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THE ASPHALT INSTITUTE
ASPHALT INSTITUTE BUILDING
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PLANNED STAGE CONSTRUCTION

WITH FULL-DEPTH® ASPHALT CONCRETE

INTRODUCTION AND DEFINITION

Planned stage construction is a means of providing fully adequate pavements with the most effective use of materials, energy, and funds. Although a technique long used by highway engineers, it has acquired added significance because of the need to conserve energy.

As defined, planned stage construction is the building of a structure by reserving a portion for placing at a later date according to design and a predetermined time schedule. The postponed segment of the structure can be in width, in length, in depth, or in a combination of dimensions.

Planned stage construction in width means building the lanes needed today while reserving the necessary right-of-way for future lanes.

Planned stage construction in length means building the pavement to the full depth and width required for the normal design but holding back some of the length for future construction.

Planned stage construction in depth means building the pavement by applying successive layers of asphalt concrete according to design and a predetermined time schedule. The first stage, however, should never be less than 100mm (4 in.) thick and the second stage should be constructed at the planned time.

The design of planned stage construction is completely different from the design of major maintenance or the rehabilitation of existing pavements.

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THE ADVANTAGES OF PLANNED STAGE CONSTRUCTION

There are several circumstances in which stage construction is advantageous:

- When funds are insufficient for construction of the full (say, 20 year) design thickness, the pavement may be designed for construction in two stages, with the first stage being designed for a shorter time period. However, it is important that plans be made to have funds available for the second stage at the proper time.
- Difficulties in estimating traffic for periods of 20 to 25 years, particularly for city streets and some low-volume rural roads, make planned stage construction attractive. A facility can be designed for a shorter time period (i.e., lesser amount of traffic) and traffic counts can be made when the facility is in actual use. From this inservice data, improved estimates of later traffic are possible.
- Experience at the AASHO Road Test indicated that pavements overlaid after they had been subjected to traffic performed somewhat better than new pavements of equal design.
- Weak spots that may develop during the service life of the first stage can be repaired prior to building the second stage.
- Careful evaluation of the condition of the pavement, toward the time when construction of the second stage is contemplated, may bring about savings based upon an extended life of the original (first stage) pavement, or construction cost savings stemming from a warranted reduction in thickness of the completed pavement.

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*Full-Depth ®Asphalt Pavement—The term Full-Depth (registered by The Asphalt Institute with the U.S. Patent Office) certifies that the pavement is one in which asphalt mixtures are employed for all courses above the subgrade or improved subgrade. A Full-Depth asphalt pavement is laid directly on the prepared subgrade.

DESIGN METHOD

The method of design for stage construction is based on the concept of "remaining life." Since the procedure involves "planned" stage construction, the pavement is designed on the presumption that the second stage overlay will be placed *before* the original pavement has used up all of its fatigue life. To ensure that this is the case, certain modifications are made to the design procedure normally used to design asphalt pavements. For more details, or to use the procedure for more precise design, refer to The Asphalt Institute manual *Thickness Design—Asphalt Pavements for Highways and Streets* (MS-1).

DESIGN REQUIREMENTS

The design procedure requires some knowledge of the following factors:

> Traffic-classified by equivalent singe-axle load applications (EAL); type of street or highway; or volume of heavy trucks.
>
> Subgrade support—classified by type of subgrade or estimated from Resilient Modulus, CBR or R-value test data.

Traffic Analysis Using Table 1

The design procedure separates traffic into six classes. Each class is associated with a particular equivalent number of 80 kN (18,000 pound) single-axle load applications (EAL), the type of highway or street, and the average daily number of heavy trucks expected on the facility during the design period.

EAL

EAL is the effect on pavement performance of any combination of axle loads of varying magnitude equated with the number of 80 kN (18,000 pound) single-axle loads required to produce an equivalent effect.

Heavy Trucks

Heavy trucks are described as two-axle, six-tire trucks or larger. Pickup, panel and light four-tire trucks are not included. Trucks with heavy-duty, widebase tires are included.

Subgrade Support

Subgrade soils are classified into three classes:

Poor soils become quite soft and plastic when wet. Included are those soils having appreciable amounts of clay and fine silt. The coarser silts and sandy loams also may exhibit poor bearing properties in areas where frost penetration into the subgrade is a factor. Typical properties: Resilient modulus = 30 MPa (4,500 psi), CBR = 3, R-value = 6.

