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April 8, 1968

MEMORANDUM

H-2-20

TO: W. B. Drake
Assistant State Highway Engineer
Chairman, Kentucky Highway Research Committee

SUBJECT: Research Report; "An Evaluation of Temperature Distribution within Asphalt Pavements and Its Relationship to Pavement Deflection"; HPR-1(3), Part II; KYHPR-64-20

The attached report presents significant progress and achievements in the area of asphalt pavement design. Benkelman beam deflections were used extensively in conjunction with our 1958 study of asphalt pavement performance; apparent relationships between 18-kip deflections and pavement structures were evident then although scatter in the data was thought to be necessarily admissible. During the spring and summer of 1966, another extensive series of pavements, built since 1958, were evaluated from the standpoint of performance and deflection. It seemed compelling at that time to adjust all deflections to some common reference temperature and so the surface temperature of the pavement was measured at each test site at the time the deflection test was made. However, the development of a temperature-deflection adjustment factor became more complicated than it was expected to be. It became rather evident that surface temperature alone would not suffice. Since temperatures were not measured at depths and since subsurface temperatures were thought to influence deflections greatly, a method of approximating or estimating temperatures at depths was desired. This became the first objective; the second objective then was to determine the magnitude of the adjusting factor.

The enabling information for the analysis of temperature and temperature distribution was provided by a one-year, continuous record of air temperature, pavement surface temperature, and temperatures at various depths in an asphaltic concrete pavement constructed for this purpose at the Asphalt Institute Laboratory at College Park, Maryland.

The source information for the determination of temperature-adjustment factor was taken from AASHO Test Road Report No. 5.

The analyses were made by H. F. Southgate, Research Engineer, who was in charge of the deflection-measurement team in 1966 and is working toward his Masters degree in Civil Engineering at the University of Kentucky. His report will be submitted toward the fulfillment of his thesis requirements.

The analysis of the main body of deflection data may now proceed in an orderly way. We will then be concerned principally with the structural adequacy of pavements designed according to the 1958 criterion and evaluations of structural equivalencies between bituminous concrete and dense-graded, crushed limestone base courses.

Concurrent with this study, an adjunctive study of traffic and EWL's (KYHPR-64-21) has been in progress. This type of information will be needed in the evaluation of the performance of the pavements with respect to structure and serviceability ratings.

Mr. Southgate's analysis of deflections (AASHO Road Test data) in terms of elastic theory is very encouraging, and a similar approach may be employed in the subsequent evaluation of the 1966 deflection data.

Respectfully submitted,

Jas. H. Havens

Jas. H. Havens
Director of Research
Secretary, Research Committee

JHH:em
cc: Research Committee
A. O. Neiser
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Research Report

AN EVALUATION OF TEMPERATURE DISTRIBUTION WITHIN ASPHALT PAVEMENTS AND ITS RELATIONSHIP TO PAVEMENT DEFLECTION

HPR-1(3), Part II; KYHPR-64-20

by

H. F. Southgate, Research Engineer

Division of Research
DEPARTMENT OF HIGHWAYS
Commonwealth of Kentucky

In Cooperation with the
U. S. Department of Transportation
Federal Highway Administration
Bureau of Public Roads

April, 1968

CHAPTER I

INTRODUCTION

Asphalts "soften" as the temperature increases and "stiffen" as the temperature decreases, and measurements have shown that the deflection and rebound of asphalt pavements in response to loads are affected to a significant degree by temperature. Historically, pavements which deflect greatly under traversing loads are short-lived. Pavements which undergo minimal deflection at some maximum load are either inherently more rigid or are more firmly supported than those which undergo greater deflection. The rigidity or "stiffness" of asphaltic concrete is not a direct measure of strength, nor is deflection an inverse measure of the strength of a pavement structure. Strength is usually expressed as the load or stress which causes overt failure; whereas stiffness or rigidity is concerned only with load-deflection (or stress-strain) relationships. It seems reasonable to say that the deflection of a pavement decreases as the thickness of the asphaltic concrete is increased and that the strength of the pavement structure is thereby increased. Therefore, in the case of a pavement which has a more-or-less uniform degree of support, deflection and thickness are empirical indicators of strength and structural adequacy. For lesser but uniform degrees of support, greater thicknesses of asphaltic concrete are compensating--effectively reducing deflection and strengthening the pavement system. Of course, the supporting capabilities of underlying soil or base courses may be improved and/or thickened to accomplish the same effect. Indeed, a multiplicity of inter-relationships is evident in a vast array of research literature concerning pavement design and performance. Elastic and viscoelastic theories have been extended and perfected, fatigue theories of failure have been studied, and each of these has been related with some degree of confidence to load and deflection.

Surface deflection (or rebound) remains the most measurable response of a pavement to an applied load. Adjustment of measured deflections to a common (or base) temperature offers further hope of reducing the temperature variate and improving the correlation between load-deflection and classical theory. The most convenient and most widely used method of measuring deflection is with the Benkelman beam (1)* (see Figures 1 and 2).

Pavement surface temperature alone does not suffice to account for the dependency of deflection on temperature; and, since temperatures at depths are known to influence deflections, subsurface temperatures must be either measured <u>in situ</u> or estimated from other correlations. The purpose of this research is as follows:

1. To develop a method for estimating the temperature at any depth in a flexible pavement up to twelve inches thick, and
2. To analyze the temperature-deflection data generated in the AASHO Road Test (2) to show that temperature adjustment factors

*The number enclosed in parenthesis is the reference number in the List of References.

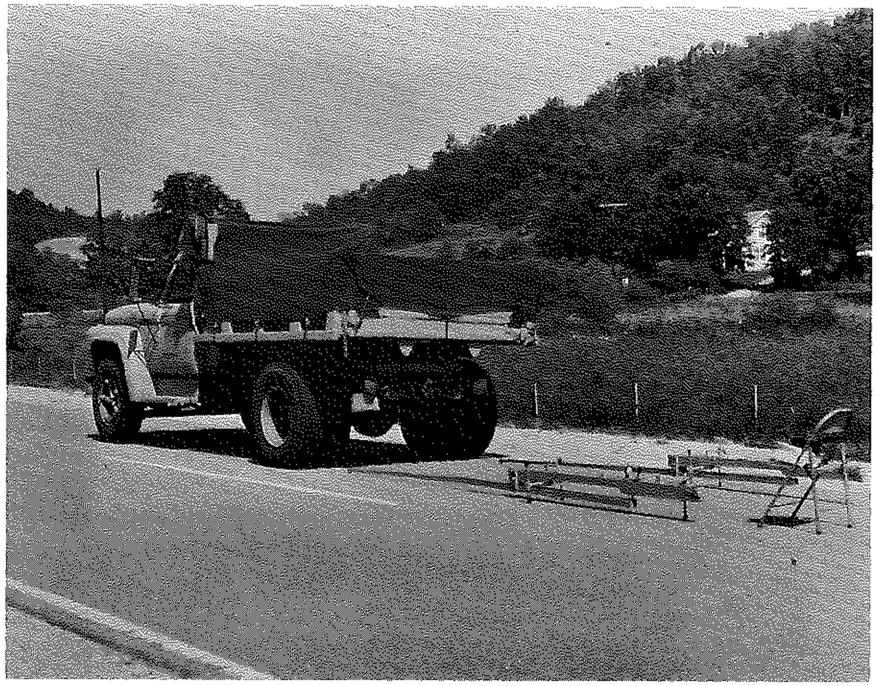

Figure 1: Benkelman Beam Deflection Test Setup

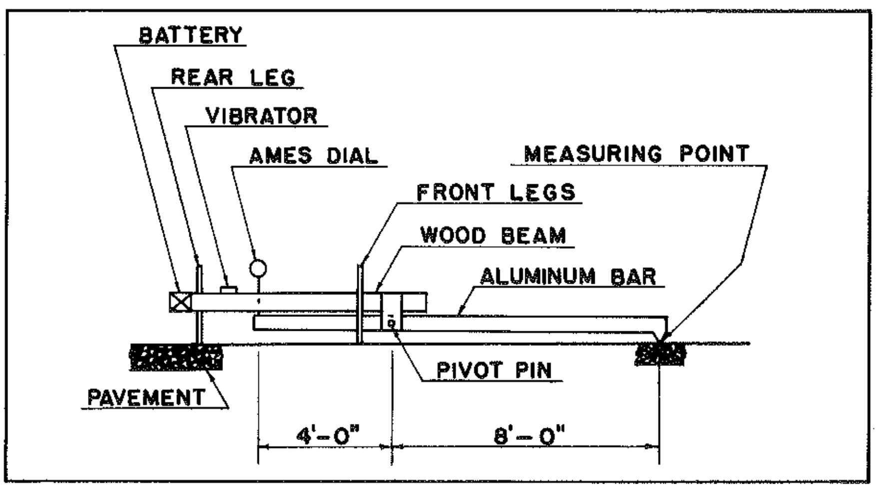

Figure 2: Basic Components of the Benkelman Beam

are generally applicable to Benkelman beam deflection measurements of bituminous pavements and to determine the magnitude of these adjustment factors.

CHAPTER II

SIGNIFICANT LITERATURE AND SOURCES OF DATA

The reports of the WASHO Road Test (1), issued in 1955, stated "Among the variables that influenced the magnitude of deflection, that of the temperature of the surfacing material was pronounced. It is probable that differences in deflection due to changes in soil or structure conditions were overshadowed by differences due to varying temperatures in some cases." In a special experiment, temperature and deflection measurements were made each hour during a 24-hour period; results from three sections with 4 inches of bituminous surfacing are shown in Figure 3. During the cooling hours, the deflections on section 6-4-18S remained abnormally high; but, when scheduled traffic was discontinued at 2:00 am, deflections thereafter moderated in relationship to the declining temperature. This delayed reaction seemed to be an anomalous phenomenon inasmuch as the temperatures were measured directly in the wheel paths--at a depth of 2 inches. Were it not for the fact that pavement temperatures were measured directly, one might conclude that traffic kept the pavement warm. However, since the temperature graph represents the average of three locations per wheel path on the three respective sections, the true relationship may have been obscured in the averaging. A companion set of pavement sections produced an average temperature curve (not shown here) which was significantly

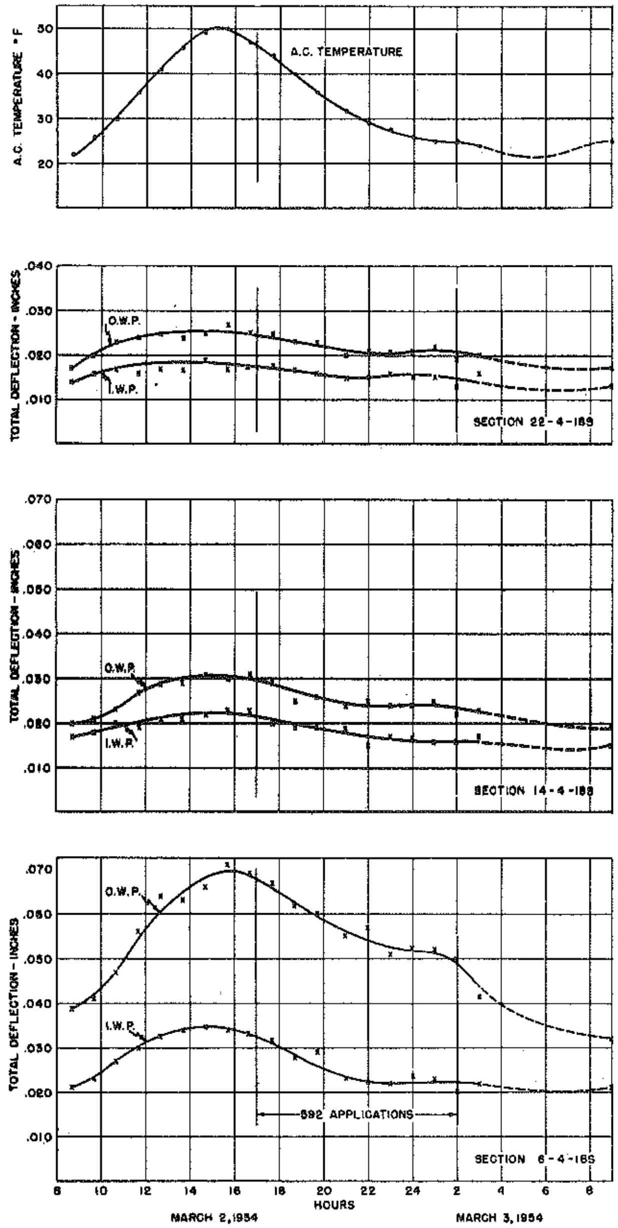

Figure 3: Twenty-Four-Hour Pavement Deflection-Temperature Study; Temperatures Recorded at a Depth of 2 Inches, (3, p. 155)

different even though the measurements were made at the same time. Deflections in the outer wheel paths were generally greater than those in the inner paths; however, this comparative manifestation seems to have resulted partly from freezing and thawing near the edge of the pavement--inasmuch as isotherms indicated that the temperatures near and beneath the centerlines of the pavements were always higher than those near the edges--and partly from structural discontinuity. On the other hand, considering temperature regimes only, it would be expected that deflections in the inner wheel paths would be greater than those in the outer paths. The load-deflection relationship for the several pavement sections on the WASHO Test Road was quite linear; the proportionality constant (load-deflection ratio) differed among the several pavement structures; and in each case, the load-deflection ratio increased curvilinearly as the temperature decreased.

Following the WASHO Test Road, the use of the Benkelman beam in pavement studies became somewhat widespread. In a study made in Kentucky (3) in 1958, beam-type, 18-kip load deflection measurements taken in the springtime correlated generally with gross thickness of pavement and were helpful in the revision of thickness-design charts. No temperature-adjustment factor was employed in the analysis. Other historical and interpretive aspects of deflection measurements are presented in a series of reports comprising a "Symposium of Flexible Pavement Behavior as Related to Deflection," (4) sponsored by the Association of Asphalt Paving Technologists in January 1962. Many investigators recognized that temperature was indeed an affecting factor--as were seasonal variations in soil moisture, etc. Customarily, deflection data were evaluated in terms of Spring, Summer, and Fall measurements in order to minimize spurious or ambient variations as well as to gain insights into the seasonal changes in pavement behavior. Even so, early morning deflections differed from noontime deflections, and a dispersion of the data was inevitable. The first tangible deflection-adjustment factor for temperature effects was developed and reported by the Canadian Department of Transport in 1961 (5; cf. 4, pp. 343-376). The correction factor was applicable only to rebound deflections and amounted to 0.002-0.003 inch per 10°F.

The AASHO Test Road became active in October, 1958, and was concluded at the end of 1960. Extensive deflection and temperature measurements were taken and they provided the most extensive array of temperature-deflection-structure data available to that time. Various analyses and interpretations have been made from these data--but at constant or interpolated temperatures. It was observed that creep-speed deflections were affected very slightly by temperatures above 80°F, although a precise analysis of the temperature-deflection relationship was not offered. The data are particularly significant to the study reported herein; the creep-speed deflections (2, Figures 89 and 90, pp. 110-111) comprise one of the main sources of data (see Figures 14 and 15) used in Chapter III of this report.

Another development enabling analysis of temperatures and temperature distributions within pavements was provided by Kallas (6) in 1966. The Asphalt Institute's laboratory at College Park, Maryland, installed a 12-foot wide asphaltic concrete pavement test section with a 10-foot length that was 6 inches thick, connected by a 2-foot transition section to the remaining 12-foot length which was 12 inches thick. The entire test plot was laid directly on the subgrade. Air temperatures, surface temperatures and temperatures at each 2-inch increment of depth were recorded from June 1964 through May 1965. Kallas' record was purposeful toward studies of deflections, stress-strain relationships, effects of moving loads, and ranges of temperatures through which mechanical behavior of asphalt mixtures might realistically be studied by laboratory testing. Kallas did not undertake an exhaustive analysis of the data. Only excerpted data were published; however, the main body of data were made available for the purpose of the study reported herein.

CHAPTER III

METHOD AND ANALYSIS

Analysis of Temperature Records

The data used to develop the temperature distributions and the prediction criterion were those recorded in 1964 and 1965 at the Asphalt Institute's laboratory at College Park, Maryland (6) (also refer to previous Chapter).

In this analysis, data for eight warm-weather months were punched on cards and automatically plotted with the aid of an IBM 7040 Computer and a Calcomp plotter. These plots were examined for the following purposes:

1. To insure that all theromocouple readings had reasonable relationships one to another for known conditions,
2. To determine if any general temperature distribution patterns frequently recurred, and
3. To see if any relationships held for a given hour on a day-to-day basis.

All thermocouple readings had reasonable relationships to other thermocouple readings. These plots could be sorted into categories of general weather conditions, such as:

1. A normal sunny day, illustrated by Figure 4,

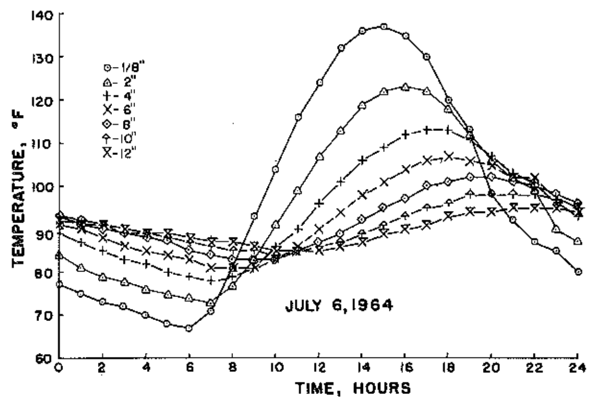

Figure 4: Temperature Distribution in an Asphaltic Concrete Pavement vs. Time, Illustrating a Normal Sunny Day

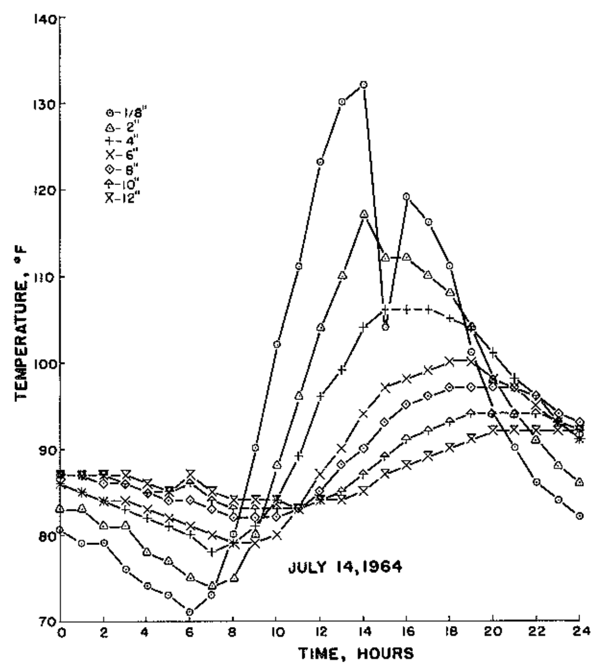

Figure 5: Temperature Distribution in an, Asphaltic Concrete Pavement vs. Time, Ilustrating the Effects of a Passing Cloud

2. A passing cloud, causing a dip in the surface temperature, illustrated by Figure 5,

3. A rain shower, causing a sharp drop in the slope of the curves illustrated by Figure 6,

4. An overcast or rainy day, causing the surface temperature to be consistently lower than the temperatures at depths, illustrated by Figure 7.

The plots also revealed that once the disturbing influence was passed, the temperature distribution pattern resumed its normal shape (see Figure 5), usually within six hours or less. They also revealed that in normal weather and at a given hour, the temperature at a given depth was approximately the same percentage value of the surface temperature even though the surface temperatures fluctuated from day to day. For a given depth, temperature fluctuations followed an orderly pattern and were influenced primarily by the surface temperature--which, in turn, was influenced by such factors as:

1. Solar radiation
2. Site features
3. Time of day
4. Weather conditions
    a. Degree of sunshine
    b. Amount of rain
    c. Snow
    d. Cloud cover
    e. Wind

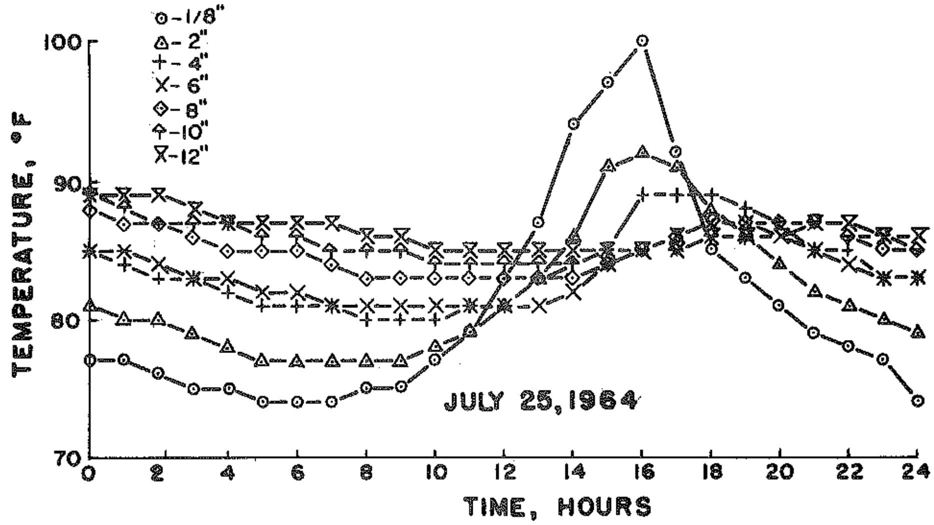

Figure 6: Temperature Distribution in an Asphaltic Concrete Pavement vs. Time, Illustrating the Effects of an Afternoon Rain Shower

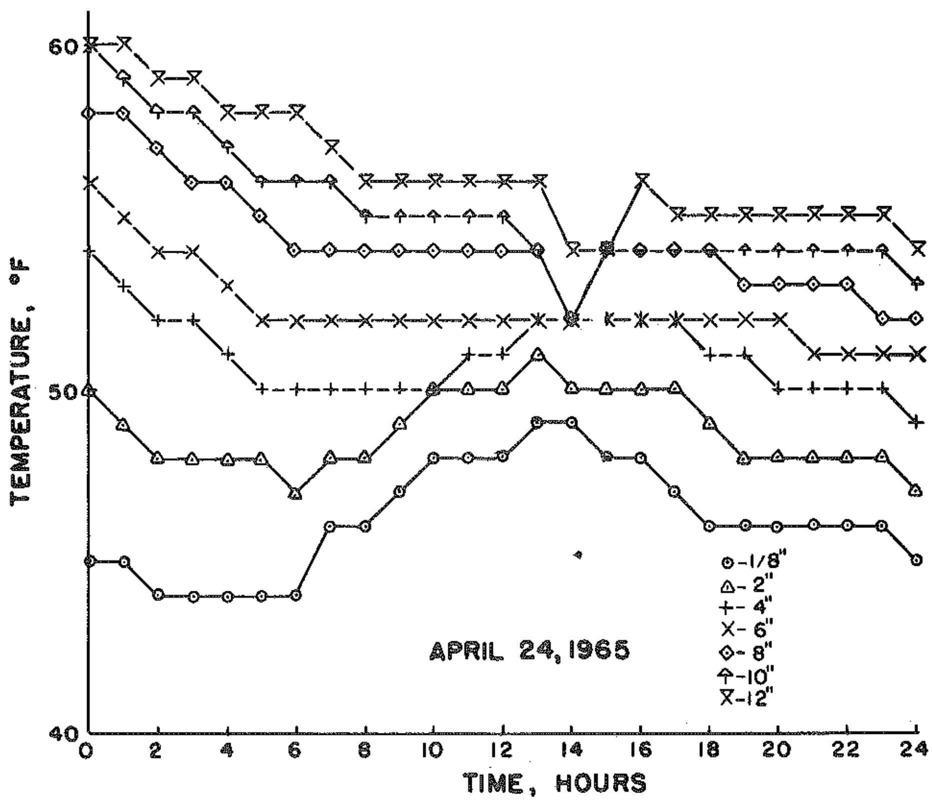

Figure 7: Temperature Distribution in an Asphaltic Concrete Pavement vs. Time, Illustrating an Overcast or Rainy Day

5. Air temperature

6. Subsurface temperature.

The plots showed that a short period of rain and extensive cloud cover reduced the surface temperature and influenced the temperatures at shallow depths; however, extended periods of inclimate weather reduced the surface temperature to nearly the level of the air temperature and proportionately decreased the temperature throughout the 12-inch thickness. Air temperatures generally dropped and recovered more slowly than the pavement surface temperature. Therefore, air-temperature history was an indication of previous long-term influences on the temperatures at various depths.

Two methods used in computing the mean daily air temperatures as a measure of the air-temperature history, were

1. The average of the twenty-four, hourly, air temperatures for each day, and
2. The average of the highest and lowest air temperatures for each day.

Although both methods gave approximately the same results, the latter was chosen for the following reasons:

1. The U. S. Weather Bureau uses this system for each reporting weather station, thus air temperature data would be readily available,
2. The U. S. Weather Bureau report does not contain air temperatures for each hour of the day, and
3. This method has some precedence in engineering work.

Consideration of air-temperature history provided an interesting and valuable result as shown in Figures 8 and 9. In Figure 8 a linear relationship between mean pavement temperatures (average of temperatures at the 0.125-, 4.0-, and 8.0-inch depths) and 0.125-inch depth temperatures is shown for each calendar month. The relationship of the months, their temperature ranges, and seasonal changes in temperatures can be readily seen. The addition of mean-monthly air temperature to each respective monthly line in Figure 8 produced Figure 9. The addition of air-temperature history to each respective month reduced the scatter of the data such that one straight line could replace all of the monthly lines. When air-temperature history was considered, April and May data for 1965 fell very nearly within the range of data for June through November, 1964; this was true in spite of the fact that the general trend of rising temperatures for May 1965, was approximately two weeks ahead of the same period for 1964. Similar analyses for 4-inch and 12-inch thick pavements indicated the same general relationships.

Temperature data for 1300 hours (local time) were chosen as trial data for further analysis. The mean pavement temperature for an 8-inch thick pavement was plotted versus the sum of the temperature at the 0.125-inch depth and the 30-day mean air-temperature history. This plot exhibited less dispersion of data points and a straight line could be fitted to the data. A straight line could also be fitted to the data for 1300 hours when the temperatures at the 4-inch depth were plotted versus the sum of 30-day mean air-temperature history and temperatures at 0.125-inch depth; however, the scatter was slightly increased. This

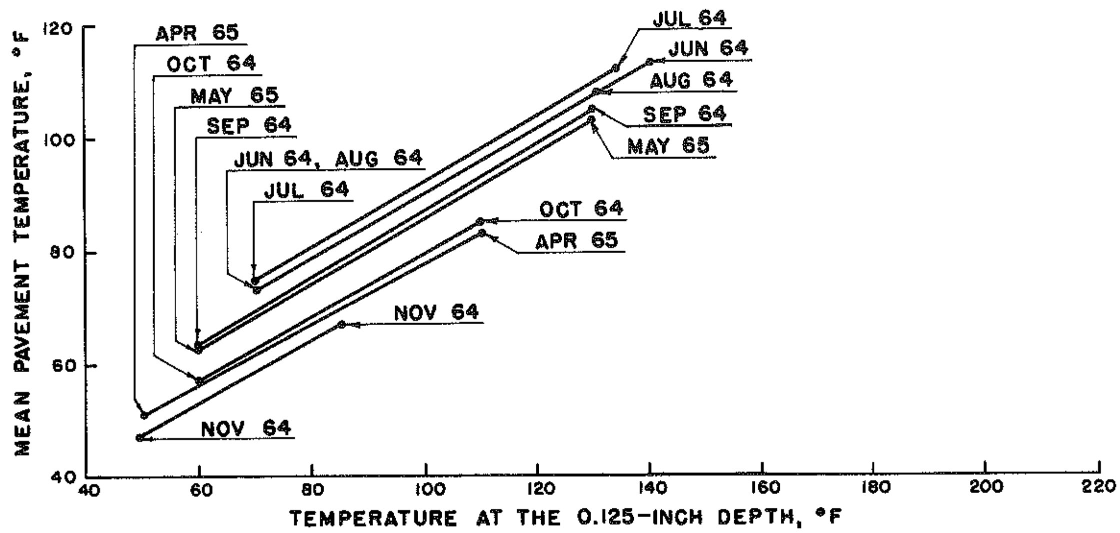

Figure 8: Mean Pavement Temperature by Calendar Months for an 8-Inch Thick Pavement at 1300 Hours vs. Temperature at the 0.126-Inch Depth

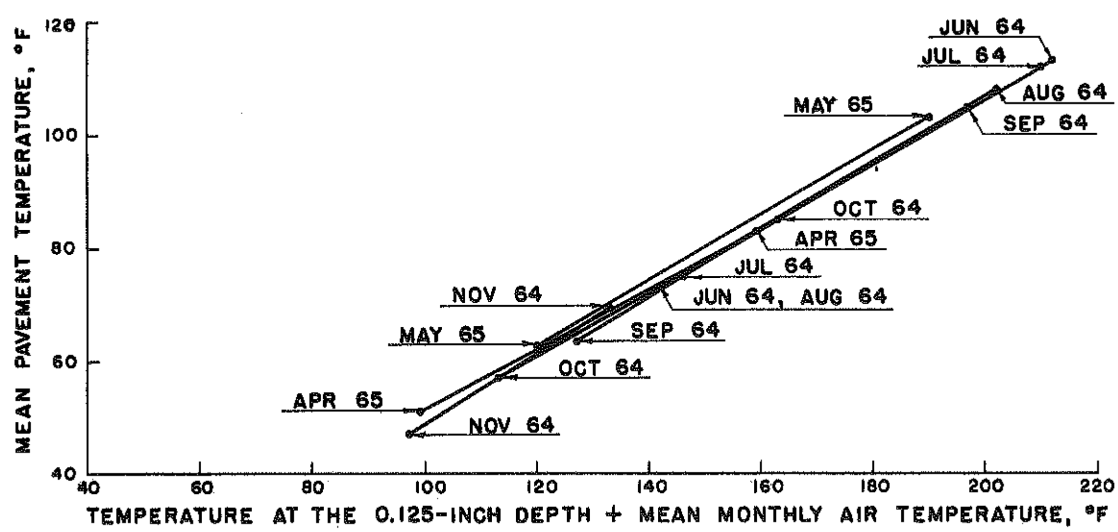

Figure 9: Mean Pavement Temperature by Calendar Month for an 8-Inch Thick Pavement at 1300 Hours vs. Temperature at the 0.125-Inch Depth Plus 5-Day Mean Air-Temperature History

apparently was the due to the elimination of the averaging effect of combined temperatures. Thus a relationship between pavement temperatures and mean-monthly air-temperature history seemed to exist.

Regression Analysis of Temperatures with Respect to Depth

To develop relationships to be used in later analyses, a regression analysis was made to the temperature-depth data. Because the method of estimating temperatures would ultimately be used to adjust Benkelman beam deflections, data for 0600 through 1900 hours were analyzed since most deflection tests would be performed during these hours.

To approximate the temperature-depth relationships for a given hour, a review of the data suggested the need for a polynomial equation of the form

$$Y = C_1 + C_2X + C_3X^2 + \ldots + C_nX^{n-1} \qquad 1$$

where Y = temperature in °F at depth X,

X = depth in inches from the pavement surface, and

$C_1, C_2, C_3, \ldots C_n$ = coefficients determined by the method of least squares.

Results showed that for the hours 0600, 0700, and 0800, a third-order polynomial provided the best fit, and a fourth-order polynomial was very nearly as accurate. For the remaining hours, a fifth-order polynomial gave the best fit, and again the fourth-order was very nearly as accurate. Therefore, a fourth-order polynomial was chosen for data representing all hours.

The only daily-temperature data that were deleted prior to regression analyses were eliminated for one of two reasons, as follows:

1. Recorder was out of operation due to maintenance; source data for these days had been interpolated between the last day of data prior to the missing day, or days, and the following day.
2. The first two days of recorded pavement temperatures after a missing day of data were eliminated because the antecedent, air temperatures were also missing from the source data.

This resulted in the elimination of 47 days of data. Therefore, data for 318 days were used in the final analysis.

The data for 1100 and 1300 hours for each day were used for trial analysis. Standard errors of estimate were calculated by the subroutine STD4DP portion of the computer program given in Appendix C, and the maximum difference between the observed temperature value and the value calculated from the polynomial was recorded. Analysis showed that the average standard error of estimate was approximately 0.50°F--the least being 0.09°F and the maximum being 2.20°F. The maximum difference between the observed and calculated temperatures ranged from 0.17°F to 5.45°F and an average of 318 values yielded 0.95°F. The large difference such as the 4.54°F, were verified by inspection of the temperature-depth data, which revealed that the real distribution was erratic. Days of data were picked at random, and further checks between observed and calculated values indicated that the curves were smooth and in close agreement with real temperatures at the respective depths.

The temperatures at the surface and at each half-inch increment of depth through 12 inches were calculated from the fourth-order polynomial equation determined for the respective day. Temperatures so calculated were plotted as ordinate values versus the measured surface temperature plus an average air-temperature history preceding the day of record (a separate graph for each depth was prepared). The plot for the 6-inch depth is presented in Figure 10; there, the average air-temperature history was computed for five days prior to the day of record. The optimum number of days for the air-temperature history was determined by further investigations described below.

The addition of an average air-temperature history to the surface temperatures was found to produce a favorable shift in the abcissa values in relation to the fixed ordinate values. Average air temperatures were computed for 1, 2, 3, 5, 7, and 10 days preceding each day of record; each set of data was adjusted and evaluated in terms of standard error of estimate. In Figure 11, the standard error of estimate is the ordinate axis and the number of days of antecedent air temperatures is the abcissa; the depth is 6 inches, and the time is 1300 hours. The standard error of estimate decreased to a minimum when two days of air-temperature history were added and then increased as the number of antecedent days increased. The minimum standard error of estimate for the 6-inch depth and for the hours 0600 through 0900 and 1800 and 1900 occurred when a ten-day average air-temperature history was added; and for the hours of 1100 through 1700 a two- to five-day average air-temperature history was optimum.

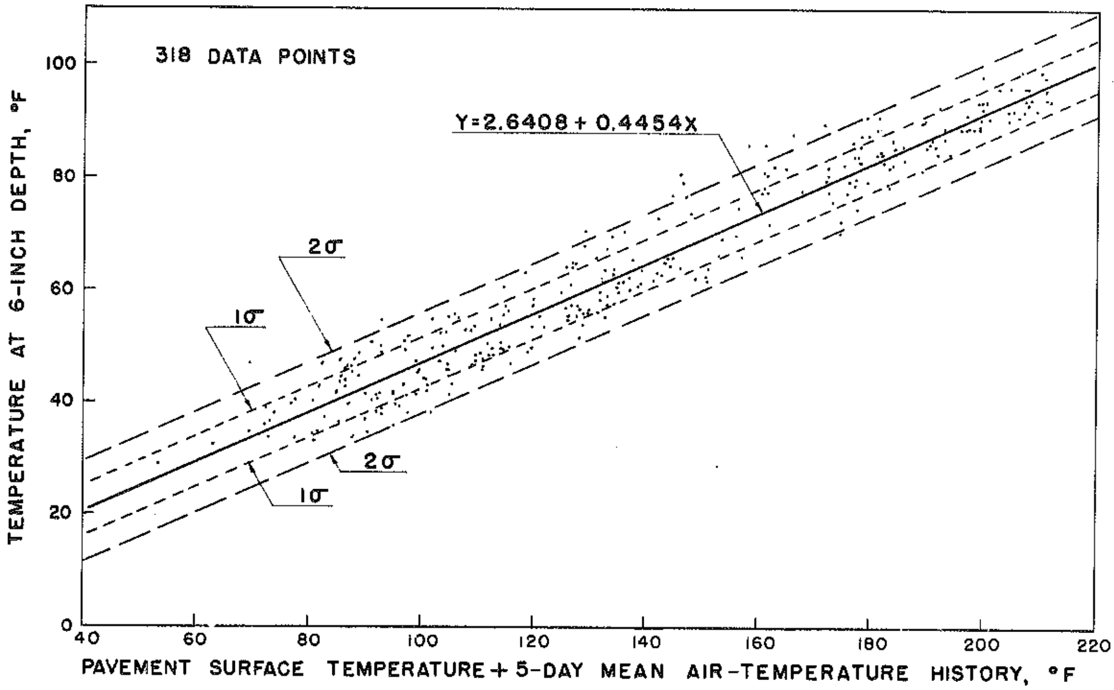

Figure 10: Temperature at the 6-Inch Depth vs. Measured Pavement Surface Temperature at 1300 Hours Plus 5-Day Mean Air-Temperature History

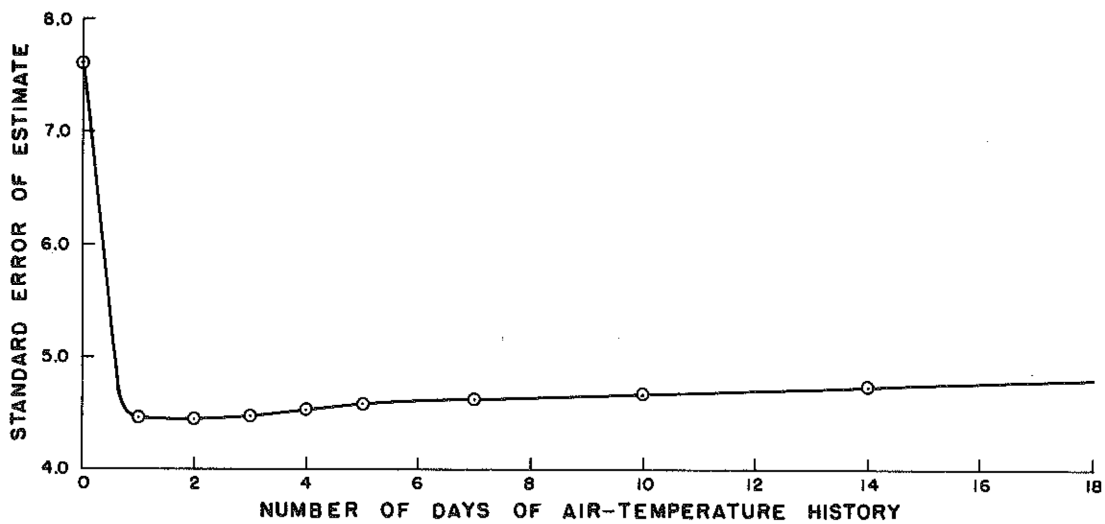

Figure 11: Standard Error of Estimate vs. Number of Days of Antecedent Air Temperatures for the 6-Inch Depth at 1300 Hours

Figure 12 was drawn to find the number of days of average air-temperatures that gave the least standard error of estimate for all depths and all hours under consideration. Ordinate values are the averages of all standard errors of estimate for all depths and for all hours under consideration, and the number of days considered is plotted on the abcissa. As can be seen, accuracy does not increase significantly beyond the five-day point. Therefore, only the five previous days are considered to be significant. Further analysis of the standard errors of estimate showed that the five-day average air-temperature history sufficed for all depths greater than 2 inches. The least standard errors of estimate for the depths 0 inches through 2 inches indicated that the best estimate was obtained by the use of the surface temperature alone. Pavement temperatures in the top 2 inches of the pavement are directly dependent upon the hour of the day and the amount of heat absorption whereas, temperatures at depths greater than 2 inches are assumed to be a function of the surface temperature, amount of heat absorption, and the past five days of temperature history.

