Additional guidance on deriving an SCI is provided in the FAARFIELD user's manual. The PCI is a numerical rating indicating the operational condition of an airport pavement based on a visual survey. The scale ranges from a high of 100 to a low of 0, with 100 representing a pavement in excellent condition and 0 representing complete failure. The PCI is measured following ASTM D 5340, Standard Test Method for Airport Pavement Condition Index Survey (see Appendix 4). For rigid pavements, 15 different types of distresses are considered in measuring the PCI. These distress types all reduce the PCI of a pavement, depending on their severity and relative effect on performance. Not all distress types are indicative of structural distress. Report DOT-FAA-PM-87/19 identifies six distress types that are indicative of the structural condition of the pavement. Table 4-1 lists these six distress types. The SCI can be computed automatically with computer programs such as MicroPAVER, provided the distresses listed in table 4-1 are used to define the SCI.

TABLE 4-1. RIGID PAVEMENT DISTRESS TYPES USED TO CALCULATE THE STRUCTURAL CONDITION INDEX, SCI

Distress	Severity Level
Corner Break	Low, Medium, High
Longitudinal/Transverse/Diagonal Cracking	Low, Medium, High
Shattered Slab	Low, Medium, High
Shrinkage Cracks (cracking partial width of slab)[a]	Low
Spalling–Joint	Low, Medium, High
Spalling–Corner	Low, Medium, High

[a] Used only to describe a load-induced crack that extends only part of the way across a slab.
The SCI does not include conventional shrinkage cracks due to curing or other non load-related problems.

An SCI of 80 is the FAA definition of structural failure of a rigid pavement, and is consistent with 50 percent of slabs in the traffic area exhibiting a structural crack. The SCI allows a more precise and reproducible rating of a pavement's condition than the previous FAA condition factor ratings, C_b and C_r.

SCI can be calculated by the following equation:

$$\mathrm{SCI} = 100 - a \times \sum_{i=1}^{m_S} \sum_{j=1}^{n_j} f(T_i, S_j, D_{ij})$$

where:

a = adjustment factor (see ASTM D 5340)
m_s = total number of distress type related to the pavement structural failure
n_j = total number of severity levels for the ith distress
$f(T_i,S_j,D_{ij})$ = deduct value for distress type T_i, at the severity level S_j, existing at density D_{ij}.

b. Cumulative Damage Factor Used (CDFU). In the case when the SCI of the existing pavement is 100 (i.e., no visible distresses contributing to a reduction in SCI), the condition of existing pavement is described by the cumulative damage factor used (CDFU), which defines the amount of life that has been used by the existing pavement up to the time of the overlay. For aggregate base layers, and assuming that traffic on the pavement has been constant over time, a good estimate of CDFU can be obtained from:

$$CDFU = \frac{L_U}{0.75\, L_D} \quad \text{when } L_U < 0.75\, L_D$$
$$= 1 \quad \text{when } L_U \geq 0.75\, L_D$$

where:

L_U = number of years of operation of the existing pavement until overlay
L_D = design life of the existing pavement in years

This equation was derived from the empirical relationship between traffic coverages and SCI given in Report No. DOT-FAA-PM-87/19 and applies to pavements on conventional (aggregate) base. However, FAARFIELD implements a modification of this empirical relationship for higher quality base materials to account for the observed performance of rigid pavements on stabilized bases. This modification essentially increases the percent of design life remaining after the SCI starts to drop from 100 if the base and subbase layers are of higher quality than an 8-inch (203 mm) aggregate subbase (aggregate base thicker than 8 inches (203 mm) or stabilized base thicker than 4 inches (102 mm)). Hence, the simple relationship given above is not valid for such structures. In FAARFIELD, the percent CDFU is computed and displayed when the Life button is clicked in the STRUCTURE window.

The procedure for computing percent CDFU for a rigid pavement with SCI = 100 follows:

(1) Set up the structure based on the original design assumptions.

(2) Estimate the traffic that has been applied to the pavement and enter it into the airplane design list.

(3) Set “Design Life” to the number of years the pavement will have been in operation up to the time of overlay.

(4) Run Life.

The percent CDFU will be displayed when the computation is completed. Values of percent CDFU greater than 100 indicate that the procedure predicts that the SCI of the pavement should be less than 100. A value of 100 should then be entered for percent CDFU as input data for the overlay design. However, since the computation of percent CDFU will be based on estimated structure properties and traffic, the value is likely to be unreliable. An alternative procedure is to run Design Structure for the original structure with design life set to the actual design life, where actual design life is typically the 20 year design period. Then repeat the steps given above and use the new value of percent CDFU.

If it is suspected that the pavement has been subjected to more or heavier traffic than assumed in the Life computation, percent CDFU should be increased from the computed value. Setting percent CDFU to 100 will give the most conservative design.

For fully unbonded concrete overlay, the modulus of the base pavement varies as a function of the SCI of the base pavement when the SCI is less than 100. This computation is done automatically within FAARFIELD. The equations for the modulus reduction as a function of the SCI are given in Report No. DOT-FAA-PM-87/19.

Example. The following steps illustrate the procedure for calculating CDFU:

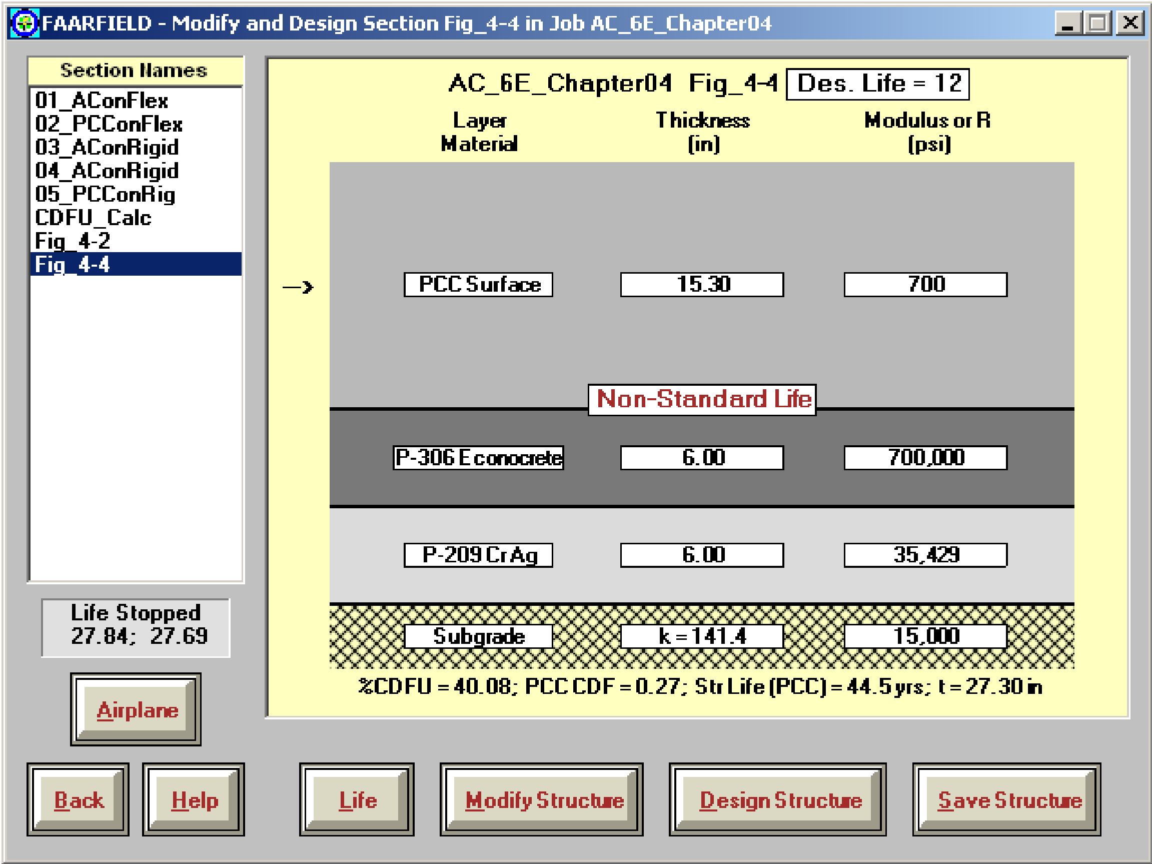


FIGURE 4-4. CDFU COMPUTATION USING FAARFIELD

(1) Set up the structure based on the original design assumptions. Assume an existing taxiway pavement composed of: 15.3 inch (388 mm) thick PCC surface course; 6 inch (152 mm) thick stabilized base course, Item P-306 Econocrete; 6 inch (152 mm) thick subbase course, Item P-209 Crushed Aggregate. The subgrade k-value is 141 pci (38.4 MN/m3), equivalent to an *E*-modulus of 15,000 psi (103.4 MPa). The existing pavement was designed to accommodate the following airplane mix: 2263 annual departures of the DC10-10 (gross taxi weight 458,000 lbs (207 700 kg)), 832 annual departures of the B747-200B Combi Mixed (gross taxi weight 833,000 lbs (377 800 kg)), and 425 annual departures of the B777-200 ER (gross taxi weight 634,500 lbs (287 800 kg)). The design life was 20 years.

(2) Estimate the traffic applied to the pavement and enter it into the airplane design list. Assume that the annual traffic levels actually applied to the pavement were: 1200 annual departures of the DC10-10, 300 annual departures of the B747, and 200 annual departures of the B777.

(3) Set “Design Life” to the number of years the pavement will have been in operation up to the time of the overlay. Assume that at the time of the overlay the taxiway will have been in operation for 12 years. In the “Structure” window, click on “Design Life” and change to 12 years. Figure 4-4 shows that the design life has been adjusted to 12 years.

(4) Run Life. The calculated percent CDFU will appear on the Structure screen, at the lower left of the pavement section. (See figure 4-4).

For the above case, FAARFIELD calculates percent CDFU equal to 40.08. For overlay design, the value CDFU = 40 percent would be used.

Higher traffic levels, heavier airplanes, or a longer "design life" will result in a higher calculated value of %CDFU. In this example, if the higher traffic levels used in the original design had actually been applied to the pavement, the percent CDFU computed by FAARFIELD would increase to 87.21.

c. Hot Mix Asphalt Overlays of Existing Rigid Pavements. The design process for hot mix overlays of rigid pavements considers two conditions for the existing rigid pavement to be overlaid: (1) SCI of the existing pavement less than 100; (2) SCI equal to 100.

(1) Structural Condition Index Less Than 100. The most likely situation is one in which the existing pavement is exhibiting some structural distress, i.e., the SCI is less than 100. If the SCI is less than 100, the overlay and base pavement deteriorate at a given rate until failure is reached. FAARFIELD assumes an initial overlay thickness and iterates on the overlay thickness until a 20-year life is predicted. A 20-year predicted life satisfies the design requirements.

(i) Example. To illustrate the procedure of designing a HMA overlay, assume an existing taxiway pavement composed of the following section: the subgrade *k*-value is 141 pci (38.4 MN/m^3), equivalent to an *E* modulus of 15,000 psi (103.42 MPa), the PCC surface course is 14 inches (356 mm) thick, the stabilized base course is 6 inches (152 mm) thick, and the subbase course is 6 inches (152 mm). Based on a visual survey, the existing pavement is assigned an SCI of 70. Frost action is negligible. Assume the existing pavement is to be strengthened to accommodate the following airplane mix: DC10-10 weighing 458,000 pounds (207 745 kg) at an annual departure level of 2,263, B747-200B Combi Mixed weighing 873,000 pounds (395 986 kg) at an annual departure level of 832, and B777-200 ER weighing 634,500 pounds (207 804 kg) at an annual departure level of 425. The flexible pavement overlay required based on FAARFIELD for these conditions is:

P-401 AC overlay	4.29 inches (109 mm)
PCC Surface	14 inches (356 mm)
P-304 Stabilized base	6 inches (152 mm)
P-209 Subbase	6 inches (152 mm)
Total pavement thickness	30.29 inches (770 mm)

The required overlay thickness is 4.29 inches (109 mm) and will be rounded up to 4.5 inches (114 mm) (See figure 4-5). The thickness generated by FAARFIELD does not address reflection cracking. Additional guidance on reflection cracking is provided in paragraph 405c(5).

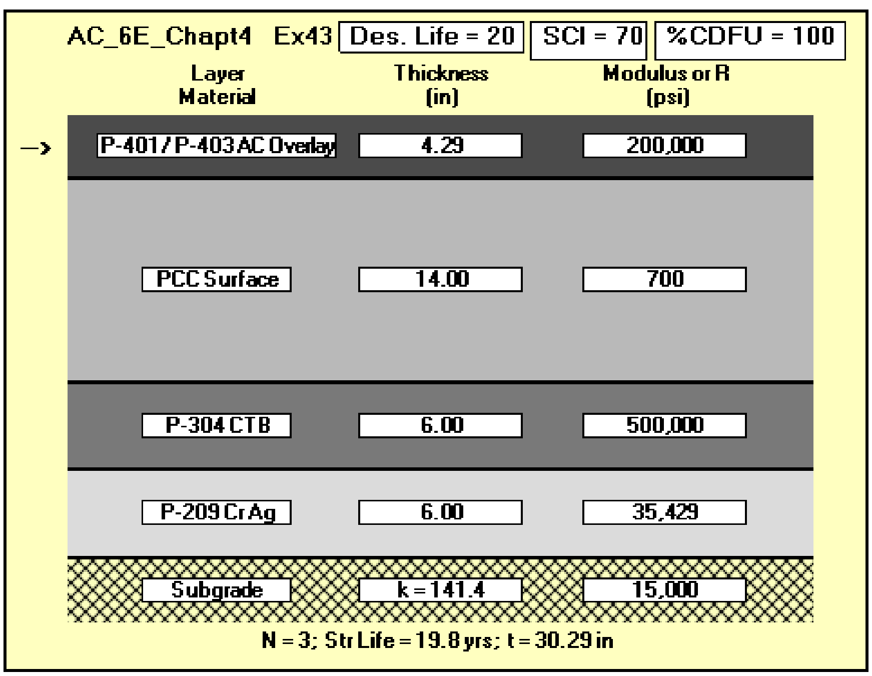


FIGURE 4-5. DESIGN EXAMPLE OF FLEXIBLE OVERLAY ON EXISTING RIGID PAVEMENT WITH SCI 70

(2) Structural Condition Index Equal to 100. An existing pavement with an SCI of 100 might require an overlay to strengthen the pavement in order to accept heavier airplanes. If the SCI of the base pavement is equal to 100, an additional input is required, the percent CDFU. FAARFIELD assumes the base pavement will deteriorate at one rate while the SCI is equal to 100 and at a different rate after the SCI drops below 100. As with case (1), a trial overlay thickness is input, and the program iterates on that thickness until a 20-year life is predicted. The design thickness is the thickness that provides a 20-year predicted life.

