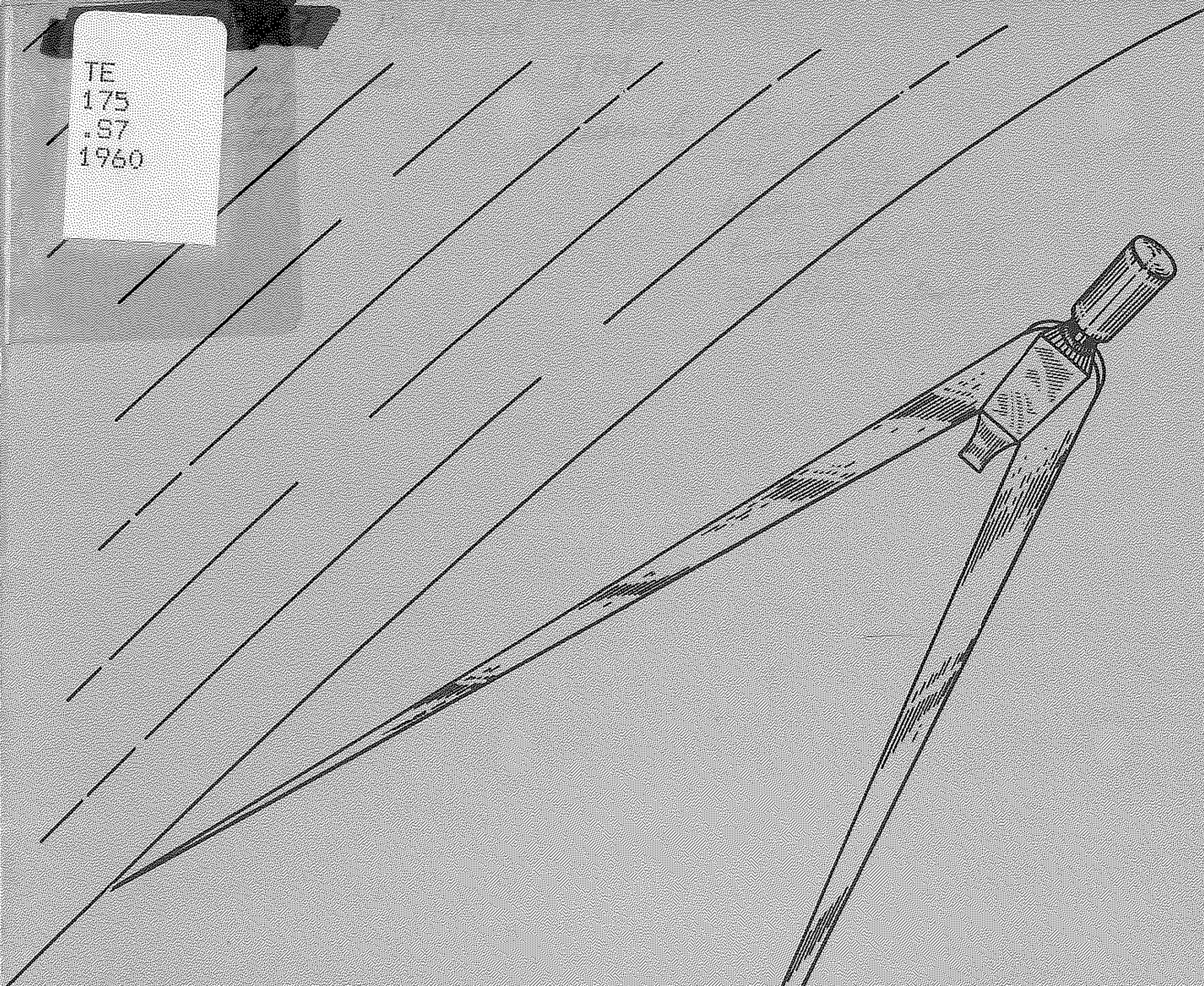


PAVEMENT TYPE SELECTION

MARCH 1960

MICHIGAN
STATE HIGHWAY DEPARTMENT

JOHN C. MACKIE
COMMISSIONER

PAVEMENT TYPE SELECTION

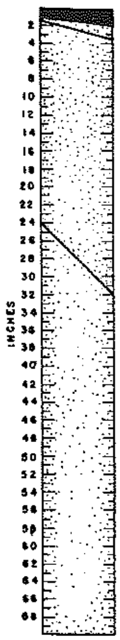
Olaf L. Stokstad
Design Development Engineer