The complete set of curves giving the best estimate of temperature at the several depths and by hour of the day are included in Appendix B. The set of curves for 1300 hours are shown in Figure 13 as a typical example.

Development of Deflection Adjustment Factors for Temperature Effects

Two types of adjustment factors were considered. The first was to assign an incremental deflection to each degree of temperature difference between the pavement temperature and the reference or standard

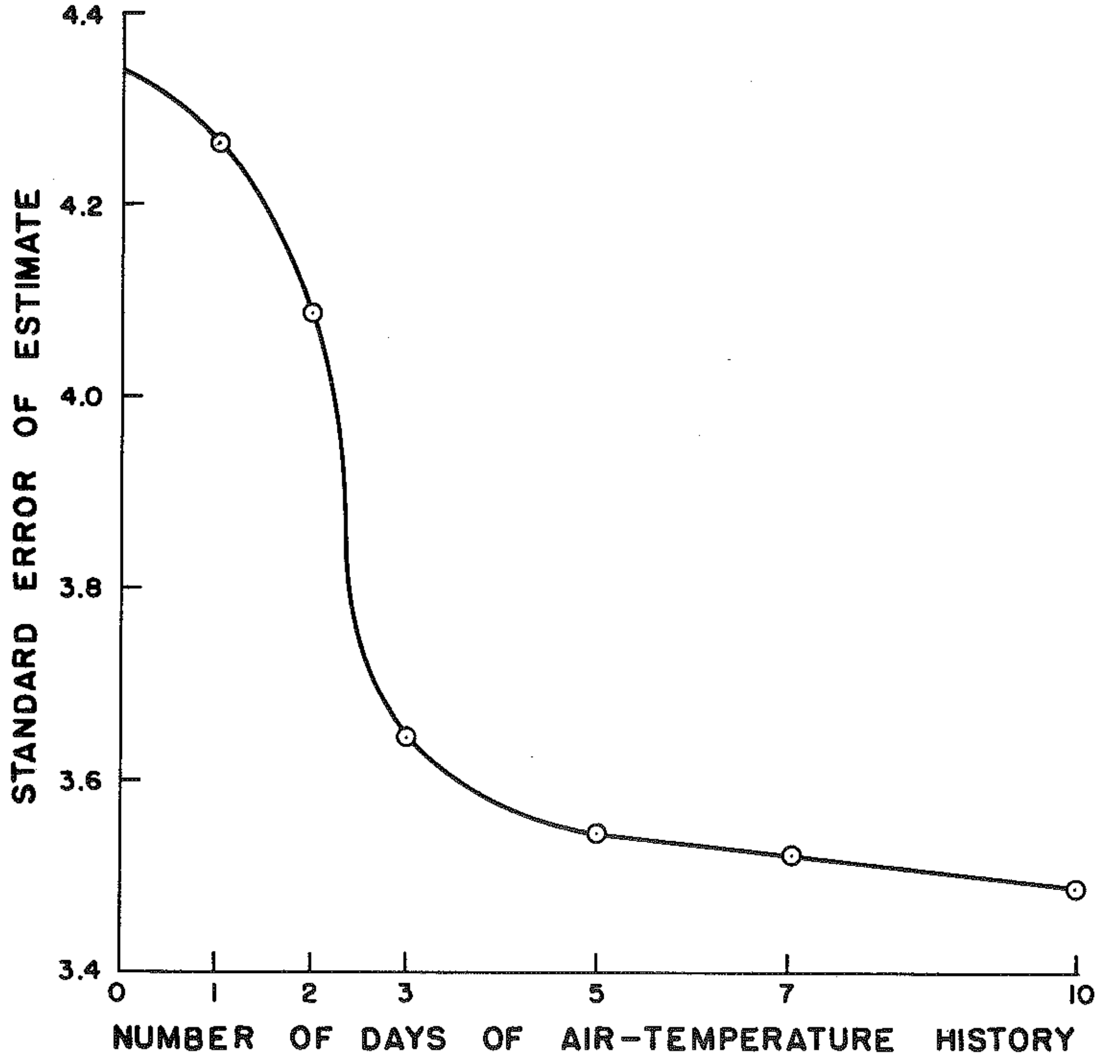

Figure 12: Standard Error of Estimate for All Depths and All Hours vs. Number of Days of Air-Temperature History

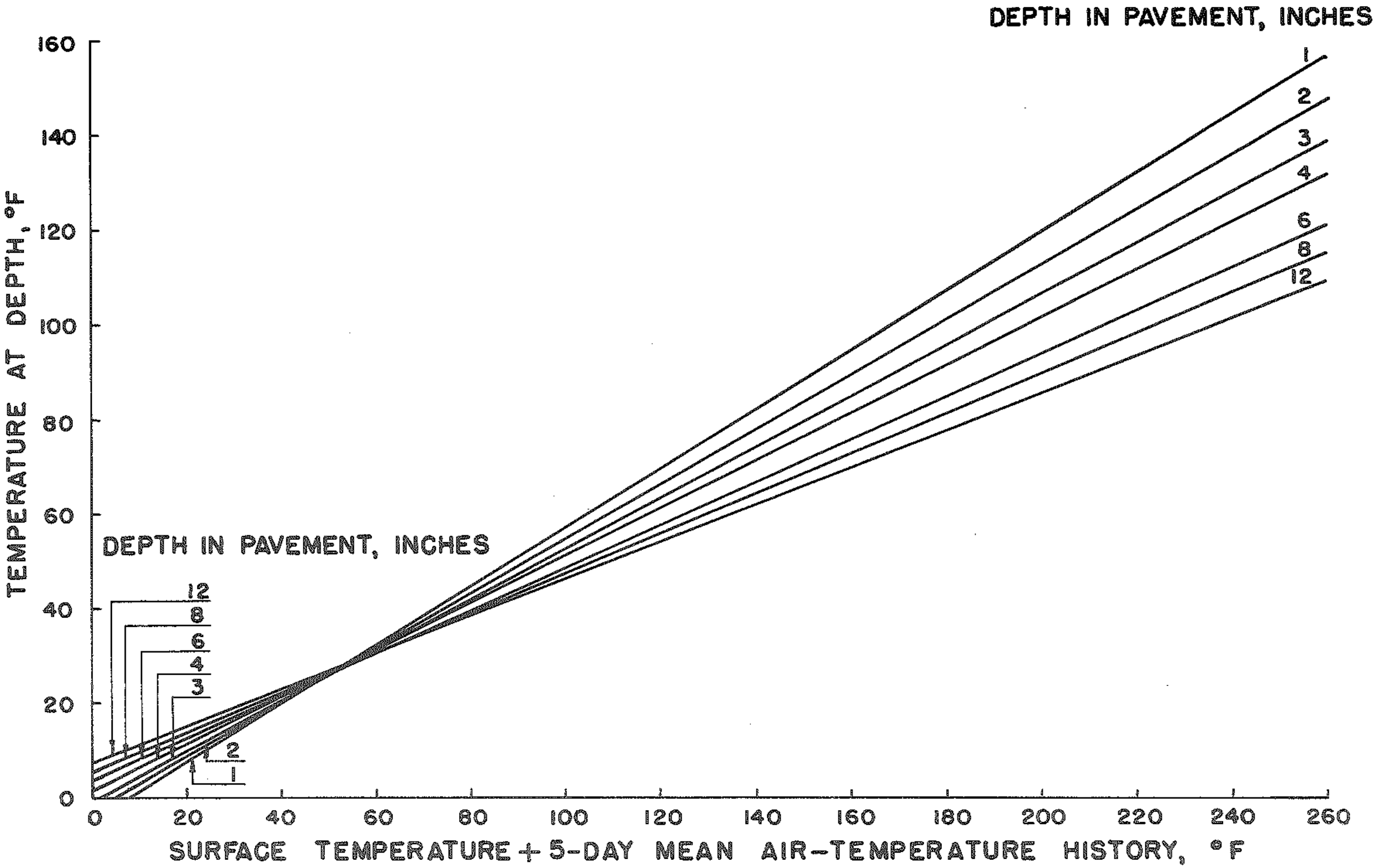

Figure 13: Temperature-Depth Prediction Graph at 1300 Hours for Pavements Greater Than 2 Inches Thick

temperature. This type of correction was employed by Kingham and Reseigh (7) and by Sebastyan (5); however, the magnitude of suggested corrections differed. The second method under consideration was use of a dimensionless, multiplicative factor that could be applied to a measured deflection at some known surface temperature or a known mean temperature of the pavement. No known reference in the literature mentions the second method.

Inspection of the AASHO Road Test curves shown in Figures 14 and 15 suggested that the dimensionless, multiplicative factor method might be more appropriate. Therefore, in this study, the curves in Figures 14 and 15 were transformed to semilogarithmic plots, temperature being the logarithmic scale. The data plotted as straight lines, and the slopes of the individual curves for each loop were very nearly parallel; however, the slopes for the several loops were not parallel. As shown in Figure 14, each surfacing thickness was the average of three structural cross sections. The equation for the straight lines was

$$M = \frac{Y_2 - Y_1}{\log T_2 - \log T_1} \qquad 2$$

where M = slope of the straight line,

Y_1, Y_2 = deflection values, and

T_1, T_2 = mean pavement temperatures in °F corresponding to the Y_1 and Y_2 deflection values, respectively.

After the slope had been determined, the deflections were computed for mean pavement temperatures 30°F through 150°F, on 10°F-intervals, by the equation

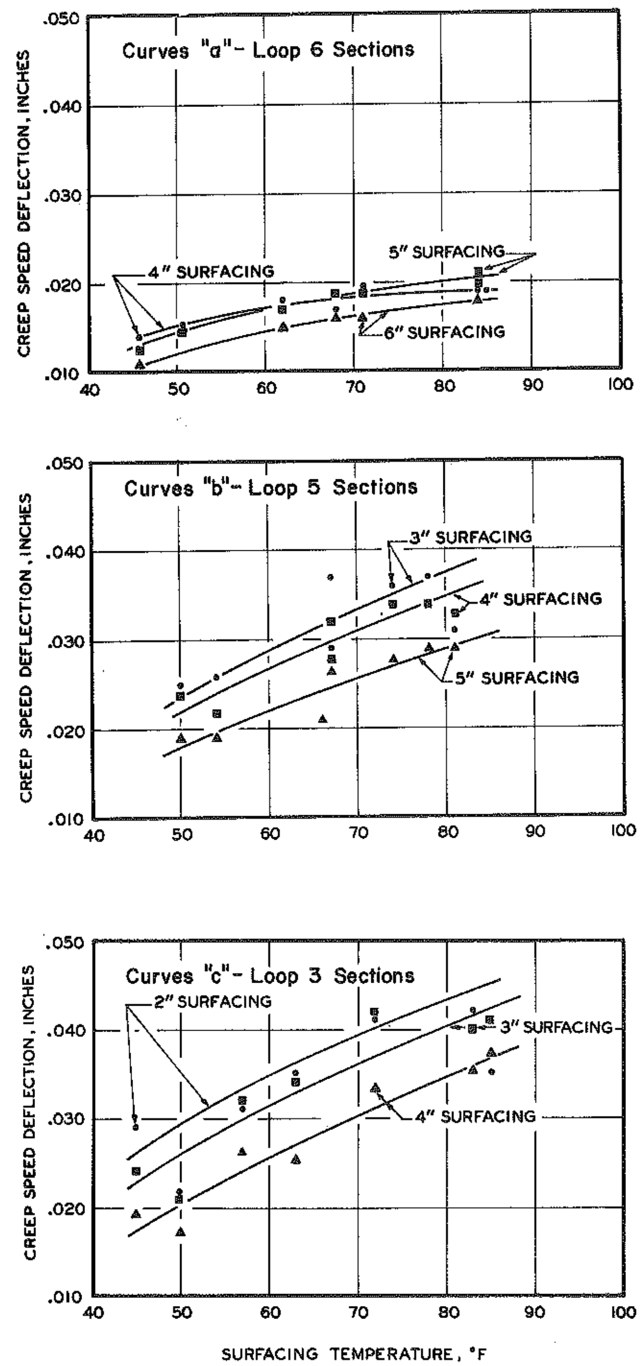

Figure 14: Deflection-Temperature Data for 12-Kip Single Axle Loads for Traffic Loops 3, 5, and 6 (5, p. 110)

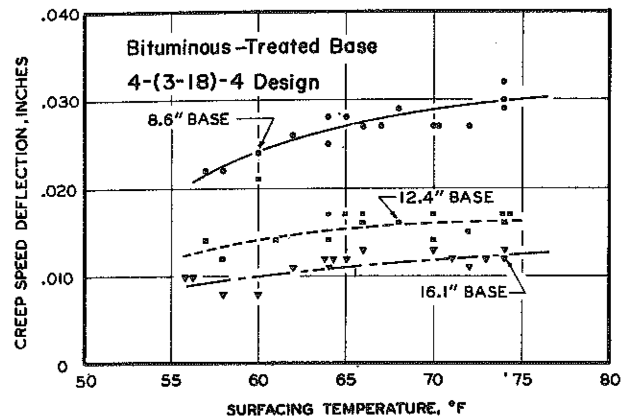

Figure 15: Deflection-Temperature Data for 30-Kip Single Axle Loads Special Wedge-Type Base Sections (5, p. 111)

$$Y_3 = Y_1 + M(\log T_3 - \log T_1) \qquad 3$$

where Y_3 = deflection at the temperature T_3,

Y_1 = same Y_1 used in Equation 2,

M = slopes as determined in Equation 2,

T_3 = temperature, °F, at which the deflection was computed, and

T_1 = same T_1 used in Equation 2.

A mean temperature of 60°F was chosen as the reference temperature, T_{60}.

The adjustment factors were derived by the following equation

$$AF = \frac{Y_{60}}{Y_3} \qquad 4$$

where AF = the adjustment factor used to adjust measured deflections due to temperature effects,

Y_{60} = computed deflection, in inches, for the mean pavement temperature 60°F from Equation 3, and

Y_3 = computed deflection, in inches, for a particular mean pavement temperature T_3 from Equation 3.

Thus, the adjustment factor is a pure number. Table 1 shows the sample calculations for the 4-inch pavement on Loop 5. Each of the twelve adjustment-factor curves was computed according to Equations 2, 3, and 4 and the curves plotted arithmetically (Figure 16) with mean pavement temperature, T_3, on the ordinate axis and the adjustment factor, AF, on the abcissa axis. Deflections, Y_3, computed from the twelve individual curves at a given mean pavement temperature, T_3, were added and averaged to obtain the final adjustment-factor curve shown in Figures 16 and 17.

Table 1

SAMPLE CALCULATIONS SHOWING DEVELOPMENT OF DEFLECTION ADJUSTMENT FACTORS FOR THE 4-INCH PAVEMENT ON LOOP 5 OF THE AASHO TEST ROAD

TEMPERATURE, T_3 (°F)	DEFLECTION, Y_3, AT TEMPERATURE T_3 (INCHES)	ADJUSTMENT FACTOR
40	0.01562	1.7106
50	0.02173	1.2296
60	0.02672	1.0000
70	0.03094	0.8636
80	0.03460	0.7723
90	0.03783	0.7063
100	0.04071	0.6563
110	0.04333	0.6167
120	0.04571	0.5846
130	0.04790	0.5578
140	0.04993	0.5351
150	0.05182	0.5156

T_1 = 52°F = Average Pavement Temperature, T_A

T_2 = 80°F = Average Pavement Temperature, T_A

Y_1 = 0.0228 = Deflection Corresponding to T_1

Y_2 = 0.0346 = Deflection Corresponding to T_2

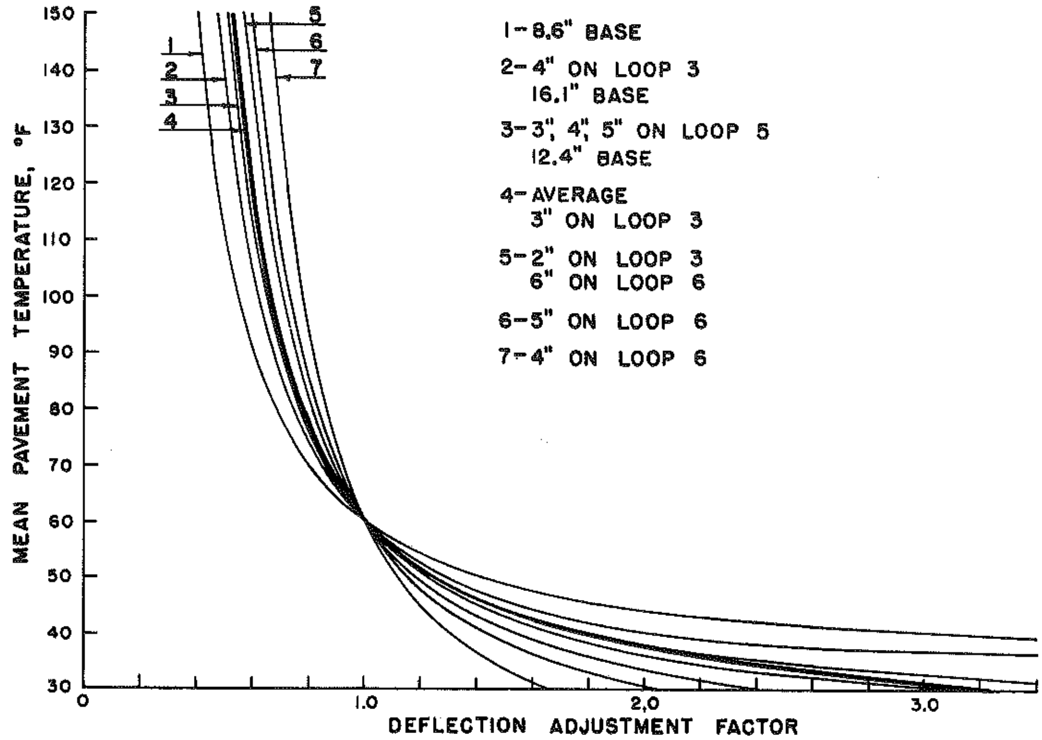

Figure 16: Mean Pavement Temperature vs. Deflection Adjustment Factors for Various Loops

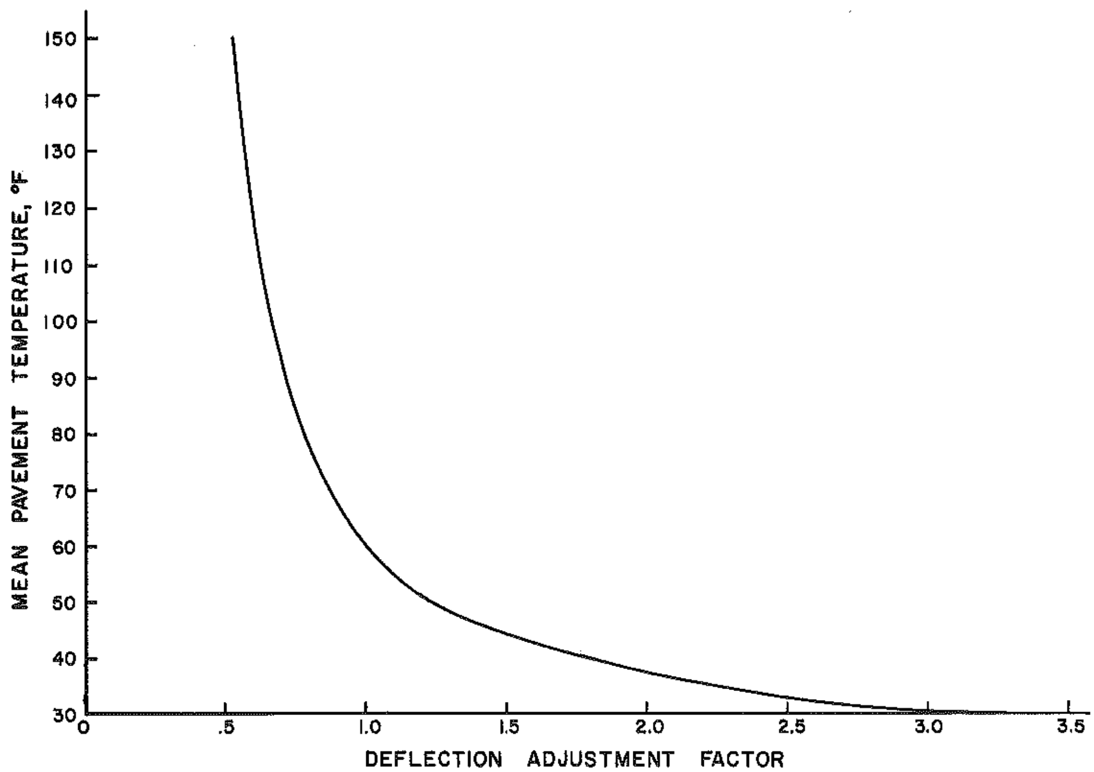

Figure 17: Mean Pavement Temperature vs. Average Deflection Adjustment Factor

Further analysis showed that there may be a relationship among average structures within a given loop--that is, except for the 8.6-inch, asphalt-treated base curve, which for some unknown reason was an outlier. There was no consistent relationship between loops and substructures as evidenced by the 2-inch surfacing on Loop 3, and the 6-inch surfacing on Loop 6, where the total structural thicknesses were 9 inches and 24 inches respectively; yet each had the same adjustment-factor curve. The same situation was present in regard to the 4-inch surfacing on Loop 3 and the 16.1-inch, asphalt-treated base section which had total structural thicknesses of 11 and 24.1 inches, respectively. The above structural relationships may have been obscured by the AASHO approach of averaging deflections for a given surfacing thickness within a loop; however, the AASHO structural-equivalency equation showed that in some cases the structural indices were vastly different. Another analysis might be made of the AASHO data shown in Figures 14 and 15 with the raw data grouped according to surfacing thickness and structural indices without regard to locations.

The adjustment-factor curve for temperature effects is applicable only to creep-speed deflections because the source data used in the analysis were taken at creep speed. Further analysis would be required to establish applicability to deflections taken at other than creep speed.

The adjustment-factor curve is applicable to any loading so long as the deflection is to be adjusted to the reference temperature for that same loading.

Relationship Between Temperature-Adjustment Factors and Modulus of Elasticity of Asphaltic Concrete

Reflection upon the Boussinesq equation for deflections at the center of a flexible plate,

$$Y = \frac{1.5\ Pa}{E} \qquad 5$$

where Y = surface deflection in inches,

P = unit load on circular plate,

a = radius of plate, and

E = modulus of elasticity of the material,

discloses that the deflection is a linear function of load as well as the modulus of elasticity of the material--which may be affected by temperature. In turn Burmister's equation for deflections under a flexible plate, using a two-layer elastic system (8),

$$Y = \frac{1.5\ Pa}{E_2} F_2 \qquad 6$$

where E_2 = modulus of elasticity of lower layer, and

F_2 = dimensionless factor depending on the ratio of moduli of elasticity of the subgrade and pavement as well as the depth-to-radius ratio,

indicates that deflections are also a function of pavement thickness and the modulus of elasticity of the pavement layer and the underlying material. The load and the radius of contact area could be considered constant for a given axle load and tire pressure.

Preliminary analysis indicated that if a ratio of the deflection, Y, of a flexible pavement having a given mean pavement temperature to the deflection, Y_1, of the same or similar pavement at a standard mean reference temperature could be developed, the Burmister equation would appear as follows:

$$AF = \frac{\frac{1.5\ Pa}{E_2} F_2}{\frac{1.5\ P_a}{E_2} F'_2} = \frac{Y}{Y'} = \frac{F_2}{F'_2} \qquad 7$$

where $F_2 = f\left(\frac{h}{a}, \frac{E_2}{E_1}\right)$ at reference temperature,

$F'_2 = f\left(\frac{h}{a}, \frac{E_2}{E'_1}\right)$, at test temperature,

h = thickness of pavement,

E_2 = modulus of elasticity of subgrade, assumed to be uneffected by temperature,

E_1 = modulus of elasticity of pavement at reference temperature, and

E'_1 = modulus of elasticity of pavement at test temperature.

Of course, when comparisons are made between pavements on differing subgrades, E_2 changes; therefore

$$AF = \frac{Y}{Y'} = \frac{F_2 E'_2}{E_2 F'_2} \qquad 8$$

where E'_2 = modulus of subgrade when differing from E_2.

It may be noted that the mere ratio of F_2 to F'_2 above is not sufficient to give the solution; therefore, E_2 must be determined independently. E_2 may be determined in terms of the Boussinesq E by direct measurements or deduced on the basis of variously-contrived devices or assumptions. The method used here is somewhat unique.

The surface deflections shown in Figures 14 and 15 were used to calculate the modulus of elasticity by the Boussinesq equation (Equation 5). This was an apparent modulus, E_c, of the composite structure of the pavement. When these values were plotted against respective thicknesses of asphaltic concrete, Figure 18, a straight line could be passed through the data points for a given Loop section at each temperature; and, upon extrapolation to zero thickness (temperature-affected thickness, in the case of asphalt-treated bases), the respective lines converged and intersected the E_c axis at an approximate value of 8400 psi. This was considered to be the subgrade modulus E_2 of Burmister's two-layered, elastic theory, equation. The F_w factors were obtained by

$$F_W = \frac{E_2}{E_c} \qquad 9$$

where F_W = Burmister's settlement coefficient.

Burmister's influence curves (8) were used to obtain the ratio of E_1/E_2. The modulus of elasticity of the asphaltic concrete was obtained from

$$E_1 = N \times E_2 \qquad 10$$

where

$$N = \frac{E_1}{E_2} .$$

The above calculations were made using the deflections at various temperatures and the E_1-values were averaged for each temperature. Simultaneous solution of the equation

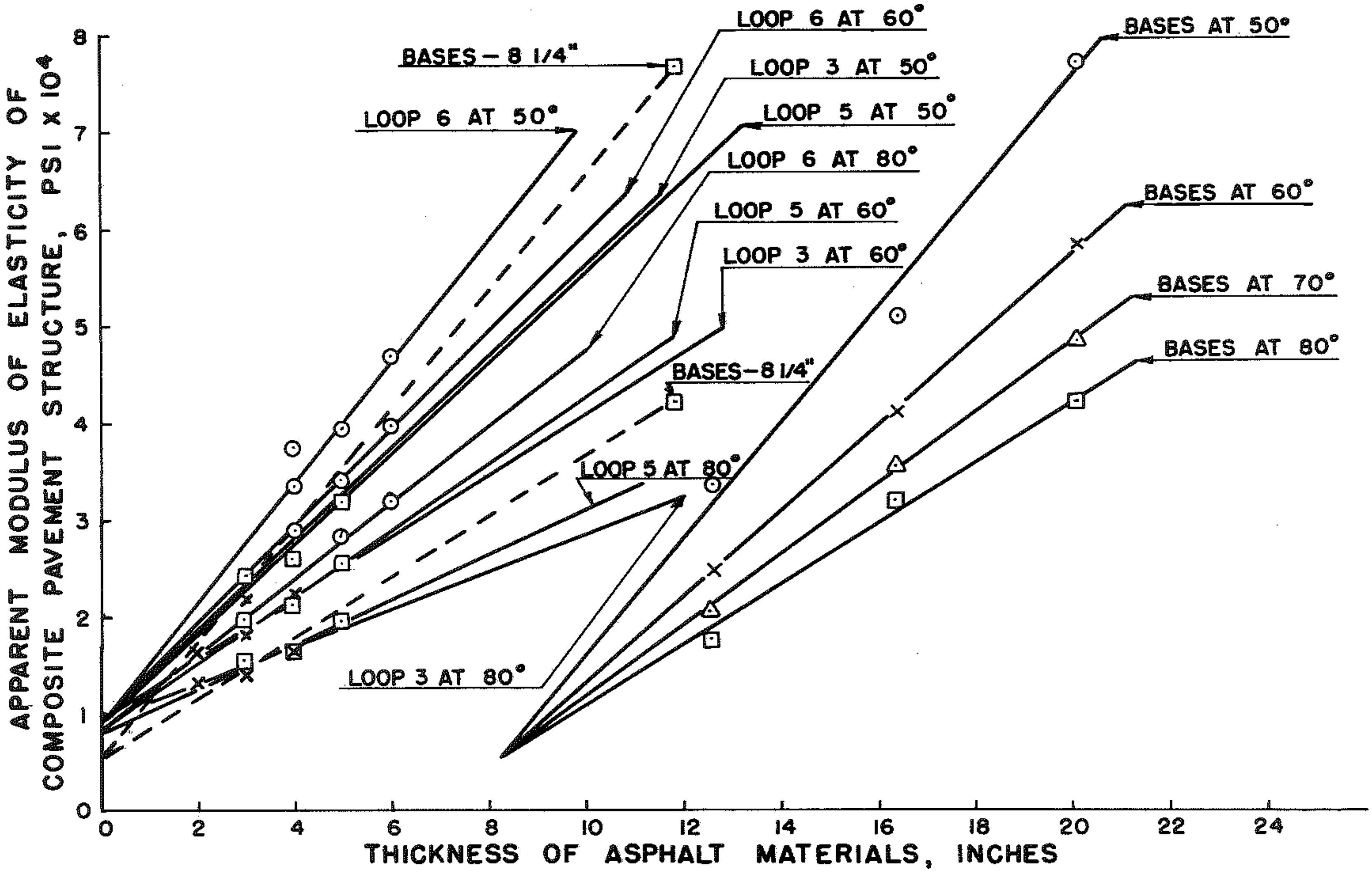

Figure 18: Apparent Modulus of Elasticity of Composite Pavement Structure vs. Pavement Thickness

$$\log_{10} E_1 = \frac{A}{T_A} + B \qquad 11$$

where T_A = absolute temperature, °R = °F + 460°F,

E_1 = average modulus of elasticity of asphaltic concrete at T_A,

at A, B, = constants,

for two different temperatures determined the values A and B. Extrapolated values for E_1 at 30°F, 40°F, 100°F, 120°F, and 140°F were then calculated. Figure 19 shows that the resulting modulus of elasticity of the asphaltic concrete pavement has a curvilinear relationship with temperature. Note that the shape of the curve is very similar to the adjustment-factor curve shown in Figure 17. The shape of the temperature-modulus curve derived by elastic theory clearly substantiates the adjustment-factor curve derived by statistical procedures. A correlation graph is shown in Figure 20. It is seen that the adjustment factor and the modulus of elasticity are related, at any stated temperature, by the equation given in Figure 20.

Comparison of Derived Temperature Distributions and Adjustment Factors with Data from Other Test Roads

The temperature-deflection data developed at the WASHO Test Road were not analyzed in this study. However, data are being gathered now by the Asphalt Institute (9) from a test site at San Diego, California. The flexible pavement at this test site contains thermocouples embedded in the pavement, and temperatures are being recorded at this time. Two days of temperature distributions, October 6, 1966 and February 17, 1967, together with their respective five days of high and low air temperatures

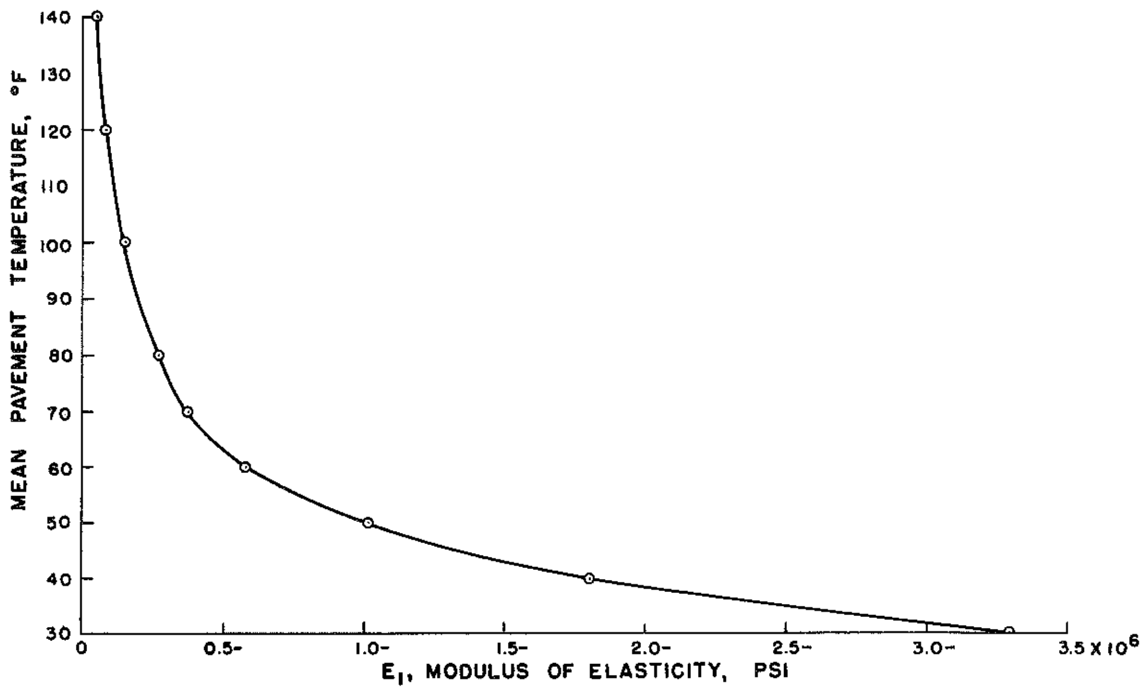

Figure 19: Mean Pavement Temperature vs. Modulus of Elasticity for Asphaltic Concrete Pavement

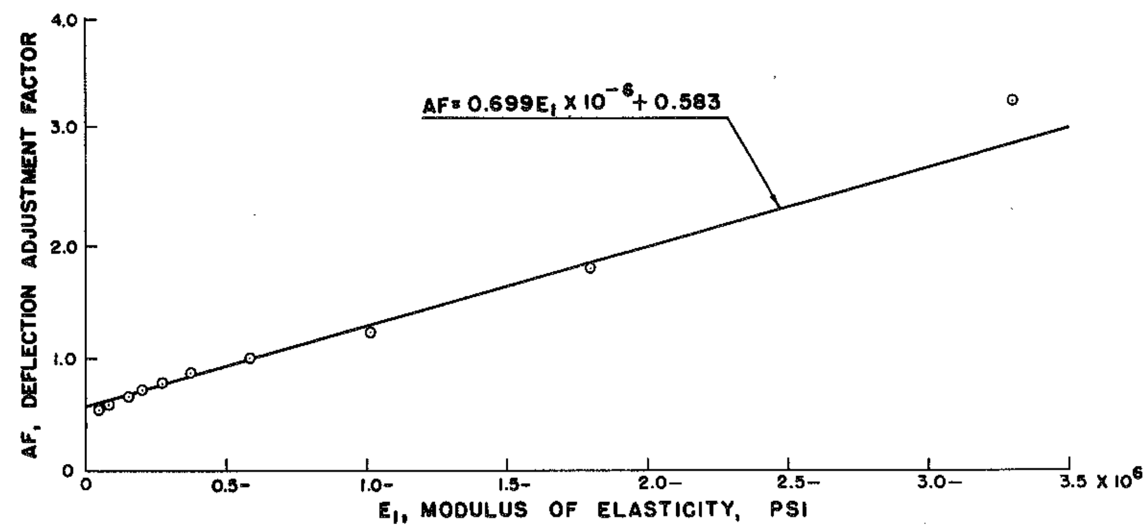

Figure 20: Correlation Between Adjustment Factor and Modulus of Elasticity for an Asphaltic Concrete Pavement

have been received from the Asphalt Institute and checked by the temperature prediction graphs contained in Appendix B. The predicted temperatures varied generally $\pm 6°F$ from the observed temperatures at the various levels. The Asphalt Institute also furnished temperature distribution data for the Colorado test pavement reported by Kingham and Reseigh (7). Table 2 contains the summary of the analyses for both San Diego and Colorado data, each compared to the predicted temperatures by the methods developed from the College Park data. A few temperatures fell outside the two standard errors of estimate given in Appendix D; however, most of the data are well within these tolerances.