(i) Example. To illustrate the procedure of designing an HMA overlay, assume an existing rigid taxiway pavement. The existing pavement section and airplane mix is the same as the example in (1) above. Frost action is negligible. The SCI is 100 (there are no visible structural distresses), but based on an analysis of the traffic that has been applied by the pavement to date, the % CDFU is estimated to be 50 percent. The flexible pavement overlay required based on FAARFIELD for these conditions is:

P-401 AC overlay	3.25 inches (83 mm)
PCC Surface	14.00 inches (356 mm)
P-304 Stabilized base	6.00 inches (152 mm)
P-209 Subbase	6.00 inches (152 mm)
Total pavement thickness	29.25 inches (743 mm)

The required overlay thickness (as shown in figure 4-6) is 3.25 inches (83 mm), which will be rounded up to 3.5 inches (89 mm). The required overlay thickness is 1 inch (25.4 mm) less than the example in (1), reflecting the fact that the PCC is in better condition.

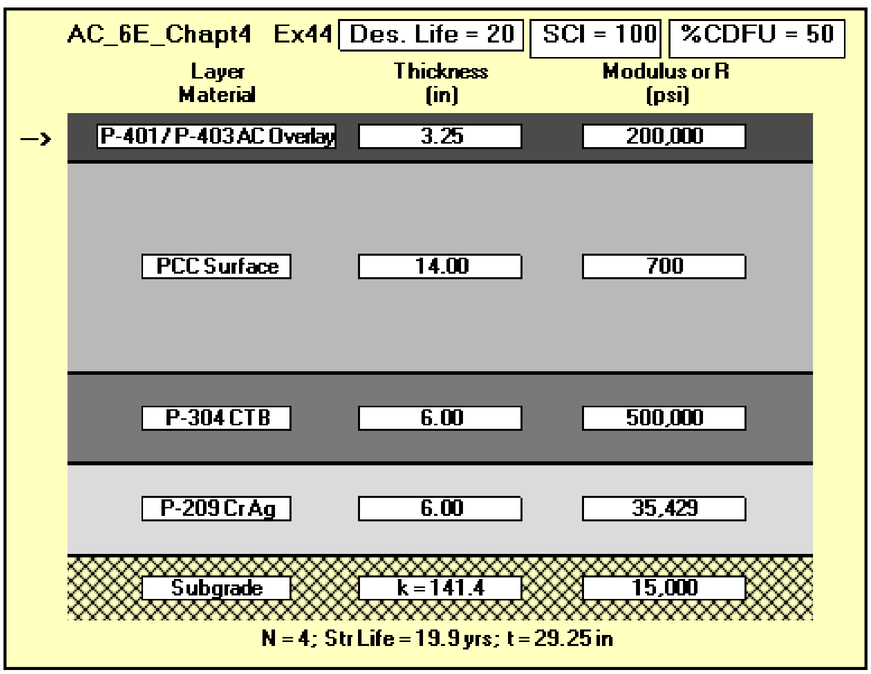


FIGURE 4-6. DESIGN EXAMPLE OF FLEXIBLE OVERLAY ON EXISTING RIGID PAVEMENT WITH SCI 100

(3) Previously Overlaid Rigid Pavement. The design of a hot mix asphalt overlay for a rigid pavement that already has an existing hot mix asphalt overlay is slightly different. The designer should treat the problem as if the existing hot mix asphalt 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. The condition of the rigid pavement should be determined using engineering judgment.

(4) Limitations. For hot mix asphalt overlay thickness, the FAARFIELD program assumes the existing rigid pavement will support load through flexural action. As the overlay thickness becomes greater, at some point the existing rigid pavement will tend to act more like a high quality base material. As the overlay thickness approaches the thickness of the rigid pavement, it may be more economical to treat the design as a new flexible pavement design on a high quality base material. For the new flexible case, the existing PCC should be considered as a variable stabilized (flexible) base layer with the modulus determined by engineering judgment. Both cases (HMA on rigid overlay, and new flexible on high quality base) should be tried, and the more economical design selected.

(5) Reflection Cracking In Hot Mix Asphalt Overlays. Reflection cracking is often a problem in hot mix asphalt overlays particularly overlays of rigid pavement. The thickness generated by FAARFIELD does not address reflection cracking. Numerous materials and techniques have been tried attempting to solve the problem with varying degrees of success. The following methods have met with some success:

(i) Coarse Aggregate Binders. The use of coarse aggregate binder course is recommended where economically feasible. Use of the largest practical size coarse aggregate in the hot mix asphalt layer immediately above the existing pavement is recommended. This practice provides some measure of protection against reflection cracking.

(ii) Rubblization of Existing PCC Pavement. If the condition of the existing rigid pavement is very poor (i.e., extensive structural cracking, joint faulting, “D” cracking, etc.), consideration may be given to using the rubblization technique. Subgrade support conditions must be considered, as weak subgrade support can cause difficulties in rubblizing the existing pavement and cause premature failures in the completed pavement. Rubblization involves purposely breaking the existing rigid pavement into small pieces and then rolling the broken pieces to firmly seat them in the foundation. A hot mix asphalt layer is then placed over the pavement. This type of section is designed as a flexible pavement, treating the broken rigid pavement as base course. Reflective cracking is reduced or eliminated with this type of construction (See AAPTP Report 04-01, Development of Guidelines for Rubblization, for additional information).

(iii) Engineering Fabrics. Research studies and field performance have shown that fabric membranes may be effective in retarding reflection cracking. While fabrics will not eliminate reflection cracking altogether, they do provide some degree of waterproofing beneath reflection cracks, thus protecting the existing pavement and foundation. At present, the waterproofing capability of fabrics, assuming the capacity of the asphalt impregnated fabric to resist rupture is not lost, appears to be the most significant contribution provided in a hot mix asphalt overlay system. Existing pavements, whether flexible or rigid, that show evidence of excessive deflections, substantial thermal stresses, and/or poor drainage, probably will exhibit no improvement by including a fabric in a structural overlay. The following conditions are recommended for fabric usage:

(iv) F**abric Properties.** The fabric should have a minimum tensile strength of at least 90 pounds (41 kg) when tested in accordance with ASTM D 4632 and a density in the range of 3 to 5.5 ounces per square yard (70 to 130 grams per square meter).

(v) Tack Coat. The proper amount of tack coat applied to the fabric is critical. Emulsified asphalt applied at a rate of from 0.15 to 0.30 gallons per square yard (0.7 to 1.4 liters per square meter) is recommended. The optimum amount of tack coat will depend on the type of fabric and the surface on which the fabric is placed.

(vi) Crack and Seat. The crack and seat process involves cracking a PCC layer into pieces typically measuring 1.5 to 2 feet (0.46 m to 0.6 m) and firmly seating the pieces into the subgrade prior to overlaying with asphalt concrete. It is an alternative method and should be evaluated by FAA Headquarters on a case-by-case basis.

(vii) Asphalt Reinforcement. Destructive tensile stresses in asphalt pavements may be reduced by incorporating a reinforcement material. Reinforcement materials are similar to fabric membranes except the reinforcement is either a woven fabric or a grid-shaped material. These materials have very high tensile strength and very low strain capacity. Products with a combination of fabric materials and reinforcement grids have been developed and appear to be successful in retarding reflective cracking. Depending upon the material type and the intended purpose, reinforcing materials may be applied across the full width of the pavement or may be limited to the immediate area around joints and cracks. FAARFIELD does not address asphalt reinforcement in the thickness design.

d. Concrete Overlays of Existing Concrete Pavements. The design of a concrete overlay of an existing rigid pavement is the most complex type of overlay to be designed. Deterioration of the concrete overlay and existing rigid pavement must be considered as well as the degree of bond between the overlay and existing pavement. FAARFIELD considers two degrees of bond and addresses each one separately for thickness design.

(1) Fully Unbonded Concrete Overlay. An unbonded concrete overlay of an existing rigid pavement is one in which steps are taken to intentionally eliminate bonding between the overlay and existing pavement. Commonly, the bond is broken by applying a thin hot mix layer to the existing rigid pavement. The interface friction coefficient between the overlay and existing pavement is set to reflect an unbonded condition. The interface coefficient is fixed and cannot be changed by the user. As with hot mix asphalt overlays, an SCI is required to describe the condition of the existing pavement. A trial overlay thickness is input and FAARFIELD iterates until a 20-year service life is predicted. The thickness that yields a 20-year service life is the design thickness. However, the minimum thickness for a fully unbonded concrete overlay is 5 inches (130 mm).

(i) Example. To illustrate the procedure of designing an unbonded concrete overlay, assume an existing taxiway pavement composed of the following section: SCI is 40 for the existing PCC surface, the subgrade k-value is 141 pci (38.4 MN/m3), corresponding to an *E*-modulus of 15,000 psi (103.42 MPa), the existing PCC surface course is 14 inches (102 mm) thick, the base course is 6 inches (305 mm) thick, and the subbase course is 6 inches (152 mm). Frost action is negligible. Assume the existing pavement is to be strengthened to accommodate the following airplane mix: DC10-10 weighing 458,000 pounds (207 745 kg) at an annual departure level of 2,263, B747-200B Combi Mixed weighing 873,000 pounds (395 986 kg) at an annual departure level of 832, and B777-200 ER weighing 634,500 pounds (207 804 kg) at an annual departure level of 425. Assume that the PCC strength is 700 psi for both the overlay and the existing concrete. The overlay structure computed by FAARFIELD for these conditions is—

PCC unbonded overlay	13.52 inches (343 mm)
Debonding layer	1.00 inches (25 mm)[1]
PCC Surface	14 inches (356 mm)
P-304 Stabilized base	6 inches (152 mm)
P-209 Subbase	6 inches (152 mm)
Total pavement thickness	39.52 inches (1 004 mm)

[1]Note: FAARFIELD does not include the debonding layer in thickness calculations.

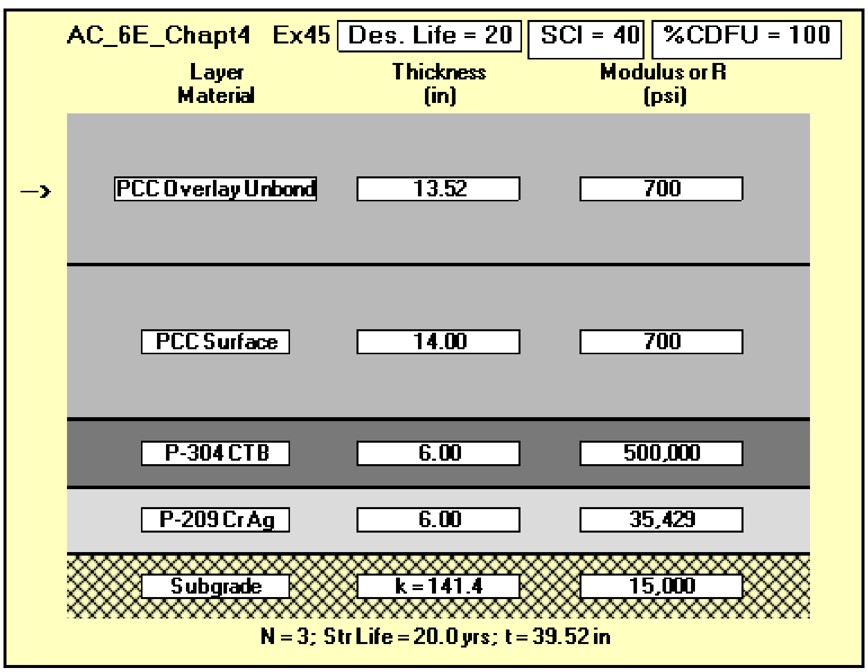


FIGURE 4-7. DESIGN EXAMPLE OF RIGID OVERLAY ON EXISTING FULLY UNBONDED RIGID PAVEMENT

Figure 4-7 shows the required overlay thickness is 13.52 inches (343 mm), which will be rounded to the nearest 0.5 inches, or 13.5 inches (343 mm).

(2) Bonded Concrete Overlays. Concrete overlays 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. In FAARFIELD, a bonded overlay can be designed as a new rigid pavement by treating the existing concrete surface and the concrete overlay as a combined single layer. The flexural strength used in the FAARFIELD computation should be the strength of the existing concrete. The thickness of the bonded overlay required is computed by subtracting the thickness of the existing pavement from the total thickness of the required slab as computed by FAARFIELD:

$$h_c = h - h_e$$

where:

h_c = required thickness of concrete overlay
h = required slab thickness computed by FAARFIELD using the flexural strength of the existing concrete
h_e = thickness of existing rigid pavement

Bonded overlays should be used only when the existing rigid pavement is in good to excellent condition. The minimum thickness of concrete overlay that is bonded to an existing rigid pavement is 3 inches (75 mm). 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 ensure the bond.