Michigan State Highway Department
John C. Mackie, Commissioner
Lansing, March 1960

PAVEMENT TYPE SELECTION

In Michigan the selection of pavement type is based upon techniques which had their beginnings in the aggregate surveys, soil surveys, and pavement condition surveys started in 1925. Over the years such surveys have continued to provide unusual opportunities for correlation of pavement behavior with foundation conditions. The soil classification system borrowed from soil science has provided the frame of reference whereby this correlation experience has been recorded, organized, and made available to succeeding generations of highway engineers.

The suitability of pavement designs and the cost of their construction cannot be properly determined before information is available on aggregate supplies and soil classification. One of the first steps, therefore, in selecting the pavement type for a new road is to determine the aggregate situation in the area and the nature of soil and drainage conditions to be encountered along the proposed route. Figures 1 and 2 are descriptions of the Bridgman and Kawkawlin soils and illustrate the manner in which 140 Michigan soils have been identified and described. Figure 3 is a sample map illustrating the method used for recording general soil engineering information for highway purposes. In addition, there are geological maps and a number of county soil survey reports available for



Litter, leaf mold and humus soil.
Leached gray fine sand.

Yellow fine sand, loose and incoherent.

Pale yellow fine sand, loose and incoherent.

SOIL DESCRIPTION

Gray-brown Podzolic Group	Bridgman Series	Fine Sand Class

Bridgman consists of deep deposits of a loose fine sand accumulated in dune form by wind action. It is free from stone and gravel.

It occurs mainly along the shore of Lake Michigan on the established dunes, knolls and winding ridges of loose fine sand. It is liable to shift under wind action where the vegetative cover is removed.

The original vegetative cover on the more stable dunes consists of mixed hardwood and pine.

Bridgman is very similar to Wallace. It differs by its occurrence on younger dunes and by the absence of a cemented "B" horizon.

The profile of Weare is similar to Bridgman. However, the greater age of the Weare is reflected in the profile by thicker weathered horizons.

The Deer Park series is very similar to Bridgman but has a thicker leached gray "A" horizon, and a darker yellow color in the remainder of the profile. It occurs mainly along the shore of Lake Superior. The forest cover was mainly white, Norway and jack pine.

The Sauble series is also very similar to Bridgman but is recognized by the faint red color of the sand. It occurs mainly along the shore of Lake Superior. It has developed a faint soil profile. The forest cover was mainly hardwood.

Since the Weare, Sauble, Deer Park and Bridgman series are all similar, combine them with Bridgman when mapping.

Along with the soil survey, study the natural vegetation with the object of using local shrubs and herbaceous vegetation for erosion control.

Construction Information

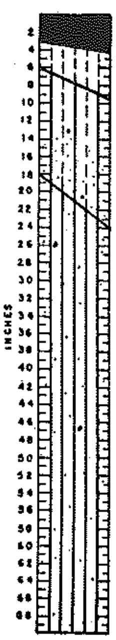
This material is considered excellent for grading operations during all seasons of the year. The loose character of the sandy material makes hauling difficult.

Figure 1. Description of Bridgman soil.

study. Such information is needed if advantage is to be taken of favorable foundation conditions to reduce the cost of highway construction.

Pavement Strength Design

Strength design methods are theoretically based on laboratory tests conducted on samples of foundation soils. No laboratory procedure has been developed, however, which will measure all of the environmental effects or assure the engineer that these laboratory test results represent the most critical condition which will be encountered under actual field conditions. This is especially true in climatic areas involving deep frost penetration and wide seasonal variations in foundation stabilities. It is at this point that engineering experience associated with natural soil formations has an opportunity to yield dividends. This correlating of soil and pavement experience which has been going on in Michigan over the last 35 years permits more accurate prediction of foundation behavior than can now be consistently developed from laboratory test values. Furthermore, this approach is cheaper and faster.