An interesting comparison between modulus of elasticity of asphaltic concrete, E_1, derived from the AASHO data, Figure 19, and laboratory measurements of the complex modulus, $|E^*|$, is also provided by Kallas' tests (10) on asphaltic concretes used on the Colorado test pavement (7, cf. Kingham and Reseigh). Kallas' Figure 3a (10), showing $|E^*|$ plotted against temperature is shown here as Figure 21. $|E^*|$ was determined by sinusoidal tension and compression loading. The most favorable agreement is with respect to the 1-cps loading frequency. The similarity between this curve and the curve in Figure 17 seems extraordinary.

Table 2

COMPARISON OF MEASURED PAVEMENT TEMPERATURES AT SAN DIEGO AND COLORADO TEST SITES TO ESTIMATION OF TEMPERATURES BY METHOD BASED UPON COLLEGE, PARK MARYLAND DATA

LOCATION	DEPTH (INCHES)	NUMBER OF OBSERVATIONS	AVERAGE DIFFERENCE BETWEEN OBSERVED AND ESTIMATED TEMPERATURES (°F)	STANDARD DEVIATION (°F)
COLORADO	2.00	59	-2.68	5.03
	4.60	4	-4.75	6.61
	5.50	5	-1.40	3.55
	5.75	25	+1.72	5.51
	6.00	25	+1.96	5.94
	7.50	4	-0.25	3.71
	9.00	5	+1.60	4.24
	10.50	50	+2.82	7.09
SAN DIEGO	3.00	2	0.00	0.00
	3.10	2	-2.00	1.41
	3.40	2	-6.00	6.00
	3.50	11	-3.50	4.69
	6.50	2	-2.50	2.55
	9.40	11	+0.09	2.50
	9.50	2	-2.50	2.55
	10.80	2	-2.50	2.55
	11.50	2	-3.50	3.54

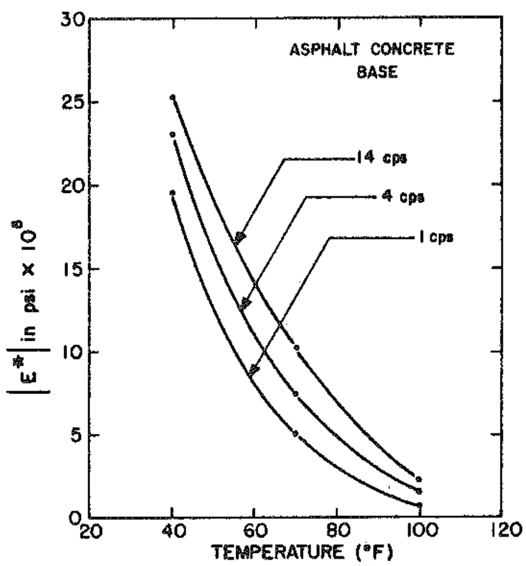

Figure 21: Relationship Between E* and Temperature for Various Loading Frequencies (10, p. 794)

CHAPTER IV

SUMMARY AND RECOMMENDATIONS

A practical and reasonably accurate method of estimating the temperature distributions within flexible pavements has been developed and presented in Appendix B. This method can be used to analyze deflection data at any time if the hour of the day and the surface temperature are included in the recorded data.

The relationship between mean pavement temperature and deflection allows any deflection test value to be adjusted to a reference temperature if the mean temperature of the pavement at the time of testing is known or is estimated by the method outlined herein.

Further study is needed to test the assumption that the average air-temperature history allows this system of estimating pavement temperature distribution to be used in other areas of the United States. Additional data are needed to determine whether the average air-temperature history adequately takes into account the effects of latitude and altitude upon pavement temperatures.

Theoretical analysis of the AASHO pavement deflection data by the two-layered elastic theory shows a curvilinear relationship between modulus of elasticity of asphaltic concrete and temperature; the magnitude of the moduli are such that a straight-line relationship exists between moduli and the multiplicative, temperature-deflection, adjustment factors.

Additional research is needed to accurately define the effects of temperature upon the basic properties of asphalt and asphaltic concrete. With additional information theoretical deflections might be obtained from multi-layered computer programs and a comparison be made between the theoretical and measured deflections. These computer programs could be used to develop an adjustment-factor curve based upon elastic theory.

As additional temperature-deflection data become available, they should be analyzed to verify, or modify the adjustment-factor curves shown in Figures 16 and 17.

APPENDIX A

ADDITIONAL EXPLANATION OF TEMPERATURE DISTRIBUTION ANALYSIS

ADDITIONAL EXPLANATION OF TEMPERATURE DISTRIBUTION ANALYSIS

The method of estimating temperature distributions is presented in Appendix B in two parts:

1. The computer analysis showed that the top 2.0 to 2.5 inches, depending upon the hour of the day, was influenced more by the surface temperature fluctuations than by average air-temperature history. Therefore, for asphalt pavements 2 inches or less in thickness, this system should be used. This means that only the surface temperature is used to enter Figures 27 through 40.

   Standard errors of estimate ranged from 0.00°F to 3.77°F for thicknesses of 2 inches or less, depending upon the hour of the day and the depth, but increased significantly for depths greater than 2 inches. Standard error of estimate, for pavements thicker than 2 inches ranged from a minimum of 2.42°F at 0700 hours to a maximum of 6.16°F at 1400 hours.

2. For pavements thicker than 2 inches, the second version should be used to predict the mid-depth and lower temperatures of the bituminous pavement. Therefore, the surface temperature plus the 5-day average air-temperature history is required to enter the temperature prediction graphs Figures 41 through 54.

In general, with the addition of 5-day air-temperature histories the standard error for estimating the pavement surface temperatures was midrange between the minimum and maximum of all standard error of estimate values. The standard error of estimate decreased as the depth increased to the zone of the 3-inch to 5-inch depths, then started to increase, reaching a maximum for temperature predictions at the bottom of the pavement. The above patterns were true except for the hours of 1700 through 1900. At these times, the largest errors of estimate were at the surface. The least errors were around the 8-inch depth, and then increased to midrange again at the 12-inch depth. This pattern was considered normal--that is, due to the time variations of sunrise and sunset. As would be expected, the temperature distribution ranges during the day were large but were comparatively small during the night and early morning periods.

The pattern of winter temperature distributions was the same for the College Park, Maryland, pavement as was found at the WASHO Test Road (1); this is reflected in the combined straight-line plots shown in Appendix B. Whereas the College Park data were not influenced significantly by edge-zone effects, the WASHO temperatures at depths near the edge of the pavement were lower than those closer to the centerline.

A plot of surface temperatures at a given hour of the day versus calendar days over a period of several years would provide a scatter of data points through which a general curve could be passed. This curve would have a general periodic shape with the amplitudes and frequencies varying from year to year as shown in Figure 22. This periodic shape portrays the variations in heat input due to changes in the inclination of the sun and seasonal weather history. Empirical analysis showed that the combination of pavement surface temperatures and a measure of air-temperature history very nearly accounted for all changes in the total available heat measured as temperature at a given depth and time as shown in Figures 23 and 24. Thus the temperature at a given depth and time of day was found to exhibit a direct straight-line relationship with the combination of measured pavement surface temperature and average air-temperature history. Therefore, the effects of season of the year were removed. Figure 25 shows the observed temperature at the 6-inch depth on the ordinate axis versus the observed surface temperatures at 1300 hours each day on the abcissa axis. The standard error of estimate for this plot was approximately $\pm 7.5°F$. Figure 10 shows the same data points as shown in Figure 25 except that the 5-day average air-temperature value has been added to the surface temperature. Two resulting effects were generally true for all hours of the day, namely:

1. The standard error of estimate was reduced approximately 40 percent from the analysis shown in Figure 25 to that shown in Figure 10.
2. The straight line in Figure 10 had a greatly reduced slope and extended over a longer range of values than that in Figure 25.

The net result of including air-temperature history was to impart greater accuracy to the temperature-prediction system.

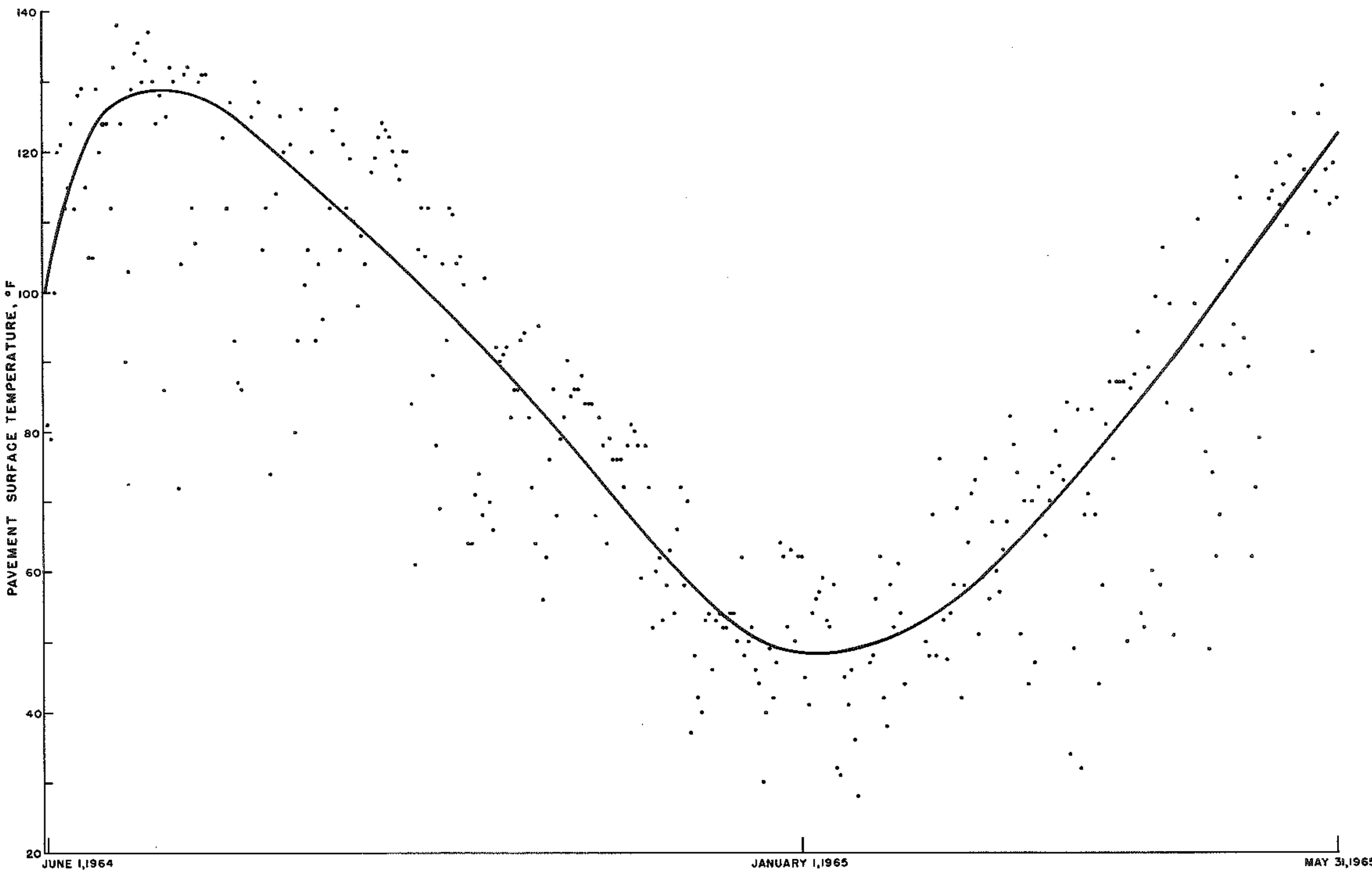

Figure 22: Pavement Surface Temperature at 1300 Hours vs. Calendar Days for the Period June 1, 1964 Through May 31, 1965

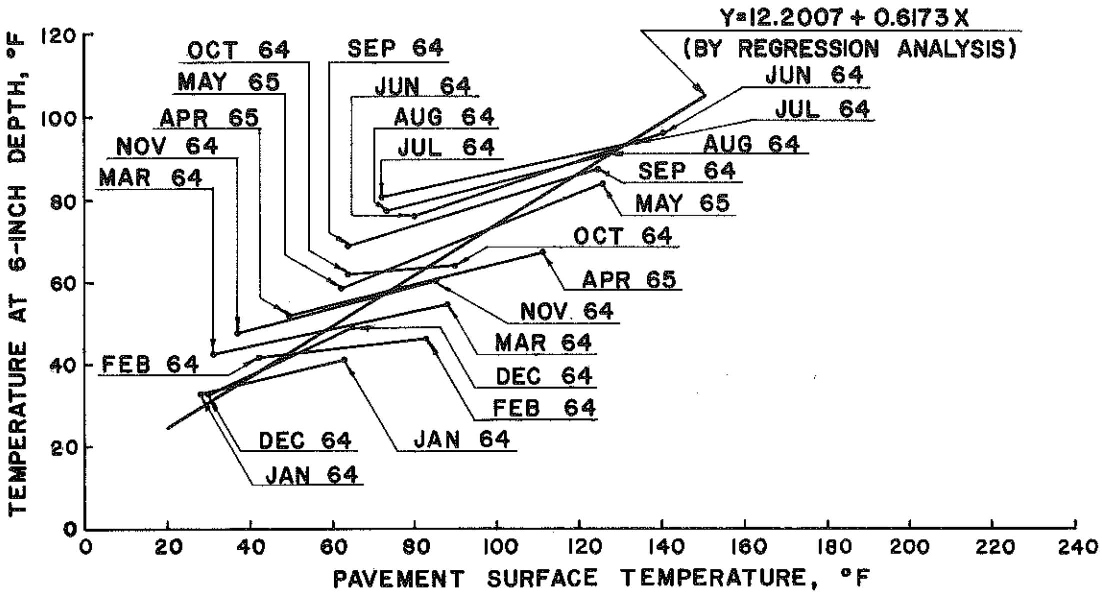

Figure 23: Temperature at the 6-Inch Depth at 1300 Hours vs. Surface Temperature by the Month

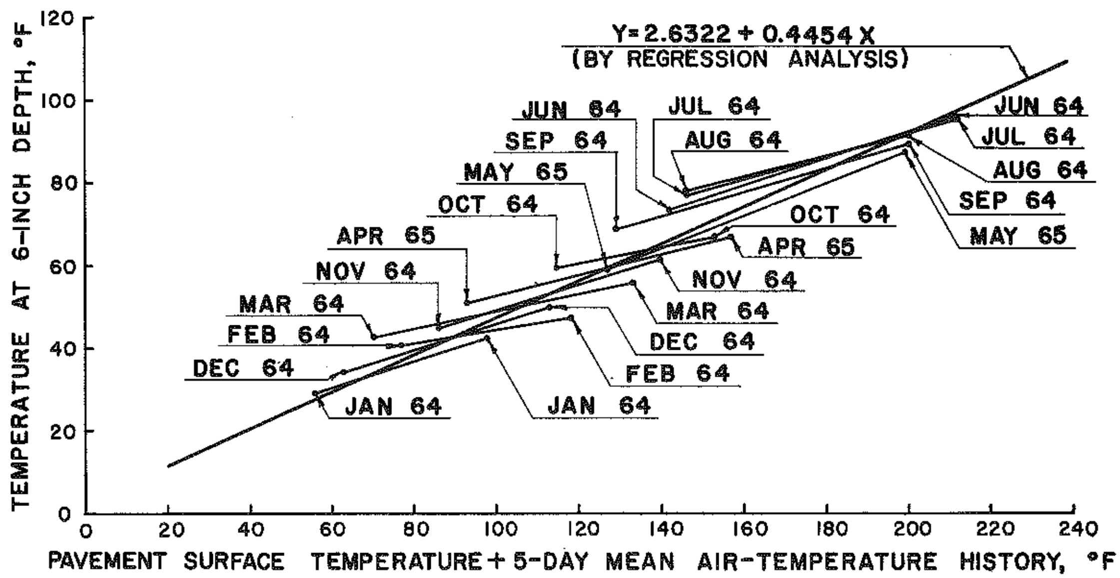

Figure 24: Temperature at the 6-Inch Depth at 1300 Hours vs. Surface Temperature Plus 5-Day Average Air Temperature History by the Month

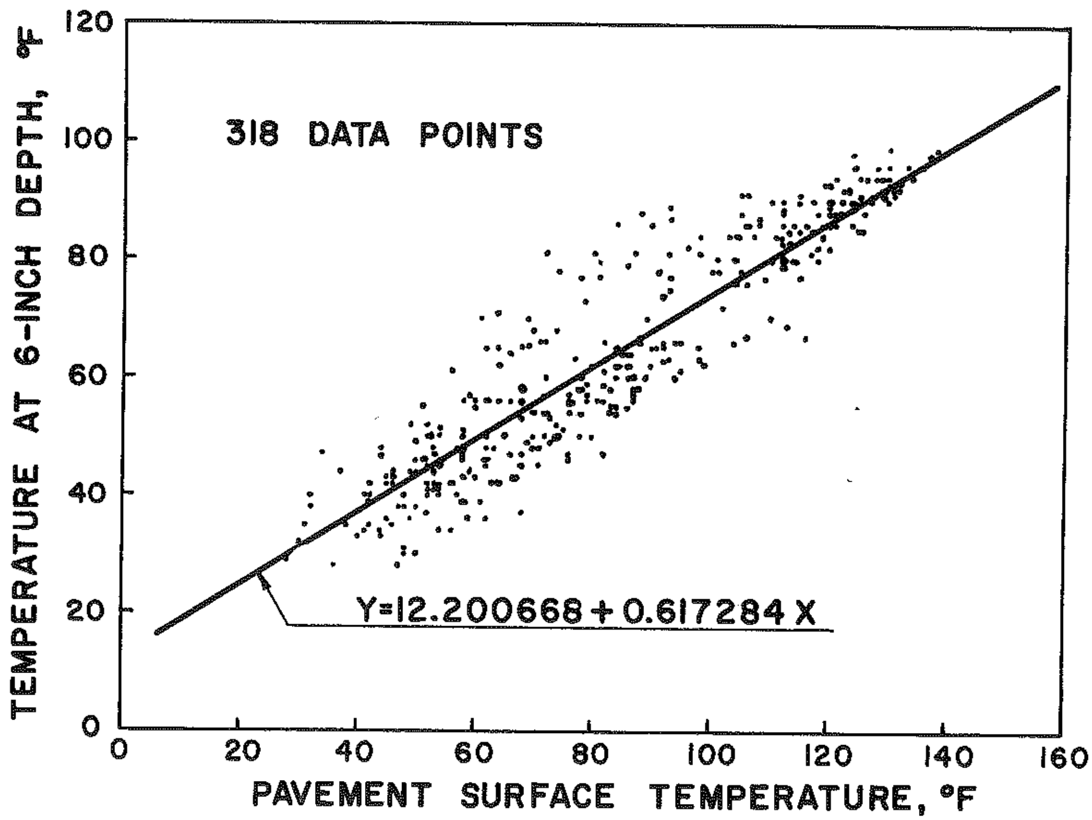

Figure 25: Measured Temperature at the 6-Inch Depth at 1300 Hours vs. Measured Surface Temperature

An analysis of the temperatures at the 6-inch depth for 1300 hours was made using only the good-weather days of the College Park data for the months April through November, the results of which are shown in Figure 26. As can be seen, the analysis of good-weather data resulted in the straight line having a slight rotation from the straight line for all-weather data (318 days). Likewise, the total for the good-weather data was only 57 percent of the spread of the entire weather data; yet, it was still within the outer limits of the all-weather data. Similar analyses at other depths, for 1300 hours, gave the same relative results; that is, the straight lines were nearly coincidental, and the total spread of good-weather data versus all-weather data was greatly reduced and within the limits of the all-weather data. The important conclusion of the above comparisons is that the confidence is increased in the accuracy of the temperatures predicted by the straight-line equations obtained by including all of the weather data.

The data used to develop the graphs presented in Appendix B and the equations presented in Appendix D do contain a fair amount of scatter; however, two standard errors of estimate would contain 95 percent of all the measured data points. Taking 1300 hours as an example, the true temperature 4 inches below the surface may be ±7.02°F from the predicted temperature. For the 8-inch depth, this value would be ±10.86°F. An example of the total overall effect upon the deflection adjustment factor is given in Table 3.

According to Table 3, the higher temperatures encountered in the summer could cause a maximum variation of 0.002 inch in the adjusted

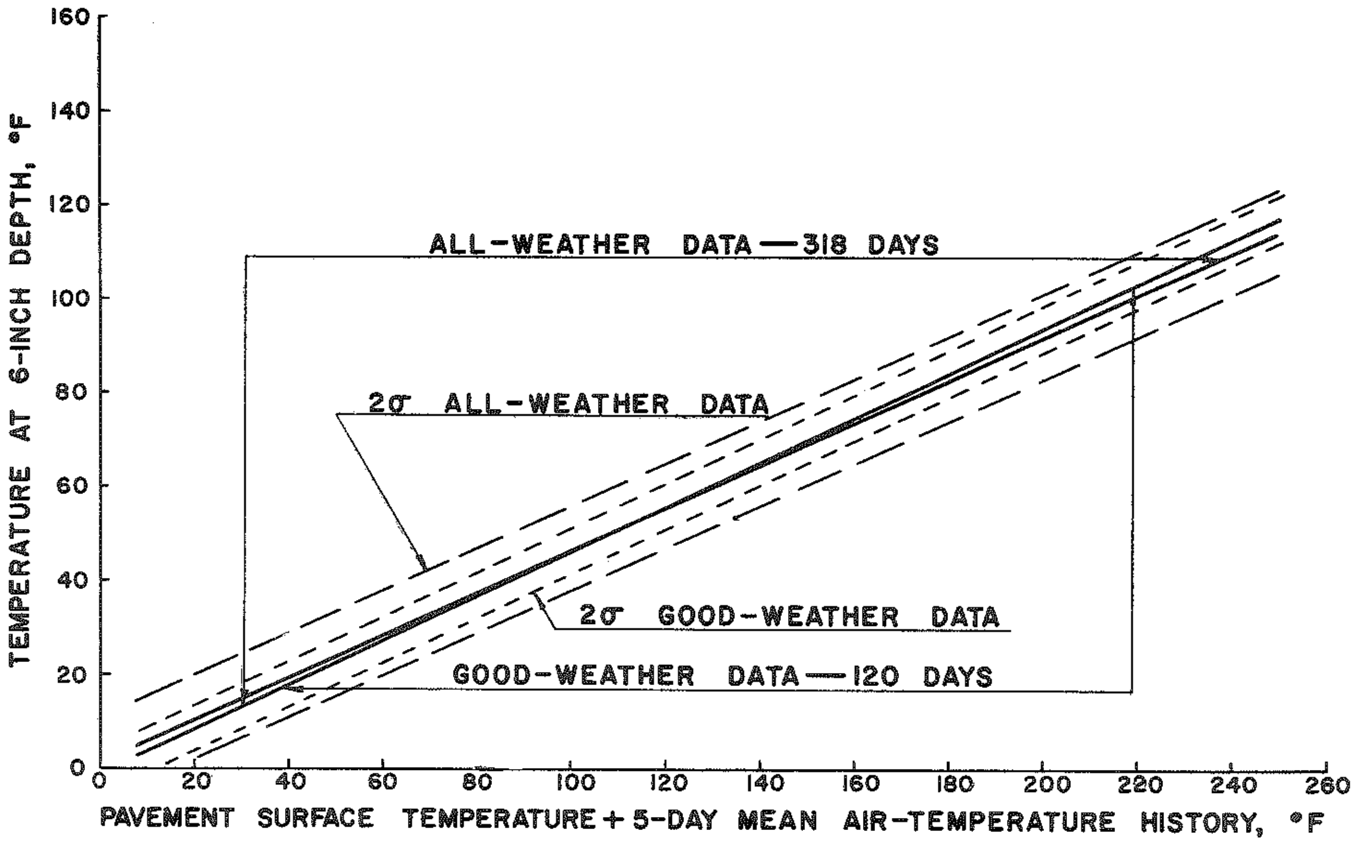

Figure 26: Temperature at the 6-Inch Depth at 1300 Hours vs. Surface Temperature Plus 5-Day Average Air-Temperature History for 318 Days of All Types of Weather and 120 Days of Good Weather Days During Warm Months of 1964

Table 3

VARIATIONS IN DEFLECTION ADJUSTMENT FACTOR AND ADJUSTED DEFLECTION
DUE TO EQUATION OF STRAIGHT LINE AND STANDARD ERRORS OF ESTIMATE
FROM REGRESSION ANALYSES FOR EXTREMES OF DATA

1	2	3	4	5	6	7	8	9	10	11	12*	13
FIELD MEASURED DEFLECTION (INCHES)	PAVEMENT SURFACE TEMPERATURE (°F)	5-DAY AVERAGE AIR-TEMP. HISTORY (°F)	COL. 2 PLUS COL. 3 (°F)	TWO STANDARD ERRORS OF ESTIMATE AT MID-DEPTH OF PAVEMENT (°F)	TEMPERATURE AT MID-DEPTH OF PAVEMENT (°F)	COL. 5 PLUS COL. 6 (°F)	TWO STANDARD ERRORS OF ESTIMATE AT BOTTOM OF PAVEMENT (°F)	TEMPERATURE AT BOTTOM OF PAVEMENT (°F)	COL. 8 PLUS COL. 9 (°F)	$\frac{(COL.\ 2)+(COL.\ 7)+(COL.\ 10)}{3}$ (°F)	ADJUSTMENT FACTOR	ADJUSTED DEFLECTION (COL. 1)(COL. 12) (INCHES)
0.050	137	72	209	0.0	102.8	102.8	0.0	92.1	92.1	110.6	0.615	0.031
0.050	137	72	209	+7.0	102.8	109.8	+ 10.9	92.1	103.0	116.6	0.598	0.030
0.050	137	72	209	-7.0	102.8	95.8	- 10.9	92.1	81.2	104.7	0.640	0.032
0.030	68	33	101	0.0	50.0	50.0	0.0	46.6	46.6	54.9	1.100	0.033
0.030	68	33	101	+7.0	50.0	57.0	+10.9	46.6	57.5	60.8	0.985	0.030
0.030	68	33	101	-7.0	50.0	43.0	-10.9	46.6	35.7	48.9	1.220	0.037

*Values Obtained from Figure 17

deflection values. However, during the spring melting period and approaching the winter freezing period, a maximum variation of 0.007 inch could be obtained with the lower surface temperatures.

The variations in the adjusted deflections for high and low surface temperatures mentioned above can be overshadowed by a slowly adjusting surface thermometer which may take as much as 15 minutes to stabilize. If the thermometer takes 15 minutes to stabilize and has been placed in a shaded portion of the pavement so that it is shielded from the sun, the pavement surface temperature may drop as much as 10° to 15°F before the thermometer becomes stabilized. This produces far more error in the deflection adjustment factor than the error caused by the wide confidence limits of the equations for prediction of temperature distribution. Table 3 also illustrates that caution is needed in applying the deflection adjustment factors to deflection test results. Extrapolation of the AASHO curves (2), shown in Figures 14 and 15, to temperatures below 55°F produces a large spread between the individual curves as shown in Figure 16.

The WASHO and Sebastyan methods of determining the pavement temperature involved the insertion of a thermometer in a pre-drilled 2-inch deep hole filled with oil. Using the temperature-prediction curve, Figure 48, Appendix B, for 1300 hours and the Table 3 value of surface temperature plus 5-day air-temperature history of 209°F, the temperature at the 2-inch depth would be 118°F. The WASHO and Sebastyan methods would use 118°F as the pavement temperature for an 8-inch thick pavement resulting in a deflection adjustment factor of 0.598 from Figure 55.

This produces an adjusted deflection of 0.030 inches--0.001 inch difference compared to the Table 3 value. Using the same approach but starting with a $T_s+\bar{A}$ of 101°F, the 2-inch depth temperature would be 61.5°F resulting in a deflection adjustment factor of 0.975. This produces an adjusted deflection of 0.029 inches--0.004 inch difference compared to the Table 3 value.

For more precise temperature distributions for a given time, it is necessary to convert local time of day of deflection measurement to "graph time" (i.e. College Park time) before entering the temperature-prediction graphs.

The actual difference in hours and minutes between sunrise at College Park, Maryland and sunrise at a given location can be obtained from the U. S. Weather Bureau, or estimated assuming 15 degrees longitude equals one hour. College Park, Maryland, is at longitude 76°56'.

The following examples illustrate how to adjust local time to equivalent "graph-time" at College Park, Maryland.

1. Given Local time = 11.43 am EST and

   local longitude = 82°17', then

   difference in sunrise times = (82°17'-76°56')/15°

   = 21 minutes

   Therefore, equivalent College Park time

   = 11:43-0:21 = 11:22 am EST.

2. Given Local time = 10:55 am CST and

   difference in sunrise times = 0 hours 46 minutes.

   Equivalent College Park time = 10:55+1:00-0:46

   = 11:09 am EST.

The equation coefficients, correlation coefficients, and their standard error of estimate are presented in Appendix D for the benefit of those who desire to inspect the time-temperature-depth relationships in more detail.

APPENDIX B

USE OF METHOD FOR PREDICTING TEMPERATURE DISTRIBUTION AND ADJUSTING PAVEMENT DEFLECTIONS FOR TEMPERATURE EFFECTS

TEMPERATURE PREDICTION GRAPHS FOR PAVEMENTS 2 INCHES OR LESS IN THICKNESS

TEMPERATURE PREDICTION GRAPHS FOR PAVEMENTS GREATER THAN 2 INCHES IN THICKNESS

MASTER CURVE FOR DETERMINING DEFLECTION ADJUSTMENT FACTORS

USE OF METHOD FOR PREDICTING TEMPERATURE DISTRIBUTION AND ADJUSTING PAVEMENT DEFLECTIONS FOR TEMPERATURE EFFECTS

USE OF METHOD FOR PREDICTING TEMPERATURE
DISTRIBUTION AND ADJUSTING PAVEMENT DEFLECTIONS
FOR TEMPERATURE EFFECTS

The temperature prediction method requires six basic items of information as follows:

1. Location of test site,
2. Date,
3. The high and low air temperature for the five days prior to the day of test,
4. Surface temperature at the time of test,
5. Time of day the test was performed, and
6. Thickness of asphaltic concrete.

The location of the test site is needed for the analysis of the deflection test data and for obtaining the necessary air temperature data from the appropriate U. S. Weather Bureau station. The date is also required to get the necessary air temperature data.

The five days of air-temperature history prior to the date of the deflection measurements can be obtained in one of three ways.

1. An air temperature recording station can be installed at the proposed test site and hourly readings taken for five days prior to deflection tests. In most cases this will not be a practical approach.

2. Obtain the high and low air temperature readings for the five calendar days prior to day of test from the nearest U. S. Weather Bureau Station. This method should be used if the test results are needed immediately and evaluations desired at the time of testing.

3. Obtain the high and low air temperatures for the five days prior to day of test from published U. S. Weather Bureau data. This is the most practical approach if evaluation of the test results is not needed immediately. In all cases, data for the nearest U. S. Weather Bureau station's data should be used if the air temperatures are not recorded at the test site prior to date of deflection tests.

Once the air temperatures are obtained, the values should be summed and averaged.

When the deflection test is performed, the surface temperature must be measured using a surface thermometer, and the date and time must also be recorded.

The surface temperature and the average air-temperature history should be added to obtain the adjusted surface temperature. The thickness of the pavement structure must be known in order to predict the temperatures at the midpoint and bottom depths from the appropriate straight lines on each hourly chart in Appendix B.

The surface, mid-depth and bottom temperatures are then averaged to obtain the mean pavement temperature. With the mean pavement temperature, Figure 17 can be used to obtain the deflection adjustment factor.

Multiply the measured deflection taken at 1300 hours by the adjustment factor to obtain the equivalent deflection that would have been measured had the mean pavement temperature been 60°F.

Temperatures desired for depths not shown, or hours for which charts are not available, may be obtained by simple interpolation between depths, or hours, given by the charts in Appendix B.

The time given for any graph or equation is defined as Eastern Standard Time at College Park, Maryland.

TEMPERATURE PREDICTION GRAPHS FOR PAVEMENTS
2 INCHES OR LESS IN THICKNESS

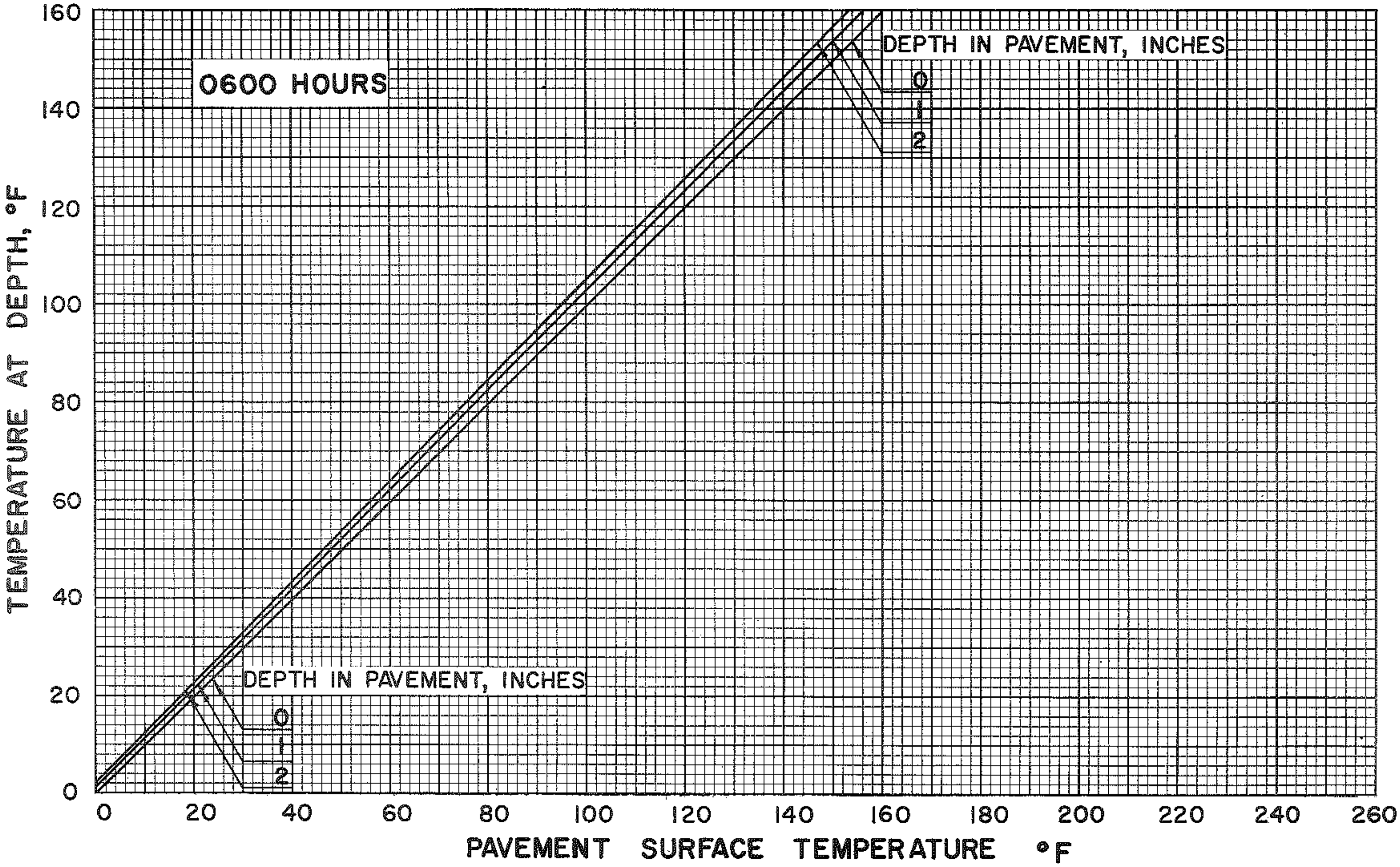

Figure 27: Temperature Prediction Graphs for Pavements Equal To or Less Than 2 Inches Thick