(3) 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.

(i) Joint Types. Joints need not be of the same type as in the old pavement except for some bonded overlay applications.

(ii) Isolation Joints. It is not necessary to provide an isolation joint for each isolation 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 isolation joint.

(iii) Timing. The timing for sawing joints is extremely critical on concrete overlays to minimize curling and warping stresses and prevent random cracking.

(iv) Contraction Joints. Contraction joints in unbonded overlays may be placed directly over or within 1 foot (0.3 m) of existing expansion, construction, or contraction joints. Joints in bonded overlays should be located within 0.5 inch (13 mm) of joints in the existing base pavement. Should spacing result in slabs too long to control cracking, additional intermediate contraction joints may be necessary.

(v) Joint Pattern. 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.

(vi) Reinforcement. Overlay slabs longer or wider than 20 feet (6.1 m) should contain embedded steel regardless of overlay thickness.

406. THICKNESS DESIGN FOR RUBBLIZED CONCRETE PAVEMENTS. Rubblization of deteriorated concrete pavements is becoming a popular method of pavement rehabilitation. The rubblization process destroys the slab action by breaking the concrete slab into 1- to 3-inch pieces at the top and 3- to 15-inch pieces at the bottom. The rubblized concrete layer behaves as a tightly keyed, interlocked, high-density non-stabilized base. The rubblized concrete base prevents the formation of reflective cracks in the asphalt concrete overlay and provides a sound base course.

The thickness design procedure for asphalt concrete overlay over a rubblized concrete base is similar to the asphalt overlay on flexible pavement. A rubblized PCC layer is available in FAARFIELD. The recommended modulus values for the Rubblized PCC layer range from 100,000-psi to 400,000-psi. Engineering judgment is required for the selection of an appropriate modulus value. The following ranges are suggested for selecting a design modulus value of rubblized PCC on airfields:

- For slabs 6 to 8 inches thick: Moduli from 100 to 135 ksi
- For slabs 8 to 14 inches thick: Moduli from 135 to 235 ksi
- For slabs >14 inches thick: Moduli from 235 to 400 ksi

The selected value is influenced by considerations such as level of conservatism in the design, exact slab thickness within the above ranges, pre-rubblized PCC modulus anticipated particle size, steel debonding conditions, and relevant historical data. For further insight into selecting a design modulus of rubblized PCC, reference AAPTP 04-01 .

For a rigid overlay placed over rubblized PCC, the thickness design procedure is similar to that for a new rigid pavement. Some engineering judgment is required for the selection of an appropriate modulus value for the rubblized PCC layer.

407. 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. Existing Flexible Pavements. Failures in flexible pavements may consist of pavement breakups, potholes and surface irregularities, and depressions.

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

When placing a concrete overlay on an existing asphalt pavement serious asphalt distresses such as subgrade failure, potholes, shoving, and rutting in excess of 2 inches need to be addressed prior to the overlay. Less severe surface irregularities and depressions may be corrected within the overlay. If the surface irregularity will cause the concrete overlay thickness to be less than the design thickness then it must be corrected prior to the overlay.

(3) Bleeding Surface. A bleeding surface may detrimentally affect the stability of the overlay and for this reason any excess hot mix asphalt material accumulated on the surface should be bladed or milled 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. Sweep after.

(4) Cracks and Joints. For cracks, and joints, 3/8 inch (10 mm) or more in width, old joint and crack filler should be removed and, if vegetation is present, a sterilant applied. The cracks and joints should then 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. The material should be allowed to dry to a hardened condition prior to overlay placement. For concrete overlays on existing asphalt pavement, joints and cracks may be cleaned and then filled as noted above or with a flowable fill material compatible with Item P-153, Controlled Low-Strength Material.

(5) Potholes. Repair potholes prior to overlay. Repairs may require removal and replacement of unstable subgrade materials. Complete repairs with a suitable mixture of bituminous material and compact in place.

(6) Grooves, Paint, Etc. It is not necessary to remove existing pavement grooves prior to an asphalt or concrete overlay. Paint must be removed or scarifed prior to an asphalt overlay to assure bonding of the overlay to the existing pavement. Paint does not require removal prior to a concrete overlay.

(7) Porous Friction Courses (PFC). Existing PFC's must be removed prior to any overlay.

(8) Surface Contaminants. Surface contaminants that will prevent bonding of the surface overlay, e.g. oil spills, must be removed prior to an asphalt overlay. The FAA recommends that excessive amounts of rubber buildup be removed prior to an overlay; however, limited amounts of rubber may be tolerated.

b. Existing Rigid Pavements. In rigid pavements, narrow transverse, longitudinal, and corner cracks will need no special attention unless there is an appreciable amount of displacement and faulting between 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 airplanes, subgrade support should be improved by pumping cement grout or specialized materials 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) Slab Removal and Replacement. 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) Leveling Course. Where the existing pavement is rough due to slab distortion, faulting, or settlement, a provision should be made for a leveling course of hot mix asphalt concrete before the overlay is commenced. Fractured slab techniques can also be used in these instances.

(3) Cracks and Joints. Cracks, and joints, 3/8 inch (10 mm) 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) Surface Cleaning. 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. Any extruding joint-sealing material should be trimmed from rigid pavements.

(5) Bonded Concrete Overlays. Bonded concrete overlays will require special attention to insure bond with the existing pavement. Surface cleaning and preparation by shot peening or mechanical texturing by cold milling are two techniques that have been used to provide a surface that will allow bonding. Adequate bond has been achieved by placing the overlay directly on the dry prepared surface. In other instances, bond was achieved by placing a neat cement grout on the prepared surface immediately ahead of the overlay placement. If a bonding agent is used, care must be taken to apply it directly in front of the fresh concrete. If the bonding agent is allowed to cure before concrete placement, the bond will be broken.

408. 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 (see Appendix 4).

a. Tack Coat. If a hot mix asphalt overlay is specified, the existing pavement should receive a light tack coat (Item P-603) 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 (75 mm) from each edge.

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

409. NEW OVERLAY MATERIALS. In recent years, some new pavement overlay materials have been used with varying degrees of success. These materials include fibrous concrete, roller compacted concrete, and rubberized asphalt. Use of materials other than conventional Portland cement concrete (Item P-501) or Plant Mix Bituminous Surface (Item P-401) require special approval on a case-by-case basis.

CHAPTER 5. PAVEMENT DESIGN FOR AIRPLANES WEIGHING LESS THAN 30,000 POUNDS

500. GENERAL. This chapter provides pavement design guidance for airfield pavements intended to serve only airplanes with gross weights less than 30,000 pounds (13 608 kg). Airplanes of this size are usually engaged in nonscheduled activities, such as agricultural, instructional, or recreational flying. Pavements designed to serve these airplanes may be flexible or rigid-type pavements. The design of pavements serving airplanes of 30,000 pounds (13 608 kg) gross weight or more should be based on the criteria contained in Chapter 3 of this publication. Some areas of airports serving light airplanes may not require paving. In these areas, the development of an aggregate-turf or turf surface may be adequate for limited operations of these light airplanes. Aggregate-turf surfaces are constructed by improving the stability of a soil with the addition of aggregate prior to development of the turf. Aggregate-turf construction is covered in some detail in the latter part of this chapter. Information on stabilization of soils can be found in Chapter 2 of this circular and in AC 150/5370-10, Standards for Specifying Construction of Airports.

501. REPORTING PAVEMENT STRENGTH. When designing pavements for light airplanes, summarize all pavement designs on FAA Form 5100-1, Airport Pavement Design, which is considered part of the Engineer's Design Report. Submit the Engineer's Design Report for FAA review and approval along with initial plans and specifications.

502. TYPICAL SECTIONS. Typical cross-sections for pavements serving light airplanes are shown in figure 5-1. No distinction is made between critical and noncritical pavement sections for pavements serving light airplanes.

503. FLEXIBLE PAVEMENT MATERIALS. Flexible pavements for light airplanes are composed of hot mix asphalt surfacing, base course, subbase, and prepared subgrade. The function of these layers and applicable specifications are discussed below.

a. Hot Mix Asphalt Surfacing. The function of the hot mix asphalt surface or wearing course is the same as discussed earlier in Chapter 3. Specifications covering the composition and quality of hot mix asphalt mixtures are given in Item P-401, Plant Mix Bituminous Mixtures or Item P-403, Plant Mix Bituminous Pavements (Base, Leveling or Surface Course). In accordance with AC 150/5370-10, state highway specifications for hot mix asphalt mixtures may be used for pavements intended to serve aircraft weighing 12,500 pounds (5 670 kg) or less.

b. Base Course. As in heavy loaded pavements, the base course is the primary load-carrying component of a flexible pavement. Specifications covering materials suitable for use as base courses for light-load pavements are as follows:

(1) Item P-208 – Aggregate Base Course
(2) Item P-209 – Crushed Aggregate Base Course
(3) Item P-210 – Caliche Base Course
(4) Item P-211 – Lime Rock Base Course
(5) Item P-212 – Shell Base Course
(6) Item P-213 – Sand-Clay Base Course
(7) Item P-219 – Recycled Concrete Aggregate Base Course
(8) Item P-301 – Soil-Cement Base Course
(9) Item P-304 – Cement-Treated Base Course
(10) Item P-306 – Econocrete Subbase Course
(11) Item P-401 – Plant Mix Bituminous Pavement
(12) Item P-403 – Plant Mix Bituminous Pavement (Base, Leveling or Surface Course)

Note: Use of some of the above materials in areas where frost penetrates into the base course may result in some degree of frost heave and/or may require restricted loading during spring thaw.

c. Subbase Course. A subbase course is usually required in flexible pavement except those on subgrades with CBR value of 20 or greater (usually GW or GP type soils). Materials conforming to specification Item P-154, Subbase Course, may be used as subbase course. Also any items listed above in paragraph 502b may be used as subbase course if economy and practicality dictate. Since the loads imposed on these pavements are much less than those on pavements designed for heavier airplanes, compaction control for base and subbase layers should be based upon ASTM D 698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft3 (600 kN-m/m3)).

d. Stabilized Base and Subbase. Stabilized base and subbase courses may be used in light-load pavements. Reduced thicknesses of base and subbase may result. The discussions of stabilized materials are given in Chapter 3.

e. Subgrade. Subgrade materials should be compacted in accordance with Item P-152 to the depths shown on Table 5-1.

TABLE 5-1. SUBGRADE COMPACTION REQUIREMENTS FOR LIGHT LOAD FLEXIBLE PAVEMENTS

Airplane Gross Weight (lbs.)	Noncohesive Soils Depth of Compaction (in.)				Cohesive Soils Depth of Compaction (in.)			
	100%	95%	90%	85%	95%	90%	85%	80%
12,500 or less	6	6-9	9-18	18-24	4	4-8	8-12	12-15
12,501 or more	8	8-12	12-24	24-36	6	6-9	9-12	12-15

General Notes:

1. Noncohesive soils, for the purpose of determining compaction control, are those with a plasticity index of less than 3.
2. Tabulated values denote depths below the finished subgrade above which densities should equal or exceed the indicated percentage of the maximum dry density as specified in Item P- 152.
3. The subgrade in cut areas should have natural densities shown or should (a) be compacted from the surface to achieve the required densities, (b) be removed and replaced at the densities shown, or (c) when economics and grades permit, be covered with sufficient select or subbase material so that the uncompacted subgrade is at a depth where the in-place densities are satisfactory.
4. For swelling soils refer to paragraph 313.
5. 1 inch = 25.4 mm, 1 lb. = 0.454 kg

504. FLEXIBLE PAVEMENT DESIGN. Program FAARFIELD is used to determine the pavement thickness requirements for airplanes weighing up to 30,000 pounds (13 608 kg) gross weight. The pavement thickness determined by FAARFIELD should be used on all areas of the airport pavement. No reduction in thickness should be made for “noncritical” areas of pavements. For very light load pavements, the design should also consider the weight of aircraft rescue and firefighting vehicles, maintenance equipment and/or fueling equipment. It is possible that these types of equipment may require a thicker pavement section than the airplanes.

a. Total Pavement Thickness. Use of the program FAARFIELD requires information on the CBR or modulus E value for the subgrade, airplane mix, gross weights, and annual departures of all airplanes. For traffic consisting of more than one airplane type, the entire mix should be entered, not equivalent departures of a “design aircraft”. The preferred method of establishing the subgrade CBR is by testing. The testing procedures described in Chapter 3 should also be applied to light load pavements.

b. Thickness of Surfacing and Base. FAARFIELD calculates the thickness of the base layer automatically. Note that the minimum thickness of hot mix asphalt surfacing is 2 inches (50 mm) and the minimum base layer thickness is 3 inches (75 mm). Additional base thickness may be required to obtain construction density requirements.

c. Thin Lifts. The reason for the minimum surfacing thickness is that layers thinner than 2 inches (50 mm) are difficult to place and compact on granular bases. Hot mix asphalt surfacing thickness of less than 2 inches (50 mm) is permissible on stabilized base materials if proper laydown and compaction can be achieved. The base course thicknesses range from 3 inches (75 mm) to 6 inches (152 mm) while the subbase thicknesses vary from 0-14 inches (0-356 mm). In some instances, difficulties may be encountered in compacting thin bases or subbases. In these cases the base or subbase thicknesses may be increased to facilitate construction even though the additional thickness is not needed for structural capacity.

