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DEVELOPMENT ENGINEERING PROCEDURAL DESIGN MEMORANDUM FOR THE CALCULATION OF ROADWAY STRUCTURAL SECTIONS

CATEGORY: **Structural Section Calculation**

DATE: **July 25, 2022**

THE CITY OF CHICO DEVELOPMENT ENGINEERING DIVISION HAS ESTABLISHED PROCEDURAL GUIDELINES TO HELP AID IN THE CALCULATION OF ROADWAY STRUCTURAL SECTIONS.

Scope

The information set forth in this Procedural Design Bulletin describes the acceptable method for calculating a roadways Structural Number (SN). All calculations and formulas are based on the newest standards set forth in the California Department of Transportation (Caltrans) 2020 Highway Design Manual (HDM). For further information and a detailed overview of these calculation and methods refer to the Caltrans 2020 HDM: https://dot.ca.gov/-/media/dot-media/programs/design/documents/hdm-complete-12312020a11y.pdf.

Overview

The Structural Number (SN) was developed to be calculated with the equation shown in Figure 1:

$$SN = a_1D_1 + a_2D_2m_2 + a_3D_3m_3 + \cdots$$

Where:

a_i= i^{th} layer coefficients;
D_i = i^{th} layer thicknesses (in inches), and
m_i= i^{th} drainage coefficient.

Figure 1

Developed with the assistance of the American Association of State Highway Officials (AASHO), the SN is the sum of the strengths of all the layers in a pavement. The SN gives the overall structural requirements needed to withstand a designs traffic loading condition(s).

I. Key terms and Definitions as defined in the "2020 Caltrans Highway Design Manual":

1. Traffic Index (TI): The Traffic Index (TI) is a measure of the number of ESALs expected in the traffic lane over the pavement design life of the facility.
2. R-Value: A measure of resistance to deformation of the soils under saturated conditions and traffic loading as determined by the stabilometer test (CT301). The California R-value, also referred to as R-value, measures the supporting strength of the subgrade and subsequent layers used in the pavement structure.
3. Subgrade: Also referred to as basement soil, it is the portion of the roadbed consisting of native

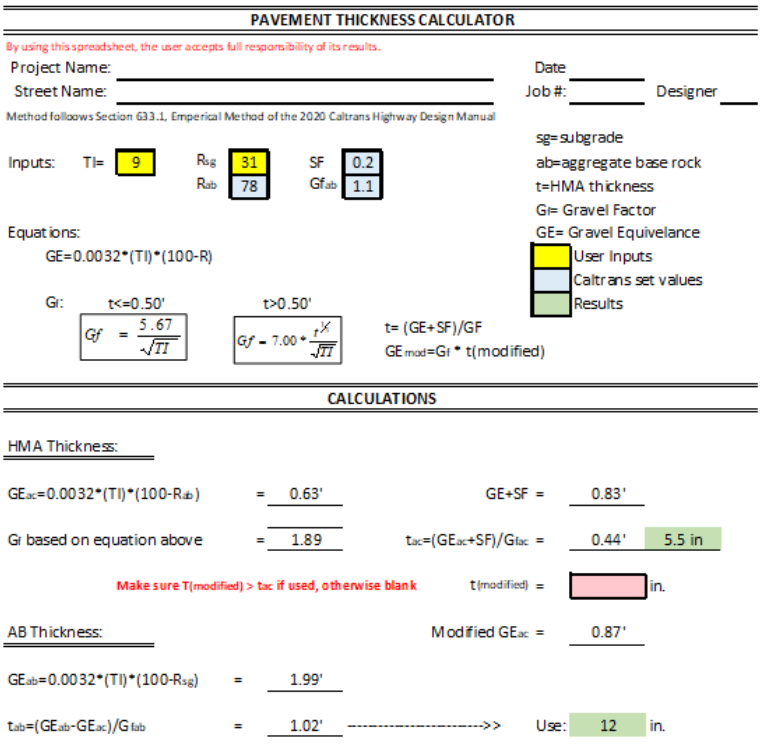
or treated soil on which pavement surface course, base, subbase, or a layer of any other material is placed.