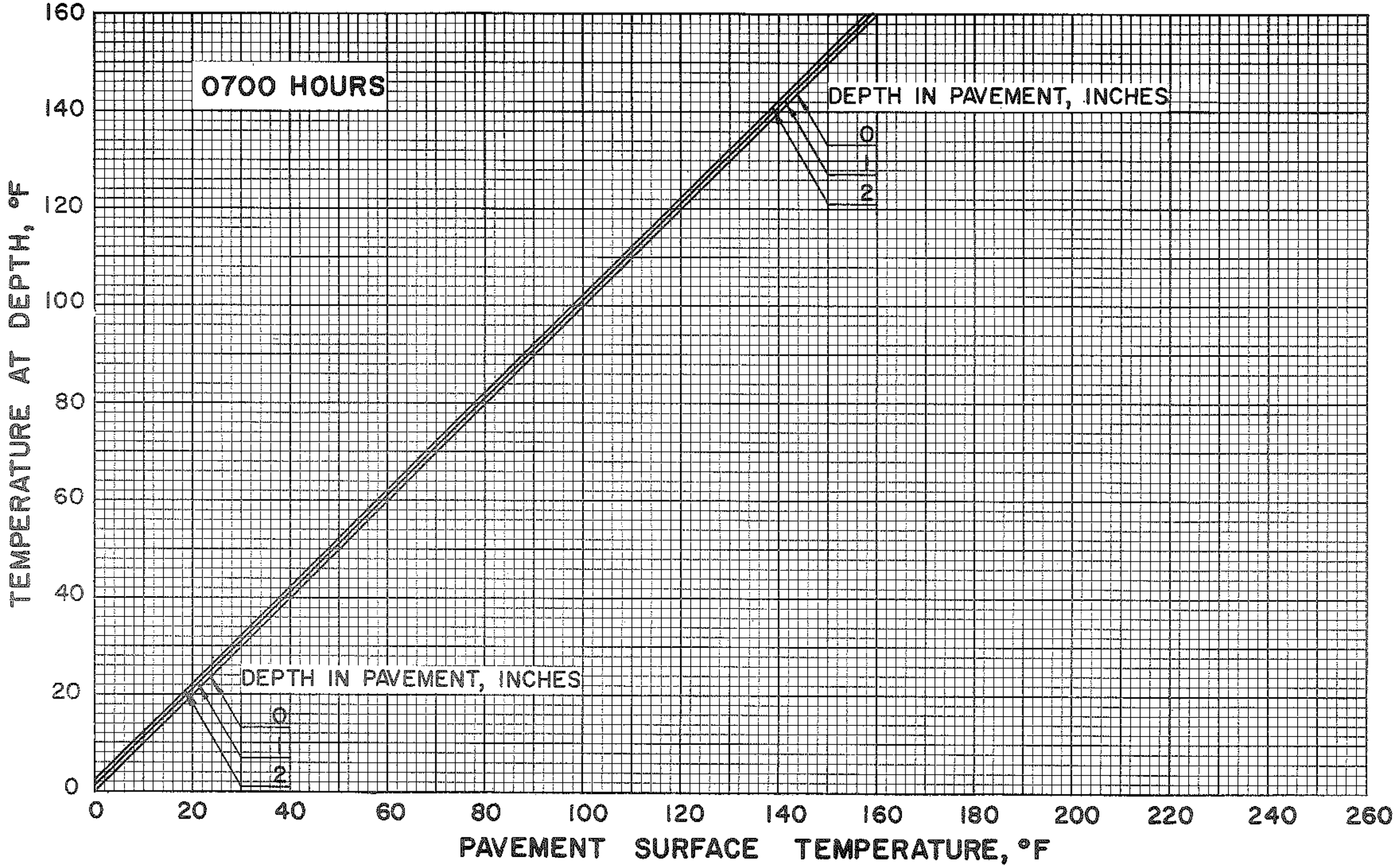

Figure 28: Temperature Prediction Graphs for Pavements Equal To or Less Than 2 Inches Thick

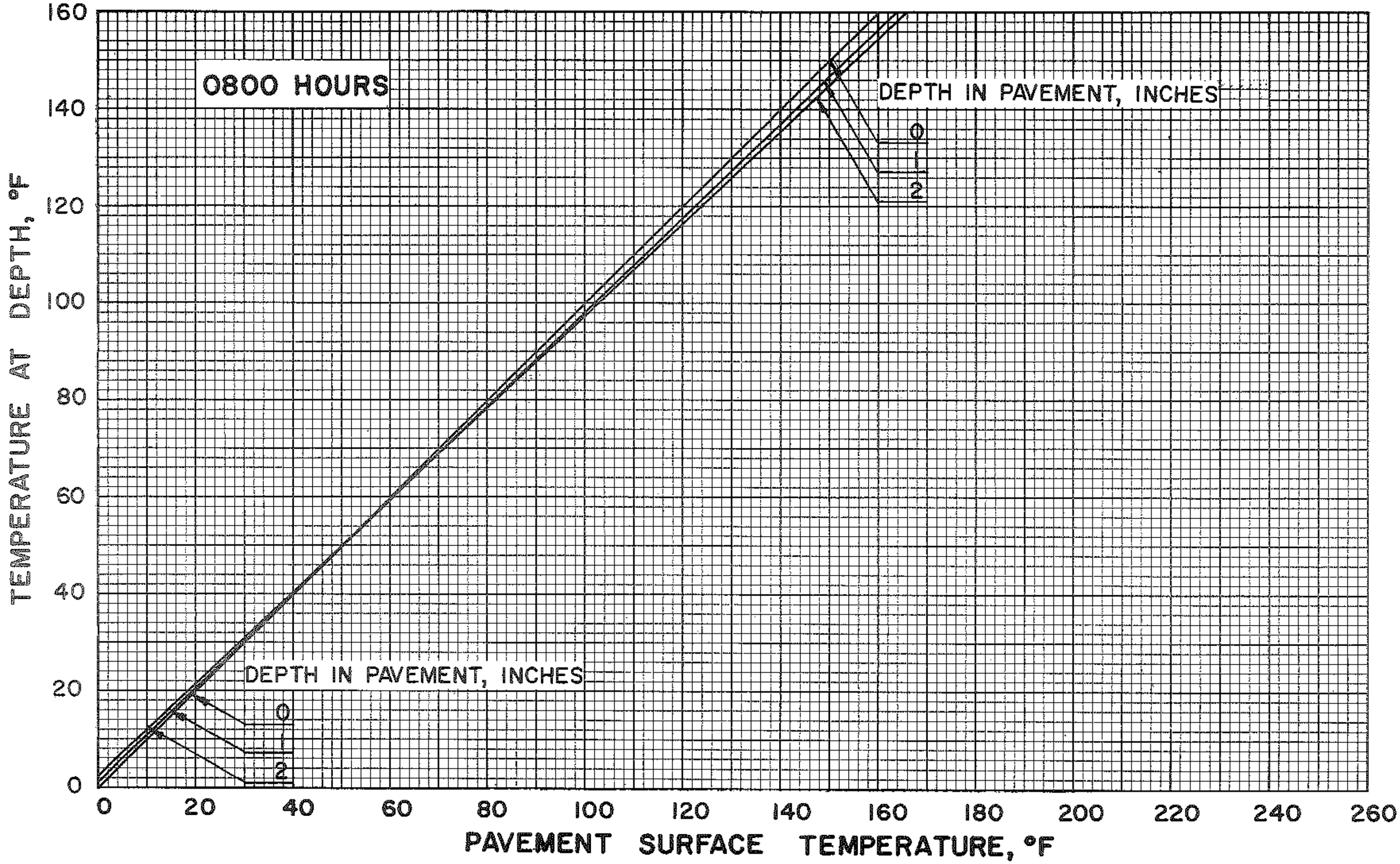

Figure 29: Temperature Prediction Graphs for Pavements
Equal To or Less Than 2 Inches Thick

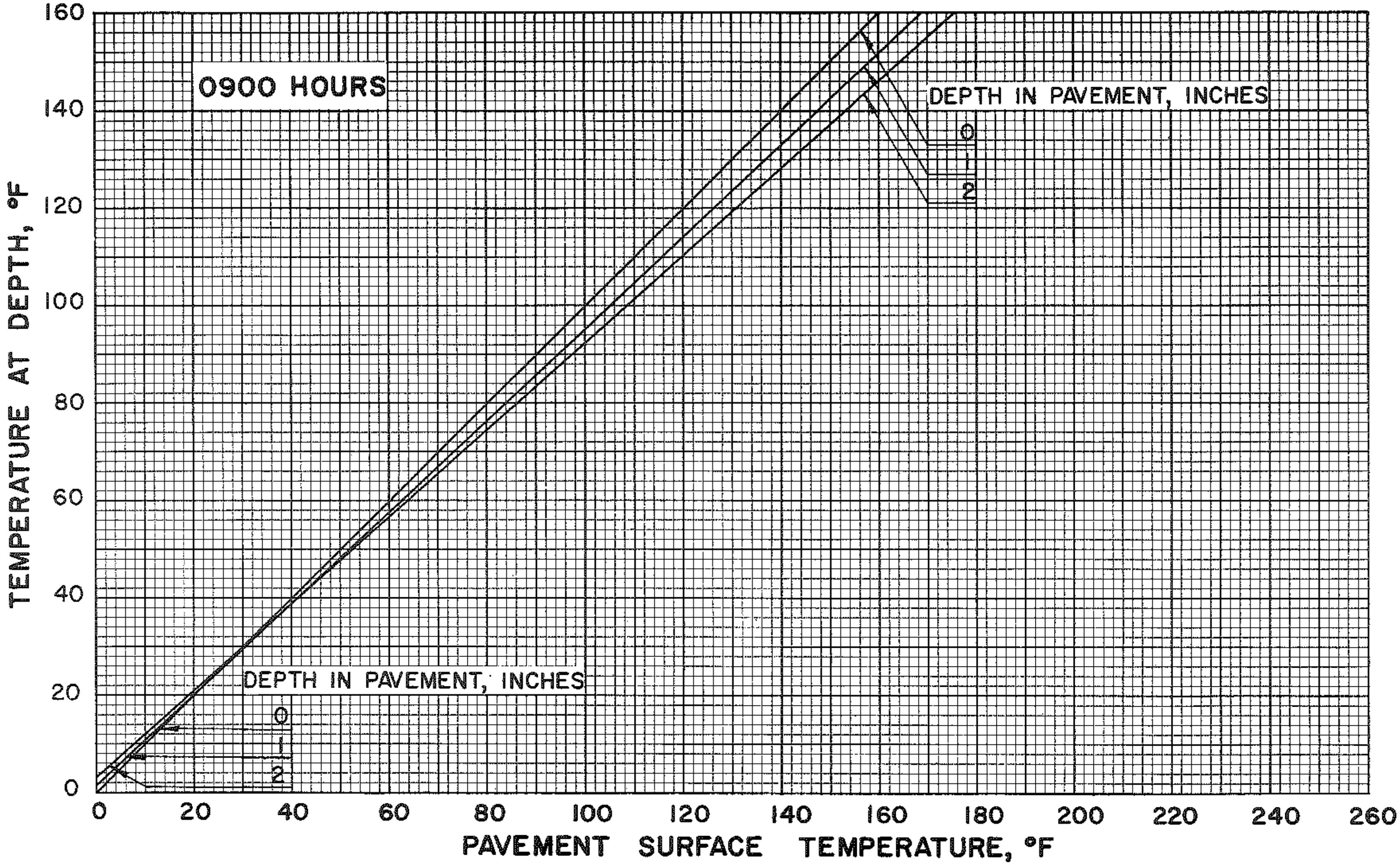

Figure 30: Temperature Prediction Graphs for Pavements Equal To or Less Than 2 Inches Thick

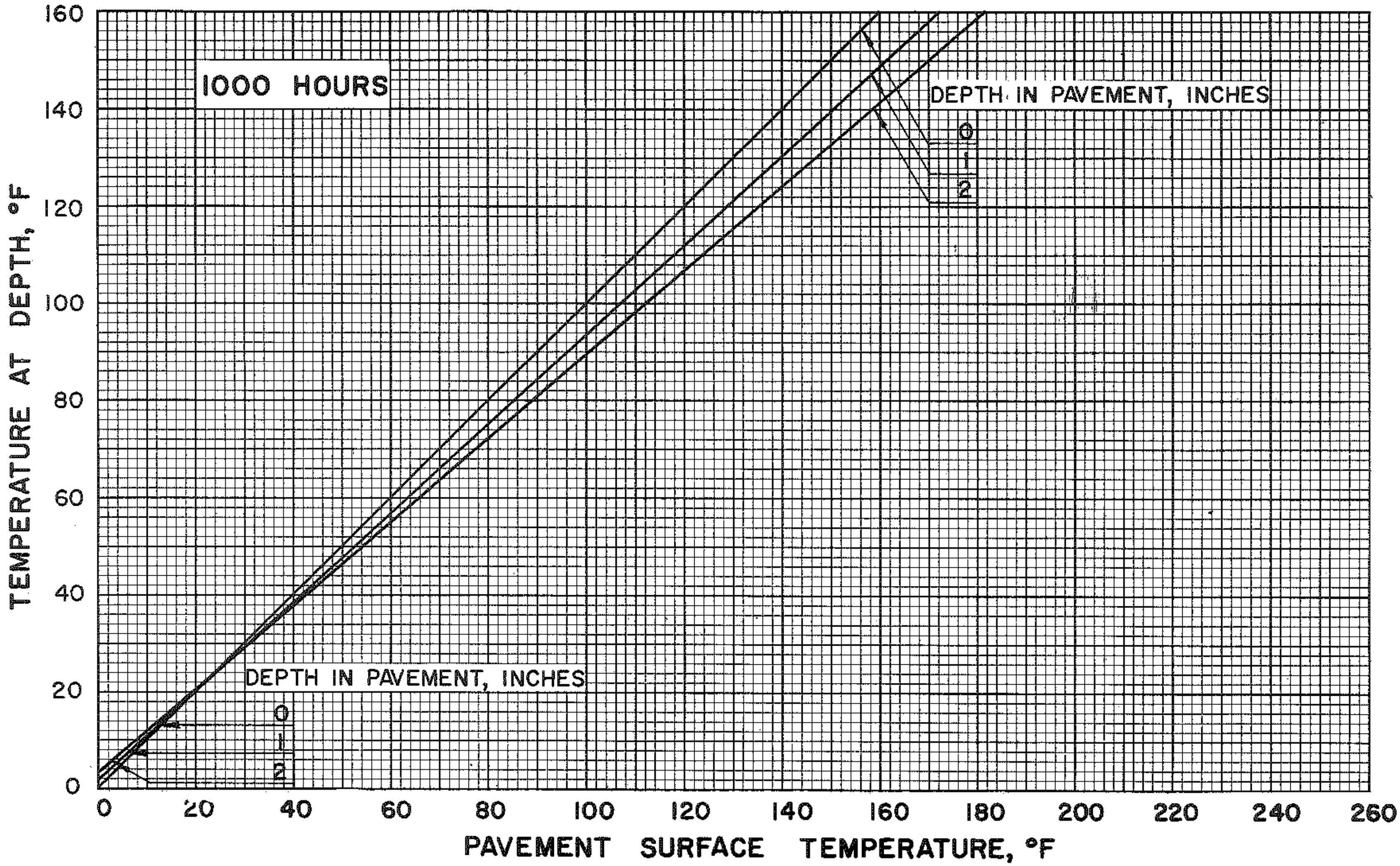

Figure 31: Temperature Prediction Graphs for Pavements Equal To or Less Than 2 Inches Thick

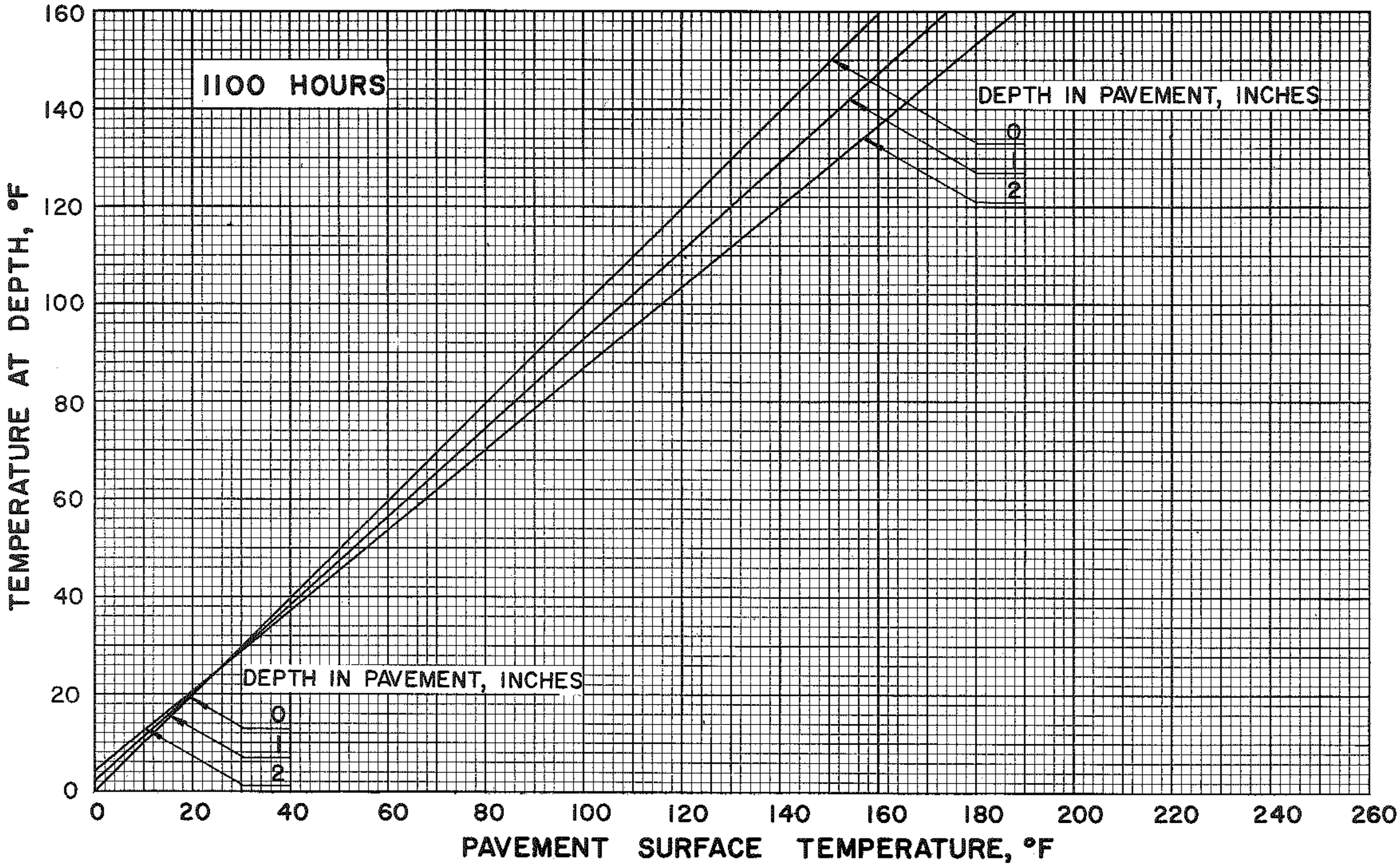

Figure 32: Temperature Prediction Graphs for Pavements Equal To or Less Than 2 Inches Thick

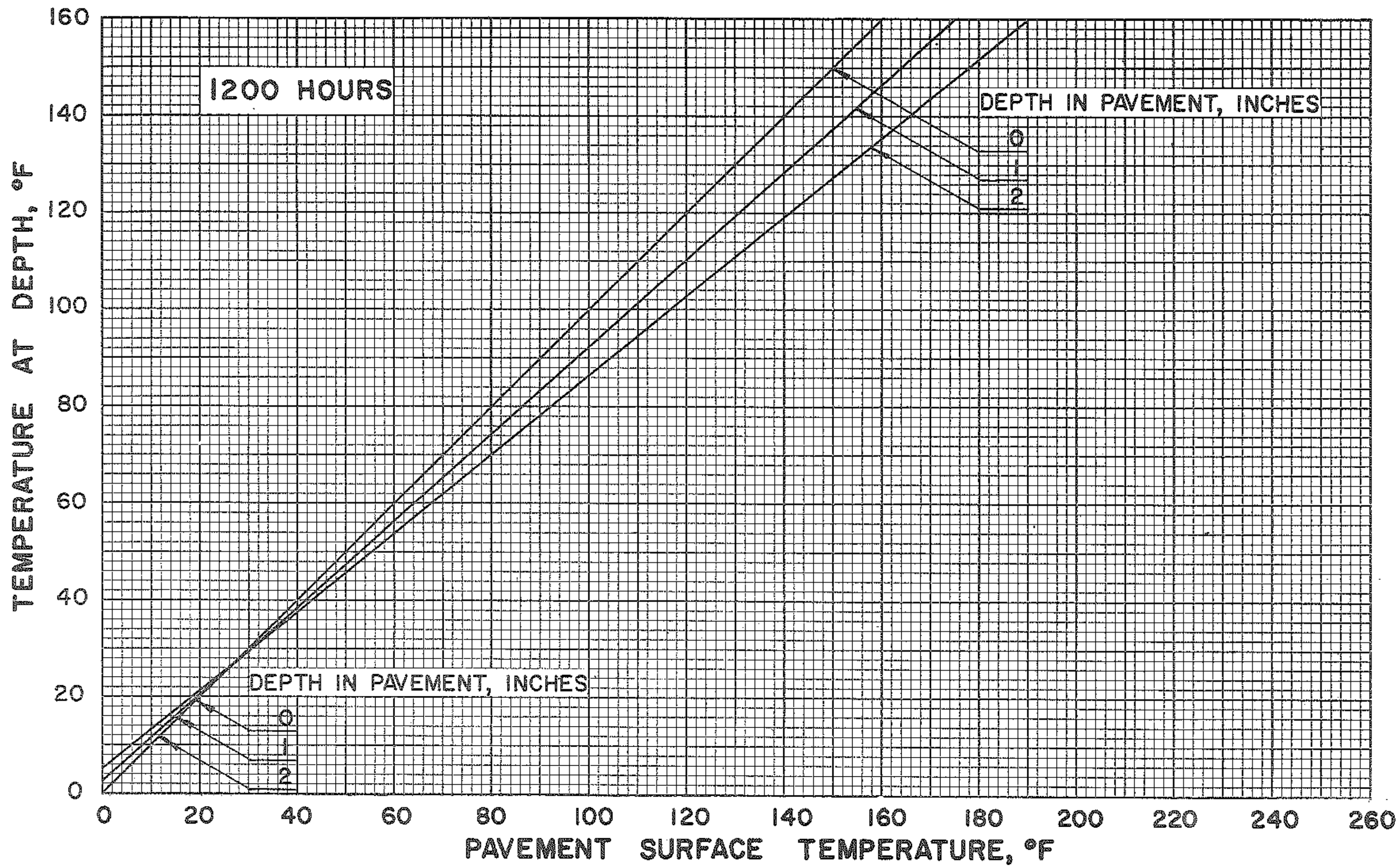

Figure 33: Temperature Prediction Graphs for Pavements Equal To or Less Than 2 Inches Thick

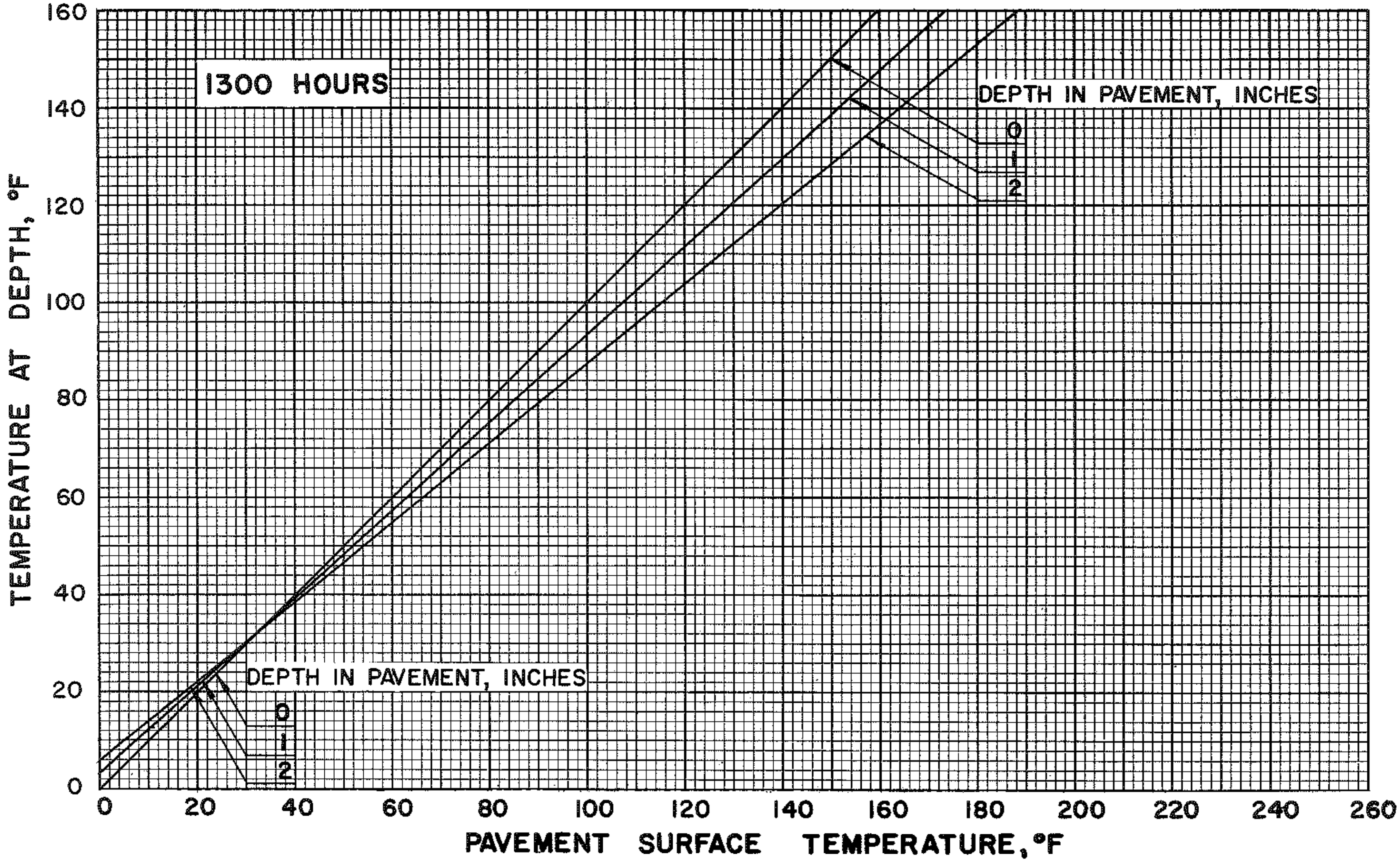

Figure 34: Temperature Prediction Graphs for Pavements Equal To or Less Than 2 Inches Thick

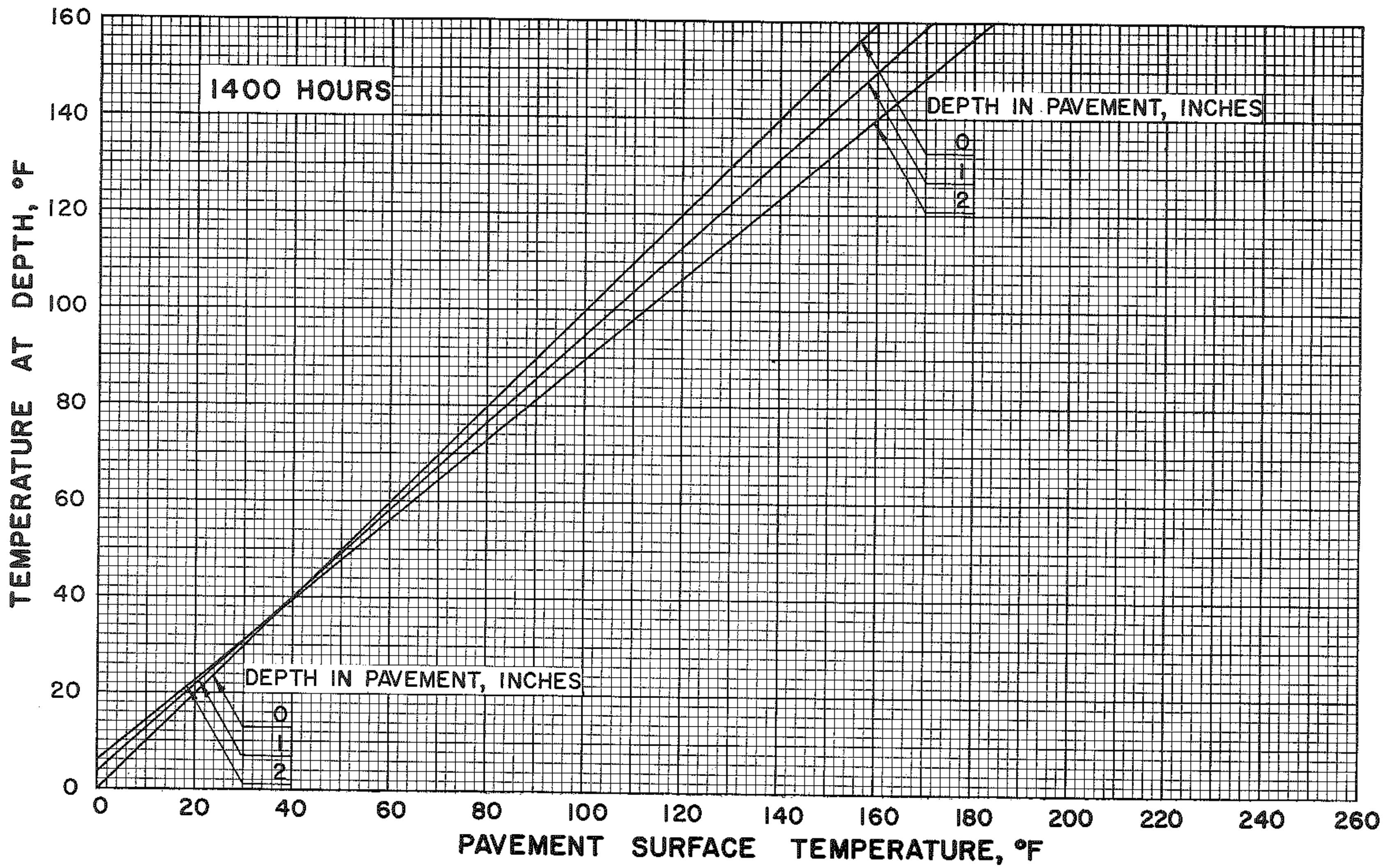

Figure 35: Temperature Prediction Graphs for Pavements Equal To or Less Than 2 Inches Thick

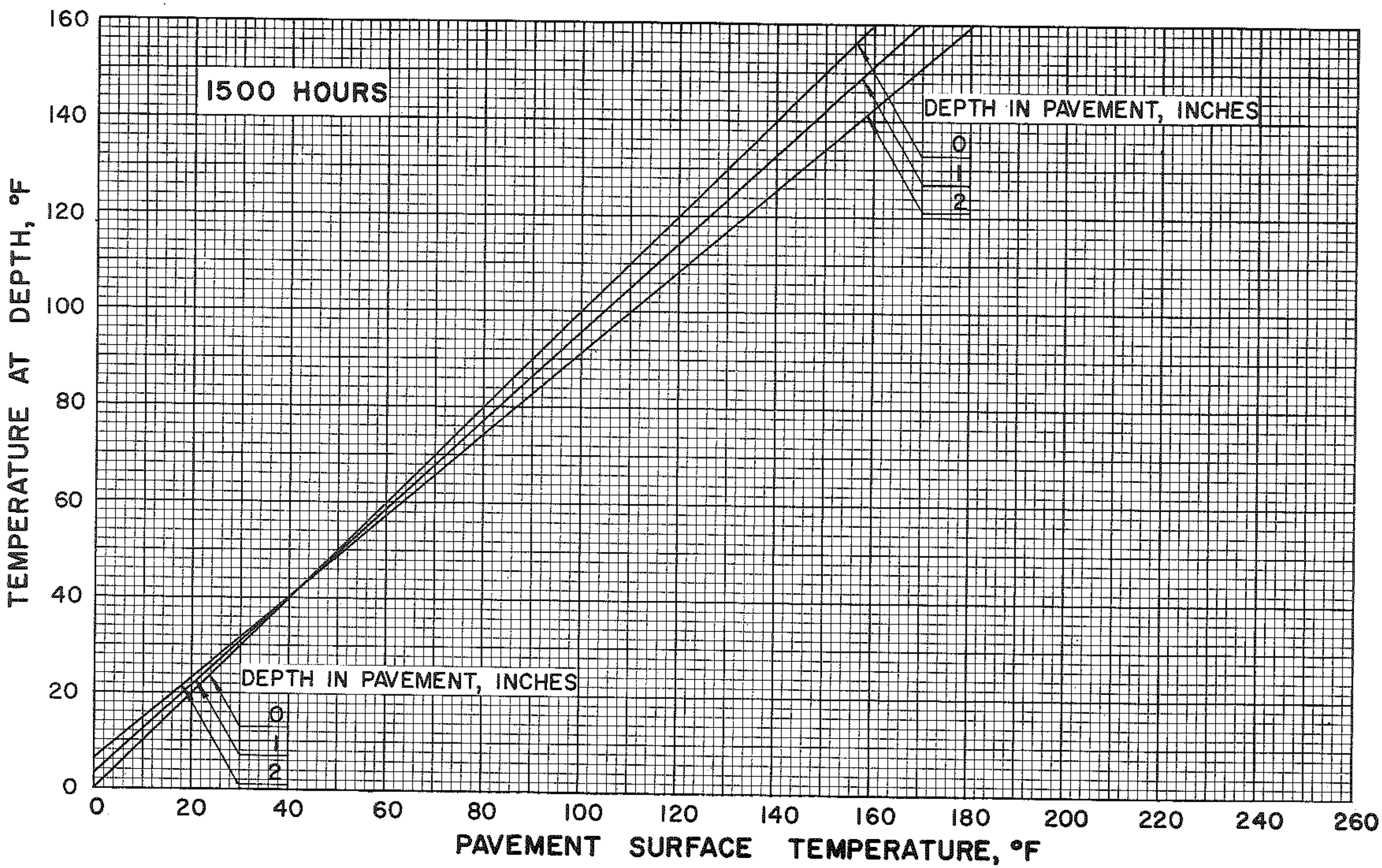

Figure 36: Temperature Prediction Graphs for Pavements Equal To or Less Than 2 Inches Thick

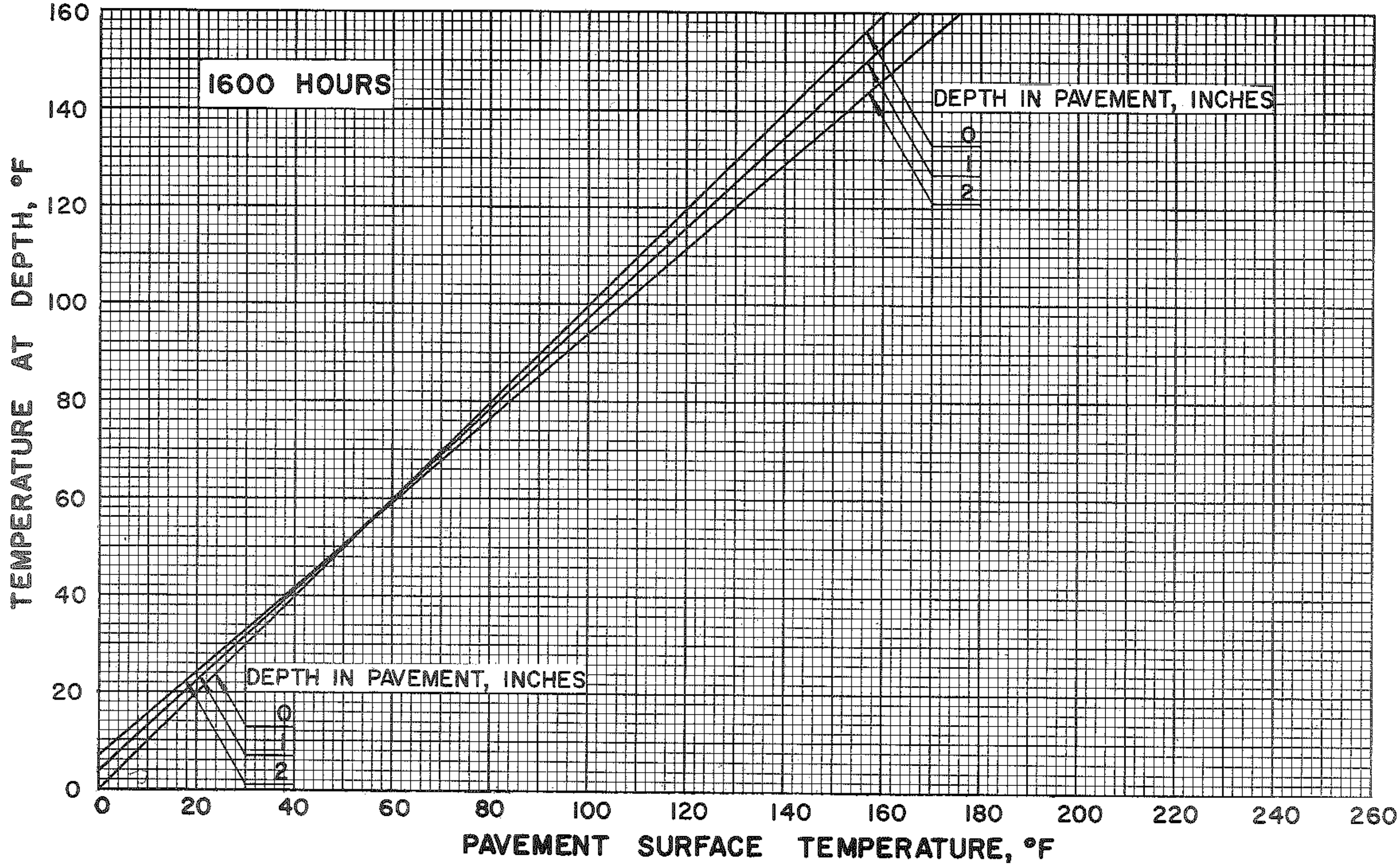

Figure 37: Temperature Prediction Graphs for Pavements Equal To or Less Than 2 Inches Thick