Dark gray loam containing considerable organic matter.

Gray gritty loam.

Pale reddish brown and yellowish brown loam to sandy clay mottled with yellow or rusty brown.

Has a coarse granular structure in places.

Pale reddish to yellowish gray calcareous sandy clay to clay mottled with yellow and gray extending to depths of several feet.

SOIL TYPE DESCRIPTION

Immature **Group**	Kawkawlin **Series**	Loam **Class**

The surface soil of Kawkawlin ranges in texture from a loam to a sandy loam.

Kawkawlin is characterized as an imperfectly drained soil. It has developed from a sandy clay glacial drift which has been reworked to some extent by the lake waters. It is practically free from stones.

The normal depth to water is indefinite, but seepage may occur at any depth. Layers and pockets of silt and sand with seepage water may be encountered. The soil with normal moisture content is slightly plastic and easily compacted but becomes hard when dry and soft and sticky when wet.

Kawkawlin occurs on the old clay lake bed of the eastern part of the Lower Peninsula, and is found mainly in Bay, Arenac, Midland, Gladwin and Saginaw Counties. The surface relief ranges from nearly level to gently undulating. The surface soil is gray to dark gray in color.

Kawkawlin is found in association with Wisner, Bergland and Munuscong. It represents a more advanced stage of soil development than Wisner. It has a distinct light gray sub-surface layer which is free of lime, and a "B" horizon of reddish brown mottled with rusty brown.

It is slightly better drained than Wisner, and while the organic content is fairly high, it is not as high as in Wisner.

Construction Information

Excavation in this material is not generally difficult. In wet periods the material will be slippery and difficult to haul over. The surface will crust and become hard in periods of prolonged hot dry weather. Seepage may be encountered but not extensive enough to be a serious construction problem.

Figure 2. Description of Kawkawlin soil.