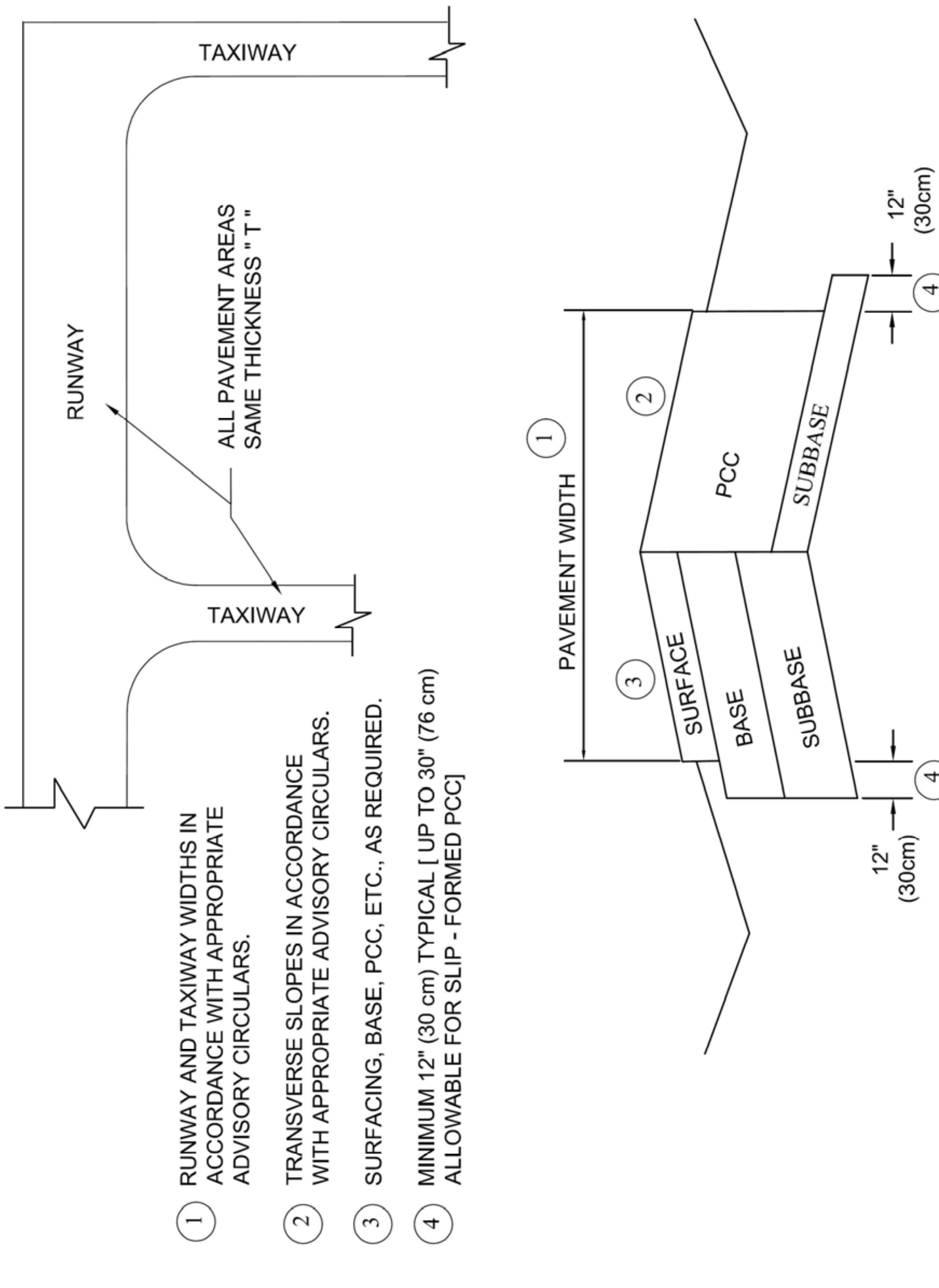


FIGURE 5-1. TYPICAL SECTIONS FOR PAVEMENTS SERVING LIGHT AIRPLANES

d. Example. As an example of the use of FAARFIELD, assume a pavement is to be designed for the following mix of airplanes:

Airplane Name	Gross Weight, lbs (tonnes)	Annual Departures
Citation-V	16,500 (7.5)	480
Super King Air-300	14,100 (6.4)	1,000
Beech Jet-400	15,500 (7.0)	60
Learjet 35A/65	18,000 (8.2)	300
KingAir–B-100	11,500 (5.2)	1,200

Also assume that the subgrade CBR = 5. The pavement will be designed assuming an HMA surface layer of 2 inches (51 mm). Figure 5-2 shows the airplane mix entered into the FAARFIELD Airplane Window.

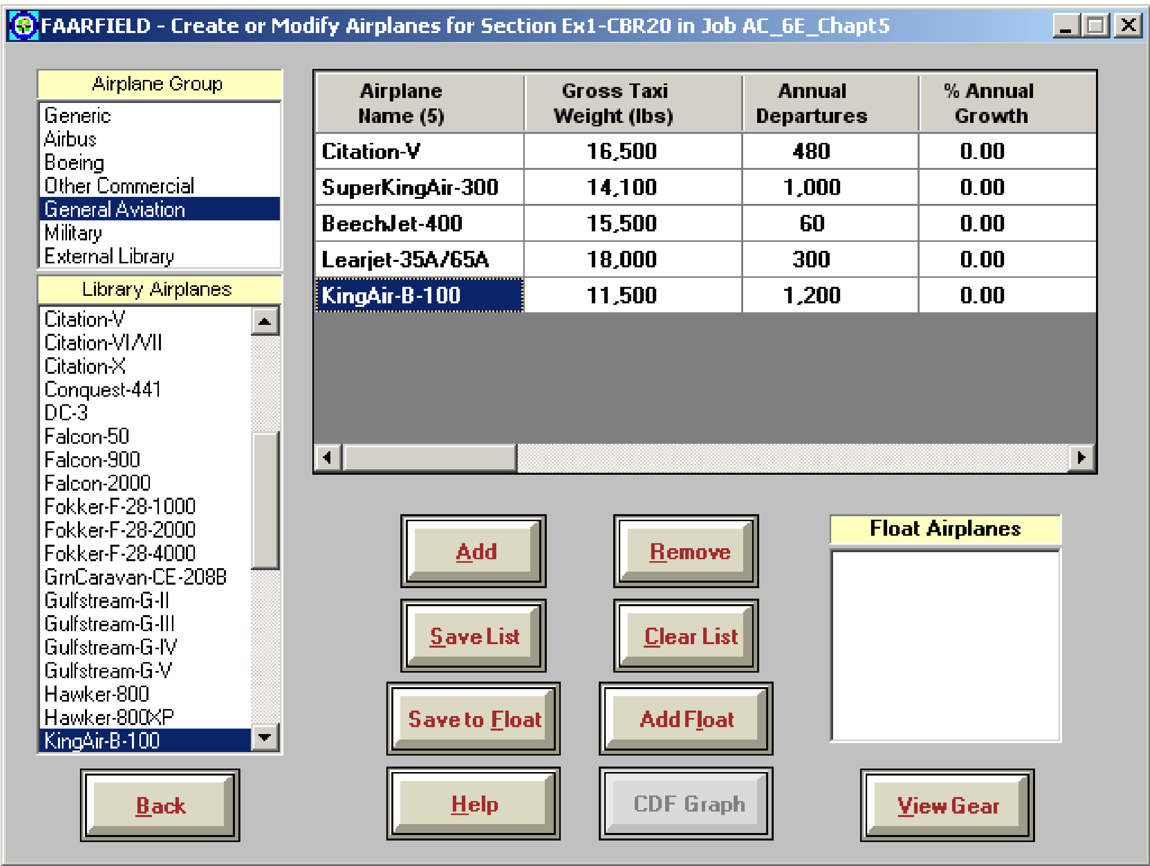


FIGURE 5-2. FAARFIELD AIRPLANE WINDOW – LIGHT LOAD PAVEMENT DESIGN

After setting the HMA thickness to 2 inches, the subgrade CBR to 5, the base layer material to P-209 CrAg and the subbase layer material to P-154 UnCrAg, click "Design Structure".

As shown in figure 5-3, the section as designed by FAARFIELD consists of the 2 in (51 mm) of HMA surfacing, on 3.67 in (94 mm) of P-209 base, and 7.46 in (189 mm) of P-154 subbase. Since difficulties in compacting a base course of less than 4 inches (102 mm) may be anticipated, the P-209 layer will be increased to 4 in (102 mm). Re-running the FAARFIELD design with the 4 in (102 mm) P-209 layer (and disabling the automatic base design option) results in a designed subbase thickness of 7.07 in (180 mm). The final thickness design consists of 2 in (51 mm) P-401 HMA surface, 4 in (102 mm) P-209 base, and 7 in (178 mm) P-154 subbase.

e. Omission of Hot Mix Asphalt Surfacing. Under certain conditions, it may be desirable to utilize a bituminous surface treatment on a prepared base course in lieu of hot mix asphalt. In such instances, the strength of the pavement is furnished by the base, subbase, and subgrade. Additional base course thickness will be necessary to make up for the missing surface course. Additional base should be provided at a ratio of 1.2 to 1.6 inches (30 to 41 mm) of base for each 1 inch (25.4 mm) of surfacing.

f. Full-Depth Asphalt Pavements. Pavements to serve light airplanes may be constructed of full-depth asphalt using the criteria specified in paragraph 318. The Asphalt Institute has published guidance on the design of full depth asphalt pavements for light airplanes in Information Series No. 154, Full Depth Asphalt Pavements for General Aviation. Use of the Asphalt Institute method of design for full-depth asphalt pavements requires approval on a case-by-case basis.

g. Local Materials. Since the base and subbase course materials discussed in Chapter 3 are more than adequate for light airplanes, full consideration should be given to the use of locally available, less-expensive materials. These locally available materials may be entirely satisfactory for light-load pavements. These materials may include locally available granular materials, soil aggregate mixtures, or soils stabilized with Portland cement, bituminous materials, or lime. The designer is cautioned, however, if the ultimate design of the pavement is greater than 30,000 pounds (13 608 kg), higher quality materials should be specified at the outset.

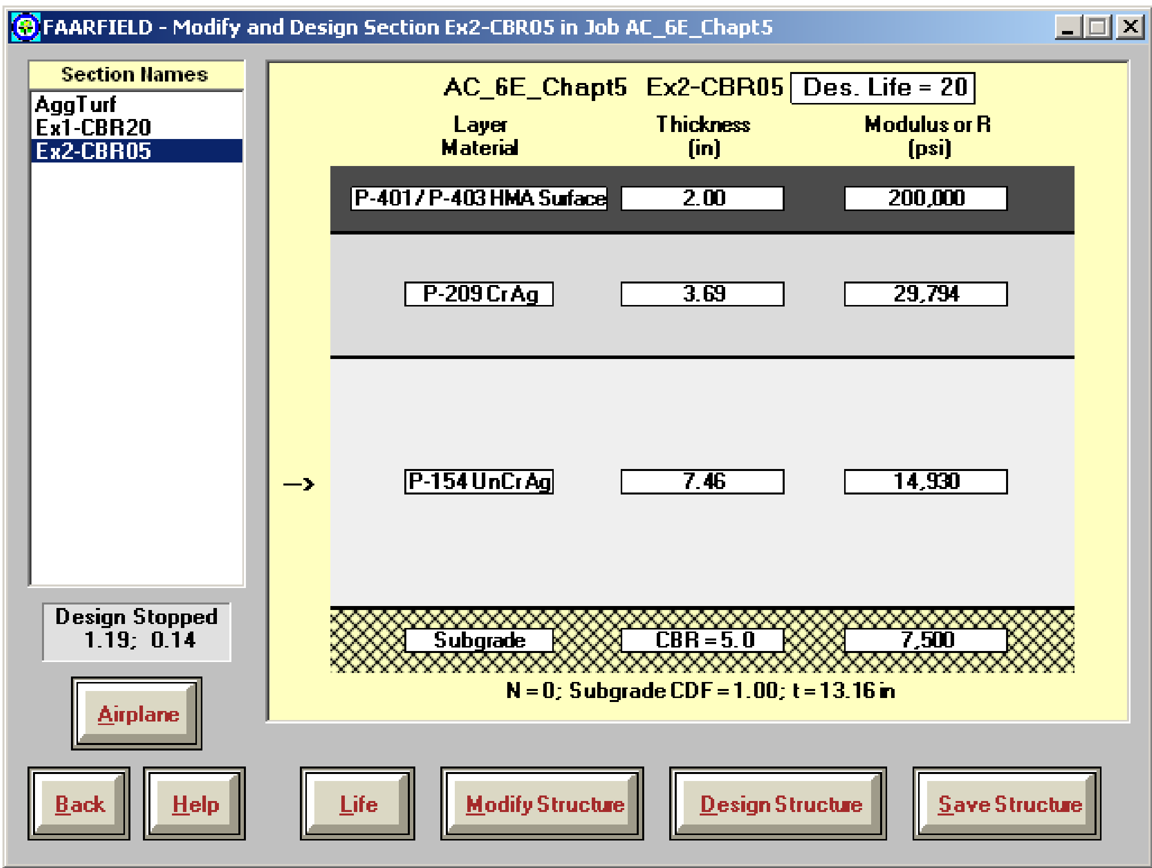


FIGURE 5-3. CALCULATION OF SUBBASE LAYER THICKNESS

505. RIGID PAVEMENT MATERIALS. Rigid pavements for light airplanes are composed of Portland cement concrete surfacing, subbase, and prepared subgrade. The functions of these layers and applicable specifications are discussed below:

a. Portland Cement Concrete. Specifications concerning the quality and placement of Portland cement concrete should be in accordance with Item P-501, Portland Cement Concrete Pavement. Local state highway specifications for paving quality concrete may be substituted for Item P-501 if desired.

b. Subbase. Rigid pavements designed to serve airplanes weighing between 12,500 pounds (5 670 kg) and 30,000 pounds (13 608 kg) will require a minimum subbase thickness of 4 inches (102 mm) except as shown in table 3-9 of Chapter 3. No subbase is required for designs intended to serve airplanes weighing 12,500 pounds (5 670 kg) or less, except when soil types OL, MH, CH, or OH are encountered. When the above soil types are present, a minimum 4-inch (102-mm) subbase should be provided. The materials suitable for subbase courses are covered in Item P-154, Subbase Course.