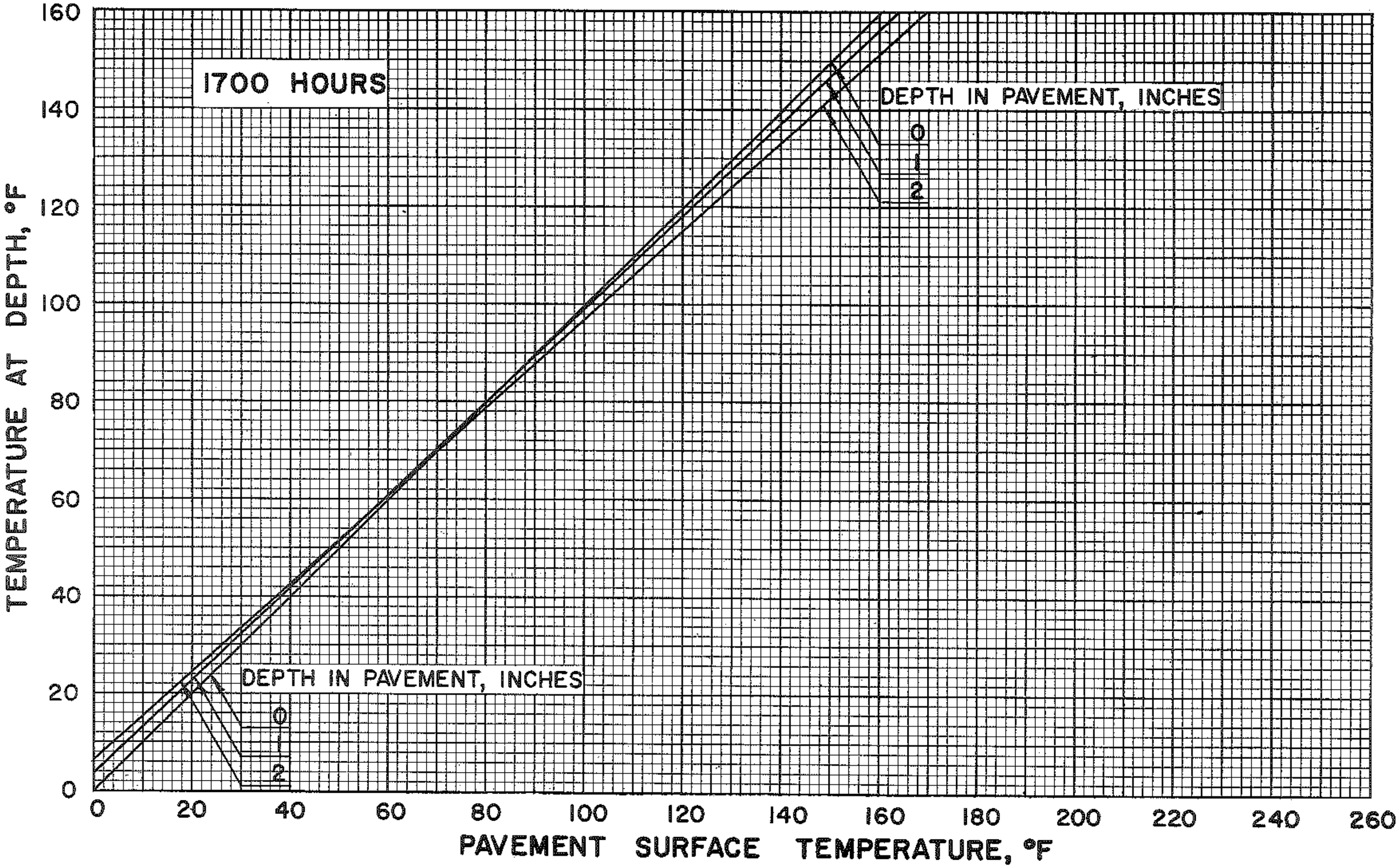

Figure 38: Temperature Prediction Graphs for Pavements Equal To or Less Than 2 Inches Thick

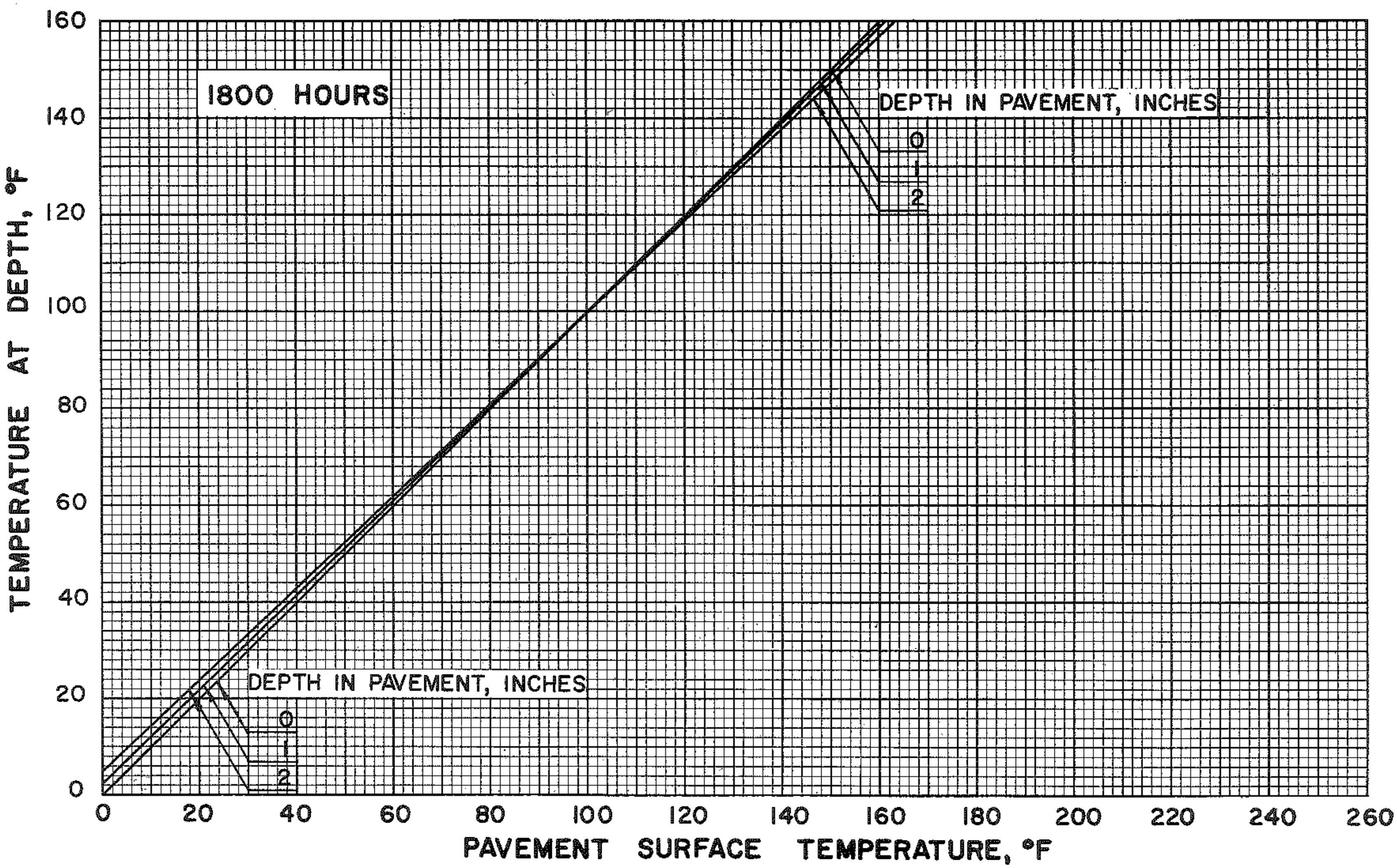

Figure 39: Temperature Prediction Graphs for Pavements Equal To or Less Than 2 Inches Thick

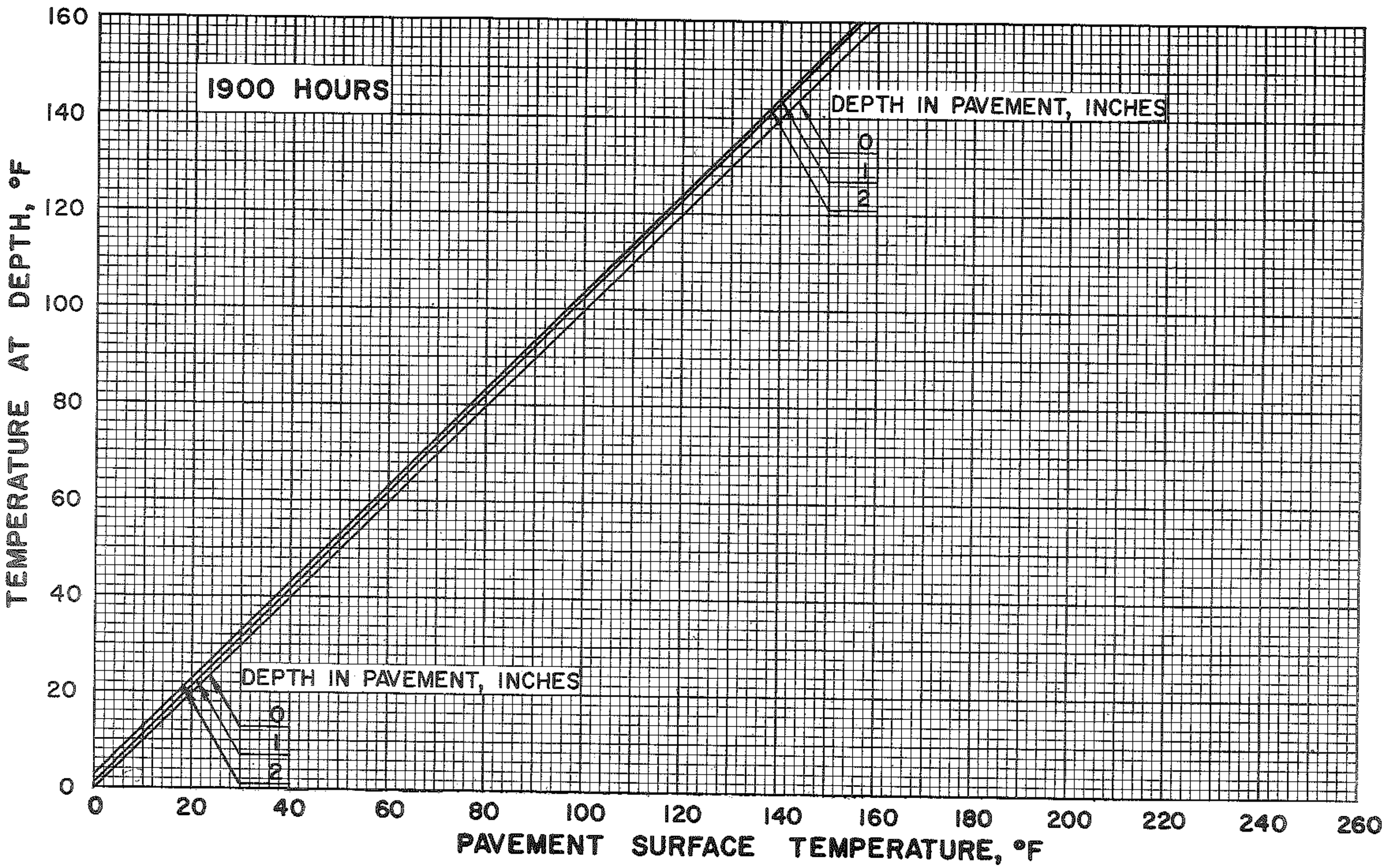

Figure 40: Temperature Prediction Graphs for Pavements Equal To or Less Than 2 Inches Thick

