California Division of Highways Procedure For Designing Composite Pavements

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•IN the California method for determining the design thickness for flexible and composite type pavements, the cohesion C or tensile strength of the various layers making up the structural section is evaluated. The design values are established from a large number of cohesiometer tests, correlation with test track data and correlation with experience on highways.

The basic design formula is

$$T = \frac{0.095\ (TI)\ (90 - R)}{\sqrt[5]{C}} \tag{1}$$

in which

- T = cover required over soil in question, in in.;
- TI = traffic index = $1.35\ (EWL)^{0.11}$;
- R = resistance value of the soil in question as determined by the stabilometer;
- C = combined cohesiometer values of the proposed overlying layers; and
- EWL = 5,000-lb equivalent wheel loads in one direction for a 10-yr design period.

Of the three variables (traffic, R-value and C-value) embodied in current design method for layer thickness determination, only the C-value, or cohesiometer value, relates to the beam strength of the surfacing and base.

Figure 1 shows the deformation of a structural section under an excessive load. Resistance to such deformation is supplied by interparticle friction (measured in terms of R-value), the tensile strength of the structural section, and the confining force due to the weight of material surrounding the loaded area. If the deforming forces overcome interparticle friction, the tensile strength must be sufficient to prevent the indicated lateral displacement. Since cohesion measures the ability of a material to resist tensile stress, its evaluation is included in the design process.

The cohesiometer test is performed on specimens 4 in. in diameter by 2½ or 3 in. high clamped to a hinged plate with a test load applied to a lever arm attached to one side of the hinged plate (Fig. 2). The cohesiometer value (C) is expressed as the breaking load in grams per inch diameter for a 3-in. specimen.

From original test track studies, it was found that the thickness of cover is proportional to $\frac{1}{\sqrt[5]{C}}$. It is very often convenient to express the total thickness of cover required in terms of gravel equivalent. The gravel equivalent is the thickness of gravel (sand, crushed stone or other granular material) required to protect the underlying material from a given load and is based on an assumed cohesion value of 100 for the granular untreated cover material. Therefore, the equation for unit gravel equivalent may be derived as follows:

Let

- Tg = thickness of gravel;
- Cg = cohesiometer value of gravel;
- Tx = thickness of other material; and
- Cx = cohesiometer value of other material.

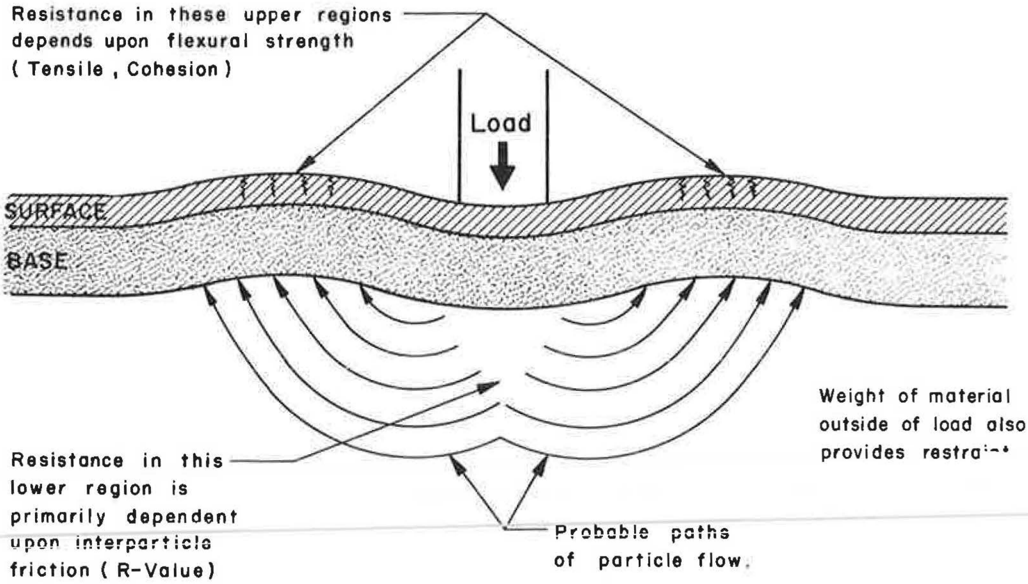

Figure 1. Schematic representation of plastic flow phenomena.

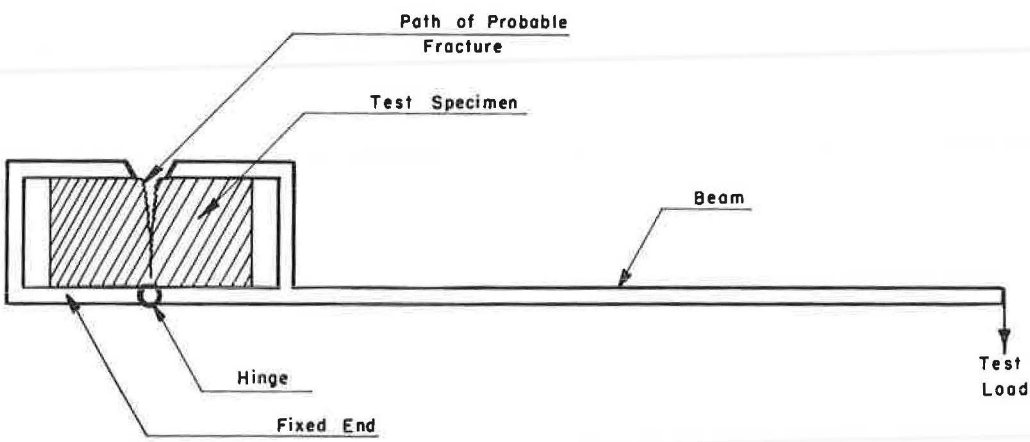

Figure 2. Schematic arrangement of apparatus used in cohesiometer test.