4. Aggregate Base Rock: A layer of selected, processed, and/or treated aggregate material that is placed immediately below the surface course. It provides additional load distribution and contributes to drainage and frost resistance.
5. Gravel Factor (GF): Refers to the relative strength of a given material compared to a standard gravel subbase material. The cohesiometer values were used to establish the Gf currently used by Caltrans.
6. Gravel Equivalence: The gravel equivalent (GE) is defined as the required gravel thickness needed to carry a load compared to a different. material's ability to carry the same load.

Approved Procedure

The City of Chico has developed a tool for determining the HMA thickness and AB thickness based on a user defined Traffic Index (TI) and a subgrade R-value. The HMA thickness will be rounded up to the nearest 1/2" increment.

From a soils report, simply input the known “TI” and “R” value(s) into the respective cells. These values will generate a minimum required HMA value and AB value. For a more accurate calculation, a Factor of Safety (SF) value, Gravel Factor (Gf_{ab}) value, and a R_{ab} (aggregate base rock) value can be inputted.



This calculator can be found on the City of Chico Development Engineering website under “Development Engineering Calculators” or at the following link: https://chico.ca.us/pod/development-engineering-fee-calculators.

A quick reference table is provided below for quickly estimating the structural HMA/AB sections only.

	TI												
	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12
HMA	3	3.5	4	4	4.5	5	5.5	5.5	6	6.5	6.5	7	7
R-Value	AB Thickness												
4	14.0	14.5	15.5	17.5	18.5	19.5	20.5	22.5	24.0	25.0	26.5	27.5	29.0
5	13.5	14.5	15.5	17.5	18.5	19.5	20.5	22.5	23.5	24.5	26.0	27.0	28.5
6	13.5	14.5	15.0	17.0	18.0	19.0	20.0	22.0	23.0	24.0	26.0	26.5	28.5
7	13.0	14.0	15.0	17.0	18.0	19.0	20.0	21.5	23.0	23.5	25.5	26.0	28.0
8	13.0	14.0	14.5	16.5	17.5	18.5	19.5	21.5	22.5	23.5	25.0	26.0	27.5
9	12.5	13.5	14.5	16.5	17.0	18.0	19.0	21.0	22.0	23.0	24.5	25.5	27.0
10	12.5	13.5	14.0	16.0	17.0	18.0	19.0	20.5	22.0	22.5	24.0	25.0	26.5
11	12.5	13.0	14.0	16.0	16.5	17.5	18.5	20.5	21.5	22.0	24.0	24.5	26.0
12	12.0	13.0	13.5	15.5	16.5	17.5	18.0	20.0	21.0	22.0	23.5	24.0	26.0
13	12.0	12.5	13.5	15.0	16.0	17.0	18.0	19.5	21.0	21.5	23.0	24.0	25.5
14	11.5	12.5	13.0	15.0	16.0	16.5	17.5	19.5	20.5	21.0	22.5	23.5	25.0
15	11.5	12.0	13.0	14.5	15.5	16.5	17.5	19.0	20.0	21.0	22.5	23.0	24.5
16	11.5	12.0	12.5	14.5	15.5	16.0	17.0	18.5	19.5	20.5	22.0	22.5	24.0
17	11.0	12.0	12.5	14.0	15.0	16.0	16.5	18.5	19.5	20.0	21.5	22.0	23.5
18	11.0	11.5	12.0	14.0	14.5	15.5	16.5	18.0	19.0	19.5	21.0	22.0	23.5
19	10.5	11.5	12.0	13.5	14.5	15.0	16.0	17.5	18.5	19.5	21.0	21.5	23.0
20	10.5	11.0	12.0	13.5	14.0	15.0	15.5	17.5	18.5	19.0	20.5	21.0	22.5
21	10.0	11.0	11.5	13.0	14.0	14.5	15.5	17.0	18.0	18.5	20.0	20.5	22.0
22	10.0	10.5	11.5	13.0	13.5	14.5	15.0	16.5	17.5	18.0	19.5	20.0	21.5