TEMPERATURE PREDICTION GRAPHS FOR PAVEMENTS GREATER THAN 2 INCHES IN THICKNESS

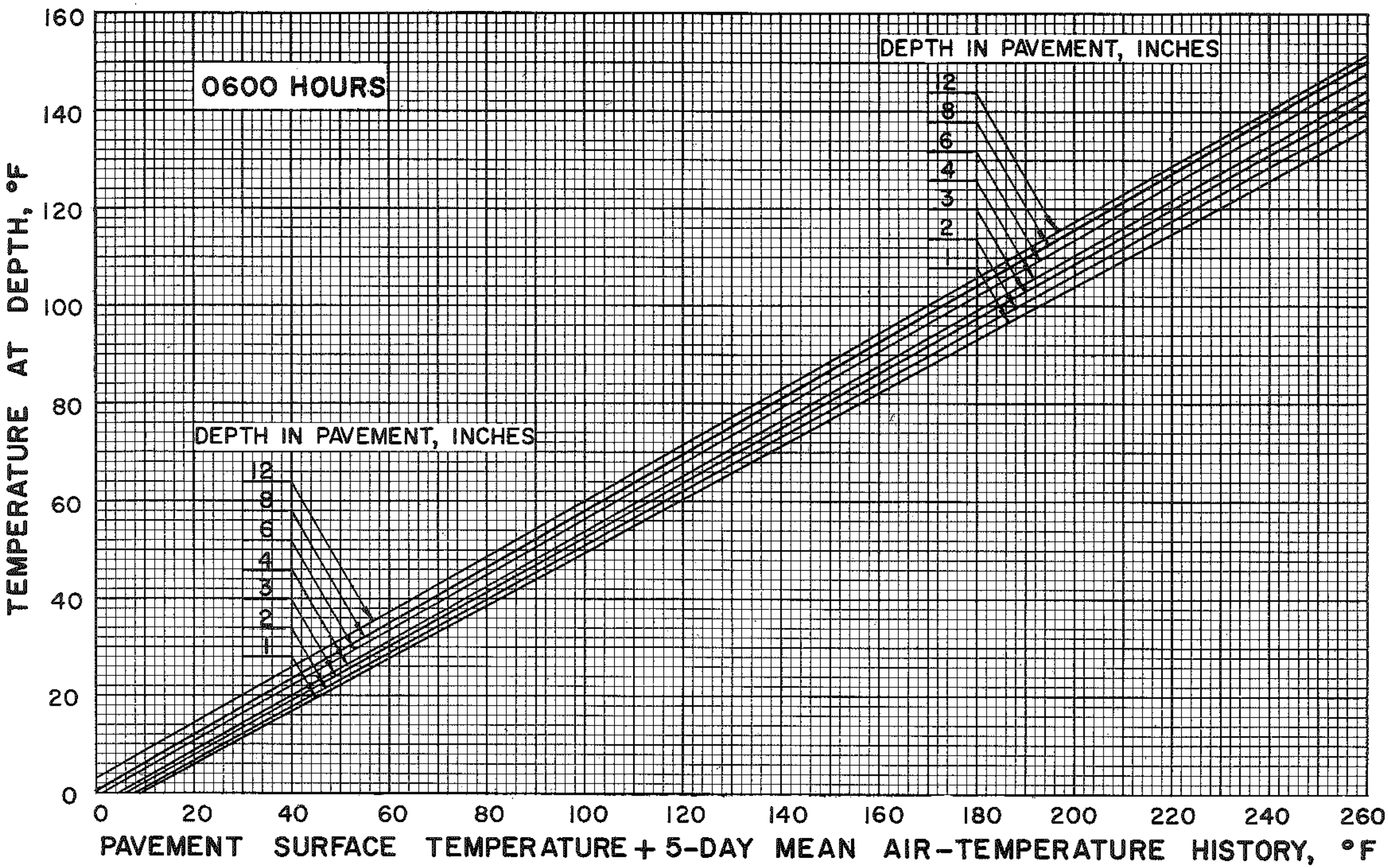

Figure 41: Temperature Prediction Graph for Pavement Greater Than 2 Inches Thick

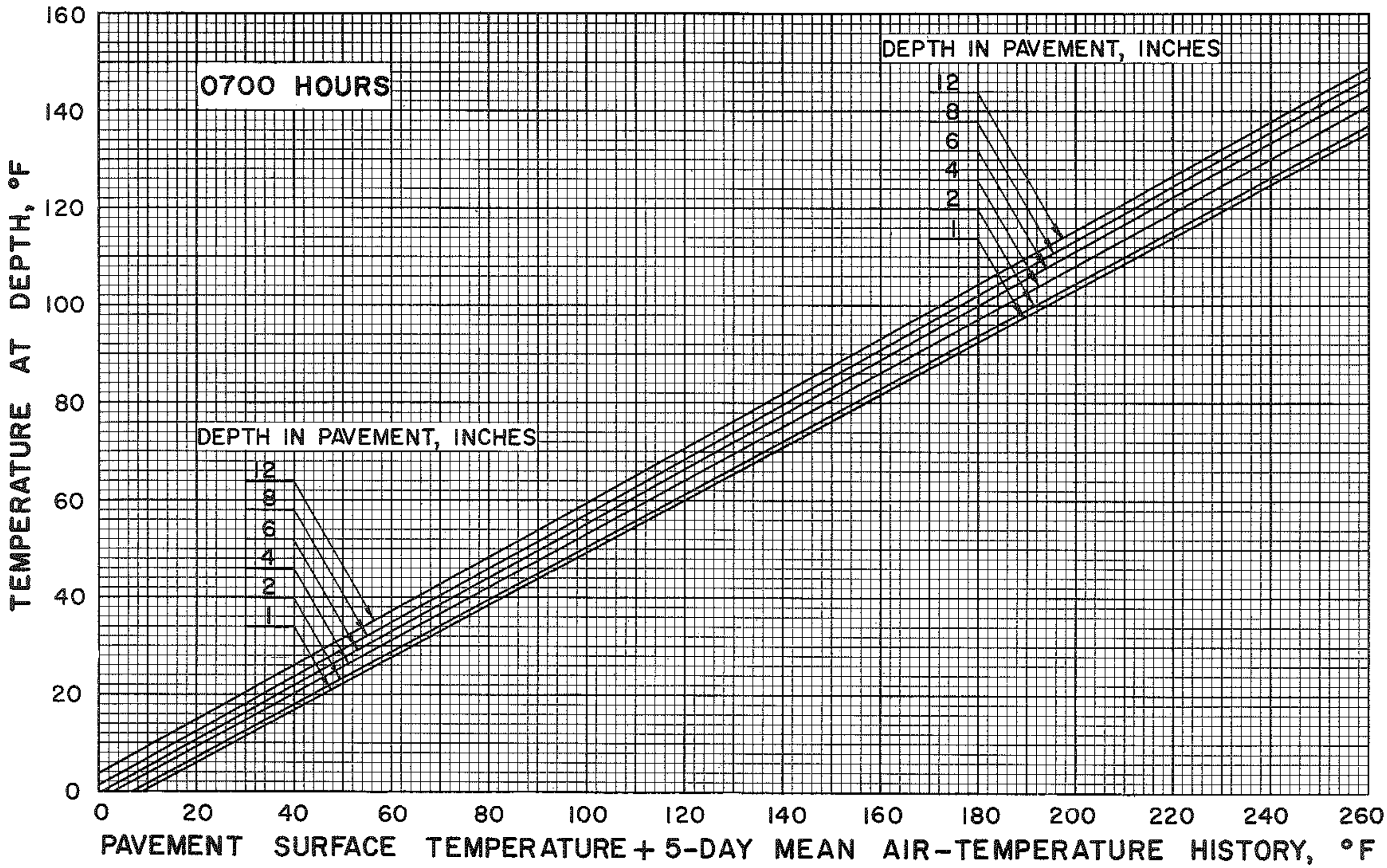

Figure 42: Temperature Prediction Graph for Pavement Greater Than 2 Inches Thick

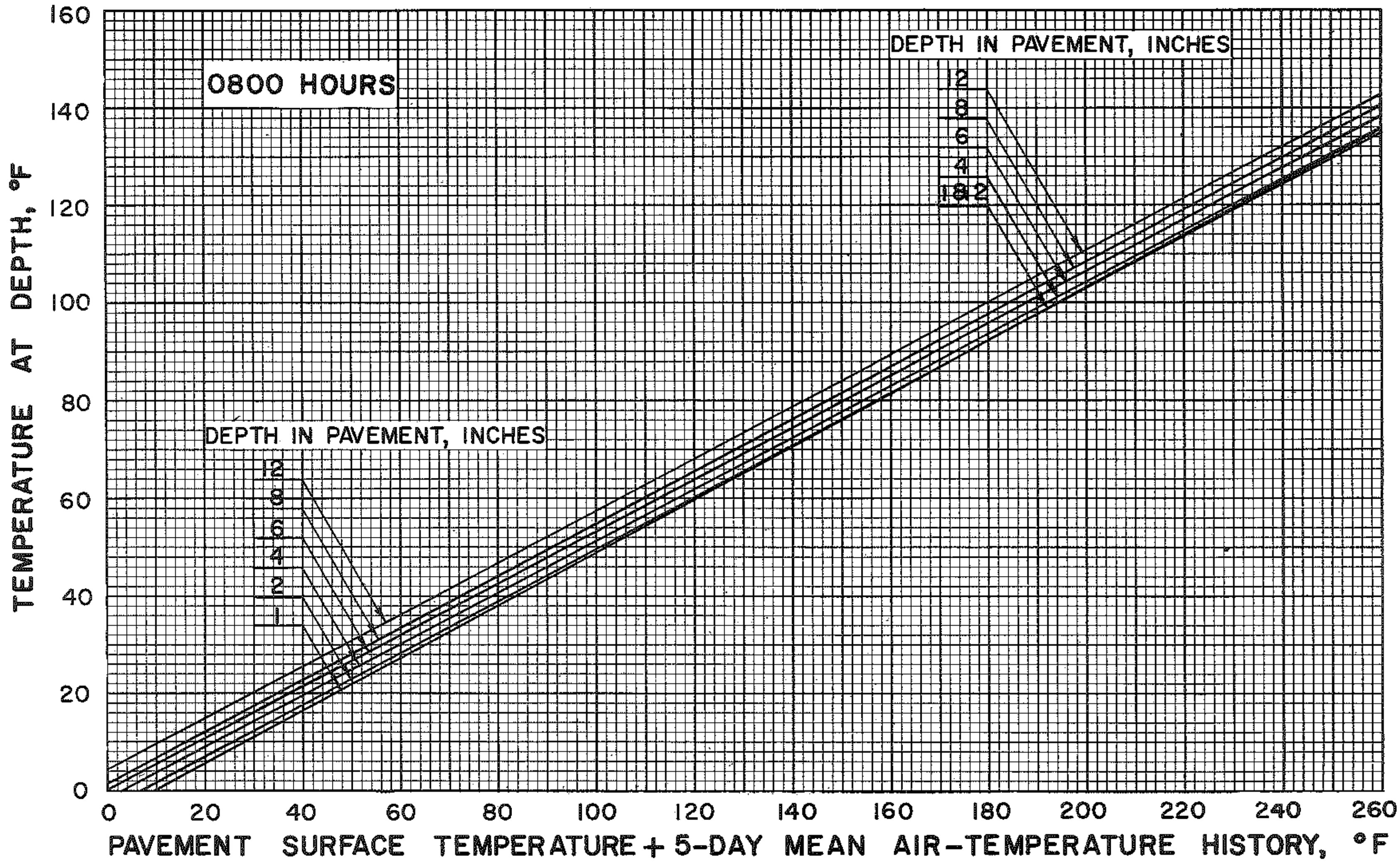

Figure 43: Temperature Prediction Graph for Pavement Greater Than 2 Inches Thick

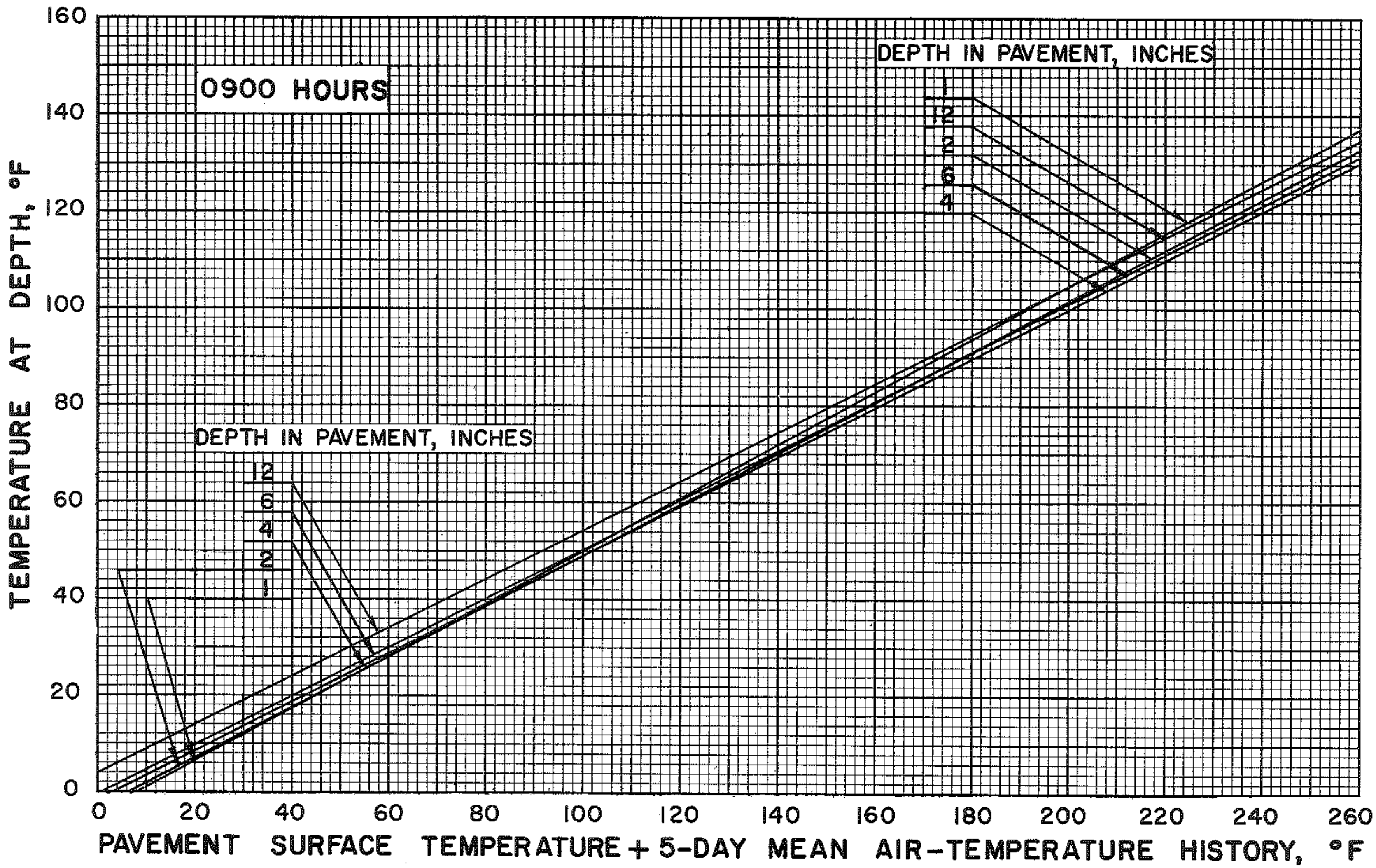

Figure 44: Temperature Prediction Graph for Pavement Greater Than 2 Inches Thick

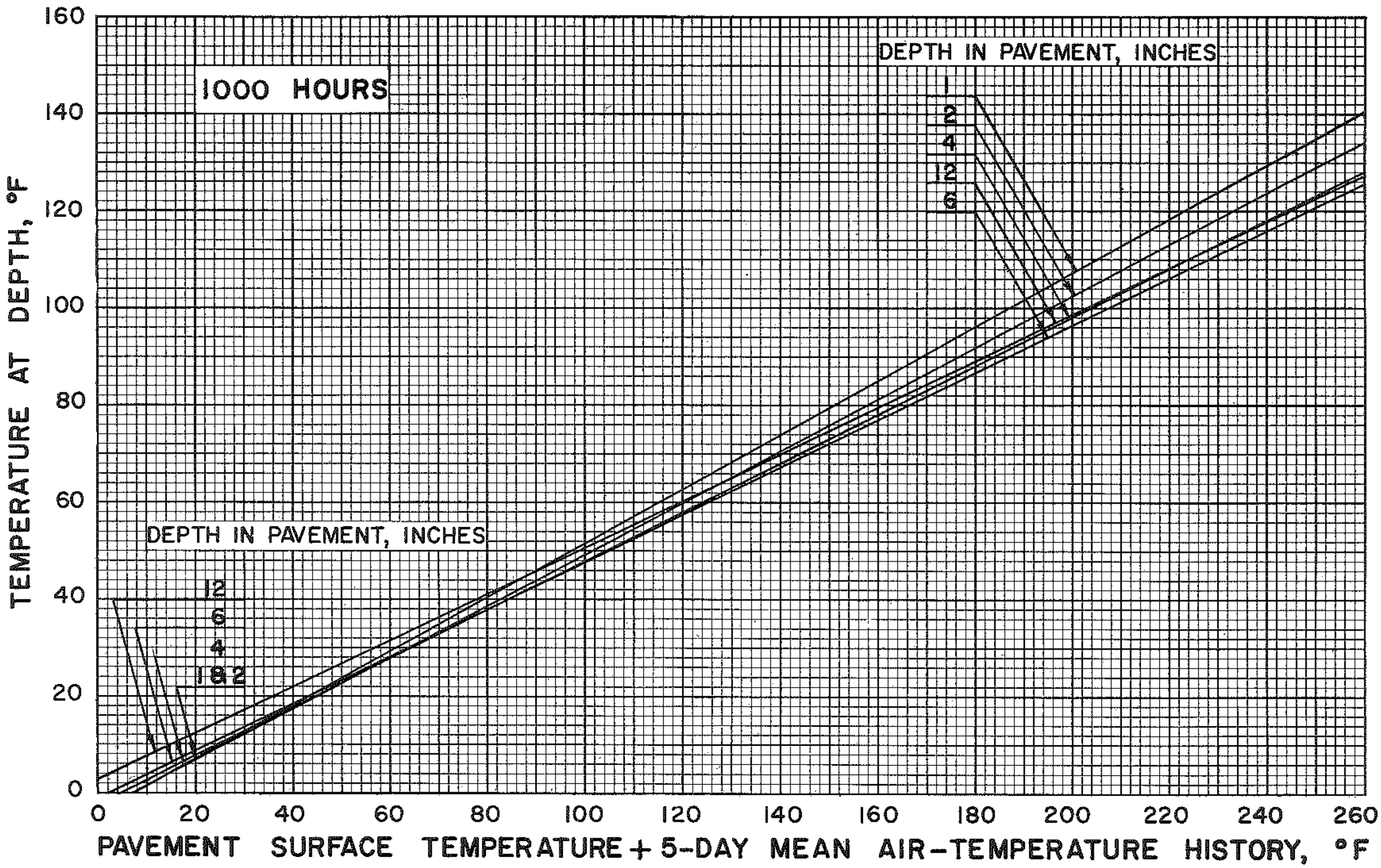

Figure 45: Temperature Prediction Graph for Pavement Greater Than 2 Inches Thick

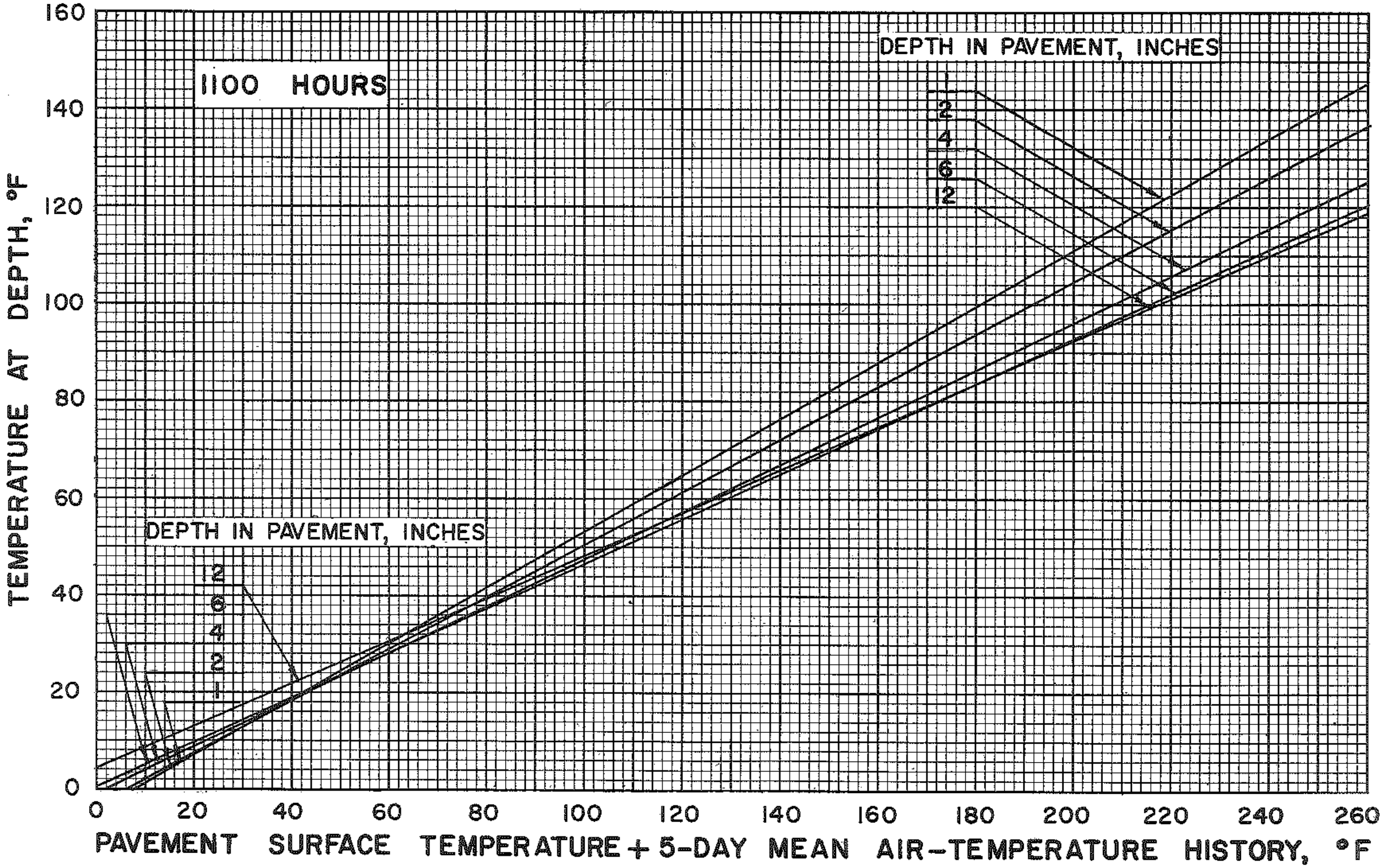

Figure 46: Temperature Prediction Graph for Pavement Greater Than 2 Inches Thick

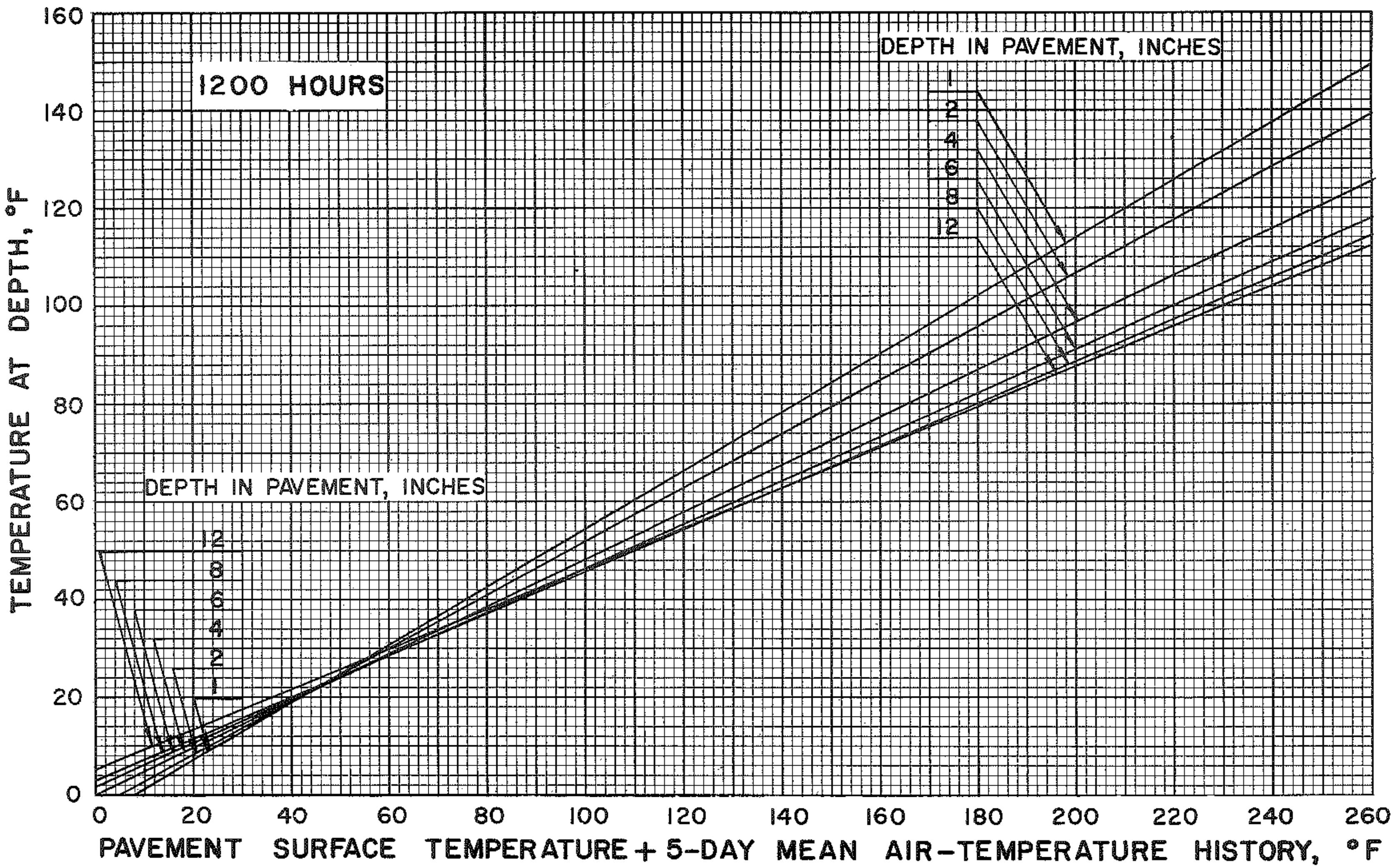

Figure 47: Temperature Prediction Graph for Pavement Greater Than 2 Inches Thick

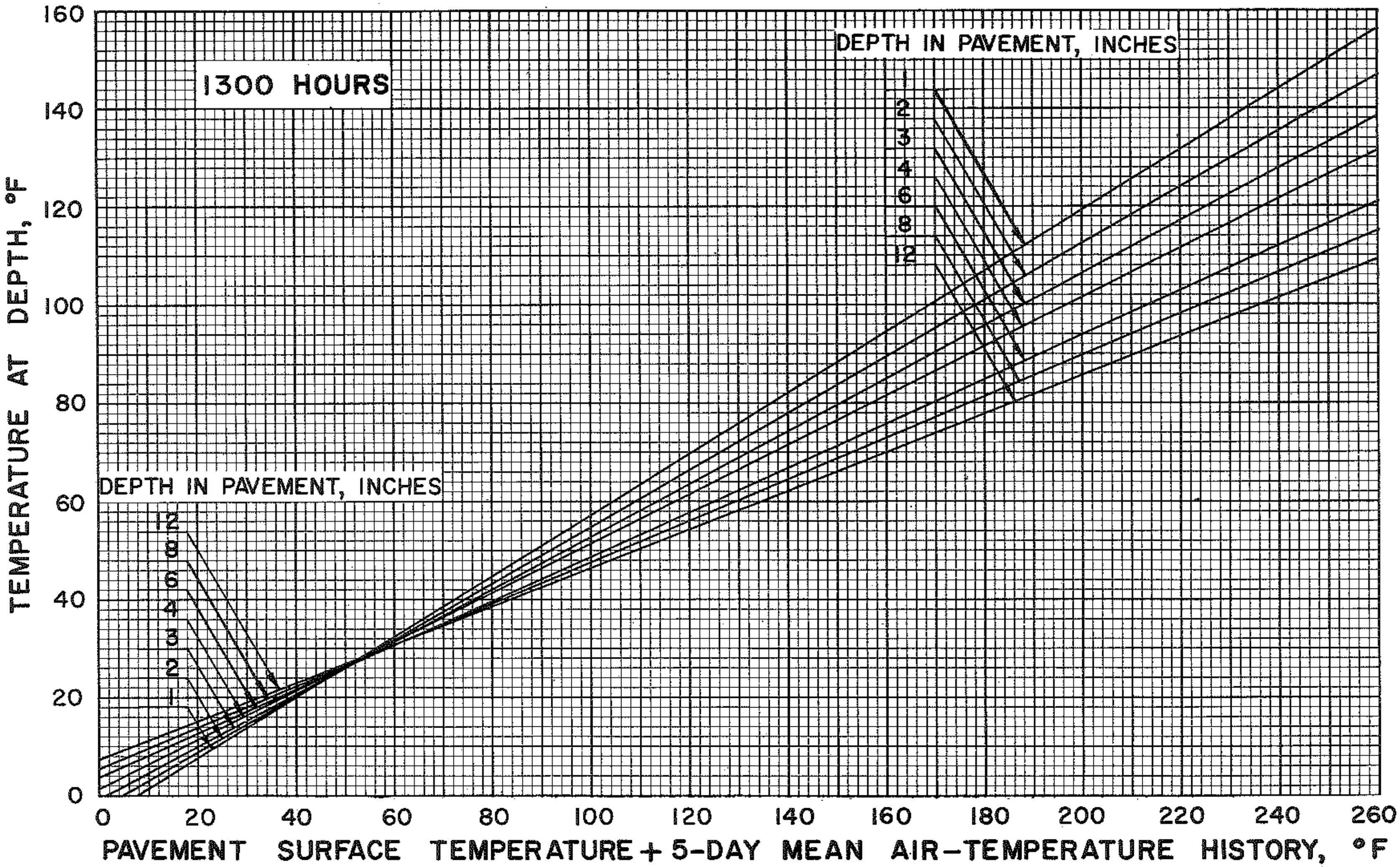

Figure 48: Temperature Prediction Graph for Pavement Greater Than 2 Inches Thick

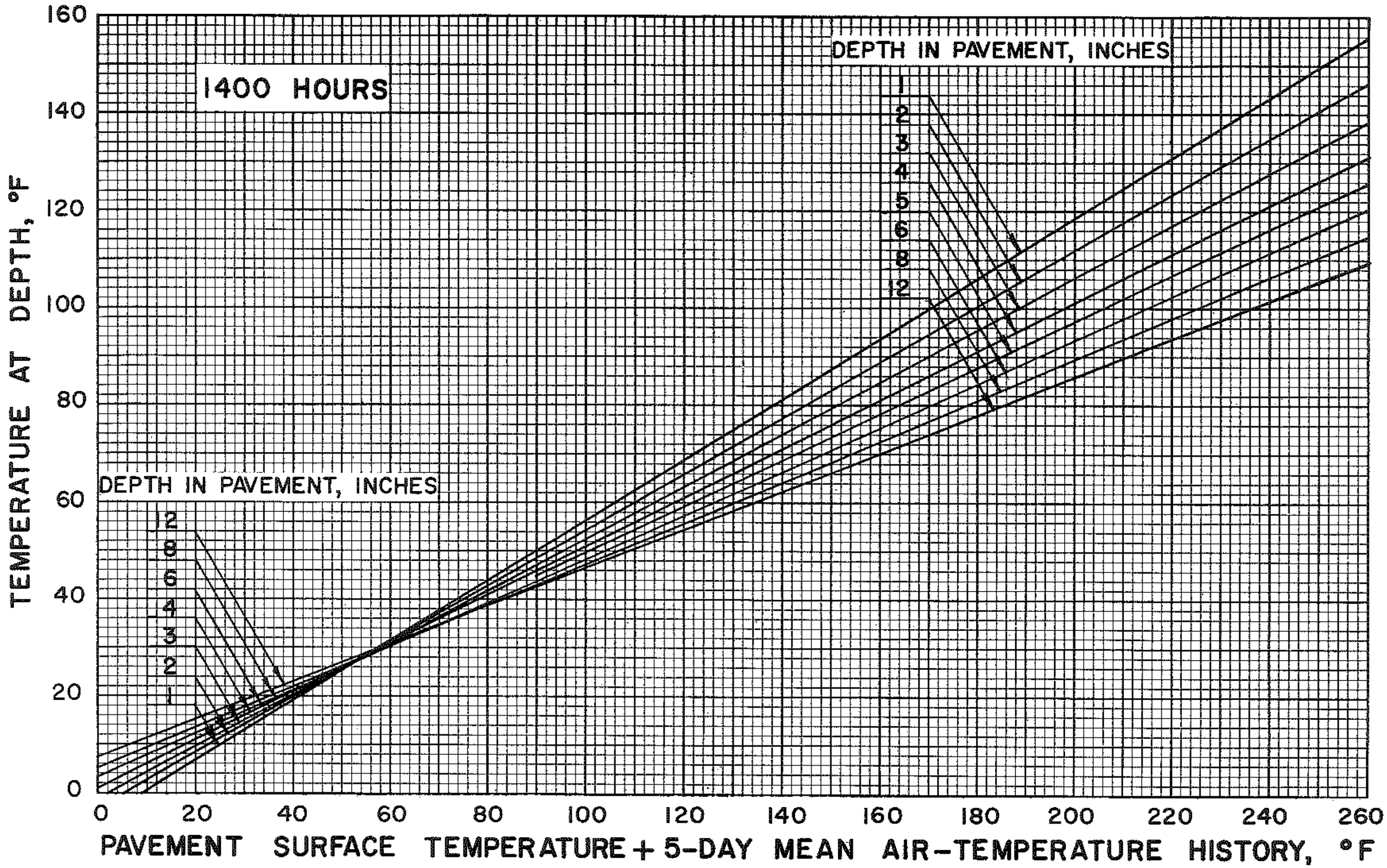

Figure 49: Temperature Prediction Graph for Pavement Greater Than 2 Inches Thick

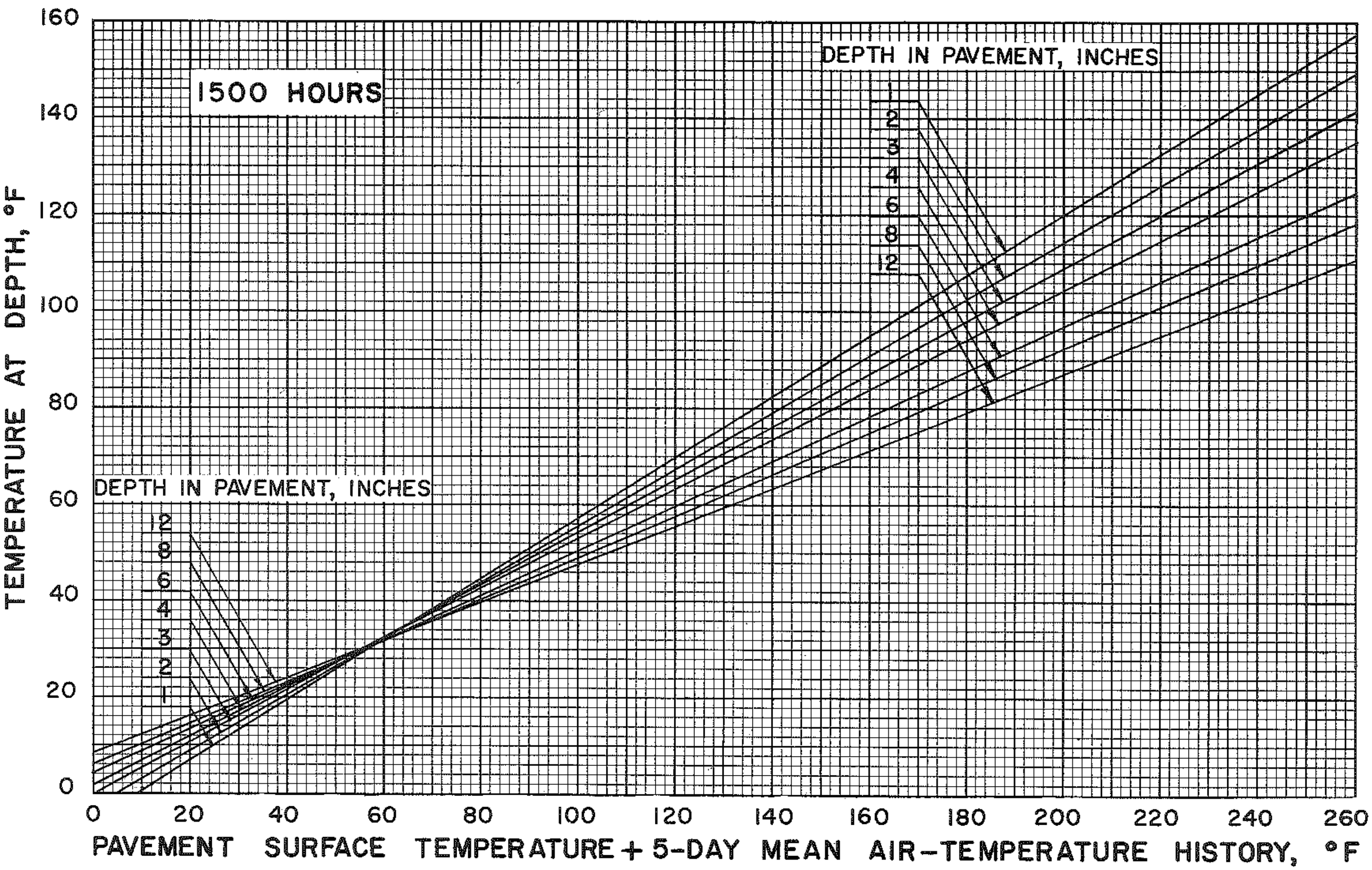

Figure 50: Temperature Prediction Graph for Pavement Greater Than 2 Inches Thick

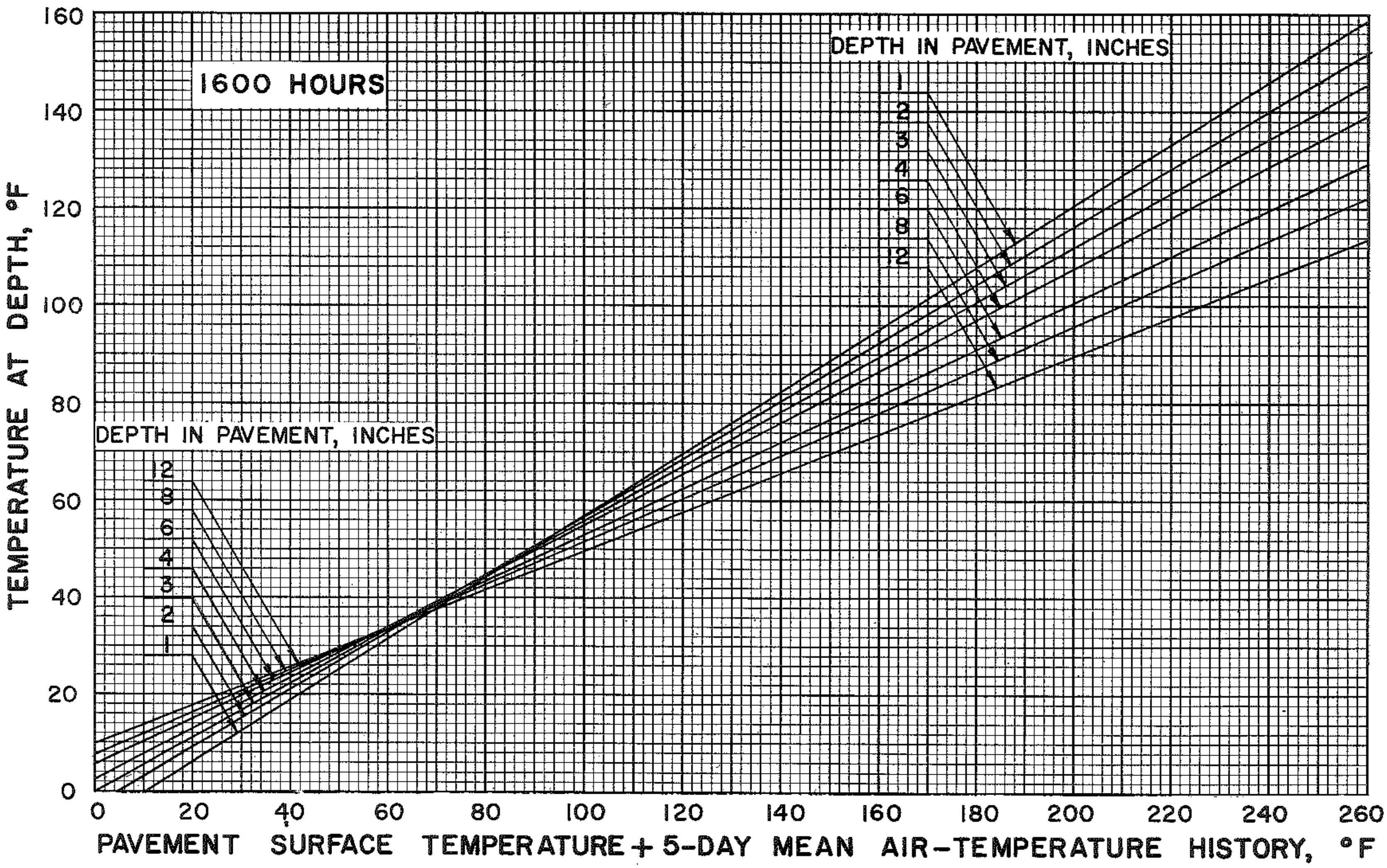

Figure 51: Temperature Prediction Graph for Pavement Greater Than 2 Inches Thick

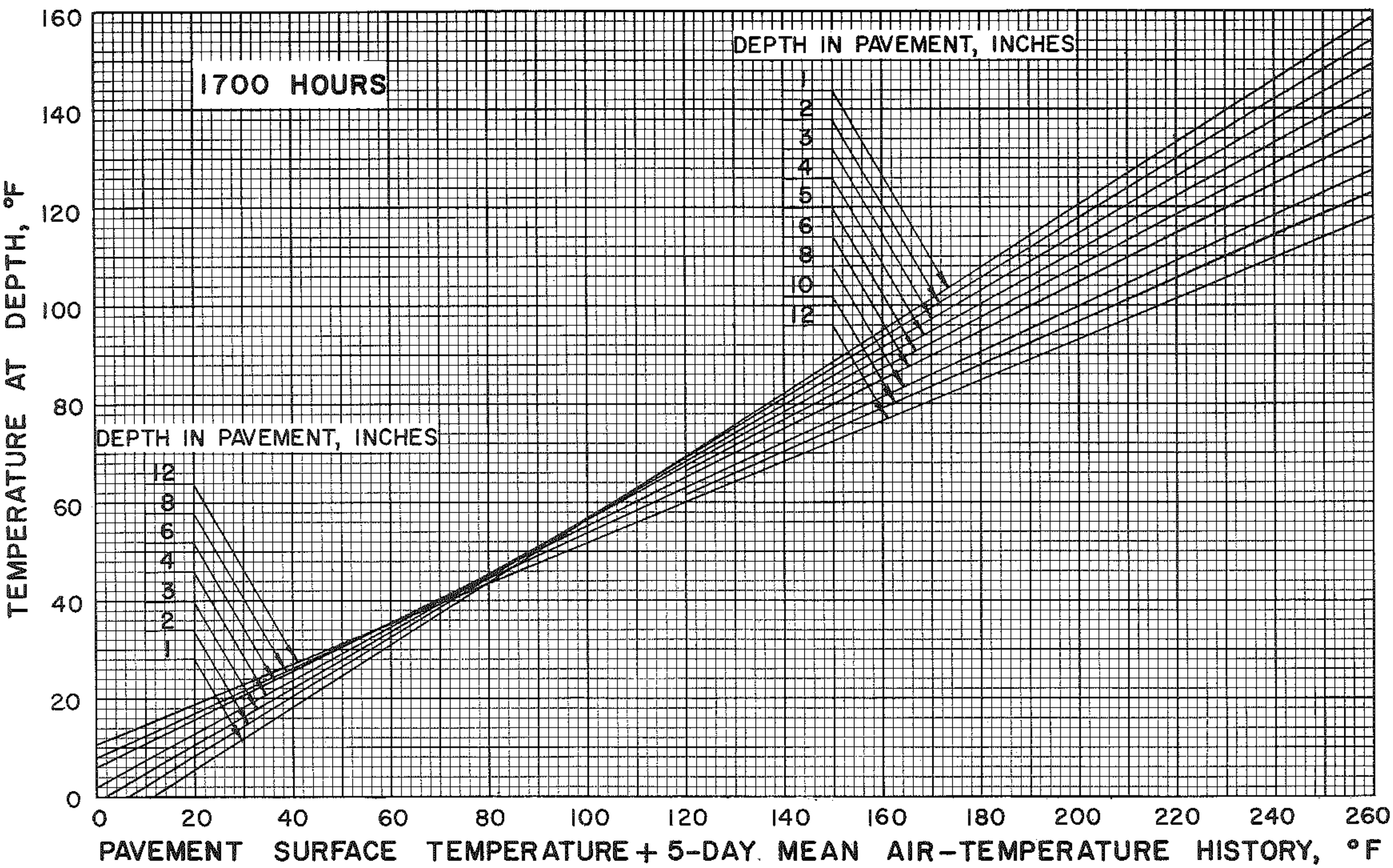

Figure 52: Temperature Prediction Graph for Pavement Greater Than 2 Inches Thick

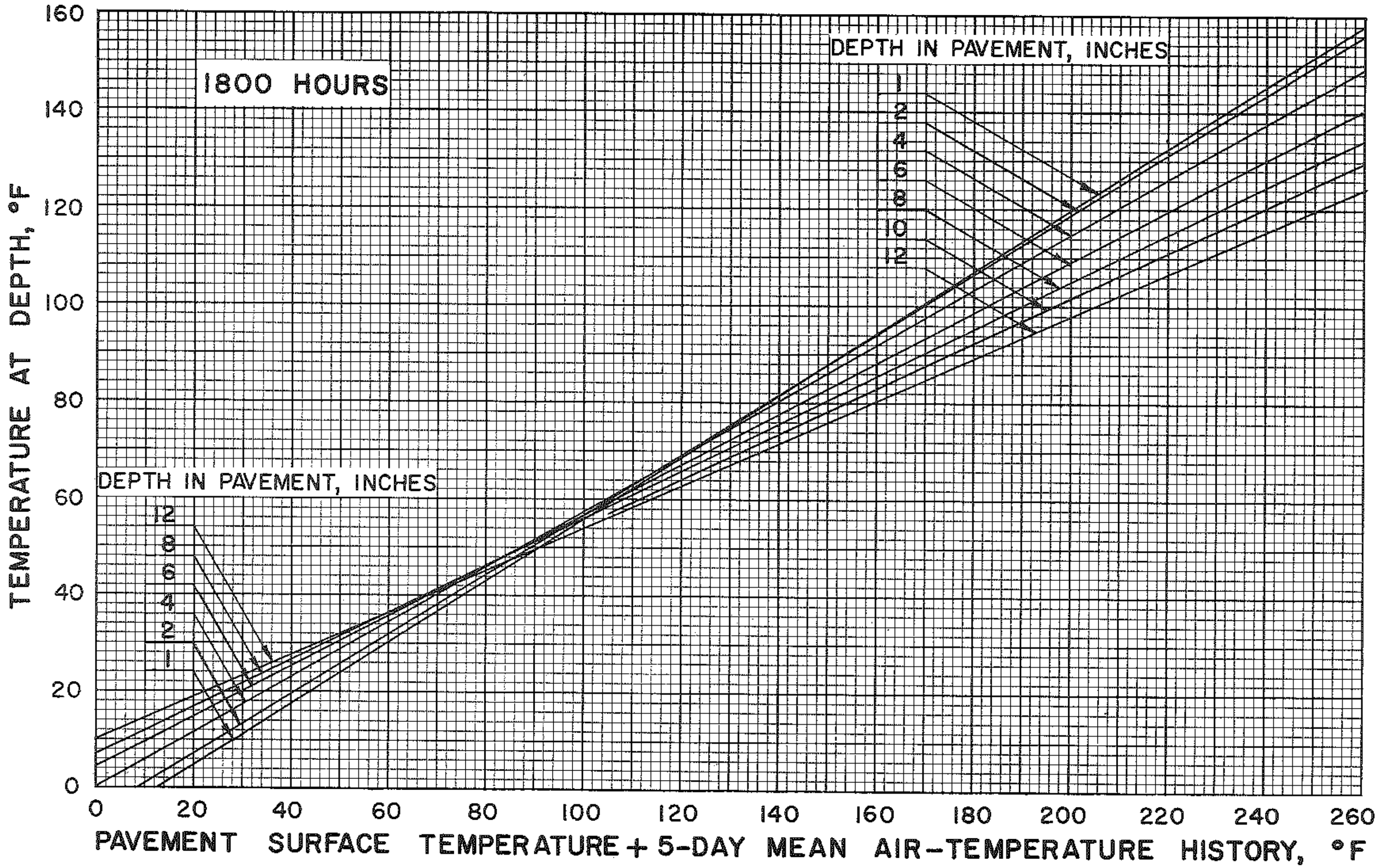

Figure 53: Temperature Prediction Graph for Pavement Greater Than 2 Inches Thick

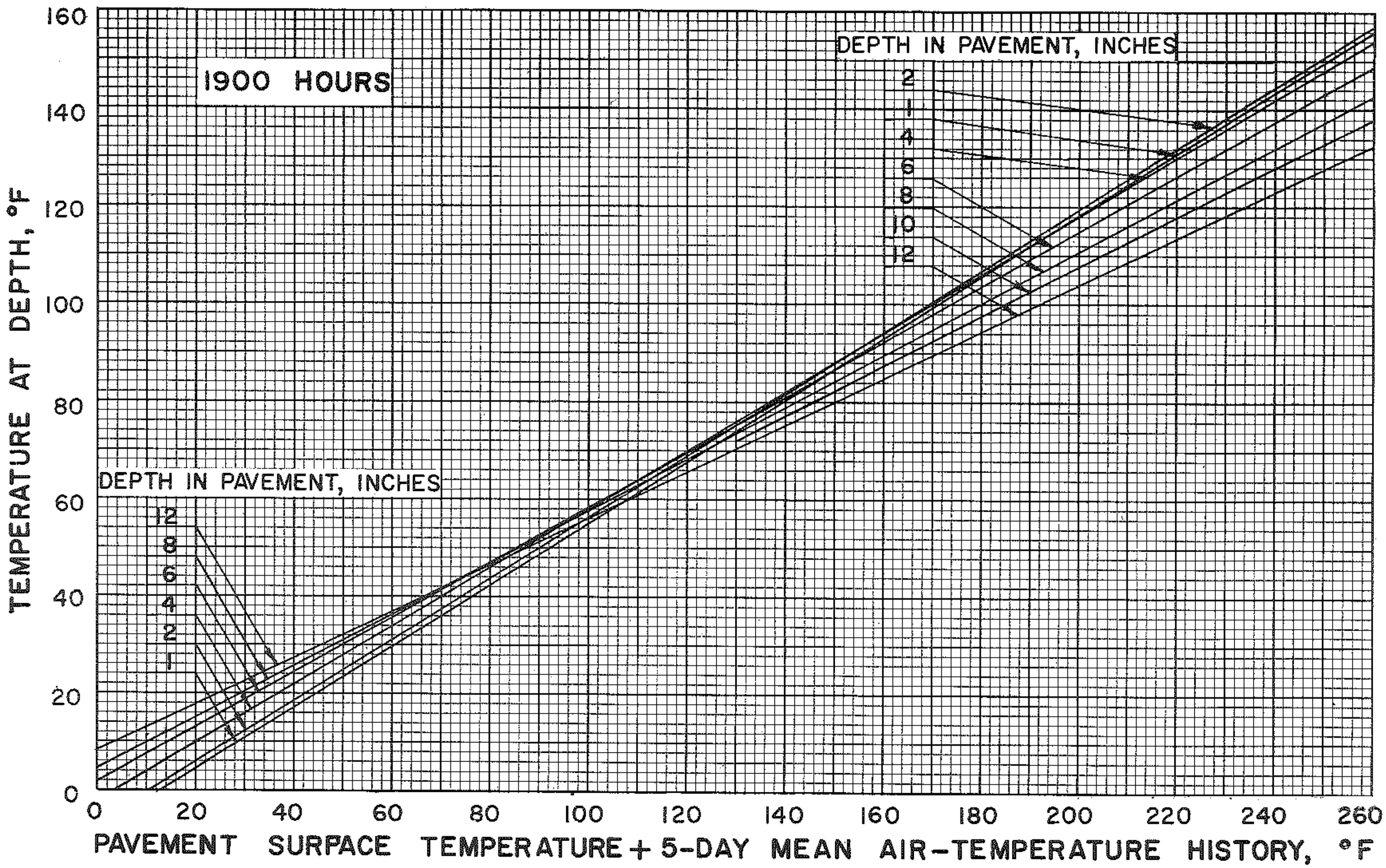

Figure 54: Temperature Prediction Graph for Pavement Greater Than 2 Inches Thick

MASTER CURVE FOR DETERMINING
TEMPERATURE-DEFLECTION ADJUSTMENT FACTORS

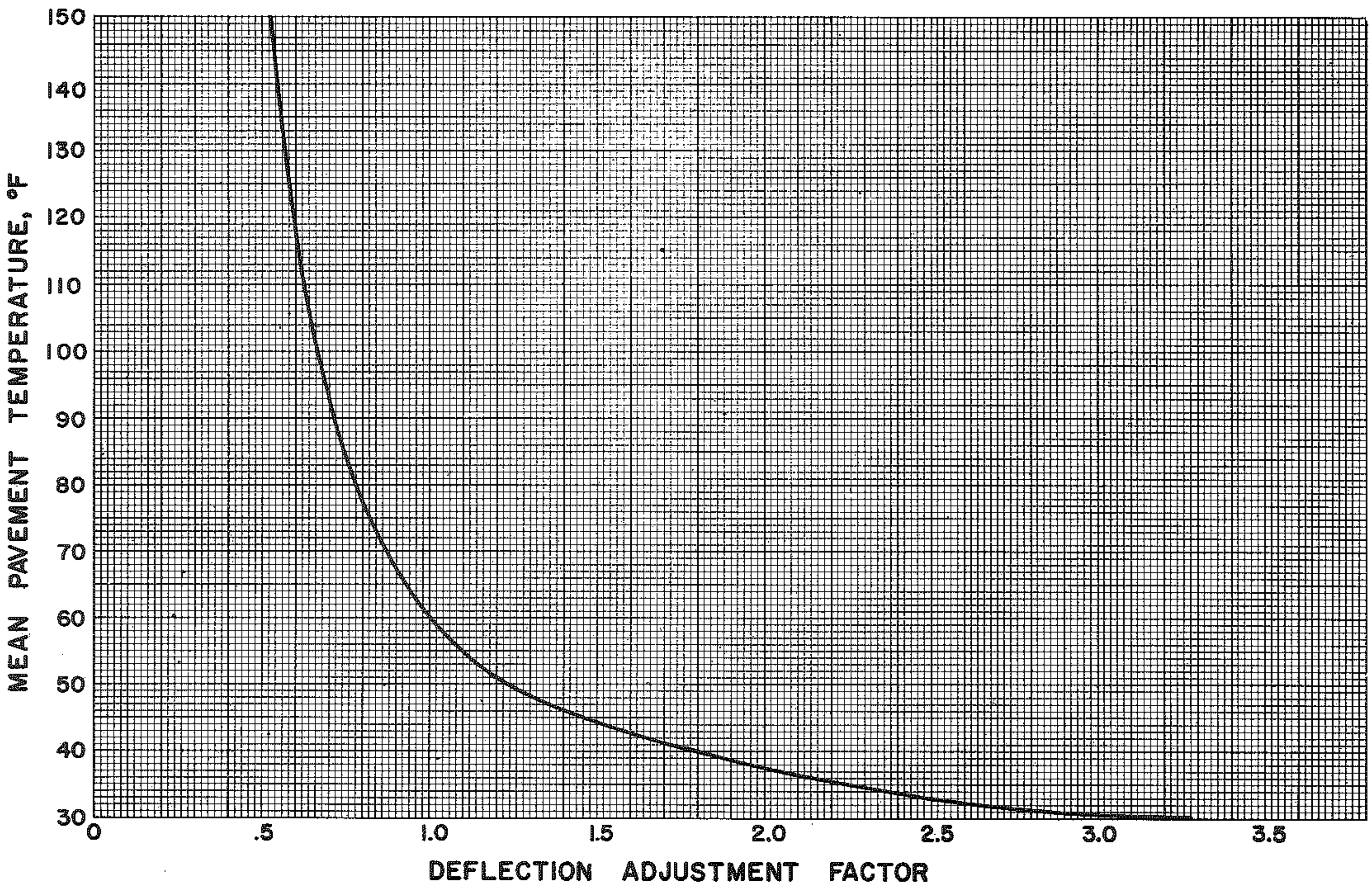

Figure 55: Mean Pavement Temperature vs. Deflection Adjustment Factor

APPENDIX C

PROGRAM TO COMPUTE STRAIGHT LINE RELATIONSHIP BETWEEN ADJUSTED SURFACE TEMPERATURE AND TEMPERATURE AT A GIVEN DEPTH

```
              C      THIS PROGRAM IS BASICALLY DIVIDED INTO TWO DISTINCT SECTIONS. THE
              C         FIRST SECTION FITS A FOURTH DEGREE POLYNOMIAL EQUATION BY
              C         REGRESSION ANALYSIS TO THE TEMPERATURE DISTRIBUTION READINGS AT
              C         THE DEPTHS 0.125, 2.0, 4.0, 6.0, 8.0, 10.0, AND 12.0 INCHES FOR
              C         A GIVEN DAY AND HOUR. THE SUBROUTINE STD4DP COMPUTES THE
              C         STANDARD ERROR OF ESTIMATE FOR THE OBSERVED TEMPERATURES AND
              C         THE POLYNOMIAL EQUATION. THE SUBROUTINE PVTTMP THEN CALCULATES
              C         AND STORES THE TEMPERATURES AT THE DEPTHS 0 THROUGH 12 INCHES
              C         ON 0.5 INCH INCREMENTS FROM THE POLYNOMIAL EQUATION.
              C         THE SECOND SECTION TAKES THESE VALUES AND FITS A STRAIGHT LINE
              C         TO THE ABOVE STORED VALUES FOR ALL DAYS OF DATA AT A GIVEN
              C         DEPTH AND A GIVEN HOUR. THE STANDARD ERROR OF ESTIMATE AND THE
              C         CORRELATION COEFFICIENT ARE COMPUTED FOR THE STRAIGHT LINE
              C         REGRESSION ANALYSIS IN THE SUBROUTINE CRLCOE.
 0001                DIMENSION AIR(400),A(400),B(400),X(400),Y(400),W(400),C(10),X1(25)
                    1,ALPHA(400),BETA(400),S(400),SGMSQ(400),PR(400),PO(400),Y1(25),
                    2X2(25),Y2(25),Y3(320,25),X3(320,25),           Y4(400),D(25),
                    3L(25),STD2(25),AI6(25),E(25),R1(25),AI5(25)
 0002                COMMON AIR,A,B
              C      IN =NUMBER OF DAYS OF MEAN DAILY AIR TEMPERATURES.
              C      N1=THE POWER OF THE EQUATION TO FIT HOURLY LEVEL TEMPERATURES.
              C      N2=THE POWER OF THE EQUATION TO FIT STRAIGHT LINE TO SURFACE
              C         TEMPERATURES AND TEMPERATURE AT A GIVEN DEPTH.
              C      JJ= NUMBER OF DAYS OF AIR TEMPERATURE DATA USED TO CALCULATE AIRIK
              C         )
              C      LL= THE NUMBER OF DAYS OF DATA PRIOR TO THE FIRST DAY OF PAVEMENT
              C         TEMPERATURE DISTRIBUTIONS.
              C      N3= TOTAL NUMBER OF DAYS OF PAVEMENT TEMPERATURE DISTRIBUTIONS
              C         DATA.
 0003                KK=0
 0004                READ(5,2) IN,N1,N2,N3,JJ,LL
 0005              2 FORMAT(6I5)
 0006                READ(5,1)(A(I),I=1,IN)
 0007              1 FORMAT(16 (F3.1,2X))
 0008                IF(LL.EQ.0) GO TO 101
 0009                CALL AIRTMP(IN,JJ,LL)
 0010                GO TO 100
 0011            101 DO 102 J=1,365
 0012            102 AIR(J)=0.
 0013            100 DO 910 KKKK=1,14
 0014                DO 99 K=1,N3
 0015                READ(5,3)IDAY,IHOUR,(Y(MM),MM=1,7)
 0016              3 FORMAT(2X,I3,1X,I2,2X,7F5.0)
 0017                IF(IDAY.LT.431) GO TO 900
 0018                KK=IDAY-430
 0019                GO TO 80
 0020            900 KK=IDAY-65
 0021             80 N=N1
 0022                M=7
              C      M=NUMBER OF LEVEL TEMPERATURES PER HOUR PER DAY TO WHICH CURVE
              C         MUST BE FITTED TO FIND SURFACE TEMPERATURE.
 0023                X(1)=0.12
 0024                W(1)=1.
 0025                DO 10 J=2,7
```

```
0026                W(J)=1.
0027                AJ=J-1
0028             10 X(J)=AJ*2.
0029             14 CONTINUE
0030                CALL FLSQFY(N,M,X,Y,W,C,ALPHA,BETA,S,SGMSQ,PR,PO)
0031                CALL STD4DP(N,C,X,Y,STD,YMAX)
0032                CALL PVTTMP(X2,Y2,C,N,X1,Y1)
0033                IDAY1=IDAY+1000
0034                DO 15 I=1,25
0035                Y3(K,I)=Y2(I)
0036             15 X3(K,I)=C(1)+AIR(KK)
0037             99 CONTINUE
            C       END OF DAILY LEVEL TEMPERATURE COMPUTATIONS.
            C       BEGIN FITTING A STRAIGHT LINE TO EACH DEPTH.
0038                DO 20 I=1,25
0039                II=1
0040                DO 16 K=1,N3
0041                DI=I
0042                AI5(I)=(DI-1.)/2.
0043                X(II)=X3(K,I)
0044                Y(II)=Y3(K,I)
0045                W(II)=1.
0046                II=II+1
0047             16 CONTINUE
0048                M=II-1
0049                N=1
0050                CALL FLSQFY(N,M,X,Y,W,C,ALPHA,BETA,S,SGMSQ,PR,PO)
            C       CRLCOE= CORRELATION COEFFICIENT R.
0051                CALL CRLCOE(R,X,Y,C,Y4, M,STD)
0052                BI=I
0053                AI6(I)=(BI-1.)/2.
0054                D(I)=C(1)
0055                E(I)=C(2)
0056                R1(I)=R
0057                STD2(I)=STD
0058             20 CONTINUE
0059                WRITE(6,85)
0060             85 FORMAT(1H1)
0061                WRITE(6,4)LL
0062              4 FORMAT(22X,95HRELATIONSHIP BETWEEN ADJUSTED SURFACE TEMPERATURE (X
                   1) AND TEMPERATURE AT DEPTH FROM SURFACE (Y),/ ,67X,5HWHERE,/ ,63X,
                   2(2HY = A + B(X),/,49X,I2,37H DAYS OF MEAN AIR TEMPERATURE HISTORY,
                   3/)
0063                WRITE(6,5)
0064              5 FORMAT(11X,4HHOUR,10X,8HPAVEMENT,9X,10HCONSTANT A,10X,13HCOEFFICIE
                   1NT B,10X,11HCORRELATION,10X,17HSTANDARD ESTIMATE,/,27X,5HDEPTH,
                   2 53X,11HCOEFFICIENT,14X,8HOF ERROR,//)
0065                DO 25 J=1,25
0066                WRITE(6,6)IHOUR,AI6(J),D(J),E(J),R1(J),STD2(J)
0067              6 FORMAT(12X,I2,12X,F5.1,6X,F12.6,12X,F10.6,14X,F7.4,12X,E15.7,/)
0068             25 CONTINUE
0069                WRITE(6,87)
0070             87 FORMAT(//////////)
0071                DO 200 J=3,5,2
```



```
0072                WRITE(7,7) IHOUR,AI6(J),D(J),E(J),LL
0073              7 FORMAT(I5,F5.1,2(8X,F12.6),8X,I2)
0074            200 CONTINUE
0075            910 CONTINUE
0076                CALL EXIT
0077                END
```