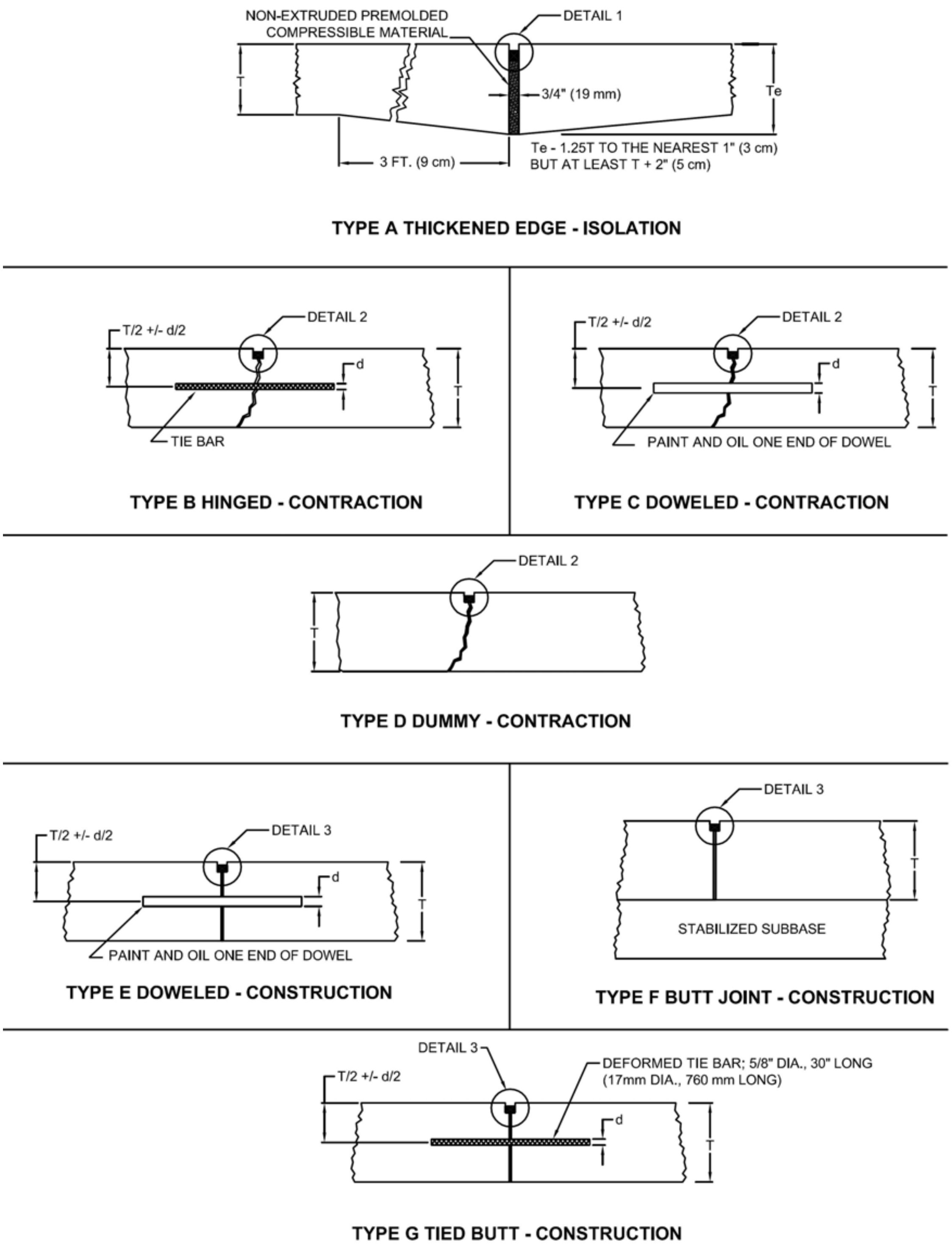
c. Subgrade. Compact subgrade materials in accordance with Item P-152 to the following depths. For cohesive soils used in fill sections, compact the entire fill to 90-percent maximum density. For cohesive soils in cut sections, compacat the top 6 inches (152 mm) of the subgrade to 90-percent maximum density. For noncohesive soils used in fill sections, compact the top 6 inches (152 mm) of fill to 100-percent maximum density, and the remainder of the fill to 95-percent maximum density. For cut sections in noncohesive soils, compact the top 6 inches (152 mm) of subgrade to 100-percent maximum density and the next 18 inches (457 mm) of subgrade to 95-percent maximum density. For treatment of swelling soils refer to paragraph 313.

506. RIGID PAVEMENT THICKNESS. The use of FAARFIELD is not necessary for light-duty rigid pavement design. Rigid pavements designed to serve airplanes weighing 12,500 pounds (5 670 kg) or less should be 5 inches (127 mm) thick or 6 inches (152 mm) thick if doweled joints are used. Those designed to serve airplanes weighing between 12,501 pounds (5 670 kg) and 30,000 pounds (13 608 kg) should be 6 inches (152 mm) thick.

Jointing of Light Load Rigid Pavements. The maximum spacing of joints for light-load rigid pavements should be 12.5 feet (3.8 m) for longitudinal joints and 15 feet (4.6 m) for transverse joints. Jointing types are shown in figure 5-4 and jointing details are shown in figure 5-5 for light-load rigid pavements. Note that several differences exist between light-load and heavy-load rigid pavement joints. For instance, butt-type construction joints are permitted when an asphalt or cement stabilized subbase is provided. Odd-shaped slabs should be reinforced with 0.05 percent steel in both directions. Odd-shaped slabs are defined as slabs that are not rectangular in shape or rectangular slabs with length-to-width ratios that exceed 1.25. Two recommended joint layout patterns are shown in figures 5-6 and 5-7 for 60 foot (18 m) and for 50 foot (15 m) wide pavements. The concept behind the jointing patterns shown is the creation of a “tension ring” around the perimeter of the pavement to hold joints within the interior of the paved area tightly closed. A tightly closed joint will function better than an open joint. The last three contraction joints and longitudinal joints nearest the free edge of the pavement are tied with #4 deformed bars, 20 inches (508 mm) long, spaced at 36 inches (914 mm) center to center. At the ends of the pavement and in locations where airplanes or vehicular traffic would move onto or off the pavement, a thickened edge should be constructed. The thickened edge should be 1.25 times the thickness of the slab and should taper to the slab thickness over a distance of 3 feet (0.9 m). Note that if a type “F” butt construction joint is used then a stabilized subbase is required as shown in figure 5-4. Alternatively, a type “E” doweled construction joint can be used at the locations shown in figures 5-6 and 5-7. If doweled joints are used, the rigid pavement thickness should be 6 inches (152 mm).

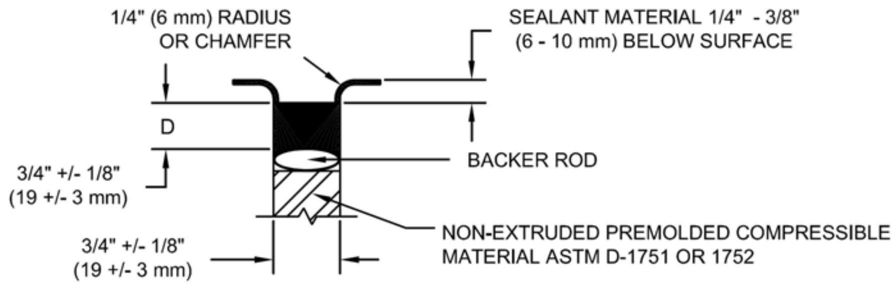
The intent of this paragraph is to allow the use of the tension ring design but limit it to pavements less than 60 feet (18 m) in width.

Pavements that do not use the tension ring design should be designed in a manner similar to Chapter 3. The general recommendations of table 3-15 may be employed for Chapter 5 pavements not using the tension ring concept; however, the designer should note that the joint designations and steel sizes and spacing discussed in Chapter 5 are different those in Chapter 3.

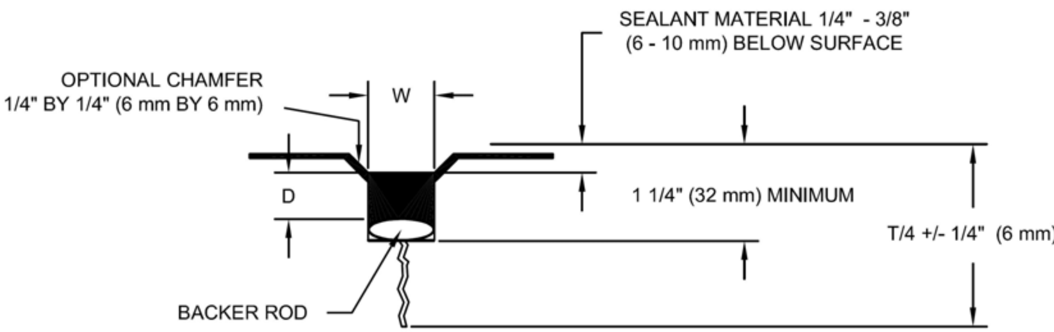


NOTES:
1. SEE NEXT PAGE FOR DETAILS 1, 2 AND 3.
2. ALL DOWELS 3/4" (19 mm) DIA., 18" (460 mm) LONG SPACED 12" (300 mm) ON CENTERS.
3. ALL TIE BARS No. 4 DEFORMED BARS 20" (510 mm) LONG, 36" (0.9 m) ON CENTERS.
4. BLACK SHADED AREA IS JOINT SEALER.
5. GROOVE MAY BE FORMED OR SAWED.

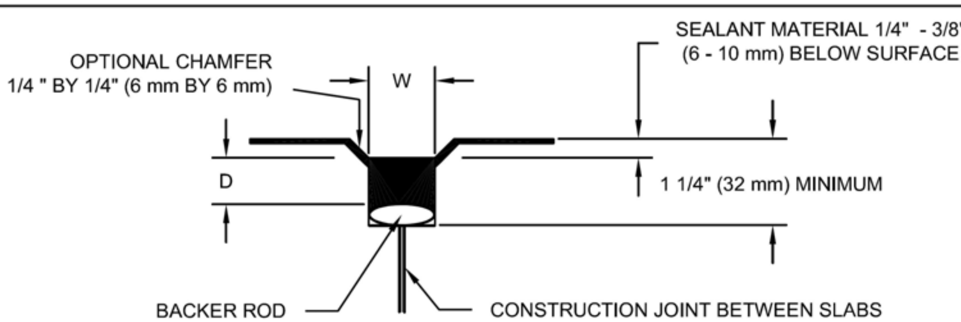
FIGURE 5-4. JOINTING TYPES FOR LIGHT-LOAD RIGID PAVEMENT



DETAIL 1
ISOLATION JOINT



DETAIL 2
CONTRACTION JOINT



DETAIL 3
CONSTRUCTION JOINT

NOTES:
1. SEALANT RESERVOIR SIZED TO PROVIDE PROPER SHAPE FACTOR, W/D. FIELD POURED AND PERFORMED SEALANTS REQUIRE DIFFERENT SHAPE FACTORS FOR OPTIMUM PERFORMANCE.
2. BACKER ROD MATERIAL MUST BE COMPATIBLE WITH THE TYPE OF SEALANT USED AND SIZED TO PROVIDE THE DESIRED SHAPE FACTOR.
3. RECESS SEALER 3/8 INCHES TO 1/2 INCHES (10 mm TO 12 mm) FOR JOINTS PERPENDICULAR TO RUNWAY GROOVES.
4. CHAMFERED EDGES ARE RECOMMENDED FOR DETAILS 2 AND 3 WHEN PAVEMENTS ARE SUBJECT TO SNOW REMOVAL EQUIPMENT OR HIGH TRAFFIC VOLUMES.
5. D - JOINT SEALANT DEPTH