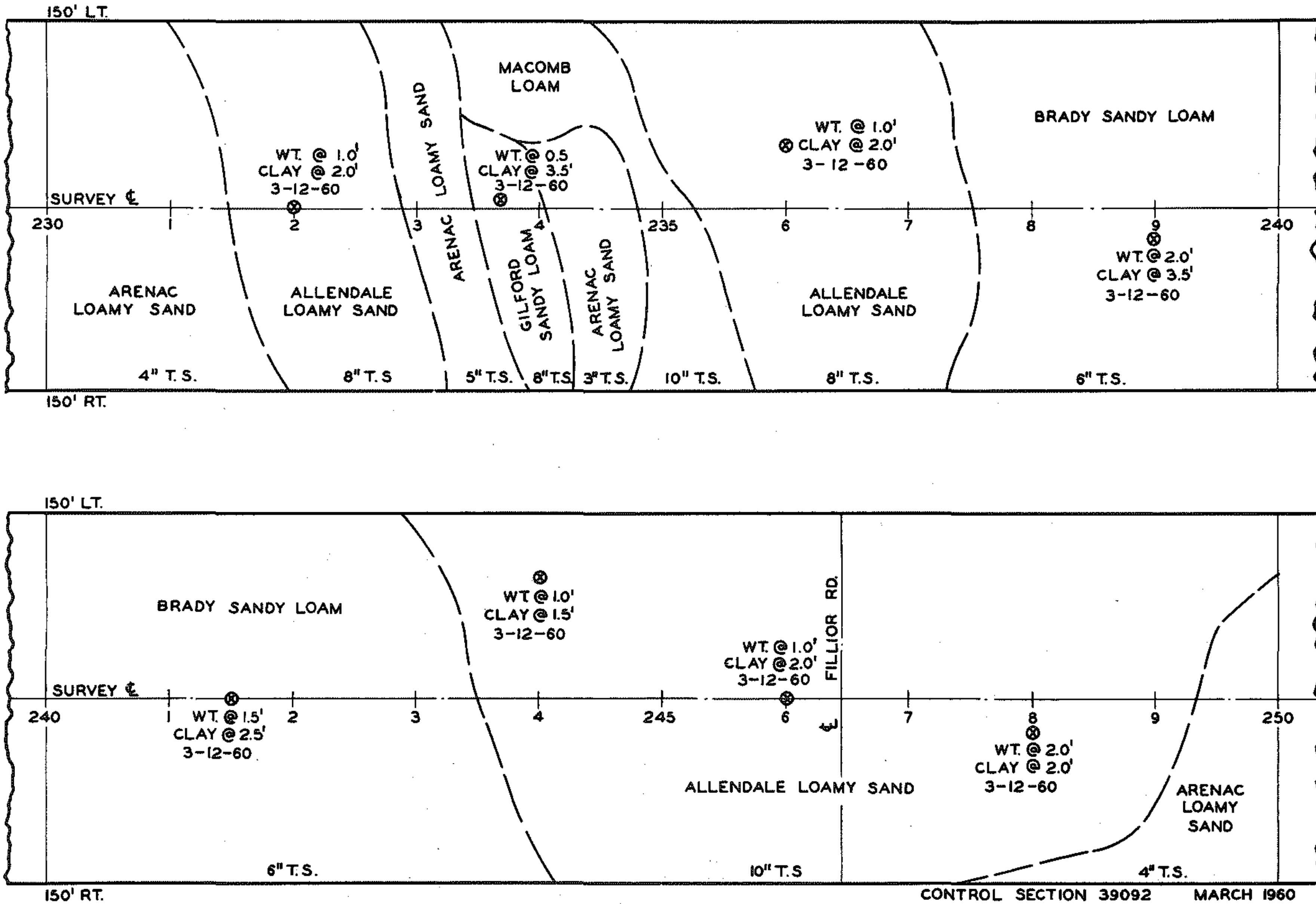


Figure 3. Sample of map used for recording general soil engineering information.

The Equivalence of Various Designs

When are rigid and flexible pavement designs equivalent with respect to strength and service life? Michigan practice in connection with this problem is based upon War Department studies carried out on a nationwide scale. This testing program included both rigid and flexible pavement types subjected to 60,000 lb wheel loads. Occasionally the two pavement types were tested side by side on the same airfield, which permitted a good comparison of both designs, especially with respect to strength. The results of this study have been used in developing design curves for equivalent flexible and rigid pavement strengths as published in the Engineering Manual for Military Construction.

Michigan Practice

It adapting the military strength design curves to Michigan highway use, it became necessary to compensate for the differences in load repetition to which airport and highway pavements are subjected. Pavement studies in Michigan indicate that this compensation can be quite accurately accomplished by assuming that a highway axle load requires the same strength design as is required by an airport wheel load. Figures 4 and 5 are design charts which translate pavement strength requirements under Michigan's conditions of soil and climate into equivalent California bearing ratio values and subgrade modulus "K" values respectively. These charts assist in a uniform application of Department policy with respect to pavement strength design.