FORTRAN IV G LEVEL 1, MOD 0 AIRTMP DATE = 68050 19/33/27

```
      SUBROUTINE AIRTMP(IN,JJ,LL)
      DIMENSION B(400),A(400),AIR(400)
      COMMON AIR,A,B
      DO 2 J=1,IN
      B(J)=0.
C     AIR(J)=AVERAGE OF PREVIOUS JJ DAYS OF MEAN DAILY AIR TEMPERATURES.
C        VALUE OF 1.1 WAS ASSIGNED TO THAT DAY AS A DUMMY TRIP VALUE.
C        IF THE MEAN AIR TEMPERATURE FOR A GIVEN DAY WAS MISSING, A
    2 AIR(J)=0.
      AJJ=LL
      IF(AJJ.EQ.0.) GO TO 20
      LLL=31-LL
      DO 10 I=LLL,JJ
   10 B(1)=B(1)+A(I)
      AIR(1)=B(1)/AJJ
   20 J=1
      WRITE(6,3)AIR(1),J,AJJ
      N=365
      I=32
      AD=LL
      DO 11 J=2,N
      DO 12 K=1,LL
      MN=I-K
      IF(A(MN ).EQ.1.1) GO TO 14
      B(J)=B(J)+A(MN )
      GO TO 12
   14 AD=AD-1.
   12 CONTINUE
      IF(B(J).EQ.0..OR.AD.LE.0.) GO TO 15
      AIR(J)=B(J)/AD
      GO TO 16
   15 AIR(J)=0.0
      AD=0.0
   16 WRITE(6,3)AIR(J),J,AD
    3 FORMAT(11X,F7.2,16X,I3,16X,F5.0)
      I=I+1
   11 AD=LL
      RETURN
      END
```

FORTRAN IV G LEVEL 1, MOD 0 PVTTMP DATE = 68050 19/33/27

```
      SUBROUTINE PVTTMP(X2,Y2,C,N,X1,Y1)
      DIMENSION X2(25),Y2(25),C(10),X(25),Y(25),X1(25),Y1(25)
      NN=N+1
      Y2(1)=C(1)
      X1(1)=0.
      DO 1 L=2,25
    1 X1(L)=X1(L-1)+0.5
      DO 3 L=2,25
      Z=0.
      XX1=X1(L)
      CALL FEVREA(C,N,XX1,Z)
    3 Y2(L)=Z
      RETURN
      END
```

```
FORTRAN IV G LEVEL  1, MOD 0              MAIN              DATE = 68050           19/33/27

                C       CRLCOE= CORRELATION COEFFICIENT R.
  0001                  SUBROUTINE CRLCOE(R,X,Y,C,Y4,II,STD)
  0002                  DIMENSION X(400),Y(400),C(10),Y4(400)
                C       Y5= SUM OF THE INDIVIDUAL COMPUTED DEPTH               TEMPERATURES
                C          USED TO BEST FIT A STRAIGHT LINE EQUATION.
  0003                  Y5=0.
  0004                  DO 1 K=1,II
                C       Y4=COMPUTED DEPTH              TEMPERATURE FROM THE STRAIGHT LINE
                C          EQUATION.
  0005                  Y4(K)=C(1)+C(2)*X(K)
  0006                1 Y5=Y5+Y(K)
  0007                  AN=II
  0008                  YA=Y5/AN
  0009                  SUMA=0.
  0010                  SUMB=0.
  0011                  DO 2 K=1,II
  0012                  SUMA=SUMA+(Y(K)-YA)**2
  0013                2 SUMB=SUMB+(Y(K)-Y4(K))**2
                C       STD=STANDARD ESTIMATE OF ERROR.
  0014                  STD=SQRT(    (SUMB/AN))
  0015                  IF(SUMA.EQ.0.) GO TO 4
  0016                  R=SQRT(ABS(1.-SUMB/SUMA))
  0017                  GO TO 3
  0018                4 R=0.
  0019                3 CONTINUE
  0020                  RETURN
  0021                  END
```

```
FORTRAN IV G LEVEL  1, MOD 0              STD4DP            DATE = 68050           19/33/27

  0001                  SUBROUTINE STD4DP(N,C,X,Y,STD,YMAX)
  0002                  DIMENSION C(10),X(7),Y(7),X1(7),Y2(7)
  0003                  SUMA=0.
  0004                  X1(1)=0.12
  0005                  DO 4 K=1,7
  0006                  AK=K-1
  0007                4 X1(K)=AK*2.
  0008                  YMAX=0.
  0009                  DO 2 K=1,7
  0010                  YDIFF=0.
  0011                  Z=0.
  0012                  XX1=X1(K)
  0013                  CALL FEVREA(C,N,XX1,Z)
  0014                  YDIFF=Z-Y(K)
  0015                  IF(ABS(YDIFF).GT.YMAX) YMAX=ABS(YDIFF)
  0016                2 SUMA=SUMA+(YDIFF)**2
  0017                  STD=SQRT(    (SUMA/7.))
  0018                  RETURN
  0019                  END
```

FORTRAN IV G LEVEL 1, MOD 0   FGEFYT   DATE = 68050   19/33/27

```
            SUBROUTINE FGEFYT(N,NO,X,Y,W,BETA,S,SGMSQ,ALPHA,PR,PO,M)          GEFYT002
            DIMENSION X(365),Y(365),BETA(365),ALPHA(365),S(365),SGMSQ(365),
           1PR(365),PO(365),W(365)
      101   FORMAT(32H  THERE IS AN ERROR IN YOUR DATA)                      GEFYT008
            IF(N-NO-M)30,30,20                                                GEFYT010
       20   PRINT 101                                                         GEFYT014
            GOTO 68                                                           GEFYT016
       30   BETA(NO+1)=0.                                                     GEFYT018
            DSQ=0.                                                            GEFYT020
            WPP=0.                                                            GEFYT022
            LXACT=0                                                           GEFYT024
            IF(N-NO-M+1)40,50,50                                              GEFYT026
       50   LXACT=1                                                           GEFYT028
       40   DO 52 J=1,M                                                       GEFYT030
            PR(J)=1.                                                          GEFYT032
            PO(J)=0.                                                          GEFYT034
       51   WPP=WPP+W(J)                                                      GEFYT036
            IF(LXACT)52,53,52                                                 GEFYT038
       53   DSQ=DSQ+W(J)*Y(J)*Y(J)                                            GEFYT040
       52   CONTINUE                                                          GEFYT042
            NON=NO+1                                                          GEFYT044
            NN=N+1                                                            GEFYT046
            DO 54 I=NON,NN                                                    GEFYT048
            LREEDO=M-I+NO                                                     GEFYT050
            WYP=0.                                                            GEFYT052
            WXPP=0.                                                           GEFYT054
            DO 55 J=1,M                                                       GEFYT056
            TEMP=W(J)*PR(J)                                                   GEFYT058
            IF(I-NN)56,57,57                                                  GEFYT060
       56   WXPP=WXPP+TEMP*X(J)*PR(J)                                         GEFYT062
       57   IF(LREEDO)55,59,59                                                GEFYT064
       59   WYP=WYP+TEMP*Y(J)                                                 GEFYT066
       55   CONTINUE                                                          GEFYT068
            IF(LREEDO)60,61,61                                                GEFYT070
       61   S(I)=WYP/WPP                                                      GEFYT072
       60   IF(LXACT)63,64,63                                                 GEFYT074
       64   DSQ=DSQ-S(I)*S(I)*WPP                                             GEFYT076
            BR=LREEDO                                                         GEFYT078
            SGMSQ(I)=DSQ/BR                                                   GEFYT080
            GOTO 73                                                           GEFYT082
       63   SGMSQ(I)=0.                                                       GEFYT084
       73   IF(I-NN)67,54,54                                                  GEFYT086
       67   ALPHA(I)=WXPP/WPP                                                 GEFYT088
            WPPO=WPP                                                          GEFYT090
            WPP=0.                                                            GEFYT092
            DO 69 J=1,M                                                       GEFYT094
            TEMP=(X(J)-ALPHA(I))*PR(J)-BETA(I)*PO(J)                          GEFYT096
            WPP=WPP+W(J)*TEMP**2                                              GEFYT098
            PO(J)=PR(J)                                                       GEFYT100
       69   PR(J)=TEMP                                                        GEFYT102
            BETA(I+1)=WPP/WPPO                                                GEFYT104
       54   CONTINUE                                                          GEFYT106
       68   RETURN                                                            GEFYT108
            END                                                               GEFYT110
```

```
FORTRAN IV G LEVEL  1, MOD 0              FLSQFY              DATE = 68050           19/33/27

                   SUBROUTINE FLSQFY(N,M,X,Y,W,C,ALPHA,BETA,S,SGMSQ,PR,PO)         LSQFY002
                   DIMENSION C( 10),ALPHA(400),BETA(400),S(400),SGMSQ(400),PR(400),
                  1PO(400),X(400),Y(400),W(400)
                   GAMDA=1.                                                         LSQFY006
                   NO=0                                                             LSQFY008
                   CALL FGEFYT(N,NO,X,Y,W,BETA,S,SGMSQ,ALPHA,PR,PO,M)               LSQFY010
                   CALL FCODA(N,C,PO,PR,ALPHA,BETA,GAMDA,S)                         LSQFY012
                   RETURN                                                           LSQFY014
                   END                                                              LSQFY016
```

```
FORTRAN IV G LEVEL  1, MOD 0              FEVREA              DATE = 68050           19/33/27

                   SUBROUTINE FEVREA (A,NA,X,Y)
                   DIMENSION A( 10)
                   Y=A(NA+1)                                                         EVREA006
                   IF(NA)2,3,2                                                       EVREA008
          2        DO 1 I=1,NA                                                       EVREA010
                   J=NA+1-I                                                          EVREA012
                 1 Y=Y*X+A(J)                                                        EVREA014
          3        RETURN                                                            EVREA016
                   END                                                               EVREA018
```

```
FORTRAN IV G LEVEL  1, MOD 0              FCODA               DATE = 68050           19/33/27

                   SUBROUTINE FCODA(N,C,PM,PR,ALPHA,BETA,GAMDA,S)                   CODA 002
                   DIMENSION C(365),ALPHA(365),BETA(365),PM(365),PR(365),S(365)
                   N1=N+1                                                            CODA 006
                   DO 42 IB=1,N1                                                     CODA 008
                   C(IB)=0.                                                          CODA 010
                   PM(IB)=0.                                                         CODA 012
         42        PR(IB)=0.                                                         CODA 014
                   PR(1)=1.                                                          CODA 016
                   C(1)=S(1)                                                         CODA 018
                   DO 50 I=1,N                                                       CODA 020
                   T2=0.                                                             CODA 022
                   N1=I+1                                                            CODA 024
                   DO 50 IB=1,N1                                                     CODA 026
                   T1=(T2-ALPHA(I)*PR(IB)-BETA(I)*PM(IB))/GAMDA                      CODA 028
                   T2=PR(IB)                                                         CODA 030
                   PM(IB)=PR(IB)                                                     CODA 032
                   PR(IB)=T1                                                         CODA 034
         50        C(IB)=C(IB)+T1*S(I+1)                                             CODA 036
                   RETURN                                                            CODA 038
                   END                                                               CODA 040
```

APPENDIX D

RESULTS OF REGRESSION ANALYSIS

RELATIONSHIP BETWEEN ADJUSTED SURFACE TEMPERATURE (X) AND TEMPERATURE AT DEPTH FROM SURFACE (Y)
WHERE
Y = A + B(X)
0 DAYS OF MEAN AIR TEMPERATURE HISTORY

HOUR	PAVEMENT DEPTH	CONSTANT A	COEFFICIENT B	CORRELATION COEFFICIENT	STANDARD ESTIMATE OF ERROR
6	0.0	-0.011902	1.000239	1.0000	0.4036713E-02
6	0.5	0.299728	1.010460	0.9993	0.6461250E 00
6	1.0	0.735046	1.018388	0.9976	0.1190809E 01
6	1.5	1.264969	1.024405	0.9954	0.1656816E 01
6	2.0	1.861633	1.028880	0.9930	0.2062833E 01
6	2.5	2.503021	1.032093	0.9904	0.2423545E 01
6	3.0	3.166290	1.034359	0.9878	0.2749861E 01
6	3.5	3.834045	1.035904	0.9851	0.3049380E 01
6	4.0	4.490311	1.036946	0.9824	0.3327072E 01
6	4.5	5.123108	1.037650	0.9796	0.3585991E 01
6	5.0	5.721649	1.038163	0.9769	0.3827933E 01
6	5.5	6.278976	1.038591	0.9742	0.4054162E 01
6	6.0	6.790482	1.039012	0.9716	0.4265714E 01
6	6.5	7.254837	1.039452	0.9691	0.4463654E 01
6	7.0	7.672287	1.039925	0.9666	0.4649290E 01
6	7.5	8.047791	1.040382	0.9642	0.4823982E 01
6	8.0	8.387711	1.040759	0.9619	0.4989021E 01
6	8.5	8.700256	1.040974	0.9596	0.5145381E 01
6	9.0	8.998627	1.040873	0.9574	0.5293443E 01
6	9.5	9.297775	1.040279	0.9552	0.5432923E 01
6	10.0	9.615189	1.038996	0.9531	0.5562811E 01
6	10.5	9.970596	1.036793	0.9510	0.5681762E 01
6	11.0	10.388870	1.033362	0.9490	0.5788875E 01
6	11.5	10.893539	1.028441	0.9469	0.5885064E 01
6	12.0	11.516174	1.021631	0.9448	0.5975228E 01

RELATIONSHIP BETWEEN ADJUSTED SURFACE TEMPERATURE (X) AND TEMPERATURE AT DEPTH FROM SURFACE (Y)
WHERE
Y = A + B(X)
0 DAYS OF MEAN AIR TEMPERATURE HISTORY

HOUR	PAVEMENT DEPTH	CONSTANT A	COEFFICIENT B	CORRELATION COEFFICIENT	STANDARD ESTIMATE OF ERROR
7	0.0	-0.011841	1.000235	1.0000	0.4062410E-02
7	0.5	0.456421	1.000667	0.9994	0.6152911E 00
7	1.0	1.004562	1.000980	0.9979	0.1119836E 01
7	1.5	1.610321	1.001248	0.9961	0.1541448E 01
7	2.0	2.255463	1.001486	0.9940	0.1903241E 01
7	2.5	2.921967	1.001740	0.9919	0.2223343E 01
7	3.0	3.593582	1.002059	0.9897	0.2514888E 01
7	3.5	4.258316	1.002434	0.9874	0.2786448E 01
7	4.0	4.904312	1.002891	0.9850	0.3042866E 01
7	4.5	5.524307	1.003402	0.9826	0.3286288E 01
7	5.0	6.108673	1.003997	0.9801	0.3517220E 01
7	5.5	6.655045	1.004627	0.9777	0.3735383E 01
7	6.0	7.160461	1.005273	0.9753	0.3940528E 01
7	6.5	7.624527	1.005888	0.9730	0.4132665E 01
7	7.0	8.048523	1.006441	0.9707	0.4312427E 01
7	7.5	8.437149	1.006857	0.9685	0.4480892E 01
7	8.0	8.796600	1.007068	0.9664	0.4639470E 01
7	8.5	9.134491	1.007005	0.9643	0.4789629E 01
7	9.0	9.461365	1.006583	0.9622	0.4932529E 01
7	9.5	9.789536	1.005710	0.9601	0.5068863E 01
7	10.0	10.134796	1.004261	0.9581	0.5198915E 01
7	10.5	10.512634	1.002142	0.9560	0.5322863E 01
7	11.0	10.942444	0.999227	0.9539	0.5441830E 01
7	11.5	11.445801	0.995370	0.9517	0.5559520E 01
7	12.0	12.045334	0.990439	0.9492	0.5684770E 01

RELATIONSHIP BETWEEN ADJUSTED SURFACE TEMPERATURE (X) AND TEMPERATURE AT DEPTH FROM SURFACE (Y)
WHERE
Y = A + B(X)
0 DAYS OF MEAN AIR TEMPERATURE HISTORY

HOUR	PAVEMENT DEPTH	CONSTANT A	COEFFICIENT B	CORRELATION COEFFICIENT	STANDARD ESTIMATE OF ERROR
8	0.0	-0.011887	1.000221	1.0000	0.4124403E-02
8	0.5	0.564606	0.983981	0.9990	0.8010700E 00
8	1.0	1.196304	0.970415	0.9969	0.1433635E 01
8	1.5	1.864868	0.959245	0.9942	0.1932388E 01
8	2.0	2.553802	0.950216	0.9915	0.2328148E 01
8	2.5	3.248962	0.943070	0.9888	0.2647514E 01
8	3.0	3.937897	0.937564	0.9864	0.2912441E 01
8	3.5	4.609512	0.933477	0.9841	0.3140021E 01
8	4.0	5.255554	0.930584	0.9819	0.3342618E 01
8	4.5	5.869308	0.928688	0.9798	0.3528356E 01
8	5.0	6.445297	0.927582	0.9778	0.3701910E 01
8	5.5	6.981064	0.927091	0.9759	0.3865608E 01
8	6.0	7.475250	0.927046	0.9740	0.4020250E 01
8	6.5	7.928558	0.927288	0.9721	0.4166066E 01
8	7.0	8.343857	0.927664	0.9704	0.4303287E 01
8	7.5	8.725418	0.928047	0.9687	0.4432448E 01
8	8.0	9.079941	0.928302	0.9670	0.4554496E 01
8	8.5	9.415497	0.928326	0.9654	0.4670608E 01
8	9.0	9.742569	0.928013	0.9638	0.4782004E 01
8	9.5	10.073578	0.927272	0.9622	0.4889763E 01
8	10.0	10.421768	0.926037	0.9606	0.4994752E 01
8	10.5	10.804001	0.924225	0.9589	0.5097993E 01
8	11.0	11.237717	0.921791	0.9571	0.5201640E 01
8	11.5	11.742371	0.918693	0.9551	0.5310723E 01
8	12.0	12.339767	0.914902	0.9527	0.5435890E 01

RELATIONSHIP BETWEEN ADJUSTED SURFACE TEMPERATURE (X) AND TEMPERATURE AT DEPTH FROM SURFACE (Y)
WHERE
Y = A + B(X)
0 DAYS OF MEAN AIR TEMPERATURE HISTORY

HOUR	PAVEMENT DEPTH	CONSTANT A	COEFFICIENT B	CORRELATION COEFFICIENT	STANDARD ESTIMATE OF ERROR
9	0.0	-0.013382	1.000224	1.0000	0.4534077E-02
9	0.5	0.748245	0.966241	0.9983	0.1139583E 01
9	1.0	1.485840	0.937842	0.9943	0.2038864E 01
9	1.5	2.195969	0.914401	0.9892	0.2743731E 01
9	2.0	2.875671	0.895335	0.9838	0.3294833E 01
9	2.5	3.521561	0.880101	0.9788	0.3727174E 01
9	3.0	4.134186	0.868149	0.9742	0.4069836E 01
9	3.5	4.710831	0.859019	0.9701	0.4345906E 01
9	4.0	5.251999	0.852248	0.9666	0.4572741E 01
9	4.5	5.758560	0.847413	0.9635	0.4762634E 01
9	5.0	6.231079	0.844134	0.9608	0.4923800E 01
9	5.5	6.672119	0.842055	0.9586	0.5061511E 01
9	6.0	7.083954	0.840861	0.9566	0.5179318E 01
9	6.5	7.470459	0.840263	0.9550	0.5279988E 01
9	7.0	7.836075	0.840004	0.9536	0.5366324E 01
9	7.5	8.184982	0.839875	0.9523	0.5441461E 01
9	8.0	8.523102	0.839689	0.9512	0.5508918E 01
9	8.5	8.856201	0.839299	0.9501	0.5572223E 01
9	9.0	9.191559	0.838585	0.9490	0.5634415E 01
9	9.5	9.537674	0.837454	0.9478	0.5697479E 01
9	10.0	9.902008	0.835871	0.9465	0.5762221F 01
9	10.5	10.293884	0.833817	0.9451	0.5828607E 01
9	11.0	10.723419	0.831304	0.9436	0.5897332E 01
9	11.5	11.200943	0.828392	0.9419	0.5972940E 01
9	12.0	11.737778	0.825158	0.9398	0.6068705E 01

RELATIONSHIP BETWEEN ADJUSTED SURFACE TEMPERATURE (X) AND TEMPERATURE AT DEPTH FROM SURFACE (Y)
WHERE
Y = A + B(X)
0 DAYS OF MEAN AIR TEMPERATURE HISTORY

HOUR	PAVEMENT DEPTH	CONSTANT A	COEFFICIENT B	CORRELATION COEFFICIENT	STANDARD ESTIMATE OF ERROR
10	0.0	-0.015564	1.000232	1.0000	0.5015224E-02
10	0.5	0.674011	0.958646	0.9980	0.1311110E 01
10	1.0	1.346024	0.922560	0.9929	0.2394931E 01
10	1.5	1.997406	0.891461	0.9858	0.3289604E 01
10	2.0	2.625580	0.864867	0.9776	0.4028322E 01
10	2.5	3.229370	0.842297	0.9691	0.4639377E 01
10	3.0	3.807190	0.823323	0.9607	0.5146211E 01
10	3.5	4.357315	0.807535	0.9528	0.5567758E 01
10	4.0	4.880341	0.794525	0.9455	0.5918853E 01
10	4.5	5.376205	0.783931	0.9390	0.6211027E 01
10	5.0	5.845444	0.775408	0.9333	0.6453172E 01
10	5.5	6.289124	0.768635	0.9285	0.6652283E 01
10	6.0	6.708939	0.763316	0.9244	0.6814237E 01
10	6.5	7.107468	0.759175	0.9211	0.6944298E 01
10	7.0	7.486664	0.755970	0.9184	0.7047559E 01
10	7.5	7.850266	0.753469	0.9162	0.7129091E 01
10	8.0	8.201599	0.751476	0.9145	0.7193909E 01
10	8.5	8.544556	0.749817	0.9130	0.7246802E 01
10	9.0	8.884033	0.748336	0.9118	0.7291821E 01
10	9.5	9.225052	0.746908	0.9106	0.7332106E 01
10	10.0	9.573456	0.745427	0.9095	0.7369586E 01
10	10.5	9.934860	0.743817	0.9084	0.7405265E 01
10	11.0	10.316147	0.742020	0.9073	0.7440176E 01
10	11.5	10.725159	0.739993	0.9060	0.7477398E 01
10	12.0	11.168793	0.737739	0.9045	0.7525390E 01

RELATIONSHIP BETWEEN ADJUSTED SURFACE TEMPERATURE (X) AND TEMPERATURE AT DEPTH FROM SURFACE (Y)
WHERE
Y = A + B(X)
0 DAYS OF MEAN AIR TEMPERATURE HISTORY

HOUR	PAVEMENT DEPTH	CONSTANT A	COEFFICIENT B	CORRELATION COEFFICIENT	STANDARD ESTIMATE OF ERROR
11	0.0	-0.016571	1.000224	1.0000	0.5426466E-02
11	0.5	1.109787	0.950237	0.9982	0.1383908E 01
11	1.0	2.174911	0.905532	0.9934	0.2521664E 01
11	1.5	3.176620	0.865770	0.9866	0.3460670E 01
11	2.0	4.113632	0.830617	0.9785	0.4241320E 01
11	2.5	4.985901	0.799744	0.9695	0.4896993E 01
11	3.0	5.793396	0.772824	0.9600	0.5454000E 01
11	3.5	6.536896	0.749547	0.9505	0.5932200E 01
11	4.0	7.216552	0.729602	0.9411	0.6345808E 01
11	4.5	7.840744	0.712674	0.9321	0.6704612E 01
11	5.0	8.405746	0.698478	0.9237	0.7015231E 01
11	5.5	8.918106	0.686713	0.9160	0.7282312E 01
11	6.0	9.382263	0.677094	0.9091	0.7509620E 01
11	6.5	9.802368	0.669349	0.9032	0.7700834E 01
11	7.0	10.185974	0.663188	0.8981	0.7860060E 01
11	7.5	10.538086	0.658358	0.8939	0.7991934E 01
11	8.0	10.866943	0.654587	0.8904	0.8101452E 01
11	8.5	11.179581	0.651629	0.8874	0.8193477E 01
11	9.0	11.485809	0.649222	0.8849	0.8272143E 01
11	9.5	11.794128	0.647133	0.8827	0.8340205E 01
11	10.0	12.115250	0.645117	0.8807	0.8398693E 01
11	10.5	12.459259	0.642946	0.8789	0.8447285E 01
11	11.0	12.837921	0.640397	0.8772	0.8485527E 01
11	11.5	13.263474	0.637246	0.8755	0.8515691E 01
11	12.0	13.748703	0.633281	0.8734	0.8547700E 01

RELATIONSHIP BETWEEN ADJUSTED SURFACE TEMPERATURE (X) AND TEMPERATURE AT DEPTH FROM SURFACE (Y)
WHERE
Y = A + B(X)
0 DAYS OF MEAN AIR TEMPERATURE HISTORY

HOUR	PAVEMENT DEPTH	CONSTANT A	COEFFICIENT B	CORRELATION COEFFICIENT	STANDARD ESTIMATE OF ERROR
12	0.0	-0.014664	1.000183	1.0000	0.4851069E-02
12	0.5	1.491135	0.946508	0.9989	0.1197802E 01
12	1.0	2.864532	0.897852	0.9956	0.2226422E 01
12	1.5	4.112045	0.853961	0.9906	0.3119107E 01
12	2.0	5.242920	0.814563	0.9840	0.3902597E 01
12	2.5	6.264648	0.779401	0.9761	0.4597485E 01
12	3.0	7.185898	0.748200	0.9670	0.5218735E 01
12	3.5	8.014999	0.720700	0.9571	0.5776584E 01
12	4.0	8.759384	0.696634	0.9467	0.6277527E 01
12	4.5	9.427719	0.675736	0.9361	0.6725497E 01
12	5.0	10.027420	0.657747	0.9256	0.7122817E 01
12	5.5	10.566757	0.642394	0.9156	0.7471187E 01
12	6.0	11.053802	0.629417	0.9063	0.7772289E 01
12	6.5	11.496704	0.618545	0.8980	0.8028378E 01
12	7.0	11.902664	0.609519	0.8906	0.8242517E 01
12	7.5	12.279388	0.602076	0.8843	0.8418692E 01
12	8.0	12.635208	0.595945	0.8790	0.8561730E 01
12	8.5	12.977631	0.590862	0.8746	0.8677010E 01
12	9.0	13.314362	0.586565	0.8708	0.8770183E 01
12	9.5	13.652924	0.582789	0.8676	0.8846880E 01
12	10.0	14.000641	0.579270	0.8647	0.8912580E 01
12	10.5	14.365509	0.575743	0.8619	0.8972879E 01
12	11.0	14.755219	0.571939	0.8589	0.9034317E 01
12	11.5	15.176758	0.567597	0.8553	0.9106239E 01
12	12.0	15.637741	0.562455	0.8507	0.9203676E 01

RELATIONSHIP BETWEEN ADJUSTED SURFACE TEMPERATURE (X) AND TEMPERATURE AT DEPTH FROM SURFACE (Y)
WHERE
Y = A + B(X)
0 DAYS OF MEAN AIR TEMPERATURE HISTORY

HOUR	PAVEMENT DEPTH	CONSTANT A	COEFFICIENT B	CORRELATION COEFFICIENT	STANDARD ESTIMATE OF ERROR
13	0.0	-0.015259	1.000183	1.0000	0.5146112E-02
13	0.5	1.668854	0.949085	0.9990	0.1194411E 01
13	1.0	3.189590	0.902025	0.9963	0.2188390E 01
13	1.5	4.560471	0.858854	0.9922	0.3030125E 01
13	2.0	5.795715	0.819409	0.9869	0.3758878E 01
13	2.5	6.907974	0.783524	0.9806	0.4404650E 01
13	3.0	7.909653	0.751031	0.9732	0.4988477E 01
13	3.5	8.812286	0.721757	0.9649	0.5523468E 01
13	4.0	9.626953	0.695522	0.9557	0.6016340E 01
13	4.5	10.363739	0.672147	0.9460	0.6469306E 01
13	5.0	11.032516	0.651444	0.9360	0.6881935E 01
13	5.5	11.642014	0.633222	0.9260	0.7252713E 01
13	6.0	12.200668	0.617284	0.9163	0.7580311E 01
13	6.5	12.715744	0.603435	0.9072	0.7864460E 01
13	7.0	13.194611	0.591466	0.8988	0.8106380E 01
13	7.5	13.643143	0.581172	0.8913	0.8309016E 01
13	8.0	14.067261	0.572340	0.8846	0.8476866E 01
13	8.5	14.471481	0.564753	0.8788	0.8615641E 01
13	9.0	14.860519	0.558187	0.8737	0.8731727E 01
13	9.5	15.237717	0.552420	0.8691	0.8831760E 01
13	10.0	15.605988	0.547217	0.8649	0.8922283E 01
13	10.5	15.967804	0.542346	0.8608	0.9010008E 01
13	11.0	16.324234	0.537572	0.8565	0.9102934E 01
13	11.5	16.676437	0.532648	0.8516	0.9212648E 01
13	12.0	17.024750	0.527328	0.8455	0.9358283E 01

RELATIONSHIP BETWEEN ADJUSTED SURFACE TEMPERATURE (X) AND TEMPERATURE AT DEPTH FROM SURFACE (Y)
WHERE
Y = A + B(X)
0 DAYS OF MEAN AIR TEMPERATURE HISTORY

HOUR	PAVEMENT DEPTH	CONSTANT A	COEFFICIENT B	CORRELATION COEFFICIENT	STANDARD ESTIMATE OF ERROR
14	0.0	-0.014908	1.000176	1.0000	0.5110677E-02
14	0.5	1.617874	0.956355	0.9992	0.1138283E 01
14	1.0	3.138977	0.914522	0.9969	0.2075321E 01
14	1.5	4.551071	0.874835	0.9937	0.2858620E 01
14	2.0	5.857529	0.837417	0.9896	0.3528015E 01
14	2.5	7.061722	0.802366	0.9847	0.4114994E 01
14	3.0	8.167587	0.769754	0.9790	0.4642776E 01
14	3.5	9.178955	0.739626	0.9725	0.5126711E 01
14	4.0	10.101028	0.711994	0.9653	0.5575705E 01
14	4.5	10.937729	0.686859	0.9575	0.5993602E 01
14	5.0	11.695068	0.664175	0.9491	0.6381099E 01
14	5.5	12.377975	0.643888	0.9405	0.6737181E 01
14	6.0	12.992279	0.625904	0.9318	0.7060488E 01
14	6.5	13.544128	0.610111	0.9233	0.7350170E 01
14	7.0	14.040009	0.596363	0.9152	0.7606460E 01
14	7.5	14.486603	0.584493	0.9076	0.7830876E 01
14	8.0	14.890869	0.574304	0.9006	0.8026187E 01
14	8.5	15.260376	0.565576	0.8943	0.8196140E 01
14	9.0	15.602524	0.558059	0.8885	0.8345046E 01
14	9.5	15.925873	0.551473	0.8833	0.8477473E 01
14	10.0	16.238449	0.545519	0.8783	0.8598064E 01
14	10.5	16.549011	0.539867	0.8735	0.8711887E 01
14	11.0	16.866119	0.534164	0.8686	0.8825481E 01
14	11.5	17.199844	0.528022	0.8631	0.8949044E 01
14	12.0	17.559448	0.521035	0.8563	0.9099929E 01

RELATIONSHIP BETWEEN ADJUSTED SURFACE TEMPERATURE (X) AND TEMPERATURE AT DEPTH FROM SURFACE (Y)
WHERE
Y = A + B(X)
0 DAYS OF MEAN AIR TEMPERATURE HISTORY

HOUR	PAVEMENT DEPTH	CONSTANT A	COEFFICIENT B	CORRELATION COEFFICIENT	STANDARD ESTIMATE OF ERROR
15	0.0	-0.014053	1.000169	1.0000	0.4955061E-02
15	0.5	1.737030	0.961899	0.9992	0.1122724E 01
15	1.0	3.370468	0.924627	0.9972	0.2029569E 01
15	1.5	4.887344	0.888615	0.9944	0.2768792E 01
15	2.0	6.288925	0.854098	0.9910	0.3382064E 01
15	2.5	7.576492	0.821281	0.9871	0.3903713E 01
15	3.0	8.753250	0.790319	0.9828	0.4360382E 01
15	3.5	9.822113	0.761348	0.9780	0.4771199E 01
15	4.0	10.787796	0.734453	0.9726	0.5148497E 01
15	4.5	11.654831	0.709699	0.9669	0.5499128E 01
15	5.0	12.429092	0.687102	0.9607	0.5826069E 01
15	5.5	13.116547	0.666659	0.9543	0.6129893E 01
15	6.0	13.724213	0.648319	0.9477	0.6410264E 01
15	6.5	14.259720	0.632004	0.9411	0.6666849E 01
15	7.0	14.731674	0.617595	0.9346	0.6900050E 01
15	7.5	15.149399	0.604943	0.9283	0.7111196E 01
15	8.0	15.522263	0.593862	0.9223	0.7302621E 01
15	8.5	15.861221	0.584131	0.9166	0.7477263E 01
15	9.0	16.177567	0.575491	0.9112	0.7638354E 01
15	9.5	16.483414	0.567655	0.9059	0.7789052E 01
15	10.0	16.791107	0.560299	0.9007	0.7932277E 01
15	10.5	17.114471	0.553060	0.8954	0.8071111E 01
15	11.0	17.467575	0.545543	0.8898	0.8209988E 01
15	11.5	17.865250	0.537318	0.8836	0.8356962E 01
15	12.0	18.323318	0.527919	0.8761	0.8527387E 01

RELATIONSHIP BETWEEN ADJUSTED SURFACE TEMPERATURE (X) AND TEMPERATURE AT DEPTH FROM SURFACE (Y)
WHERE
Y = A + B(X)
0 DAYS OF MEAN AIR TEMPERATURE HISTORY

HOUR	PAVEMENT DEPTH	CONSTANT A	COEFFICIENT B	CORRELATION COEFFICIENT	STANDARD ESTIMATE OF ERROR
16	0.0	-0.012772	1.000160	1.0000	0.4731920E-02
16	0.5	1.928452	0.967963	0.9993	0.1058209E 01
16	1.0	3.747055	0.935767	0.9977	0.1886806E 01
16	1.5	5.440445	0.903940	0.9955	0.2535632E 01
16	2.0	7.007767	0.872809	0.9931	0.3049247E 01
16	2.5	8.448746	0.842663	0.9904	0.3466099E 01
16	3.0	9.765259	0.813740	0.9876	0.3817651E 01
16	3.5	10.958252	0.786263	0.9846	0.4127937E 01
16	4.0	12.032135	0.760380	0.9812	0.4413618E 01
16	4.5	12.989899	0.736237	0.9776	0.4684782E 01
16	5.0	13.837631	0.713907	0.9736	0.4946310E 01
16	5.5	14.580887	0.693450	0.9692	0.5199530E 01
16	6.0	15.227524	0.674865	0.9646	0.5443817E 01
16	6.5	15.785599	0.658126	0.9599	0.5677920E 01
16	7.0	16.264511	0.643160	0.9550	0.5900814E 01
16	7.5	16.674500	0.629858	0.9500	0.6112176E 01
16	8.0	17.027283	0.618066	0.9451	0.6312368E 01
16	8.5	17.335022	0.607598	0.9402	0.6502241E 01
16	9.0	17.611618	0.598220	0.9353	0.6682726E 01
16	9.5	17.871140	0.589665	0.9305	0.6854506E 01
16	10.0	18.129486	0.581621	0.9257	0.7017861E 01
16	10.5	18.403244	0.573740	0.9209	0.7173172E 01
16	11.0	18.710114	0.565632	0.9158	0.7322024E 01
16	11.5	19.068527	0.556870	0.9105	0.7469679E 01
16	12.0	19.498413	0.546986	0.9042	0.7628847E 01

RELATIONSHIP BETWEEN ADJUSTED SURFACE TEMPERATURE (X) AND TEMPERATURE AT DEPTH FROM SURFACE (Y)
WHERE
Y = A + B(X)
0 DAYS OF MEAN AIR TEMPERATURE HISTORY