FIGURE 5-5. JOINTING DETAILS FOR LIGHT-LOAD RIGID PAVEMENT

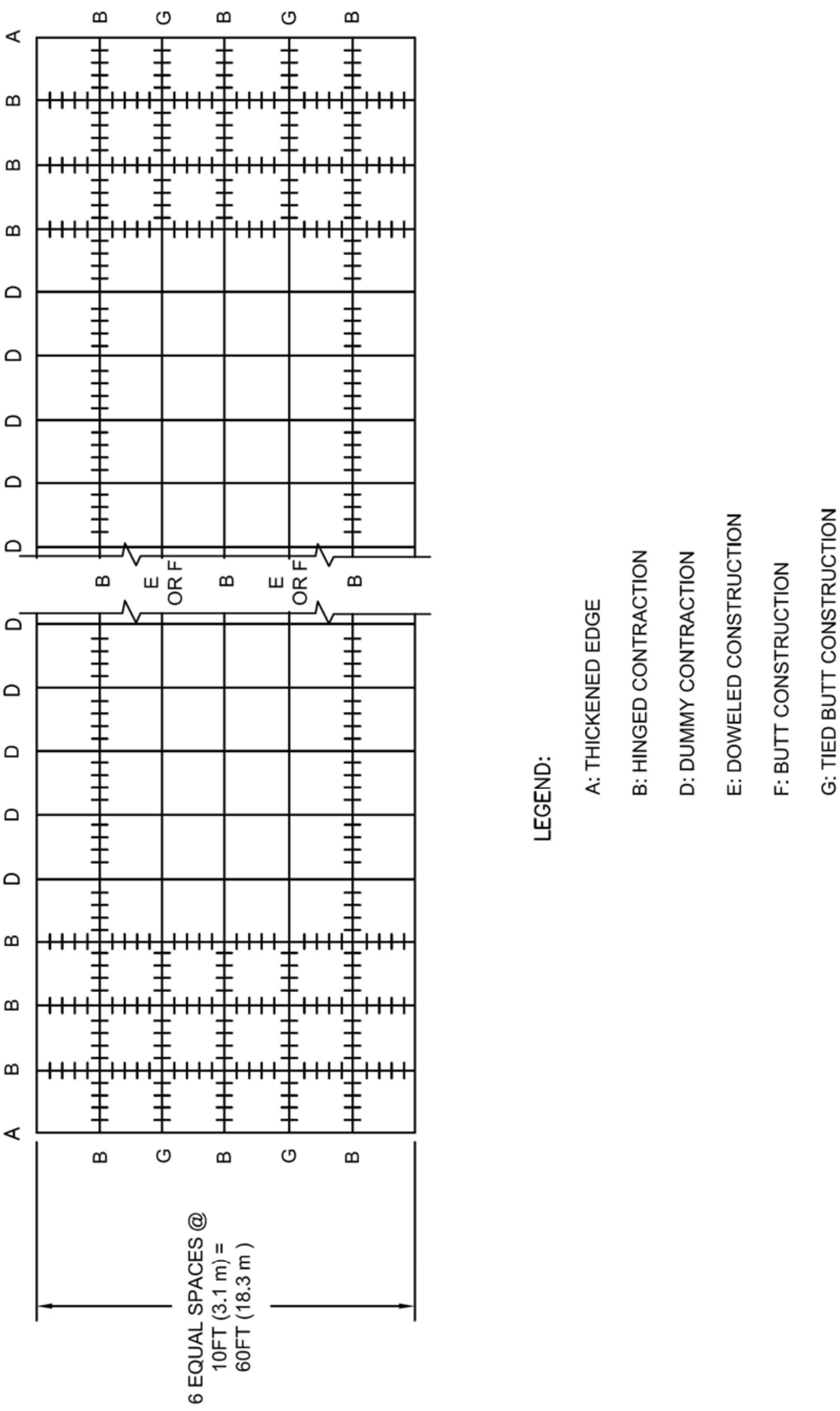


FIGURE 5-6. JOINTING LAYOUT PATTERNS FOR LIGHT-LOAD RIGID PAVEMENT – 60 FEET WIDE

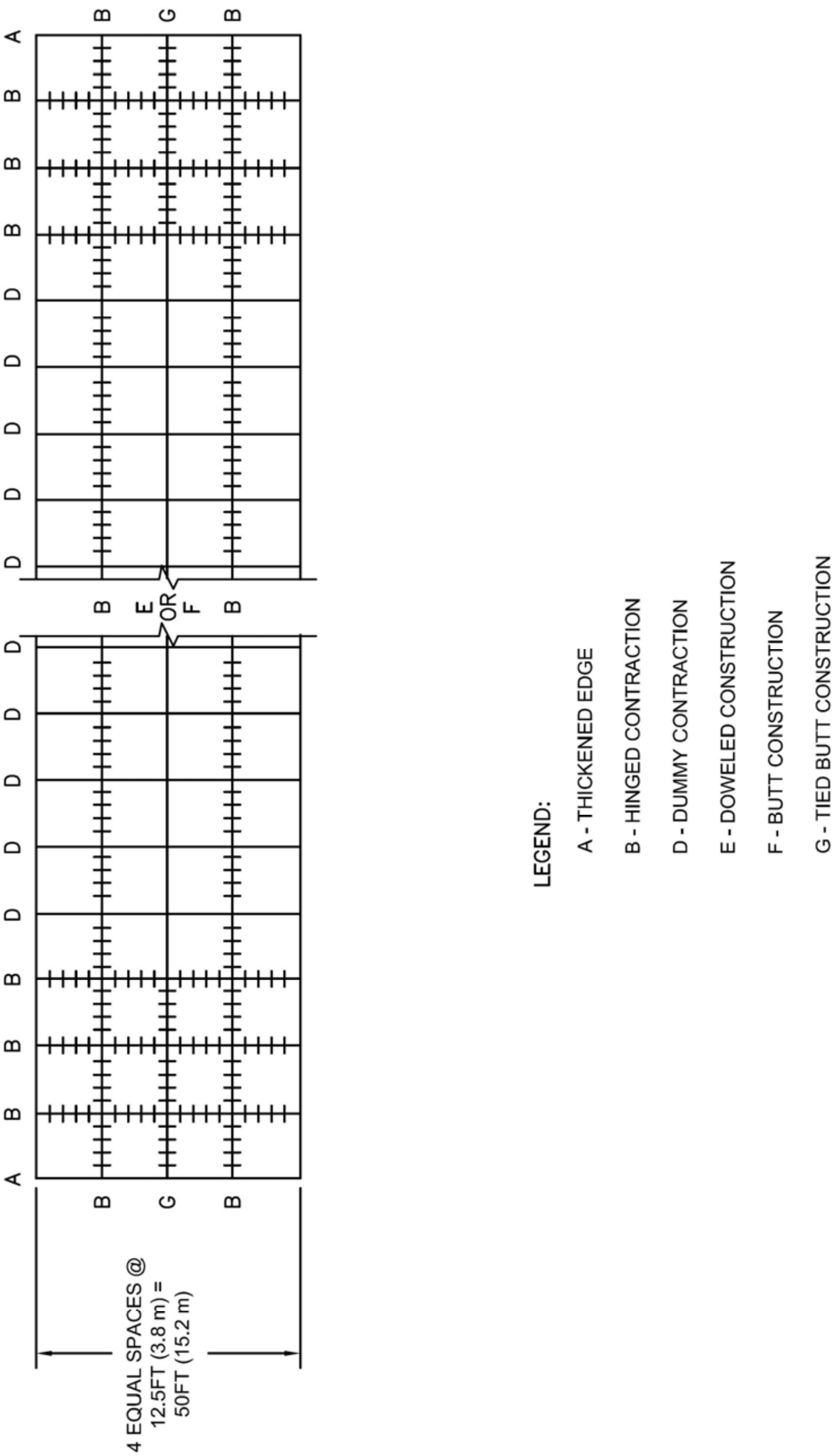


FIGURE 5-7. JOINTING LAYOUT PATTERNS FOR LIGHT-LOAD RIGID PAVEMENT – 50 FEET WIDE

507. AGGREGATE TURF. Aggregate-turf differs from normal turf in that the stability of the underlying soil is increased by the addition of granular materials prior to establishment of the turf. The objective of this type of construction is to provide a landing area that will not soften appreciably during wet weather and yet has sufficient soil to promote the growth of grass. Aggregate-turf should be considered only for areas designed to serve non jet airplanes having gross weights of 12,500 pounds (5 670 kg) or less.

a. Materials. Construction details and material requirements are covered in Item P-217, Aggregate-Turf Pavement. Typically, aggregate-turf construction will consist of a soil seedbed layer (soil or soil/aggregate combination) over an aggregate stabilized base course. The aggregate stabilized base course consists of soil stabilized crushed stone, soil-stabilized gravel or soil-stabilized sand conforming to the requirements of P-217.

b. Thickness. The thickness to be stabilized with the granular materials varies with the type of soil and the drainage and climatic conditions. The minimum thickness of aggregate stabilized soil can be computed from FAARFIELD using the CBR of the subgrade, as shown in the following example. The minimum thickness of the soil seedbed is not determined by structural considerations, but is the thickness required to support the growth of grass.

c. Example. Assume that the airplane mix consists of the following: King Air B-100 (11,500 lbs, 1200 annual departures) and Citation 525 (10,500 lbs, 1200 annual departures). The subgrade CBR = 5. Figure 5-8 shows the use of FAARFIELD for determining the thickness of the aggregate stabilized base course layer. A minimum thickness of 2 inches (51 mm) is assigned to the turf seedbed, although the actual thickness of soil will be determined by growing requirements. The turf seedbed is represented as an undefined layer, with a nominal E-modulus of 3,000 psi (21 MPa). The design layer (aggregate stabilized base) is represented as P-154 uncrushed aggregate. In this example, the thickness required for the aggregate stabilized base course is 11.3 inches (287 mm), which will be rounded to 11.5 inches (300 mm).

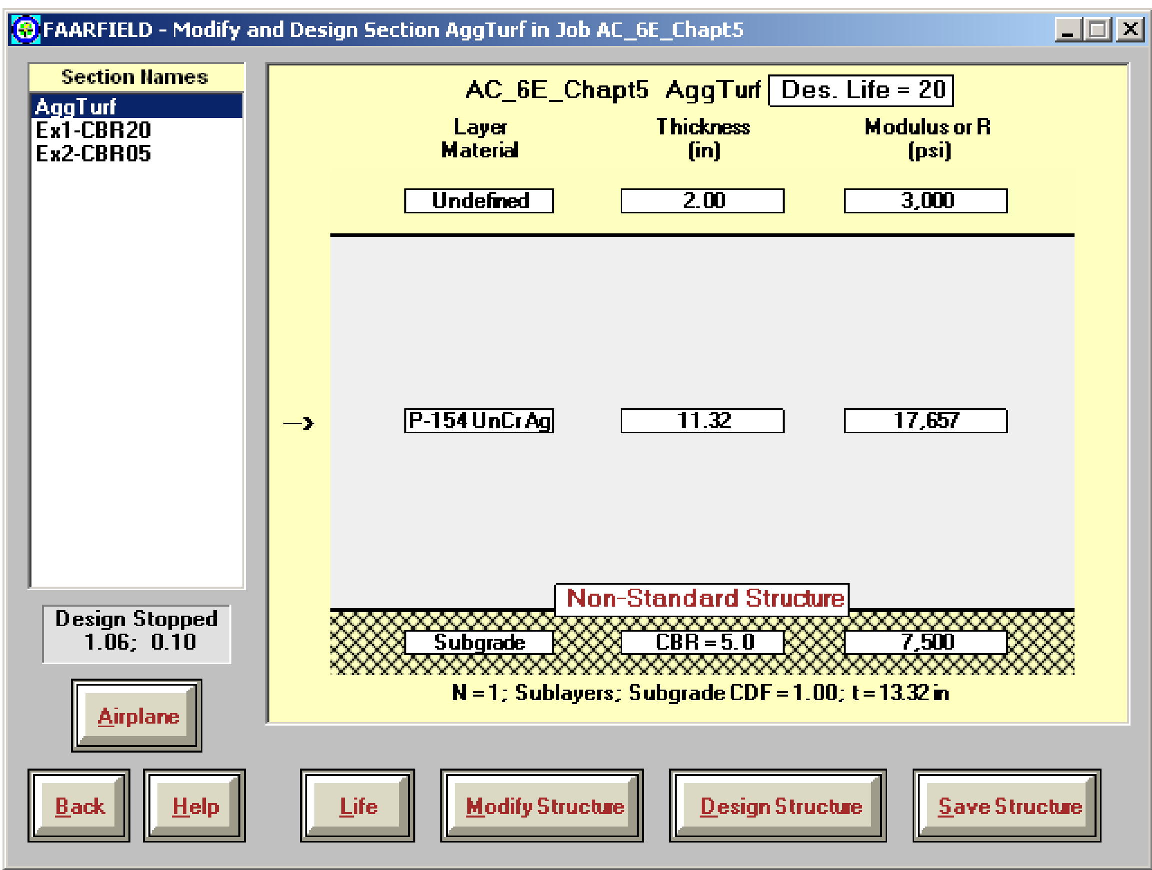


FIGURE 5-8. DESIGN EXAMPLE FOR AGGREGATE TURF PAVEMENT.

508. OVERLAYS. Overlays of pavements intended to serve light airplanes are designed in the same manner as overlays for heavy airplanes.

509. HELIPORT/VERTIPORT DESIGN. The guidance contained in paragraph 500 of this section is appropriate for pavements designed to serve rotary-wing airplanes. Where direct thermal effects of jet blast is a concern (e.g., at vertiports serving tiltrotor traffic), incorporation of unique pavement formulations specific to thermal resistance may be required. Any pavement that is subjected to the direct thermal effects of high temperature exhaust gases can become progressively damaged with repeated thermal cycles, resulting in surface spalling, a potential for foreign object damage (FOD), as well as subsequent deterioration of the affected slab. An example formulation for thermal resistant pavement can be found in TR-2079-SHR, Development of Mix Designs for F/A-18 Resistant Pavement Systems.

CHAPTER 6. PAVEMENT EVALUATION

600. PURPOSES OF PAVEMENT EVALUATION. Airport pavement evaluations are necessary to assess the ability of an existing pavement to support different types, weights, or volumes of airplane traffic. The load carrying capacity of existing bridges, culverts, storm drains, and other structures should also be considered in these evaluations. Evaluations may be also necessary to determine the condition of existing pavements for use in the planning or design of improvements to the airport. Evaluation procedures are essentially the reverse of design procedures. This chapter covers the evaluation of pavements for all weights of airplanes.

601. EVALUATION PROCESS. The evaluation of airport pavements should be a methodical step-by-step process. The recommended steps in the evaluation process described below should be used regardless of the type of pavement.

a. Records Research. A thorough review of construction data and history, design considerations, specifications, testing methods and results, as-built drawings, and maintenance history should be performed. Weather records and the most complete traffic history available are also parts of a usable records file.

b. Site Inspection. The site in question should be visited and the condition of the pavements noted by visual inspection. This should include, in addition to the inspection of the pavements, an examination of the existing drainage conditions and drainage structures at the site. Evidence of the adverse effects of frost action, swelling soils, reactive aggregates, etc., should also be noted. The principles set forth in Chapter 2 of this circular and in AC 150/5320-5, Surface Drainage Design, apply.

c. Sampling and Testing. The need for and scope of physical tests and materials analyses will be based on the findings made from the site inspection, records research, and type of evaluation. A complete evaluation for detailed design will require more sampling and testing than, for example, an evaluation intended for use in a master plan. Sampling and testing is intended to provide information on the thickness, quality, and general condition of the pavement elements.