Medium soils retain a moderate degree of firmness under adverse moisture conditions. Included are such soils as loams, silty sands, and sand-gravels containing moderate amounts of clay and fine silt. Typical properties: Resilient modulus = 80 MPa (12,000 psi), CBR = 8, R-value = 20.

Good subgrade soils retain a substantial amount of their load-support capacity when wet. Included are the clean sands and sand-gravels and soils free of detrimental amounts of plastic materials. Excellent subgrade soils are unaffected by moisture or frost. They include clean and sharp sands and gravels, particularly those that are well graded. Typical properties: Resilient modulus = 170 MPa (25,000 psi), CBR = 17, R-value = 43.

The Asphalt Institute's *Soils Manual*, Manual Series No. 10 (MS-10), describes in detail the commonly used soil evaluation systems and test procedures. Field evaluation of the soil involves visual inspection and simple field tests.

Asphalt Concrete

This procedure includes designs for typical asphalt concrete surface and base course materials. Asphalt concrete mixtures should be designed to meet the criteria for test limits recommended in the Asphalt Institute publication, *Model Construction Specifications for Asphalt Concrete and Other Plant-Mix Types* (SS-1).

TABLE 1 TRAFFIC CLASSIFICATIONS

Traffic Class	EAL	Type of Street or Highway	Approximate Range — Number of Heavy Trucks Expected During Design Period
I	5×10^3	• Parking lots, driveways • Light traffic residential streets • Light traffic farm roads	≤7,000
II	10^4	• Residential Streets • Rural farm and residential roads	7,000-15,000
III	10^5	• Urban minor collector streets • Rural minor collector roads	70,000-150,000
IV[(1)]	10^6	• Urban minor arterial and light industrial streets • Rural major collector and minor arterial highways	700,000-1,500,000
V[(1)]	3×10^6	• Urban freeways, expressways and other principal arterial highways • Rural Interstate and other principal arterial highways	2,000,000-4,500,000
VI[(1)]	10^7	• Urban Interstate highways • Some industrial roads	7,000,000-15,000,000

[(1)]Whenever possible the traffic analysis and design procedures given in The Asphalt Institute manual, *Thickness Design—Asphalt Pavements for Highways and Streets* (MS-1) should be used for roads and streets in traffic category IV or higher.

STEPS IN DESIGN
(U.S. Customary Units)

Stage 1

(1) Select a subgrade class as indicated above. Interpolate using Figure 1, if appropriate.

(2) Select a traffic class or EAL for Stage 1 from Table 1 or use the procedure of Chapter IV, *Thickness Design—Asphalt Pavements for Highways and Streets* (MS-1). Interpolate between classes on Figure 1, if appropriate. Record n_1 = EAL selected.

(3) Calculate adjusted EAL, $(N_1) = 1.67\ n_1$.

(4) Select Full-Depth asphalt thickness h_1 for stage 1 from Figure 1 using EAL $= N_1$.

This procedure assumes that the pavement is essentially undamaged, structurally, at the end of the Stage 1 design period. If extensive distress is evident, then the project should be treated as an overlay design problem. A method of evaluating pavement distress is found in The Asphalt Institute publication, *A Pavement Rating System for Low-Volume Asphalt Roads* (IS-169). Procedures for asphalt overlay design are given in the Institute manual, *Asphalt Overlays for Pavement Rehabilitation* (MS-17).

If at the end of Stage 1 the pavement appears to be in good condition, or *to estimate the anticipated overlay thickness for planned stage construction,* the following procedure is followed.

Stage 2

(1) Select a traffic class or EAL for Stage 2. Record n_2 = EAL selected.

(2) Calculated adjusted $N_2 = 2.5\ n_2$

(3) Select Full-Depth asphalt thickness h_2 for Stage 2 from Figure 1 using EAL $= N_2$.

(4) Calculate thickness of overlay $h_0 = h_2 - h_1$.

EXAMPLE
(U.S. Customary Units)

A minor collector street is to be designed for stage construction. It is expected that it will fall in Traffic Class III with EAL = 100,000. The first stage is to be designed for 25% or an EAL = 25,000. Subgrade class is medium, Resilient modulus = 12,000 psi.

Stage 1

(1) Subgrade, resilient modulus = 12,000 psi

(2) Traffic for Stage 1, EAL = 25,000

(3) Adjusted EAL (N_1) = 1.67 × 25,000 = 41,750

(4) From Figure 1, h_1 = 4.0 in.