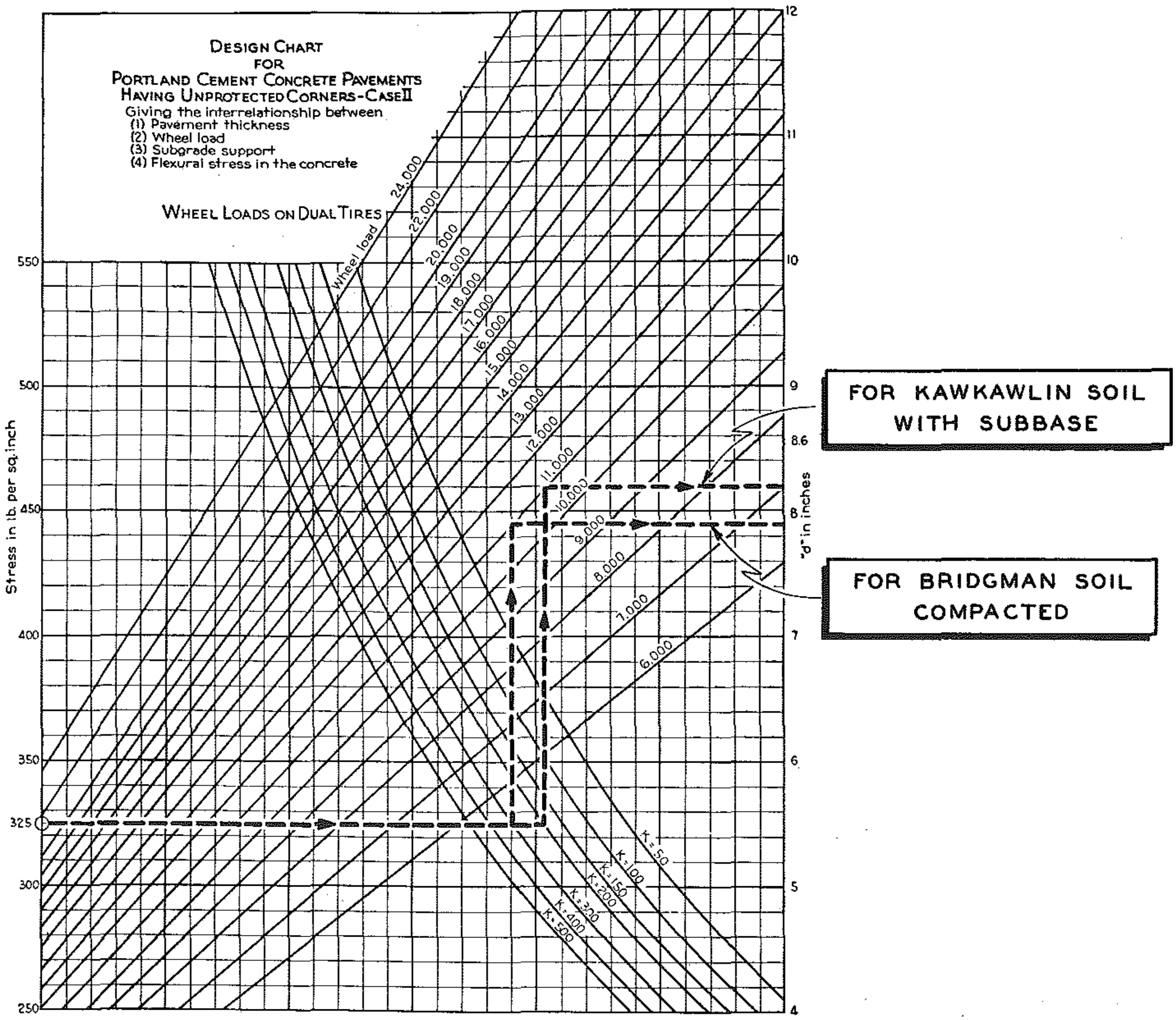