(1) Direct Sampling Procedures. The basic evaluation procedure for planning and design will be visual inspection and reference to the FAA design criteria, supplemented by the additional sampling, testing, and research, which the evaluation processes may warrant. For relatively new pavement constructed to FAA standards and without visible sign of wear or stress, strength may be based on inspection of the FAA Form 5100-1, Airport Pavement Design, and the as-constructed sections, with modification for any material variations or deficiencies of record. Where age or visible distress indicates the original strength no longer exists, further modification should be applied on the basis of judgment or a combination of judgment and supplemental physical testing. For pavements that consist of sections not readily comparable to FAA design standards, evaluation should be based on FAA standards after material comparison and equivalencies have been applied.

(2) Nondestructive Testing. Several methods of nondestructive testing (NDT) of pavements are available. For purposes of this discussion, NDT means observing pavement response to a controlled dynamic load, as in the case of the falling-weight deflectometer (FWD), or other physical stimulus such as a mechanical wave. NDT provides a means of evaluating pavements that tends to remove some of the subjective judgment needed in other evaluation procedures. AC 150/5370-11, Use of Nondestructive Testing Devices in the Evaluation of Airport Pavements, contains guidance on nondestructive testing. The major advantages of nondestructive testing are: the pavement is tested in place under actual conditions of moisture, density, etc.; the disruption of traffic is minimal; and the need for destructive tests is minimized. Research efforts are continuing in the area of nondestructive testing to broaden its application. Several different NDT procedures are available in addition to that described in AC 150/5370-11. These other procedures may be used when approved by the FAA. The common NDT tools available to assist the evaluator include: FWD, ground penetrating radar (GPR), infrared thermography, etc.

(i) Falling Weight Deflectometer. Falling weight deflectometers impart an impulse load to the pavement with a free-falling weight. The magnitude of the dynamic load depends on the mass of the weight and the height from which it is dropped. The resulting deflections of the pavement surface are typically measured using an array of sensors. The Heavy Falling Weight Deflectometer (HWD) uses a greater dynamic load than FWD and may be more suitable for some airport applications. FWD and HWD can be used in conjunction with appropriate software to estimate pavement layer properties. AC 150/5370-11 gives guidance for the use of FWD and HWD equipment.

(ii) Ground Penetrating Radar. Ground penetrating radar can be useful in studying subsurface conditions nondestructively. Ground penetrating radar depends on differences in dielectric constants to discriminate between materials. The technique is sometimes used to locate voids or foreign objects, such as, abandoned fuel tanks, tree stumps, etc. in embankments.

(iii) Infrared Thermography. Infrared thermography is a nondestructive testing procedure whereby differences in infrared emissions are observed allowing certain physical properties of the pavement to be determined. Infrared thermography is purportedly capable of detecting delaminations in bonded rigid overlay pavements and in reinforced rigid pavements.

d. Pavement Condition Index. The determination of the Pavement Condition Index (PCI) is often a useful tool in the evaluation of airport pavements. The PCI is a numerical rating of the surface condition of a pavement and is a measure of functional performance with implications of structural performance. PCI values range from 100 for a pavement with no defects to 0 for a pavement with no remaining functional life. The index is useful in describing distress and comparing pavements on an equal basis. AC 150/5380-6, Guidelines and Procedures for Maintenance of Airport Pavements, contains information on PCI surveys. The FAA recommends that airports follow ASTM D 5340, Standard Test Method for Airport Pavement Condition Index Surveys.

e. Evaluation Report. The analyses, findings, and test results should be incorporated in an evaluation report, which becomes a permanent record for future reference. While evaluation reports need not be in any particular form, it is recommended that a drawing identifying limits of the evaluation be included. Analysis of information gained in the above steps should culminate in the assignment of load carrying capacity to the pavement sections under consideration. When soil, moisture, and weather conditions conductive to detrimental frost action exist, an adjustment to the evaluation may be required.

602. FLEXIBLE PAVEMENTS. Evaluation of flexible pavements requires, as a minimum, the determination of the thickness of the component layers, and the CBR of the subgrade.

a. Layer Thicknesses. The thickness of the various layers in the flexible pavement structure must be known in order to evaluate the pavement. Thicknesses may be determined from borings or NDT. As-built drawings and records can also be used to determine thicknesses if the records are sufficiently complete and accurate.

b. Subgrade CBR. Laboratory CBR tests should be performed on soaked specimens in accordance with ASTM D 1883, Bearing Ratio of Laboratory-Compacted Soils. Field CBRs should be performed in accordance with the procedure given in The Asphalt Institute Manual Series 10 (MS-10), Soils Manual. Field CBR tests on existing pavements less than 3 years old may not be representative unless the subgrade moisture content has stabilized. The evaluation process assumes a soaked CBR is and will not give reliable results if the subgrade moisture content has not reached the ultimate in situ condition. In situations where it is impractical to perform laboratory or field CBR tests, a back calculated subgrade elastic modulus value may be obtained from NDT test results. AC 150/5370-11 gives the procedures for obtaining the back calculated modulus value. The FAARFIELD program assumes that CBR is related to the subgrade modulus as E = 1500xCBR (E in psi), so that the back calculated modulus value can be input directly into FAARFIELD without manually converting to CBR.

c. Layer Properties. As stated in paragraph 303, in FAARFIELD materials are designated by corresponding FAA specifications. Where flexible pavements have been constructed to FAA standards, each layer should be assigned a material type corresponding to the appropriate FAA specification. For example, where an existing flexible pavement consists of an HMA surface on a high-quality crushed aggregate base meeting FAA Item P-209, the base layer should be input as P-209 Crushed Aggregate in FAARFIELD. Where the quality of materials in a pavement structure to be evaluated differ significantly from the assumptions for FAA standard materials as given in AC 150/5370-10B, it may be necessary to use the “undefined” or “variable” layer types in FAARFIELD to input an appropriate modulus value or use lower quality material to model structure (e.g., P-154 for P-209).

603. APPLICATION OF FLEXIBLE PAVEMENT EVALUATION PROCEDURES. After all of the evaluation parameters of the existing flexible pavement have been established using the guidance given in the above paragraphs, the evaluation process is essentially the reverse of the design procedure. The FAARFIELD program can be used to determine the structural life of the existing pavement for a given traffic mix, or alternatively, the allowable load of an airplane on a pavement structure that will produce a 20-year life for a given number of annual departures. Required inputs are the subgrade CBR or modulus value, thicknesses of surfacing, base and subbase courses and annual departure levels for all airplanes using the pavement.

a. Example 1. An existing taxiway pavement was constructed to FAA standards and consists of a 5 inch (127 mm) HMA surface layer (Item P-401), 9 inch (229 mm) HMA stabilized base layer (Item P-403), and 24 inch (610 mm) crushed aggregate subbase layer (Item P-209). The subgrade was previously evaluated by field CBR measurements and found to be CBR 7. The taxiway will serve the following mix of airplanes:

Airplane Name	Gross Weight, lbs (tonnes)	Annual Departures
DC10-10	458,000 (207.7)	2263
B747-200B Combi Mixed	873,000 (396.0)	832
B777-200 ER	634,500 (287.8)	425
B737-800	174,700 (79.2)	8000
A320-100	150,796 (68.4)	4380

FAARFIELD will be used to determine the available structural life based on the above traffic mixture. Both total thickness and base thickness will be checked. The following steps are used:

(1) Enter the above airplane list using the Airplanes screen.

(2) In the Structure screen, enter the layer thickness and material type for each layer (figure 6-1).

(3) Click the "Life" button. The predicted life for the given structure and traffic is 155.2 years, which exceeds the 20-year requirement.

Next, the adequacy of the stabilized base layer should be checked. This should be done by designing the P-401/P-403 stabilized base course for the required life in accordance with the procedures given in Chapter 3. For the load carrying capacity to be met, the minimum base course thickness requirement should be less than the existing base course thickness. In this example, the design procedure requires a stabilized base thickness of 6.25 (11/1.6) inches (159 mm) for the 20-year life, which is less than the existing 9 inches (229 mm). Therefore, an overlay would not be required to serve the anticipated traffic mix.

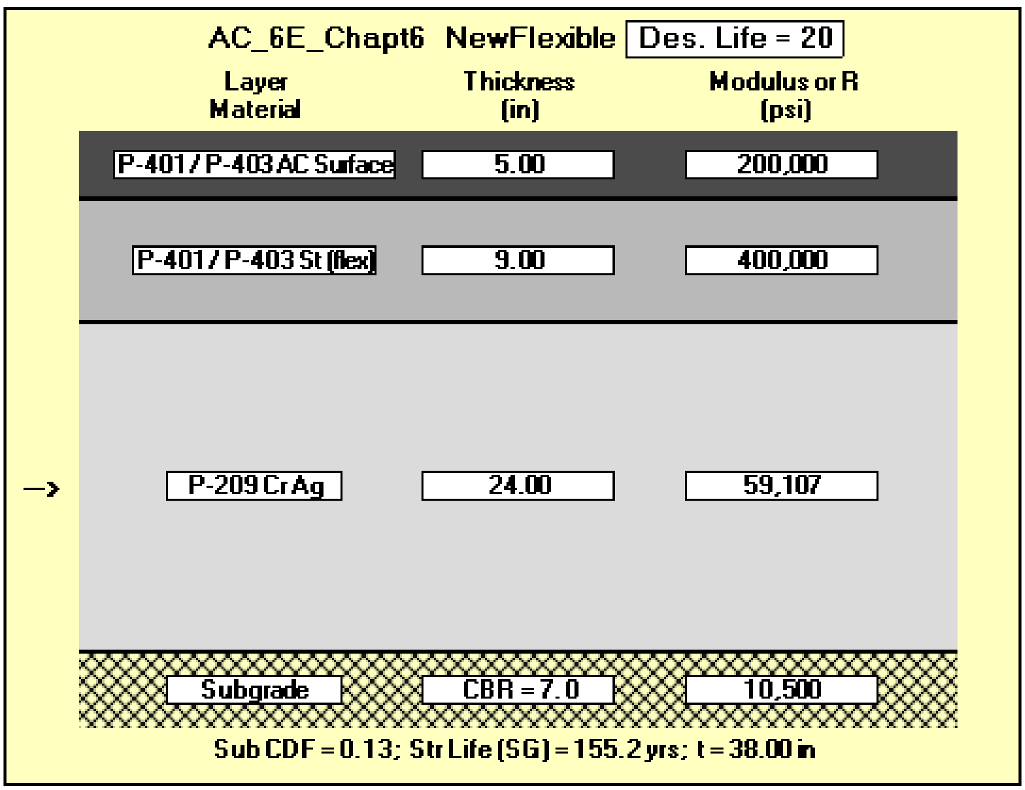


FIGURE 6-1. EXAMPLE OF A FLEXIBLE PAVEMENT STRUCTURE FOR EVALUATION

b. Example 2. For the pavement in Example 1, but with a subgrade CBR = 3, FAARFIELD will be used to determine the allowable gross weight of a B737-800 airplane for a 20-year life. Assume 10,000 annual departures of the B737-800.

(1) In the Airplanes screen, remove all airplanes except the B737-800. For annual departures, enter 10,000.In the Structure screen, enter the layer thickness and material type for each layer (figure 6-1).

(2) Click the “Life” button to compute the predicted Structural Life.

(3) Continue to modify the airplane gross weight until Structural Life = 20.0 years.

(4) In this example, the gross weight of the B737-800 producing the 20-year life is 152,950 lbs. (69.4 tonnes).

(5) For this gross weight, check the adequacy of the base layer, using the stabilized base design procedure given in Chapter 3. In this example, the design procedure requires a stabilized base thickness of 9.0 inches, which agrees with the existing structure.

To support 10,000 annual departures of the B737-800 on the existing pavement structure, the gross weight should be limited to 152,950 lbs. (69.4 tonnes). If the airplane is to be operated at higher weights, this may cause a reduction in the structural life.

604. RIGID PAVEMENTS. Evaluation of rigid pavements requires, as a minimum, the determination of the thickness of the component layers, the flexural strength of the concrete, and the subgrade modulus.

a. Layer Thicknesses. The thickness of the component layers is sometimes available from construction records. Where information is not available or of questionable accuracy, thicknesses may be determined by borings or test pits in the pavement.

b. Concrete Flexural Strength. The flexural strength of the concrete is most accurately determined from test beams sawed from the existing pavement and tested in accordance with ASTM C 78. Quite often this method is impractical as sawed beams are expensive to obtain and costs incurred in obtaining sufficient numbers of beams to establish a representative sample is prohibitive. Construction records, if available, may be used as a source of concrete flexural strength data. The construction data may require adjustment due to the age of the concrete.

Correlations between concrete flexural strength and other concrete strength tests are available. It should be noted that correlations between flexural strength and other strength tests are approximate and considerable variations are likely.