Stage 2

(1) Subgrade, as before, 12,000 psi

(2) Traffic class is expected to be about Class III, EAL (n_2) estimated to be 100,000

(3) Adjusted EAL (N_2) = 2.5 × 100,000 = 250,000

(4) From Figure 1, h_2 = 6.0 in.

(5) Overlay thickness, h_0 = 6.0 − 4.0 = 2.0 in.

SEE NEXT PAGE FOR DESIGN CHART

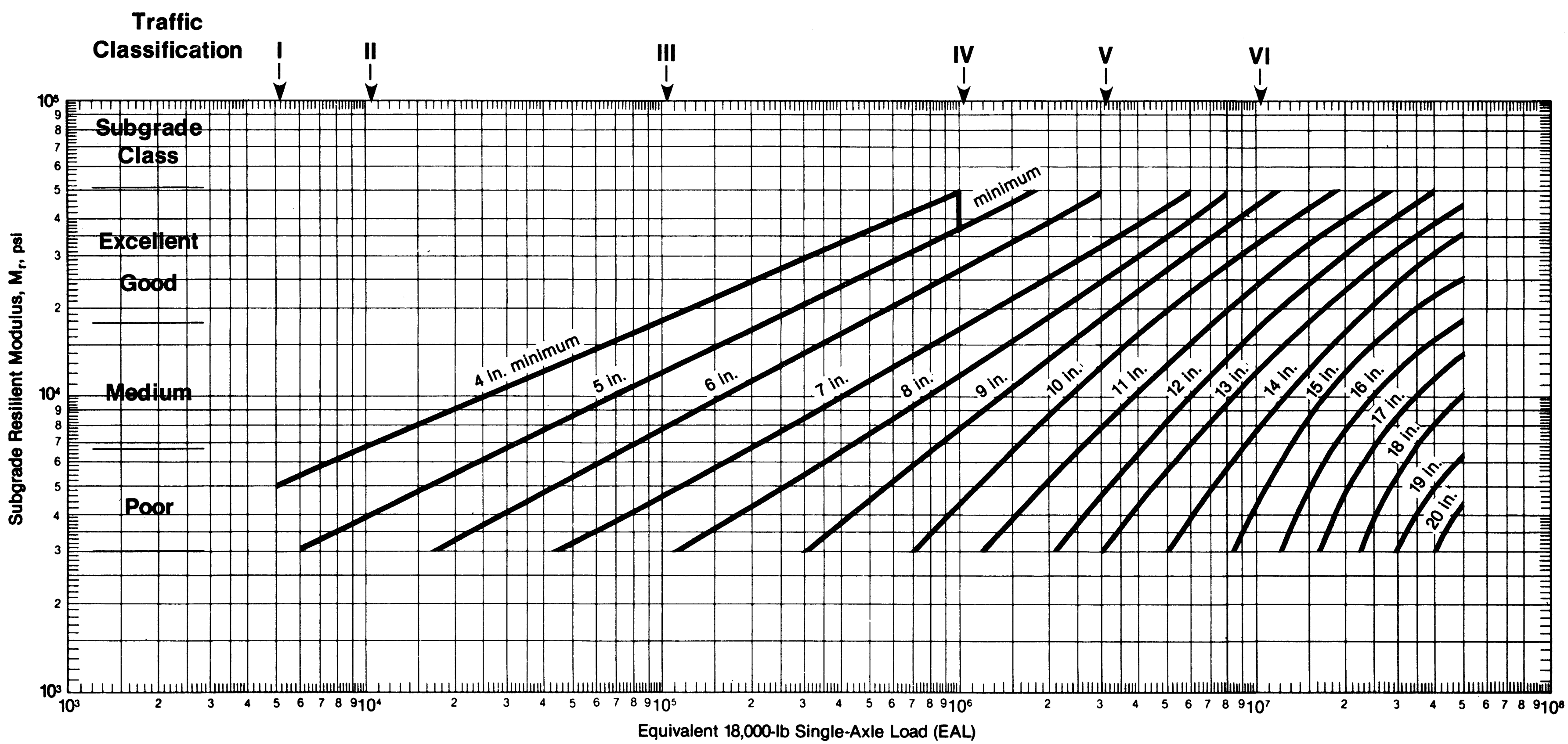

Figure 1 — Full-Depth Asphalt Concrete Design Chart