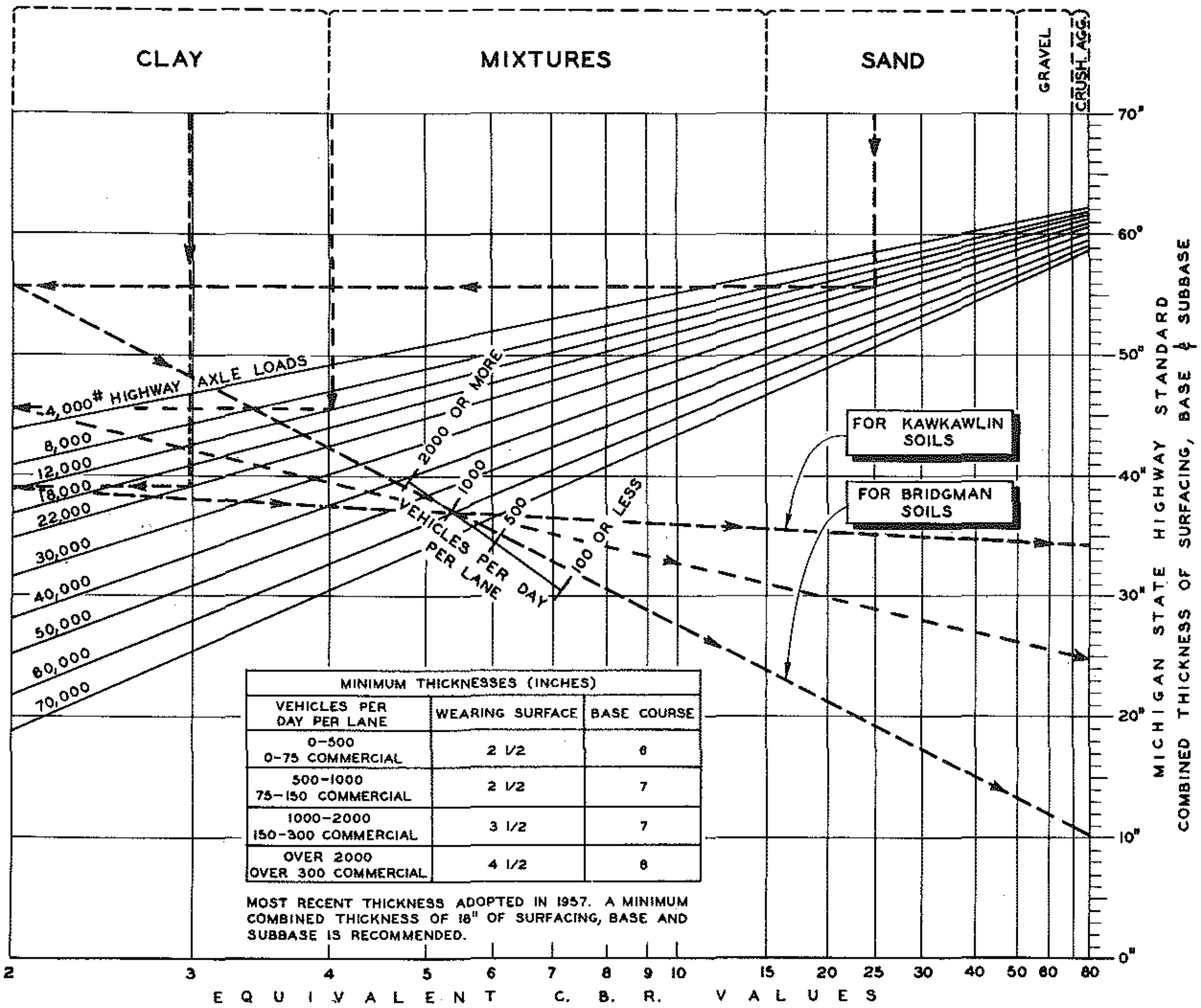