An approximate relationship between concrete flexural strength and tensile splitting strength (ASTM C 496) exists and can be computed by the following formula:

$$R = 1.02(T) + 117$$

where:

R = flexural strength, psi
T = tensile split strength, psi

Note: For conversions in metric units the above formula remains the same, except the + 117 psi constant should be changed to + 0.81 MPa.

c. Subgrade Modulus. The modulus of subgrade reaction, *k*, is ideally determined by plate bearing tests performed on the subgrade. These tests should be made in accordance with the procedures established in AASHTO T 222. An important part of the test procedure for determining the subgrade reaction modulus is the correction for soil saturation, which is contained in the prescribed standard. The normal application utilizes a correction factor determined by the consolidation testing of samples at in situ and saturated moisture content. For evaluation of older pavement, where evidence exists that the subgrade moisture has stabilized or varies through a limited range, the correction for saturation is not necessary. If a field plate bearing test is not practical, the modulus of subgrade reaction may be estimated by the formula in paragraph 205a(4) of this circular. Alternatively, a backcalculated subgrade elastic modulus value may be obtained from NDT test results. AC 150/5370-11 gives the procedures for obtaining the backcalculated modulus value. The FAARFIELD program assumes that *k* is related to the subgrade modulus as $E = 26\,k^{1.284}$ (E in psi), so that the back calculated E modulus value can be input directly into FAARFIELD without manually converting to *k*.

d. Layer Properties. As stated in paragraph 303, in FAARFIELD materials are designated by corresponding FAA specifications. Where rigid pavements have been constructed to FAA standards, each layer should be assigned a material type corresponding to the appropriate FAA specification. For example, where an existing rigid pavement consists of a PCC surface on a cement stabilized base meeting FAA Item P-304, the base layer should be input as P-304 CTB in FAARFIELD. Where the quality of materials in a pavement structure to be evaluated differ significantly from the assumptions for FAA standard materials as given in AC 150/5370-10, it may be necessary to use the “undefined” or “variable” layer types in FAARFIELD to input an appropriate modulus value. In FAARFIELD, the number of structural layers above the subgrade for a rigid pavement is limited to 4, including the PCC surface. If the actual rigid pavement structure to be evaluated consists of more than 4 distinct layers, two or more of the lower layers can be combined to reduce the total number of layers to 4 or fewer for analysis. Since rigid pavement evaluation is not highly sensitive to modulus properties of lower layers above the subgrade, the life computation should not be significantly affected.

605. APPLICATION OF RIGID PAVEMENT EVALUATION PROCEDURES. After all of the evaluation parameters of the existing rigid pavement have been established using the guidance given in the above paragraphs, the evaluation process is essentially the reverse of the design procedure. The FAARFIELD program can be used to determine the structural life of the existing pavement for a given traffic mix, or alternatively, the allowable load of an airplane on a pavement structure that will produce a 20-year life for a given number of annual departures. The FAARFIELD program allows the back calculated E modulus value to be input directly.

a. Example. An existing taxiway was constructed to FAA standards and consists of a 16 inch (406 mm) PCC surface layer (Item P-501), 8 inch (203 mm) stabilized base (Item P-304), and 10 inch (254 mm) granular subbase (Item P-154). The current concrete flexural strength was estimated from compressive tests on cores as 700 psi (4.83 MPa). The subgrade was evaluated by NDT testing and found to have an E-modulus of approximately 13,000 psi (89.6 MPa). The anticipated traffic mix is the same as the example in paragraph 603. FAARFIELD is used to evaluate the structural life as follows:

(1) Enter the airplane list, including gross weights and annual departures, using the Airplanes screen.

(2) In the Structure screen, enter the layer thickness and material type for each layer (figure 6-2).

(3) Click the “Life” control button. The predicted life for the given structure and traffic is 28.2 years, which exceeds the 20-year requirement.

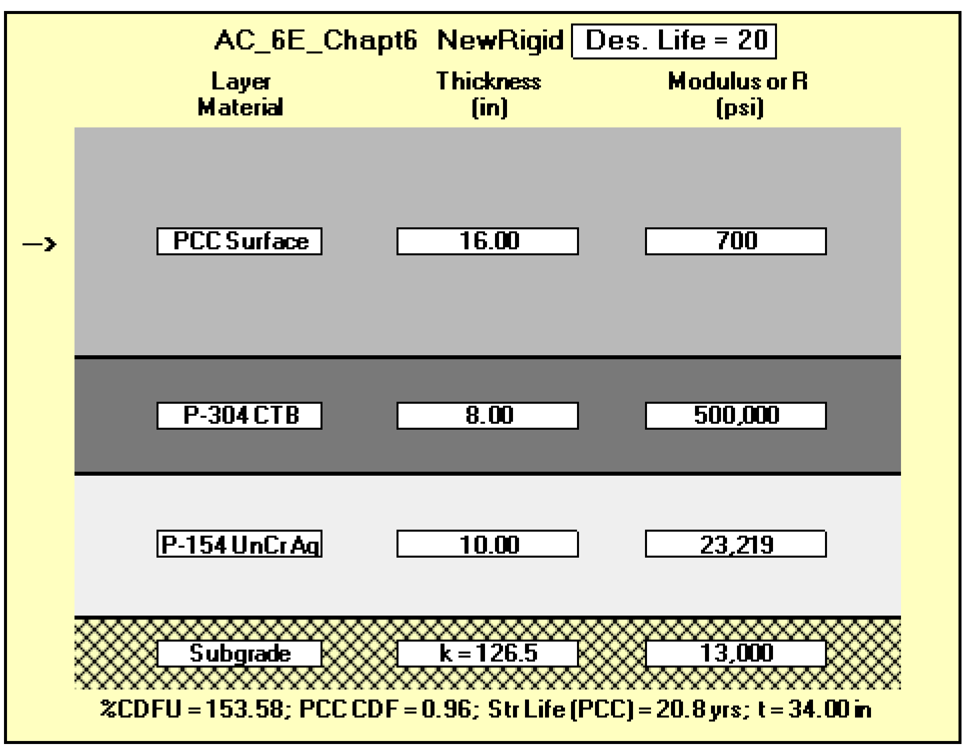


FIGURE 6-2. EXAMPLE OF A RIGID PAVEMENT STRUCTURE FOR EVALUATION

606. USE OF RESULTS. If the evaluation is being used for planning purposes and the existing pavement is found to be deficient in accordance with the design standards given in Chapter 3 or 5, the sponsor should be notified as to the deficiency and consideration should be given to corrective action. If the evaluation is being used a part of the design for a project to reconstruct or upgrade the facility, the procedures given in Chapters 3,4, or 5 should be used to design the reconstruction or overlay project. In this instance the main concern is not the load carrying capacity but rather the difference between the existing pavement structure and the section that is needed to support forecast traffic.

607. REPORTING PAVEMENT STRENGTH. The International Civil Aviation Organization (ICAO) developed a standardized method of reporting airport pavement strength known as the Aircraft Classification Number/Pavement Classification Number (ACN/PCN). This method of reporting is based on the concept of reporting strength in terms of a standardized equivalent single wheel load. While FAARFIELD can be used to establish allowable airplane loads based on a given structure and airplane departure level (see Example 2 in paragraph 603), it is recommended that PCN calculations be based on the same method adopted by ICAO for calculating ACN. For this purpose, the FAA developed a software program, COMFAA, which computes ACN following the procedures specified by ICAO. AC 150/5335-5, Standardized Method of Reporting Airport Pavement Strength – PCN, provides guidance on reporting PCN using the COMFAA software.

CHAPTER 7. PAVEMENT DESIGN FOR AIRFIELD SHOULDERS

700. PURPOSE. This chapter provides a design procedure for paved airfield shoulders.

701. APPLICATION. The design procedure for paved or surfaced shoulders applies to all airports that accommodate Design Group III or higher airplanes.

702. BACKGROUND. The need for paved or surfaced shoulders is created due to erosion and generation of debris from jet blast. As airplanes grew in size, so did the size of the airplane engines and their respective increase in jet thrust or jet blast. Jet blast can cause problems with erosion of unprotected soil immediately adjacent to airfield pavements. To mitigate this problem, the FAA recommends paved shoulders for runways, taxiway, and aprons that will accommodate Group III and higher airplanes. In addition to providing protection from jet blast, the shoulder must be capable of safely supporting "occasional" passage of the most demanding airplanes as well as emergency and maintenance vehicles.

703. PURPOSE OF DESIGN PROCEDURE. The procedure for shoulder pavement thickness design is intended to provide a minimum pavement structure to support limited operations of airplanes. The design is intended to provide sufficient support for unintentional or emergency operations of an airplane on the shoulder pavement. Use standard airfield pavement design requirements to design all areas of pavement where airplanes regularly operate.

The minimum section provided by the shoulder pavement design procedure will not perform in the same fashion as full strength airfield pavements. The shoulder pavement is intended to allow safe operation of the airplanes across the paved area without damage to the airplanes. Flexible shoulder pavement sections may experience noticeable vertical movements with each passage of an airplane and may require inspection and/or limited repair after each operation. Rigid shoulder pavement sections may experience cracking with each operation.

704. REPORTING PAVED SHOULDER DESIGN. Summarize all paved shoulder designs on FAA Form 5100-1, Airport Pavement Design, which is considered par of the Engineer's Design Report. Submit the Engineer's Design Report for FAA review and approval along with initial plans and specifications.

705. DESIGN PROCEDURE. The design procedure is based upon the FAA pavement design software (FAARFIELD) and utilizes a modified design procedure to determine the most demanding airplane (MDA) for shoulder pavement design purposes. Several of the procedural assumptions in the standard pavement design (traffic distribution, pass-to-coverage ratios, etc.) are not valid and are not used for the shoulder pavement design procedure. The procedure determines the minimum pavement section required for the MDA, assuming a total of 10 departures. A composite traffic mixture is not considered for the shoulder design.

The shoulder pavement design procedure determines the MDA by calculating pavement thickness requirements for all airplanes utilizing or expected to utilize the airport. The airplane requiring the thickest pavement section is considered the MDA. The following steps are used to complete the design procedure:

a. Use the FAARFIELD software to create a new job file and proposed pavement section for the shoulder design. Include all desired pavement layers, e.g. surface course, base course, stabilized course, subbase course, etc. Adjust layer thickness to observe minimum thickness requirements for shoulder design.

NOTE: Due to minimum pavement layer requirements in the formal airfield pavement design procedure, it may be necessary to use the "undefined" pavement layer to represent the proposed shoulder pavement cross-section.

b. Input one airplane from the traffic mixture for analysis.

(1) Adjust airplane operating weights as appropriate.
(2) Change annual departures to 1.0 departure.

c. Return to the Structure screen and confirm that the design period is 10 years.

NOTE: The intent of this design procedure is to design a pavement for 10 total departures of the most demanding airplane. By setting annual departures to 1 and the design period to 10, the total departures are 10.

d. Confirm the composition and thickness of pavement layers and that the correct layer is designated for thickness iteration. The iteration layer will be shown with a small arrow along the left side. Drainage from the adjacent airfield pavement should be considered in the total thickness of the shoulder pavement section to avoid trapping water under the airfield pavement. A thicker shoulder section or sub-drain may be appropriate.

e. Click on the “Design Structure” button to establish the minimum pavement section for the individual airplane.

f. Repeat steps 1 through 5 for all airplanes in the traffic mixture. The pavement section with the greatest thickness requirement is the design for the shoulder pavement.

EVALUATION AID: To reduce the list of individual airplanes requiring evaluation, include all airplanes from the airport traffic mixture and set annual departures of all airplanes to 1,200 annual departures. Create the proposed shoulder pavement section in the structure screen, then click the “Life” button instead of the “Design Structure” button. Return to the airplane mixture, and scroll over to the column labeled “CDF Max for Airplanes”. The airplane with the highest CDF Max value will be the most demanding airplane in most instances and will control the shoulder design. However, the top few airplanes with the highest CDF Max values should be evaluated because the thickness of the pavement section being evaluated will influence which airplane is the most demanding.

706. PAVEMENT LAYER THICKNESS AND MATERIAL REQUIREMENTS.

a. Asphalt Surface Course Materials. The minimum recommended thickness for asphalt surfacing material is 3 inches (76 mm). The material should be of high quality, similar to FAA Item P-401, and compacted to an average target density of 93 percent of maximum theoretical density. Material produced for use with high traffic volume highway pavement is acceptable provided the compaction specified for the highway application is obtained.

b. Portland Cement Concrete Surface Course Materials. The minimum recommended thickness for rigid pavement design is 6 inches. Portland Cement Concrete (PCC) must be a high quality, durable material capable of resisting deterioration due to environmental factors. The PCC should be similar to FAA Item P-501, with a minimum design flexural strength of 600 psi (4.14 MPa). Material produced for use with high traffic volume highway pavement is acceptable provided that environmental durability is addressed.

c. Base Course Materials. Base course materials must be high quality crushed stone or stabilized materials similar to FAA Items P-208, P-209, P-301, or P-304. Materials produced for use with high traffic volume highway pavement may be acceptable provided they possess qualities similar to the FAA specification items. Crushed stone material must possess a minimum CBR value of 80. The recommended minimum thickness of the base course material is 6 inches. The minimum base course thickness may be reduced to 4 inches (102 mm) by increasing the minimum asphalt thickness by 1 inch (25.4 mm). Place base course material in accordance with the appropriate standard from AC 150/5370-10 or in accordance with the applicable State Highway standard. Additional consideration should be given to frost heave susceptibility of the material when used in frost-susceptible zones.

d. Subbase Course Materials. Subbase course material must provide a minimum CBR value of 20. Materials produced by State Highway standards are acceptable provided the minimum CBR value is obtained. Place subbase course material in accordance with AC 150/5370-10, Item P-154, or in accordance with the applicable State Highway standard. Additional consideration should be given to frost heave susceptibility of the material when used in frost susceptible zones. The minimum recommended thickness is 4 inches (102 mm). See paragraph 707 below.

e. Subgrade Materials. Preparation of subgrade materials should be in accordance with AC 150/5370-10, Item P-152.

707. EMERGENCY AND MAINTENANCE VEHICLE CONSIDERATIONS. In most cases, the pavement design selected by the shoulder design procedure should provide sufficient strength for unlimited operations of maintenance and emergency vehicles. If high operations of these vehicles are anticipated, the shoulder design should be verified for all anticipated service other than airplane usage.

708. AREAS SUSCEPTIBLE TO FROST HEAVE. In areas prone to frost heave, it may be necessary to increase the thickness of the shoulder pavement to avoid differential frost heave. Additional thickness of the pavement beyond that necessary for structural design may be achieved with any material suitable for pavement construction. The material should possess a CBR value higher than the subgrade and have non-frost susceptible properties. Place the additional layer immediately on the subgrade surface below all base and subbase layers. The FAA recommends limited subgrade frost protection in accordance with paragraph 307a(2).