F 鋪面厚度設計個人電腦程式之簡介

F.1 AASHTO 厚度設計法(1993 年版) - (PAVEMENT ANALYSIS SOFTWARE, PAS)

F.2 PCA 厚度設計法(1990 年版) - (PCAPAV)

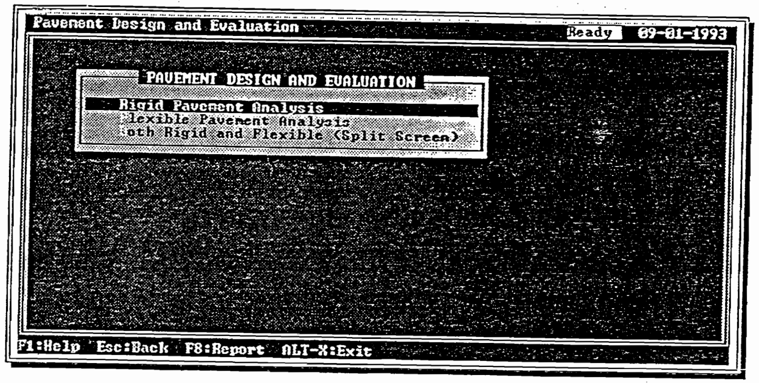
(資料來源：

1. American Concrete Pavement Association, "Pavement Analysis Software" (PAS), Arlington Heights, Illinois, U.S.A., 1993.
2. Portland Cement Association, "PCAPAV -Thickness Design of Highway and Street Pavements," Skokie, Illinois, U.S.A., 1990.

F.1 AASHTO 厚度設計法(1993 年版) - (PAVEMENT ANALYSIS SOFTWARE, PAS)

PAVEMENT DESIGN AND EVALUATION

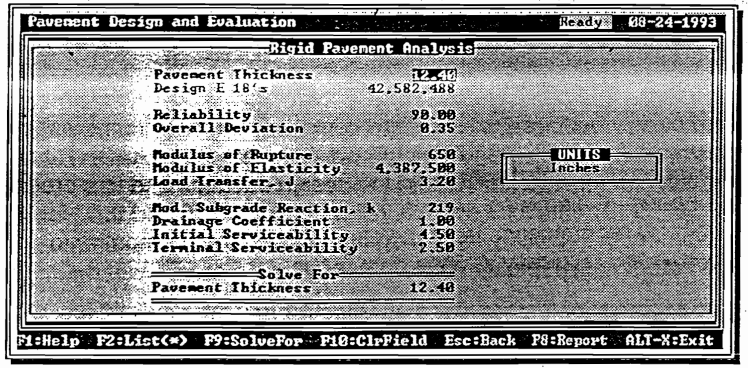
You can design new pavements or analyze old pavements with PAS's pavement design and evaluation module. Depending on your problem, you can work with both rigid and flexible pavements either separately or in a side-by-side format.



RIGID PAVEMENT DESIGN AND EVALUATION

The 'Rigid Pavement Analysis' section uses the methodology of Part II of the 1993 Guide. However, correlation equation from compressive strengths, modulus of rupture, and concrete modulus of elasticity from the American Concrete Institute are also included on the 'HELP' screens to aid the user in determining appropriate values. Similarly, 'HELP' screens and correlation equation between modulus of subgrade reaction (k), soil resilient modulus (M_r), California bearing ratio (CBR), and resistance value (R) from the Army Corps of Engineers and NCHRP Project 128 are also included.

Note: The correlation equation for CBR and R-value on the 'HELP' screens are for estimating the soil resilient modulus and should not to be used to relate each other.



Inputs for the 'Rigid Pavement Analysis' screen are pavement thickness, design E-18s, reliability, overall standard deviation, modulus of rupture, modulus of elasticity, load transfer (J), modulus of subgrade reaction (k), drainage coefficient, and initial and terminal serviceability. By using the 'F9 SolveFor' function key, you can solve for any of these variables, except modulus of elasticity, terminal serviceability, and overall deviation.

Although the AASHO Road test included concrete pavements from 2.5 to 12.5 inches, we recommend that the minimum new pavement thickness for streets be 5.0 inches and for parking lots 4.0 inches. Therefore, PAS uses 4.0 and 20.0 inches, respectively, as the minimum and maximum allowable inputs for thickness. Of course, overlays can be less than 4.0 inches.

The input variable for design E-18's does not include boundary values. The design E-18's are either the allowable or predicted traffic expressed in E-18s. For more information, see 'Traffic Conversion' in the user's guide, 'Traffic' in the 'Simplified Guide,' or Section 2.1.2 of Part II of the 1993 AASHTO Guide.