Figure 4. Design chart from "Concrete Pavement Design," (Portland Cement Association)

Figure 6 is a copy of a design standard for pavement thickness which has been developed to satisfy average conditions of climate and traffic in Michigan. The designs shown may be varied to fit climatic extremes or special soil conditions.

Cost Studies

The next step in selecting a pavement design is to develop cost figures for various pavement types based on prices which are normal for the area involved. Examples of such cost estimates are included as Exhibits A and B, illustrating costs to be expected when building over both frost susceptible soils and over non-frost susceptible soils. The degree of frost susceptibility, the likely California bearing ratio values, or the



MINIMUM THICKNESSES (INCHES)		
VEHICLES PER DAY PER LANE	WEARING SURFACE	BASE COURSE
0-500 0-75 COMMERCIAL	2 1/2	6
500-1000 75-150 COMMERCIAL	2 1/2	7
1000-2000 150-300 COMMERCIAL	3 1/2	7
OVER 2000 OVER 300 COMMERCIAL	4 1/2	8

MOST RECENT THICKNESS ADOPTED IN 1957. A MINIMUM COMBINED THICKNESS OF 18" OF SURFACING, BASE AND SUBBASE IS RECOMMENDED.

Figure 5. Equivalent C. B. R. values for flexible pavement design.

subgrade modulus "K" values for critical seasons, are estimated from the soil classification information previously referred to. With this background costs can be estimated by the station, by the mile, or for the entire project.

Other Factors to be Considered

In selecting pavement types, there are other factors to be considered in addition to construction costs. For instance, it is not practical for obvious reasons to divide a highway into short sections of different pavement types. A 20-mile section has been generally determined as the minimum length needed in order not to complicate maintenance operations. With respect to the long term cost of maintenance, there is no significant difference between flexible and rigid pavements of equivalent strength design.

Occasionally earlier construction may influence the selection of pavement type. For instance, when converting a single roadway into a dual facility, it may be prudent to duplicate the original construction rather than have parallel roadways consisting of two different materials.

Finally, there is a factor which has been referred to as an "assurance factor" which gains importance from the general need for a feeling of confidence in a product or process. This need for assurance that a design will function as intended may lead to the selection of a rigid pavement design in which surfacing aggregates are locked in place by a crystal-