Then

$$\frac{Tg}{Tx} = \frac{\frac{1}{\sqrt[5]{Cg}}}{\frac{1}{\sqrt[5]{Cx}}} = \frac{\sqrt[5]{Cx}}{\sqrt[5]{Cg}} = \sqrt[5]{\frac{Cx}{Cg}} \tag{2}$$

If Tx = 1 in. and Cg = 100 (cohesiometer for untreated soils or gravel), then

$$Tg = \sqrt[5]{\frac{Cx}{100}} \tag{3}$$

Application of Eq. 3 to Class A CTB which has a cohesiometer value of 1,500 gives

$$Tg = \sqrt[5]{\frac{1,500}{100}} = 1.72 \text{ in. of gravel per inch of CTB}$$

Table 1 shows the cohesiometer values and unit gravel equivalents assigned to various layers of the structural section.

A reduction in base thickness from that required for uncemented-aggregate bases is, therefore, made when Class A or B CTB in composite pavements is used.

1. Class A CTB reduces the thickness of untreated base by 42 percent.
2. Class B CTB reduces the thickness of untreated base by 33 percent.

It should be pointed out, however, that if the reduction in thickness from an untreated base layer results in a CTB thickness of less than 6 in., it is advisable, from the construction standpoint and due to variations encountered in the construction of

TABLE 1

Layer	Cohesiometer Value	Unit Gravel Equivalent (in./in.)
Surfacing:		
Asphalt concrete (plant mixed)	400	1.32
Road-mixed asphalt surfacing	150	1.08
Base:		
Aggregate base (untreated)	100	1.32
Cement-treated base, Class A (750 psi at 7 days)	1,500	1.72
Cement-treated base, Class B (400 psi at 7 days)	750	1.50
Cement-treated base, Class C (80+ R-value)	100	1.00
Lime-treated base (80+ R-value)	100	1.00
Asphalt-treated base (plant mixed)	400	1.32
Asphalt-treated base (road mixed)	150	1.08
Subbase:		
Aggregate subbase (untreated)	100	1.00
Cement-treated subbase	100	1.00
Lime-treated subbase	100	1.00

any base, that the CTB layer be built at least 6 in. thick and preferably not less than 8 in. when used under asphalt-concrete surfacing carrying heavy traffic. The California test track indicated that cement-treated bases of less than 5 in. thickness over a saturated subgrade are subject to early breakup after exposure to a comparatively small number of truck repetitions.

A more detailed description of the California method of design is presented in Test Method No. Calif. 301.

An example of the application of cohesiometer value in the design formula follows:

A. Multilayered systems require the combining of individual cohesions to obtain an equivalent value for use in the design equation, shown as follows:

1. Assume the following structural section over a basement soil:
   (a) 4 in. of asphaltic concrete (AC),
   (b) 8 in. of Class A cement-treated base (CTB), and
   (c) 4 in. of imported subbase material (ISM).
2. Refer to Table 1 for the unit gravel equivalents (GE).
   (a) GE of 4-in. AC = 1.32 × 4 in. = 5.28 in.
   (b) GE of 8-in. CTB = 1.72 × 8 in. = 13.76 in.
   (c) GE of 4-in. ISM = 4.00 in.
   (d) Total GE for the three layers = 23.04 or 23 in.
3. Knowing the actual assumed thickness (16 in.) of the system and having calculated its gravel equivalent, the cohesiometer value is determined by the following formula:

$$\text{Coh} = \left(\frac{\text{GE}}{\text{T}}\right)^5 \times 100 = \left(\frac{23}{16}\right)^5 \times 100 = 620$$

B. For the purpose of this design problem, assume a traffic index of 10.0 (about 50 million EWL) and a design R-value for the basement soil of 20.

C. Then, using the design equation and above values for the variables, the required thickness of cover over the basement soil may be calculated from

$$\text{T} = \frac{0.095\ (\text{TI})\ (90 - \text{R})}{\sqrt[5]{\text{Coh}}} = \frac{0.095\ (10)\ (90 - 20)}{\sqrt[5]{620}} = 18.4 \text{ in.}$$

D. Since the required thickness of 18.4 in. is greater than the assumed thickness of 16.0 in., the proposed design is not adequate.

E. Therefore, assuming 8 in. of ISM (instead of 4 in.) and retaining the 4 in. of AC and 8 in. of Class A CTB (total cover = 20 in.), the design requirement is recalculated.

1. Combined cohesiometer value is recalculated using the preceding method; the value now becomes 450.
2. By substituting this value in the design equation, a required thickness of 19.7 in. is determined.
3. Since the assumed cover thickness is 20 in., the design calling for 4-in. AC, 8-in. CTB Class A and 8-in. ISM will be satisfactory over the existing basement soil.
4. In actual practice there are charts, tables and special slide rules that greatly facilitate these calculations.