HOUR	PAVEMENT DEPTH	CONSTANT A	COEFFICIENT B	CORRELATION COEFFICIENT	STANDARD ESTIMATE OF ERROR
17	0.0	-0.011551	1.000154	1.0000	0.4398331E-02
17	0.5	1.559372	0.980666	0.9994	0.9498014E 00
17	1.0	3.136368	0.958719	0.9981	0.1693221E 01
17	1.5	4.695816	0.934999	0.9964	0.2275101E 01
17	2.0	6.216492	0.910129	0.9945	0.2735132E 01
17	2.5	7.679459	0.884677	0.9925	0.3107275E 01
17	3.0	9.069168	0.859140	0.9904	0.3419053E 01
17	3.5	10.372910	0.833960	0.9881	0.3691270E 01
17	4.0	11.580246	0.809509	0.9857	0.3938279E 01
17	4.5	12.683807	0.786101	0.9831	0.4168770E 01
17	5.0	13.678299	0.763996	0.9802	0.4387184E 01
17	5.5	14.562408	0.743375	0.9772	0.4595048E 01
17	6.0	15.336319	0.724370	0.9740	0.4792540E 01
17	6.5	16.003983	0.707042	0.9707	0.4979486E 01
17	7.0	16.571365	0.691400	0.9673	0.5156184E 01
17	7.5	17.047195	0.677382	0.9639	0.5323651E 01
17	8.0	17.443375	0.664869	0.9605	0.5483602E 01
17	8.5	17.774536	0.653673	0.9570	0.5638150E 01
17	9.0	18.057739	0.643553	0.9535	0.5789357E 01
17	9.5	18.312347	0.634203	0.9499	0.5938880E 01
17	10.0	18.561981	0.625246	0.9462	0.6087983E 01
17	10.5	18.831223	0.616257	0.9422	0.6237930E 01
17	11.0	19.148697	0.606740	0.9378	0.6391540E 01
17	11.5	19.545166	0.596137	0.9328	0.6555608E 01
17	12.0	20.054398	0.583831	0.9266	0.6744905E 01

RELATIONSHIP BETWEEN ADJUSTED SURFACE TEMPERATURE (X) AND TEMPERATURE AT DEPTH FROM SURFACE (Y)
WHERE
Y = A + B(X)
0 DAYS OF MEAN AIR TEMPERATURE HISTORY

HOUR	PAVEMENT DEPTH	CONSTANT A	COEFFICIENT B	CORRELATION COEFFICIENT	STANDARD ESTIMATE OF ERROR
18	0.0	-0.011688	1.000168	1.0000	0.4481014E-02
18	0.5	1.069839	0.994236	0.9995	0.8505638E 00
18	1.0	2.284515	0.983713	0.9983	0.1523255E 01
18	1.5	3.588867	0.969518	0.9969	0.2055308E 01
18	2.0	4.944351	0.952495	0.9953	0.2479373E 01
18	2.5	6.316299	0.933407	0.9936	0.2823202E 01
18	3.0	7.674179	0.912942	0.9920	0.3109313E 01
18	3.5	8.991272	0.891720	0.9902	0.3354948E 01
18	4.0	10.245499	0.870278	0.9884	0.3572431E 01
18	4.5	11.418259	0.849082	0.9864	0.3769882E 01
18	5.0	12.495377	0.828523	0.9844	0.3952258E 01
18	5.5	13.467468	0.808905	0.9823	0.4122369E 01
18	6.0	14.328110	0.790473	0.9800	0.4282016E 01
18	6.5	15.075272	0.773390	0.9777	0.4432660E 01
18	7.0	15.712189	0.757732	0.9753	0.4575954E 01
18	7.5	16.244156	0.743523	0.9729	0.4713890E 01
18	8.0	16.632663	0.730688	0.9705	0.4848746E 01
18	8.5	17.041855	0.719089	0.9679	0.4982640E 01
18	9.0	17.340622	0.708513	0.9653	0.5117270E 01
18	9.5	17.602203	0.698664	0.9625	0.5253547E 01
18	10.0	17.853271	0.689174	0.9596	0.5391714E 01
18	10.5	18.124878	0.679607	0.9565	0.5531913E 01
18	11.0	18.452499	0.669439	0.9531	0.5675645E 01
18	11.5	18.875763	0.658072	0.9491	0.5828132E 01
18	12.0	19.437836	0.644844	0.9442	0.6002099E 01

RELATIONSHIP BETWEEN ADJUSTED SURFACE TEMPERATURE (X) AND TEMPERATURE AT DEPTH FROM SURFACE (Y)
WHERE
Y = A + B(X)
0 DAYS OF MEAN AIR TEMPERATURE HISTORY

HOUR	PAVEMENT DEPTH	CONSTANT A	COEFFICIENT B	CORRELATION COEFFICIENT	STANDARD ESTIMATE OF ERROR
19	0.0	-0.013107	1.000202	1.0000	0.4795291E-02
19	0.5	0.212540	1.012410	0.9995	0.7841498E 00
19	1.0	0.713562	1.017877	0.9983	0.1406752E 01
19	1.5	1.432785	1.017666	0.9969	0.1900626E 01
19	2.0	2.316193	1.012780	0.9955	0.2294536E 01
19	2.5	3.315414	1.004137	0.9940	0.2612992E 01
19	3.0	4.387253	0.992562	0.9926	0.2876039E 01
19	3.5	5.493530	0.978808	0.9912	0.3099245E 01
19	4.0	6.600769	0.963542	0.9898	0.3294044E 01
19	4.5	7.680634	0.947351	0.9883	0.3468313E 01
19	5.0	8.710098	0.930740	0.9868	0.3627183E 01
19	5.5	9.670715	0.914133	0.9852	0.3773952E 01
19	6.0	10.549789	0.897860	0.9835	0.3910873E 01
19	6.5	11.338455	0.882194	0.9819	0.4039824E 01
19	7.0	12.034027	0.867300	0.9801	0.4162653E 01
19	7.5	12.638458	0.853274	0.9783	0.4281376E 01
19	8.0	13.158478	0.840128	0.9765	0.4397936E 01
19	8.5	13.605728	0.827798	0.9746	0.4514010E 01
19	9.0	13.997757	0.816124	0.9725	0.4630603E 01
19	9.5	14.356354	0.804873	0.9704	0.4747856E 01
19	10.0	14.708344	0.793733	0.9682	0.4865083E 01
19	10.5	15.085342	0.782311	0.9658	0.4981346E 01
19	11.0	15.525238	0.770116	0.9632	0.5096704E 01
19	11.5	16.070007	0.756585	0.9603	0.5214565E 01
19	12.0	16.766220	0.741087	0.9567	0.5345007E 01

RELATIONSHIP BETWEEN ADJUSTED SURFACE TEMPERATURE (X) AND TEMPERATURE AT DEPTH FROM SURFACE (Y)
WHERE
Y = A + B(X)
5 DAYS OF MEAN AIR TEMPERATURE HISTORY

HOUR	PAVEMENT DEPTH	CONSTANT A	COEFFICIENT B	CORRELATION COEFFICIENT	STANDARD ESTIMATE OF ERROR
6	0.0	-4.866104	0.528197	0.9789	0.3449551E 01
6	0.5	-4.868881	0.536155	0.9829	0.3143880E 01
6	1.0	-4.719452	0.542733	0.9855	0.2919492E 01
6	1.5	-4.449905	0.548146	0.9873	0.2752795E 01
6	2.0	-4.090195	0.552590	0.9886	0.2629677E 01
6	2.5	-3.666412	0.556240	0.9895	0.2542962E 01
6	3.0	-3.202454	0.559258	0.9900	0.2489326E 01
6	3.5	-2.718246	0.561776	0.9903	0.2466612E 01
6	4.0	-2.231674	0.563918	0.9903	0.2472108E 01
6	4.5	-1.756439	0.565780	0.9901	0.2501894E 01
6	5.0	-1.305008	0.567450	0.9898	0.2551130E 01
6	5.5	-0.885635	0.568990	0.9894	0.2614751E 01
6	6.0	-0.503342	0.570441	0.9888	0.2688226E 01
6	6.5	-0.160889	0.571831	0.9882	0.2768046E 01
6	7.0	0.141663	0.573170	0.9876	0.2851864E 01
6	7.5	0.408585	0.574440	0.9869	0.2938313E 01
6	8.0	0.645386	0.575618	0.9861	0.3026602E 01
6	8.5	0.862259	0.576647	0.9854	0.3115988E 01
6	9.0	1.071213	0.577463	0.9846	0.3205304E 01
6	9.5	1.287827	0.577975	0.9838	0.3292613E 01
6	10.0	1.530457	0.578081	0.9830	0.3375243E 01
6	10.5	1.819901	0.577659	0.9822	0.3450321E 01
6	11.0	2.181534	0.576556	0.9815	0.3516004E 01
6	11.5	2.641891	0.574616	0.9808	0.3573728E 01
6	12.0	3.231659	0.571658	0.9800	0.3631770E 01

RELATIONSHIP BETWEEN ADJUSTED SURFACE TEMPERATURE (X) AND TEMPERATURE AT DEPTH FROM SURFACE (Y)
WHERE
Y = A + B(X)
5 DAYS OF MEAN AIR TEMPERATURE HISTORY

HOUR	PAVEMENT DEPTH	CONSTANT A	COEFFICIENT B	CORRELATION COEFFICIENT	STANDARD ESTIMATE OF ERROR
7	0.0	-5.239517	0.535052	0.9800	0.3441641E 01
7	0.5	-4.979446	0.537260	0.9830	0.3178228E 01
7	1.0	-4.633270	0.539352	0.9851	0.2983894E 01
7	1.5	-4.221741	0.541347	0.9867	0.2830332E 01
7	2.0	-3.764084	0.543262	0.9879	0.2703239E 01
7	2.5	-3.278427	0.545121	0.9889	0.2598114E 01
7	3.0	-2.779221	0.546932	0.9896	0.2515788E 01
7	3.5	-2.279556	0.548699	0.9902	0.2458791E 01
7	4.0	-1.790680	0.550429	0.9905	0.2428728E 01
7	4.5	-1.320587	0.552116	0.9905	0.2424953E 01
7	5.0	-0.877594	0.553762	0.9905	0.2444475E 01
7	5.5	-0.464844	0.555350	0.9902	0.2482739E 01
7	6.0	-0.085297	0.556872	0.9899	0.2534808E 01
7	6.5	0.260666	0.558304	0.9894	0.2596357E 01
7	7.0	0.574860	0.559627	0.9889	0.2664234E 01
7	7.5	0.860321	0.560819	0.9884	0.2736551E 01
7	8.0	1.124069	0.561840	0.9878	0.2812368E 01
7	8.5	1.373138	0.562662	0.9871	0.2891147E 01
7	9.0	1.618286	0.563243	0.9864	0.2972196E 01
7	9.5	1.871201	0.563542	0.9857	0.3054242E 01
7	10.0	2.146820	0.563508	0.9850	0.3135463E 01
7	10.5	2.460815	0.563094	0.9842	0.3214109E 01
7	11.0	2.832367	0.562241	0.9834	0.3290076E 01
7	11.5	3.281418	0.560892	0.9825	0.3367630E 01
7	12.0	3.831543	0.558976	0.9815	0.3459613E 01

RELATIONSHIP BETWEEN ADJUSTED SURFACE TEMPERATURE (X) AND TEMPERATURE AT DEPTH FROM SURFACE (Y)
WHERE
Y = A + B(X)
5 DAYS OF MEAN AIR TEMPERATURE HISTORY

HOUR	PAVEMENT DEPTH	CONSTANT A	COEFFICIENT B	CORRELATION COEFFICIENT	STANDARD ESTIMATE OF ERROR
8	0.0	-5.757812	0.554145	0.9819	0.3528869E 01
8	0.5	-5.255661	0.546708	0.9838	0.3291212E 01
8	1.0	-4.717880	0.540792	0.9846	0.3171495E 01
8	1.5	-4.158264	0.536215	0.9850	0.3103441E 01
8	2.0	-3.588852	0.532808	0.9853	0.3049305E 01
8	2.5	-3.021240	0.530418	0.9857	0.2993183E 01
8	3.0	-2.464569	0.528893	0.9862	0.2932394E 01
8	3.5	-1.926865	0.528093	0.9867	0.2870846E 01
8	4.0	-1.414124	0.527886	0.9872	0.2814632E 01
8	4.5	-0.930313	0.528146	0.9876	0.2769388E 01
8	5.0	-0.479935	0.528762	0.9879	0.2738873E 01
8	5.5	-0.063629	0.529628	0.9881	0.2724575E 01
8	6.0	0.318314	0.530650	0.9881	0.2726024E 01
8	6.5	0.667709	0.531739	0.9880	0.2741517E 01
8	7.0	0.987213	0.532819	0.9878	0.2768926E 01
8	7.5	1.281860	0.533819	0.9876	0.2806242E 01
8	8.0	1.557159	0.534684	0.9872	0.2851794E 01
8	8.5	1.821854	0.535355	0.9868	0.2904108E 01
8	9.0	2.085068	0.535793	0.9863	0.2961566E 01
8	9.5	2.357330	0.535969	0.9857	0.3022100E 01
8	10.0	2.651459	0.535854	0.9852	0.3083193E 01
8	10.5	2.981461	0.535433	0.9846	0.3142467E 01
8	11.0	3.362518	0.534705	0.9840	0.3199240E 01
8	11.5	3.812134	0.533667	0.9833	0.3257441E 01
8	12.0	4.349014	0.532332	0.9825	0.3330249E 01

RELATIONSHIP BETWEEN ADJUSTED SURFACE TEMPERATURE (X) AND TEMPERATURE AT DEPTH FROM SURFACE (Y)
WHERE
Y = A + B(X)
5 DAYS OF MEAN AIR TEMPERATURE HISTORY

HOUR	PAVEMENT DEPTH	CONSTANT A	COEFFICIENT B	CORRELATION COEFFICIENT	STANDARD ESTIMATE OF ERROR
9	0.0	-5.539398	0.575742	0.9809	0.3940010E 01
9	0.5	-4.920395	0.559093	0.9843	0.3453667E 01
9	1.0	-4.330688	0.545433	0.9854	0.3253210E 01
9	1.5	-3.771729	0.534415	0.9851	0.3213490E 01
9	2.0	-3.243729	0.525707	0.9844	0.3241305E 01
9	2.5	-2.747238	0.518997	0.9835	0.3285800E 01
9	3.0	-2.281799	0.513997	0.9828	0.3326235E 01
9	3.5	-1.846252	0.510430	0.9823	0.3357737E 01
9	4.0	-1.439499	0.508048	0.9819	0.3381818E 01
9	4.5	-1.060226	0.506622	0.9815	0.3401280E 01
9	5.0	-0.705902	0.505937	0.9813	0.3418017E 01
9	5.5	-0.374161	0.505805	0.9812	0.3432579E 01
9	6.0	-0.061783	0.506053	0.9810	0.3444682E 01
9	6.5	0.234772	0.506531	0.9810	0.3454029E 01
9	7.0	0.519257	0.507109	0.9809	0.3461049E 01
9	7.5	0.796494	0.507674	0.9809	0.3467244E 01
9	8.0	1.071045	0.508136	0.9809	0.3475029E 01
9	8.5	1.348175	0.508424	0.9808	0.3487105E 01
9	9.0	1.633926	0.508485	0.9806	0.3505480E 01
9	9.5	1.934311	0.508292	0.9803	0.3530530E 01
9	10.0	2.256088	0.507833	0.9799	0.3560587E 01
9	10.5	2.606567	0.507116	0.9795	0.3592653E 01
9	11.0	2.993118	0.506171	0.9791	0.3624891E 01
9	11.5	3.424133	0.505046	0.9786	0.3661633E 01
9	12.0	3.907669	0.503813	0.9778	0.3721681E 01

RELATIONSHIP BETWEEN ADJUSTED SURFACE TEMPERATURE (X) AND TEMPERATURE AT DEPTH FROM SURFACE (Y)
WHERE
Y = A + B(X)
5 DAYS OF MEAN AIR TEMPERATURE HISTORY

HOUR	PAVEMENT DEPTH	CONSTANT A	COEFFICIENT B	CORRELATION COEFFICIENT	STANDARD ESTIMATE OF ERROR
10	0.0	-4.686996	0.594720	0.9761	0.4698489E 01
10	0.5	-4.433289	0.575208	0.9831	0.3802548E 01
10	1.0	-4.154877	0.558403	0.9866	0.3275863E 01
10	1.5	-3.857697	0.544046	0.9877	0.3062668E 01
10	2.0	-3.546677	0.531886	0.9871	0.3069937E 01
10	2.5	-3.226654	0.521687	0.9854	0.3200837E 01
10	3.0	-2.901337	0.513228	0.9832	0.3385262E 01
10	3.5	-2.574448	0.506298	0.9807	0.3582659E 01
10	4.0	-2.248245	0.500694	0.9782	0.3772123E 01
10	4.5	-1.925507	0.496237	0.9759	0.3943540E 01
10	5.0	-1.607483	0.492751	0.9737	0.4092155E 01
10	5.5	-1.295715	0.490077	0.9719	0.4216110E 01
10	6.0	-0.990097	0.488065	0.9704	0.4315394E 01
10	6.5	-0.690689	0.486583	0.9692	0.4391361E 01
10	7.0	-0.396881	C.485508	0.9683	0.4446671E 01
10	7.5	-0.107300	0.484730	0.9677	0.4485053E 01
10	8.0	0.180084	0.484151	0.9673	0.4510932E 01
10	8.5	0.467804	0.483686	0.9670	0.4528898E 01
10	9.0	0.758270	0.483269	0.9667	0.4543000E 01
10	9.5	1.055801	0.482834	0.9665	0.4556048E 01
10	10.0	1.364716	0.482338	0.9662	0.4569275E 01
10	10.5	1.689575	0.481745	0.9660	0.4582645E 01
10	11.0	2.035751	0.481037	0.9657	0.4596399E 01
10	11.5	2.405515	0.480202	0.9653	0.4614276E 01
10	12.0	2.817123	0.479247	0.9647	0.4648936E 01

RELATIONSHIP BETWEEN ADJUSTED SURFACE TEMPERATURE (X) AND TEMPERATURE AT DEPTH FROM SURFACE (Y)
WHERE
Y = A + B(X)
5 DAYS OF MEAN AIR TEMPERATURE HISTORY

HOUR	PAVEMENT DEPTH	CONSTANT A	COEFFICIENT B	CORRELATION COEFFICIENT	STANDARD ESTIMATE OF ERROR
11	0.0	-5.799683	0.625102	0.9752	0.5362478E 01
11	0.5	-5.058044	0.599140	0.9821	0.4345553E 01
11	1.0	-4.346054	0.575992	0.9860	0.3677132E 01
11	1.5	-3.667755	0.555476	0.9878	0.3314344E 01
11	2.0	-3.026169	0.537413	0.9878	0.3196444E 01
11	2.5	-2.422882	0.521623	0.9867	0.3250635E 01
11	3.0	-1.860382	0.507937	0.9846	0.3410299E 01
11	3.5	-1.338699	0.496182	0.9818	0.3626052E 01
11	4.0	-0.857468	0.486190	0.9786	0.3865082E 01
11	4.5	-0.416534	0.477798	0.9751	0.4106167E 01
11	5.0	-0.014084	0.470842	0.9716	0.4335434E 01
11	5.5	0.352676	0.465162	0.9681	0.4543981E 01
11	6.0	0.686600	0.460606	0.9650	0.4726693E 01
11	6.5	0.991394	0.457020	0.9623	0.4881662E 01
11	7.0	1.272308	0.454253	0.9599	0.5009747E 01
11	7.5	1.534439	0.452158	0.9580	0.5114061E 01
11	8.0	1.783905	0.450594	0.9564	0.5199149E 01
11	8.5	2.027710	0.449418	0.9550	0.5270035E 01
11	9.0	2.273819	0.448494	0.9539	0.5331088E 01
11	9.5	2.530792	0.447685	0.9529	0.5384836E 01
11	10.0	2.807831	0.446862	0.9519	0.5431535E 01
11	10.5	3.114975	0.445892	0.9511	0.5469481E 01
11	11.0	3.463028	0.444655	0.9504	0.5496986E 01
11	11.5	3.863556	0.443024	0.9497	0.5516795E 01
11	12.0	4.328766	0.440883	0.9488	0.5543557E 01

RELATIONSHIP BETWEEN ADJUSTED SURFACE TEMPERATURE (X) AND TEMPERATURE AT DEPTH FROM SURFACE (Y)
WHERE
Y = A + B(X)
5 DAYS OF MEAN AIR TEMPERATURE HISTORY

HOUR	PAVEMENT DEPTH	CONSTANT A	COEFFICIENT B	CORRELATION COEFFICIENT	STANDARD ESTIMATE OF ERROR
12	0.0	-6.787613	0.649606	0.9744	0.5950899E 01
12	0.5	-5.522888	0.619264	0.9805	0.4933372E 01
12	1.0	-4.398026	0.591984	0.9849	0.4133697E 01
12	1.5	-3.401733	0.567576	0.9878	0.3551316E 01
12	2.0	-2.520599	0.545849	0.9893	0.3193398E 01
12	2.5	-1.743652	0.526622	0.9895	0.3057146E 01
12	3.0	-1.059372	0.509708	0.9884	0.3112389E 01
12	3.5	-0.456467	0.494930	0.9862	0.3305371E 01
12	4.0	0.074646	0.482112	0.9830	0.3579165E 01
12	4.5	0.544235	0.471083	0.9791	0.3888264E 01
12	5.0	0.961685	0.461672	0.9748	0.4201376E 01
12	5.5	1.336044	0.453711	0.9703	0.4498549E 01
12	6.0	1.675491	0.447043	0.9658	0.4767978E 01
12	6.5	1.988358	0.441504	0.9617	0.5003644E 01
12	7.0	2.282288	0.436936	0.9579	0.5203742E 01
12	7.5	2.563660	0.433191	0.9546	0.5369519E 01
12	8.0	2.839630	0.430117	0.9519	0.5504461E 01
12	8.5	3.115875	0.427567	0.9495	0.5613348E 01
12	9.0	3.398743	0.425397	0.9476	0.5701648E 01
12	9.5	3.692856	0.423467	0.9459	0.5774764E 01
12	10.0	4.002808	0.421643	0.9443	0.5837830E 01
12	10.5	4.333237	0.419788	0.9428	0.5896023E 01
12	11.0	4.687515	0.417775	0.9413	0.5955849E 01
12	11.5	5.069382	0.415471	0.9394	0.6027882E 01
12	12.0	5.481277	0.412758	0.9367	0.6131066E 01

RELATIONSHIP BETWEEN ADJUSTED SURFACE TEMPERATURE (X) AND TEMPERATURE AT DEPTH FROM SURFACE (Y)
WHERE
Y = A + B(X)
5 DAYS OF MEAN AIR TEMPERATURE HISTORY

HOUR	PAVEMENT DEPTH	CONSTANT A	COEFFICIENT B	CORRELATION COEFFICIENT	STANDARD ESTIMATE OF ERROR
13	0.0	-7.726624	0.664848	0.9754	0.6193493E 01
13	0.5	-6.129105	0.634388	0.9799	0.5331517E 01
13	1.0	-4.729111	0.606634	0.9832	0.4643430E 01
13	1.5	-3.505051	0.581437	0.9857	0.4101624E 01
13	2.0	-2.435791	0.558647	0.9874	0.3698589E 01
13	2.5	-1.501053	0.538107	0.9882	0.3439805E 01
13	3.0	-0.682617	0.519673	0.9881	0.3330934E 01
13	3.5	0.035904	0.503204	0.9871	0.3364367E 01
13	4.0	0.670547	0.488554	0.9851	0.3514449E 01
13	4.5	1.235367	0.475586	0.9822	0.3744632E 01
13	5.0	1.743546	0.464161	0.9787	0.4018326E 01
13	5.5	2.205673	0.454148	0.9746	0.4305511E 01
13	6.0	2.632156	0.445415	0.9702	0.4584656E 01
13	6.5	3.031677	0.437831	0.9659	0.4841998E 01
13	7.0	3.411224	0.431273	0.9617	0.5070277E 01
13	7.5	3.776535	0.425617	0.9578	0.5267241E 01
13	8.0	4.132355	0.420741	0.9543	0.5434437E 01
13	8.5	4.481354	0.416527	0.9511	0.5575827E 01
13	9.0	4.825562	0.412859	0.9483	0.5696704E 01
13	9.5	5.164658	0.409628	0.9457	0.5802666E 01
13	10.0	5.497818	0.406718	0.9433	0.5899012E 01
13	10.5	5.822281	0.404027	0.9410	0.5991114E 01
13	11.0	6.134293	0.401447	0.9386	0.6085961E 01
13	11.5	6.428177	0.398876	0.9358	0.6195656E 01
13	12.0	6.697708	0.396214	0.9322	0.6343144E 01

RELATIONSHIP BETWEEN ADJUSTED SURFACE TEMPERATURE (X) AND TEMPERATURE AT DEPTH FROM SURFACE (Y)
WHERE
Y = A + B(X)
5 DAYS OF MEAN AIR TEMPERATURE HISTORY

HOUR	PAVEMENT DEPTH	CONSTANT A	COEFFICIENT B	CORRELATION COEFFICIENT	STANDARD ESTIMATE OF ERROR
14	0.0	-8.328522	0.671945	0.9768	0.6205424E 01
14	0.5	-6.724533	0.645349	0.9803	0.5477618E 01
14	1.0	-5.256470	0.620145	0.9829	0.4891350E 01
14	1.5	-3.916748	0.596393	0.9849	0.4411175E 01
14	2.0	-2.697708	0.574138	0.9864	0.4022655E 01
14	2.5	-1.592438	0.553414	0.9874	0.3727332E 01
14	3.0	-0.593063	0.534237	0.9879	0.3534626E 01
14	3.5	0.307297	0.516612	0.9876	0.3452002E 01
14	4.0	1.116135	0.500529	0.9867	0.3476348E 01
14	4.5	1.840775	0.485966	0.9849	0.3591364E 01
14	5.0	2.488342	0.472885	0.9825	0.3771984E 01
14	5.5	3.066086	0.461237	0.9795	0.3991553E 01
14	6.0	3.580933	0.450956	0.9761	0.4226995E 01
14	6.5	4.040207	0.441966	0.9724	0.4461151E 01
14	7.0	4.450958	0.434173	0.9687	0.4682842E 01
14	7.5	4.820190	0.427472	0.9651	0.4886016E 01
14	8.0	5.154465	0.421746	0.9616	0.5068652E 01
14	8.5	5.461761	0.416858	0.9583	0.5231542E 01
14	9.0	5.748047	0.412664	0.9553	0.5377150E 01
14	9.5	6.020569	0.409003	0.9525	0.5508778E 01
14	10.0	6.286194	0.405701	0.9497	0.5630097E 01
14	10.5	6.551727	0.402570	0.9471	0.5745532E 01
14	11.0	6.823730	0.399408	0.9443	0.5861778E 01
14	11.5	7.109436	0.395998	0.9411	0.5991031E 01
14	12.0	7.415192	0.392114	0.9370	0.6155895E 01

RELATIONSHIP BETWEEN ADJUSTED SURFACE TEMPERATURE (X) AND TEMPERATURE AT DEPTH FROM SURFACE (Y)
WHERE
Y = A + B(X)
5 DAYS OF MEAN AIR TEMPERATURE HISTORY

HOUR	PAVEMENT DEPTH	CONSTANT A	COEFFICIENT B	CORRELATION COEFFICIENT	STANDARD ESTIMATE OF ERROR
15	0.0	-9.017609	0.674095	0.9786	0.6035117E 01
15	0.5	-7.242508	0.650641	0.9814	0.5424464E 01
15	1.0	-5.598557	0.627893	0.9833	0.4952848E 01
15	1.5	-4.083588	0.606002	0.9847	0.4570451E 01
15	2.0	-2.694397	0.585097	0.9858	0.4250906E 01
15	2.5	-1.428070	0.565291	0.9866	0.3986132E 01
15	3.0	-0.280502	0.546671	0.9871	0.3779511E 01
15	3.5	0.752869	0.529308	0.9872	0.3638605E 01
15	4.0	1.677383	0.513250	0.9869	0.3568738E 01
15	4.5	2.498978	0.498524	0.9862	0.3568489E 01
15	5.0	3.224579	0.485135	0.9849	0.3628830E 01
15	5.5	3.860916	0.473073	0.9833	0.3735437E 01
15	6.0	4.416046	0.462301	0.9812	0.3872448E 01
15	6.5	4.898605	0.452763	0.9789	0.4025699E 01
15	7.0	5.317505	0.444387	0.9764	0.4184526E 01
15	7.5	5.682999	0.437072	0.9739	0.4342159E 01
15	8.0	6.005066	0.430702	0.9713	0.4495250E 01
15	8.5	6.295059	0.425141	0.9687	0.4643011E 01
15	9.0	6.564575	0.420227	0.9661	0.4786077E 01
15	9.5	6.826111	0.415785	0.9635	0.4925719E 01
15	10.0	7.092789	0.411610	0.9608	0.5063433E 01
15	10.5	7.378159	0.407484	0.9579	0.5201351E 01
15	11.0	7.696259	0.403167	0.9549	0.5344102E 01
15	11.5	8.062592	0.398393	0.9513	0.5501934E 01
15	12.0	8.492447	0.392882	0.9467	0.5696117E 01

RELATIONSHIP BETWEEN ADJUSTED SURFACE TEMPERATURE (X) AND TEMPERATURE AT DEPTH FROM SURFACE (Y)
WHERE
Y = A + B(X)
5 DAYS OF MEAN AIR TEMPERATURE HISTORY

HOUR	PAVEMENT DEPTH	CONSTANT A	COEFFICIENT B	CORRELATION COEFFICIENT	STANDARD ESTIMATE OF ERROR
16	0.0	-10.162643	0.673901	0.9810	0.5723636E 01
16	0.5	-8.112961	0.653843	0.9828	0.5277569E 01
16	1.0	-6.191666	0.633829	0.9839	0.4948110E 01
16	1.5	-4.402832	0.614090	0.9847	0.4672193E 01
16	2.0	-2.748535	0.594830	0.9854	0.4416732E 01
16	2.5	-1.229507	0.576226	0.9861	0.4171013E 01
16	3.0	0.154510	0.558433	0.9868	0.3938438E 01
16	3.5	1.405334	0.541576	0.9874	0.3729910E 01
16	4.0	2.525818	0.525756	0.9878	0.3558363E 01
16	4.5	3.519852	0.511054	0.9880	0.3434612E 01
16	5.0	4.392700	0.497518	0.9879	0.3364332E 01
16	5.5	5.151352	0.485176	0.9874	0.3346814E 01
16	6.0	5.803238	0.474027	0.9866	0.3375859E 01
16	6.5	6.358109	0.464047	0.9854	0.3442167E 01
16	7.0	6.825577	0.455187	0.9841	0.3535990E 01
16	7.5	7.217514	0.447372	0.9825	0.3648996E 01
16	8.0	7.546768	0.440500	0.9807	0.3775018E 01
16	8.5	7.827362	0.434447	0.9788	0.3909824E 01
16	9.0	8.074982	0.429058	0.9767	0.4050457E 01
16	9.5	8.305740	0.424161	0.9746	0.4194493E 01
16	10.0	8.537674	0.419551	0.9723	0.4339790E 01
16	10.5	8.789795	0.415002	0.9698	0.4484982E 01
16	11.0	9.082428	0.410263	0.9672	0.4631359E 01
16	11.5	9.437210	0.405053	0.9642	0.4786306E 01
16	12.0	9.877090	0.399070	0.9605	0.4968796E 01

RELATIONSHIP BETWEEN ADJUSTED SURFACE TEMPERATURE (X) AND TEMPERATURE AT DEPTH FROM SURFACE (Y)
WHERE
Y = A + B(X)
5 DAYS OF MEAN AIR TEMPERATURE HISTORY

HOUR	PAVEMENT DEPTH	CONSTANT A	COEFFICIENT B	CORRELATION COEFFICIENT	STANDARD ESTIMATE OF ERROR
17	0.0	-10.400696	0.663348	0.9827	0.5270919E 01
17	0.5	-8.724335	0.651177	0.9833	0.5085541E 01
17	1.0	-7.042160	0.637577	0.9835	0.4951490E 01
17	1.5	-5.379395	0.622958	0.9836	0.4817133E 01
17	2.0	-3.759491	0.607701	0.9839	0.4661539E 01
17	2.5	-2.202225	0.592143	0.9843	0.4482656E 01
17	3.0	-0.724350	0.576585	0.9848	0.4288454E 01
17	3.5	0.660309	0.561290	0.9854	0.4091192E 01
17	4.0	1.940247	0.546484	0.9860	0.3903698E 01
17	4.5	3.107666	0.532355	0.9864	0.3736942E 01
17	5.0	4.157486	0.519050	0.9868	0.3598643E 01
17	5.5	5.087540	0.506682	0.9869	0.3492728E 01
17	6.0	5.898804	0.495323	0.9869	0.3419704E 01
17	6.5	6.594666	0.485011	0.9866	0.3377678E 01
17	7.0	7.182373	0.475743	0.9862	0.3363640E 01
17	7.5	7.671005	0.467479	0.9857	0.3374557E 01
17	8.0	8.073486	0.460143	0.9849	0.3407900E 01
17	8.5	8.405533	0.453615	0.9840	0.3461620E 01
17	9.0	8.685760	0.447744	0.9829	0.3533688E 01
17	9.5	8.935211	0.442339	0.9817	0.3621663E 01
17	10.0	9.178680	0.437170	0.9802	0.3722747E 01
17	10.5	9.443665	0.431968	0.9786	0.3834731E 01
17	11.0	9.760376	0.426431	0.9766	0.3958359E 01
17	11.5	10.162079	0.420215	0.9742	0.4101438E 01
17	12.0	10.685532	0.412937	0.9710	0.4284748E 01

RELATIONSHIP BETWEEN ADJUSTED SURFACE TEMPERATURE (X) AND TEMPERATURE AT DEPTH FROM SURFACE (Y)
WHERE
Y = A + B(X)
5 DAYS OF MEAN AIR TEMPERATURE HISTORY

HOUR	PAVEMENT DEPTH	CONSTANT A	COEFFICIENT B	CORRELATION COEFFICIENT	STANDARD ESTIMATE OF ERROR
18	0.0	-10.059219	0.646552	0.9835	0.4828848E 01
18	0.5	-8.988922	0.643291	0.9839	0.4748799E 01
18	1.0	-7.757767	0.637212	0.9839	0.4706961E 01
18	1.5	-6.415558	0.628885	0.9838	0.4657830E 01
18	2.0	-5.005539	0.618825	0.9838	0.4582998E 01
18	2.5	-3.567490	0.607504	0.9839	0.4479802E 01
18	3.0	-2.136795	0.595351	0.9842	0.4353648E 01
18	3.5	-0.743378	0.582742	0.9845	0.4213149E 01
18	4.0	0.586685	0.570012	0.9849	0.4067303E 01
18	4.5	1.832657	0.557443	0.9853	0.3923952E 01
18	5.0	2.977844	0.545275	0.9857	0.3789024E 01
18	5.5	4.010696	0.533698	0.9860	0.3666520E 01
18	6.0	4.923218	0.522863	0.9862	0.3558880E 01
18	6.5	5.713638	0.512860	0.9864	0.3467588E 01
18	7.0	6.383514	0.503746	0.9865	0.3393800E 01
18	7.5	6.939301	0.495525	0.9865	0.3338698E 01
18	8.0	7.392563	0.488154	0.9864	0.3303539E 01
18	8.5	7.758682	0.481544	0.9861	0.3289286E 01
18	9.0	8.058212	0.475562	0.9857	0.3296062E 01
18	9.5	8.316452	0.470024	0.9852	0.3322717E 01
18	10.0	8.562820	0.464700	0.9845	0.3366937E 01
18	10.5	8.831863	0.459316	0.9835	0.3426369E 01
18	11.0	9.162430	0.453547	0.9824	0.3501127E 01
18	11.5	9.597351	0.447030	0.9809	0.3597990E 01
18	12.0	10.185745	0.439343	0.9788	0.3736321E 01

RELATIONSHIP BETWEEN ADJUSTED SURFACE TEMPERATURE (X) AND TEMPERATURE AT DEPTH FROM SURFACE (Y)
WHERE
Y = A + B(X)
5 DAYS OF MEAN AIR TEMPERATURE HISTORY

HOUR	PAVEMENT DEPTH	CONSTANT A	COEFFICIENT B	CORRELATION COEFFICIENT	STANDARD ESTIMATE OF ERROR
19	0.0	-8.205109	0.616586	0.9828	0.4382286E 01
19	0.5	-8.152405	0.624727	0.9832	0.4381021E 01
19	1.0	-7.780243	0.628806	0.9832	0.4414680E 01
19	1.5	-7,152756	0.629464	0.9831	0.4438004E 01
19	2.0	-6.330750	0.627308	0.9830	0.4432266E 01
19	2.5	-5.368027	0.622885	0.9830	0.4393793E 01
19	3.0	-4.313370	0.616694	0.9832	0.4326395E 01
19	3.5	-3.210052	0.609190	0.9835	0.4236866E 01
19	4.0	-2.095383	0.600771	0.9838	0.4132533E 01
19	4.5	-1.002106	0.591795	0.9842	0.4019950E 01
19	5.0	0.044449	0.582559	0.9846	0.3904348E 01
19	5.5	1.022873	0.573318	0.9851	0.3789718E 01
19	6.0	1.917709	0.564278	0.9855	0.3679042E 01
19	6.5	2.719498	0.555592	0.9858	0.3574743E 01
19	7.0	3.424042	0.547364	0.9862	0.3479081E 01
19	7.5	4.032791	0.539650	0.9864	0.3394400E 01
19	8.0	4.552994	0.532453	0.9866	0.3323017E 01
19	8.5	4.996857	0.525732	0.9868	0.3266889E 01
19	9.0	5.382492	0.519396	0.9868	0.3227072E 01
19	9.5	5.733871	0.513298	0.9866	0.3203245E 01
19	10.0	6.080338	0.507247	0.9864	0.3193708E 01
19	10.5	6.456497	0.501002	0.9861	0.3196242E 01
19	11.0	6.903061	0.494270	0.9856	0.3210302E 01
19	11.5	7.465515	0.486715	0.9848	0.3241000E 01
19	12.0	8.196274	0.477940	0.9837	0.3305026E 01

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