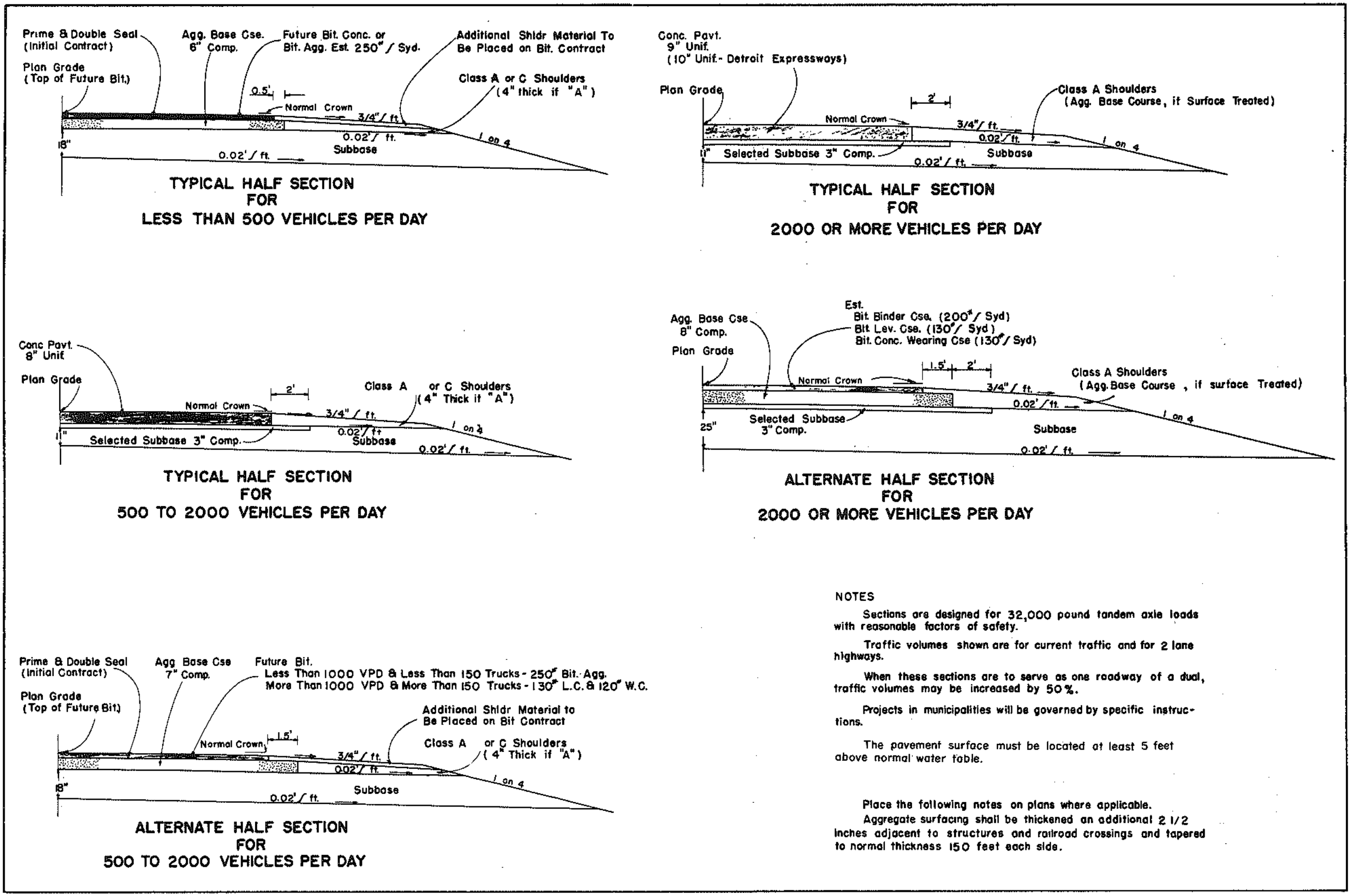


Figure 6. Typical Cross-sections as shown in book of design standards.

line structure, or to the preference for a flexible pavement design in which the wearing course is characterized mainly by toughness. In either case, this factor will always exert a strong influence on pavement selection.

Conclusion

It should be emphasized that the proper solution to a design problem does not necessarily demand the lowest construction costs. Rather it means the selection of a pavement which will yield the greatest returns per unit of investment in terms of safe, comfortable, and convenient transportation over a reasonable period of time. As a representative of the people who pay for these facilities, it is the engineer's responsibility to select the pavement type which will best satisfy this requirement.

CONSTRUCTION COSTS
(Sand Dune Location)
Exhibit A

Design Factors

Bridgman soils

Free drainage

Non-frost susceptible

California bearing ratio - 20

Subgrade modulus - 300

No subbase needed

Rigid Pavement Design

9" Portland cement concrete pavement at $4.24 per sq. yd.

Reinforcement---------------------- .65 " " "

Cost per mile of 24 ft. pavement -------------- $ 68,851.20

Flexible Pavement Design

4 1/2"	Bituminous concrete	-------$10.22 per ton ------	$ 33,113.00
8"	Aggregate base	-------------- 2.00 " " ------	12,000.00
	Extra shoulder gravel	----------------------------	3,700.00
	Prime	--	803.00
	Cost per mile of 24 ft. pavement	--------------	$ 49,616.00

24' Rigid pavement design -------------------------------- $ 68,851.00

24' Flexible pavement design ------------------------------ 49,616.00

Difference ---------------------------------- $ 19,235.00

CONSTRUCTION COSTS
(Clay Lake Bed Location)
Exhibit B

Design Factors

Kawkawlin soil series

Frost susceptible

Subject to mud pumping

Subgrade modulus "K" - 50

On subbase - 200

California bearing ratio - 3

12" subbase needed for pumping control

Rigid Pavement Design

9"	Portland cement concrete pavement at	$4.24 per sq. yd.	
	Reinforcement ----------------------	.65 " " "	$ 68,851.20
14"	Subbase - 11,156 cu. yds. at ---------	1.60 " cu. yd.	17,849.60
	Cost per mile for 24 ft. pavement -------------		$ 86,700.80

Flexible Pavement Design

4 1/2"	Bituminous concrete ---------	$10.22 per ton ------	$ 33,113.00
8"	Aggregate base ---------------	2.00 " " ------	12,000.00
28"	Subbase ---------------------	1.60 " cu. yd. --	40,550.00
3"	Extra shoulder gravel ----------	2.00 " ton ------	3,700.00
	Prime --		803.00
	Cost per mile for 24 ft. pavement -------------		$ 90,166.00

24'	Flexible pavement design ------------------------------	$ 90,166.00
24'	Rigid pavement design ---------------------------------	86,700.00
	Difference ---------------------------------	$ 3,466.00