23	10.0	10.5	11.0	12.5	13.5	14.0	14.5	16.5	17.5	18.0	19.0	20.0	21.0
24	9.5	10.0	11.0	12.5	13.0	13.5	14.5	16.0	17.0	17.5	19.0	19.5	21.0
25	9.5	10.0	10.5	12.0	12.5	13.5	14.0	15.5	16.5	17.0	18.5	19.0	20.5
26	9.0	9.5	10.5	12.0	12.5	13.0	14.0	15.5	16.0	17.0	18.0	18.5	20.0
27	9.0	9.5	10.0	11.5	12.0	13.0	13.5	15.0	16.0	16.5	17.5	18.0	19.5
28	9.0	9.5	10.0	11.5	12.0	12.5	13.0	14.5	15.5	16.0	17.5	18.0	19.0
29	8.5	9.0	9.5	11.0	11.5	12.0	13.0	14.5	15.0	15.5	17.0	17.5	18.5
30	8.5	9.0	9.5	11.0	11.5	12.0	12.5	14.0	15.0	15.5	16.5	17.0	18.5
31	8.0	8.5	9.0	10.5	11.0	11.5	12.0	13.5	14.5	15.0	16.0	16.5	18.0
32	8.0	8.5	9.0	10.5	11.0	11.5	12.0	13.5	14.0	14.5	16.0	16.0	17.5
33	7.5	8.0	8.5	10.0	10.5	11.0	11.5	13.0	14.0	14.0	15.5	16.0	17.0
34	7.5	8.0	8.5	10.0	10.0	10.5	11.5	12.5	13.5	14.0	15.0	15.5	16.5
35	7.5	7.5	8.0	9.5	10.0	10.5	11.0	12.5	13.0	13.5	14.5	15.0	16.0
36	7.0	7.5	8.0	9.0	9.5	10.0	10.5	12.0	12.5	13.0	14.0	14.5	15.5
37	7.0	7.0	7.5	9.0	9.5	10.0	10.5	11.5	12.5	12.5	14.0	14.0	15.5
38	6.5	7.0	7.5	8.5	9.0	9.5	10.0	11.5	12.0	12.5	13.5	14.0	15.0
39	6.5	7.0	7.0	8.5	9.0	9.5	9.5	11.0	11.5	12.0	13.0	13.5	14.5
40	6.5	6.5	7.0	8.0	8.5	9.0	9.5	10.5	11.5	11.5	12.5	13.0	14.0
41	6.0	6.5	6.5	8.0	8.5	8.5	9.0	10.5	11.0	11.5	12.5	12.5	13.5
42	6.0	6.0	6.5	7.5	8.0	8.5	9.0	10.0	10.5	11.0	12.0	12.0	13.0
43	5.5	6.0	6.0	7.5	7.5	8.0	8.5	9.5	10.5	10.5	11.5	12.0	13.0
44	5.5	5.5	6.0	7.0	7.5	8.0	8.0	9.5	10.0	10.0	11.0	11.5	12.5
45	5.0	5.5	5.5	7.0	7.0	7.5	8.0	9.0	9.5	10.0	11.0	11.0	12.0
46	5.0	5.0	5.5	6.5	7.0	7.0	7.5	8.5	9.0	9.5	10.5	10.5	11.5
47	5.0	5.0	5.0	6.5	6.5	7.0	7.0	8.5	9.0	9.0	10.0	10.0	11.0
48	4.5	4.5	5.0	6.0	6.5	6.5	7.0	8.0	8.5	8.5	9.5	10.0	10.5
49	4.5	4.5	4.5	6.0	6.0	6.5	6.5	7.5	8.0	8.5	9.0	9.5	10.5
50	4.0	4.5	4.5	5.5	6.0	6.0	6.5	7.5	8.0	8.0	9.0	9.0	10.0

This reference table can be found on the City of Chico Development Engineering website under "Development Engineering Calculators" or at the following link: https://drive.google.com/drive/folders/1r5c5D_k5CMKPAYD7IvNzt3ipU3f8HXin?usp=sharing.

Summary of Procedure

To quickly calculate the thickness of HMA and AB one will only need the Traffic Index (TI) and R-value. TI values can be calculated directly by the City of Chico Traffic Engineering Division when requested.

For a quick calculation, the City of Chico has provided a SN quick reference table.

City Review and Approval

The provided information is to be used as a processing tool to help aid in the calculation of Structural Numbers. All calculations done by applicants do not ensure that the City of Chico will accept the data and calculations provided/done by applicants. The City of Chico will perform their own calculations based on the information provided in the soils report.

The City of Chico holds no guarantees this tool will result in the actual required HMA and AB.

References

https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.941.8697&rep=rep1&type=pdf