As discussed in the 'Simplified Guide,' reliability is essentially a factor of safety for a given design. reliability input ranges from 50 to 100 percent. The 'HELP' screen for reliability provides recommendations for an appropriate value depending on roadway functional classification:

FUNCTIONAL CLASSIFICATION	RECOMMENDED LEVEL OF RELIABILITY Urban	Rural
Interstate/Freeways	85 - 99.9	80 - 99.9
Principal Arterials	80 - 99	75 - 95
Collectors	80 - 95	75 - 95
Local	50 - 80	50 - 80

The overall deviation, or standard deviation, is a coefficient that describes how well the AASHO Road Test data fit the AASHTO design equations. It also is an input in the design equation and this program. AASHTO recommends using a value between 0.30 and 0.40 for rigid pavements. Typically, 0.35 is an adequate value for most rigid pavement design problems.

The modulus of rupture is the average 28-day third-point flexural strength of the concrete. AASHTO recommends you increase the minimum specified flexural strength (S_c) by a 'z' factor multiplied by the standard deviation (SD) of the flexural strength to determine the design flexural strength (S'_c).

$$S'_c(\text{design}) = S_c + z(SD)$$

The 'z' factor is a function of the percentage of tests allowed below the minimum specified value. For more information on this, see the 'Simplified Guide,' or section 2.3.4 of Part II of the 1993 Guide.

Modulus of elasticity describes the stress-strain properties of a material. Since this value can be difficult to determine for concrete, it is usually correlated to the compressive or flexural strength by the use of ACI equations. By using the 'HELP' screen, PAS will calculate the modulus of elasticity based on the flexural strength. The value PAS calculates on the help screen will be transferred to the main input screen.

The load transfer coefficient, or J-factor describes the slab interaction across a joint. A lower J-factor indicates better load transfer across the joint. Edge support and load transfer devices also increase slab

E 18's Millions	Doweled & Mesh Reinforced Edge Support No	Yes	Aggregate Interlock Edge Support No	Yes	Continuously Reinforced Edge Support No	Yes	Pavement Class
Up to 0.3	3.2	2.7	3.2	2.8	—	—	Local Streets & Roads
0.3 to 1	3.2	2.7	3.4	3.0	—	—	
1 to 3	3.2	2.7	3.6	3.1	—	—	
3 to 10	3.2	2.7	3.8	3.2	2.9	2.5	Arterials and Highways
10 to 30	3.2	2.7	4.1	3.4	3.0	2.6	
over 30	3.2	2.7	4.3	3.6	3.1	2.6	

Load Transfer, J: 3.20

interaction and decrease the J-factor. The J-factor 'HELP' screen displays J-factor recommendations depending on the pavement type and edge support. We have adopted these recommendations which were originated by the Portland Cement Association. They fall within the guideline values that AASHTO recommends.

The modulus of subgrade reaction, or k-value describes the support strength for rigid pavements. Typical values range from about 50 psi/in for soft, marshy soils to about 500 psi/in for cement-treated and lean concrete bases. The modulus of subgrade reaction 'HELP' screen provides a correlation between the resilient modulus of the subgrade and base course to the k-value for different subbase materials.

Pavement Design and Evaluation — Ready — 08-24-1993

RIGID SUBGRADE ANALYSIS

Material Type	Resilient Modulus (psi)	Loss of Support
Cement Treated Granular Base	1,000,000 - 2,000,000	0 - 1
Cement Aggregate Mixture	500,000 - 1,000,000	0 - 1
Asphalt Treated Base	350,000 - 1,000,000	0 - 1
Bituminous Stabilized Mixture	40,000 - 300,000	0 - 1
Lime Stabilized Base	20,000 - 70,000	1 - 3
Unbounded Granular Materials	15,000 - 45,000	1 - 3
Fine Graded or Natural Subgrade	3,000 - 40,000	2 - 3

1) Resilient Modulus of the Subgrade = 4,118
2) Resilient Modulus of the Base = 25,000 (Hit Enter for None)
3) Base Thickness (4 to 12 inches) = 4.0
4) Depth to Rigid Foundation = ∞ (Hit Enter if > 10')
5) Loss of Support (0, 1, 2, or 3)(*) = 0
>> MODULUS OF SUBGRADE REACTION, k = 219 psi/in

UNITS: psi

F9:SolveFor to Calculate k value

F1:Help F2:List(*) F9:SolveFor F10:ClrField Esc:Back F8:Report ALT-X:Exit

The drainage coefficient (C_d) is available to quantify the drainage capabilities of the pavement structure. Pavement structures with poor drainage have a low C_d while good draining pavement structures have higher C_d values. The 'HELP' screen which is found within the subgrade 'HELP' screen, recommends the following values:

Quality of Drainage	Percent of Time Pavement Structure is Exposed to Moisture Levels Approaching Saturation: Less than 1%	1 - 5 %	5 - 25 %	Greater than 25%
Excellent	1.25 - 1.20	1.20 - 1.15	1.15 - 1.10	1.10
Good	1.20 - 1.15	1.15 - 1.10	1.10 - 1.00	1.00
Fair	1.15 - 1.10	1.10 - 1.00	1.00 - 0.90	0.90
Poor	1.10 - 1.00	1.00 - 0.90	0.90 - 0.80	0.80
Very Poor	1.00 - 0.90	0.90 - 0.80	0.80 - 0.70	0.70

Note: The drainage coefficient (C_d) values are based on the poor soil conditions found at the AASHO Road Test. Therefore, we do not *recommend assigning C_d values less than 1.0, except in extremely poor soil locations.*

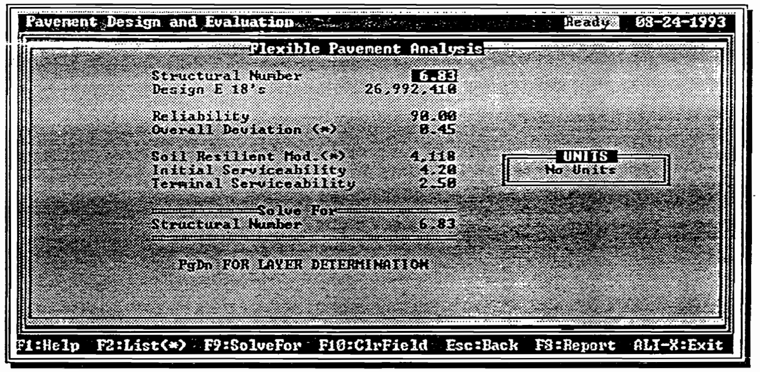
The 'Rigid Pavement Analysis' screen provides an input for initial and terminal serviceability. The serviceability scale ranges from 0 to 5 with a '5' being a perfect pavement and a '0' being a pavement that is impassable. The initial serviceability (p_i) was 4.5 for rigid pavement and 4.2 for flexible pavements at the road test. These are good starting values for a design problem if no other information is available. The terminal serviceability (p_t) is the serviceability at which a pavement is considered to require major rehabilitation. The 'HELP' screen for terminal serviceability (p_t) provides the following recommendations for selecting the terminal serviceability depending on roadway functional classification:

Typical Minimum Terminal Serviceability (pt) values for various road and street classifications.

pt	Street or Highway Classification
2.50	Interstate and Major Highways or Arterials
2.25	Prime Secondary Routes, Industrial & Commercial Streets
2.00	Secondary Routes, Residential Streets & Parking Lots

FLEXIBLE PAVEMENT DESIGN AND EVALUATION

The 'Flexible Pavement Analysis' section is based on Part II of the 1993 Guide. Correlation equations between the soil resilient modulus (M_r), and the California bearing ratio (CBR), and resistance value (R) developed by the Army Corps of Engineers and NCHRP Project 128 are found on the 'HELP' screens. The relationships for CBR and R-value are for estimating the soil resilient modulus and cannot be used to relate CBR and R-values.



Inputs for the 'Flexible Pavement Analysis' screen are structural number (SN), design E-18s, reliability, overall standard deviation, soil resilient modulus, and initial and terminal serviceability. Like the 'Rigid Pavement Analysis' screen, you can use the 'F9 SolveFor' function key on any input variable to determine its result based on the other input values.

The structural number (SN) of a flexible pavement system indicates the required total pavement section. The first input field on the 'Flexible Pavement Analysis' screen is for the SN. In most ordinary flexible pavement design problems, the user will solve for this value.

The input variable for design E-18's does not include boundary values. The design E-18's are either the allowable or predicted traffic expressed in E-18s. For more information, see 'Traffic Conversion' in the user's guide, 'Traffic' in the 'Simplified Guide,' or Section 2.1.2 of Part II of the 1993 AASHTO Guide.

Reliability in flexible pavement design is similar to reliability for rigid pavement design. The 'HELP' screen for reliability provides the same recommendations based on roadway functional classification.

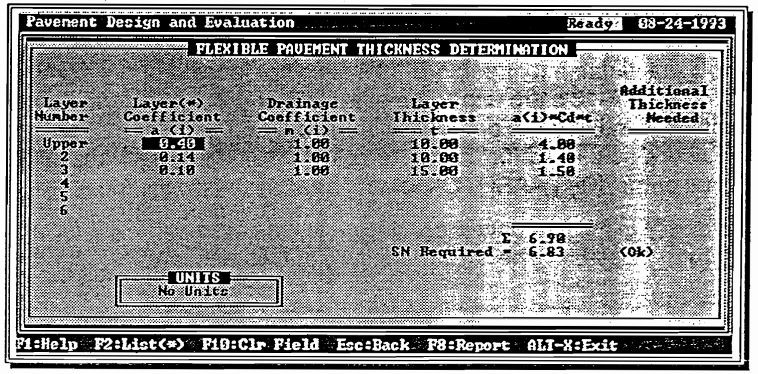
The overall deviation, or standard deviation, is a coefficient that describes how well the AASHO Road Test data fits the AASHTO design equations. It also is an input in the design equation and this program. AASHTO recommends using a value between 0.40 and 0.50 for flexible pavements. Typically, 0.45 is an adequate value for most flexible pavement design problems.

The soil resilient modulus describes the subgrade strength for flexible pavements. Typical values range from about 1000 psi for soft, marshy soils to about 40,000 psi for stable coarse grained soils. The 'HELP' screen for soil resilient modulus includes correlation equations between for soil resilient modulus and the CBR and R-value.

The 'Flexible Pavement Analysis' input screen provides an input for both initial and terminal serviceability. Remember, the serviceability scale ranges from 0 to 5 with a '5' being a perfect pavement and a '0' being a pavement that is impassable. The initial serviceability (p_i) was 4.2 for flexible pavements at the road test. This is a good starting value for a flexible pavement design problem if no other information is available. The terminal serviceability (p_t) is the serviceability at which a pavement is considered to require major rehabilitation. The 'HELP' screen for terminal serviceability (p_t) provides the same recommendations for selecting the terminal serviceability as are shown for rigid pavements.

Flexible Layer Determination

An additional step is necessary to complete a flexible pavement design. This is because the AASHTO flexible design equation only provides a structural number to characterize the pavement thickness,. After determining the SN, it is necessary to determine layer thicknesses which when combined will provide the required structural number. This is accomplished by pressing the 'PgDn' key to access the 'Layer Determination' screen:



The flexible pavement 'Layer Determination' screen provides a simple spreadsheet format for trying different combinations of layers and materials. In a flexible pavement design, a coefficient is assigned to each flexible pavement layer that converts the actual layer thickness to a layer structural number. The coefficients are indicative of the relative strengths of the materials. The sum of all the layer structural numbers must equal or exceed the required structural number (SN) from the AASHTO equation.

The SN is converted to layer thickness by using the following formula:

$$SN = a_1t_1 + a_2t_2m_2 + a_3t_3m_3 + ...$$

where

a_1,a_2,a_3 = layer coefficients representative of the surface, base, subbase, etc. These are based on the ability of a material to function as a structural component of the pavement. Typical values for several materials can be found in the 'HELP' screen. For more information, see section 2.3.5 of the 1993 Guide.

t_1,t_2,t_3 = actual thickness of the surface, base, subbase, etc. in inches.

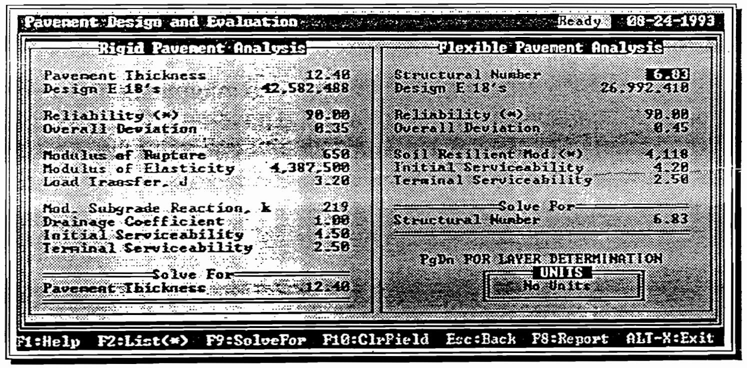
m_2,m_3 = drainage coefficients for the base, subbase, etc. Values for the drainage coefficient can be found in the 'HELP' screen. For more information, see section 2.4.2 of the 1993 Guide.

The pavement thickness is found by iterating layer thickness until the sum of the $a_i*t_i*m_i$ of each layer is equal or greater than the required SN.

The Additional Thickness Needed column on the right-hand side of the 'Layer Determination' screen provides a check to ease layer thickness design. The column displays how much additional thickness is needed to meet the total SN for the layer/material on which the cursor rests. You may use the value PAS displays to adjust your layer thicknesses and optimize your design.

BOTH RIGID AND FLEXIBLE PAVEMENT DESIGN AND EVALUATION

This split screen performs the same functions as both the Rigid Pavement Analysis' and 'Flexible Pavement Analysis' screens. However, it allows you to perform both designs in a side-by-side format, so that you can easily make direct comparisons between the two pavement types. All inputs, variables and 'HELP' screens are identical. You are still required to press the 'PgDn' key for the flexible pavement 'Layer Determination' screen.



NOTE: When using the split screen for design and evaluation, you must press 'F9 SolveFor' twice: once to solve for the rigid unknown and once for the flexible unknown.