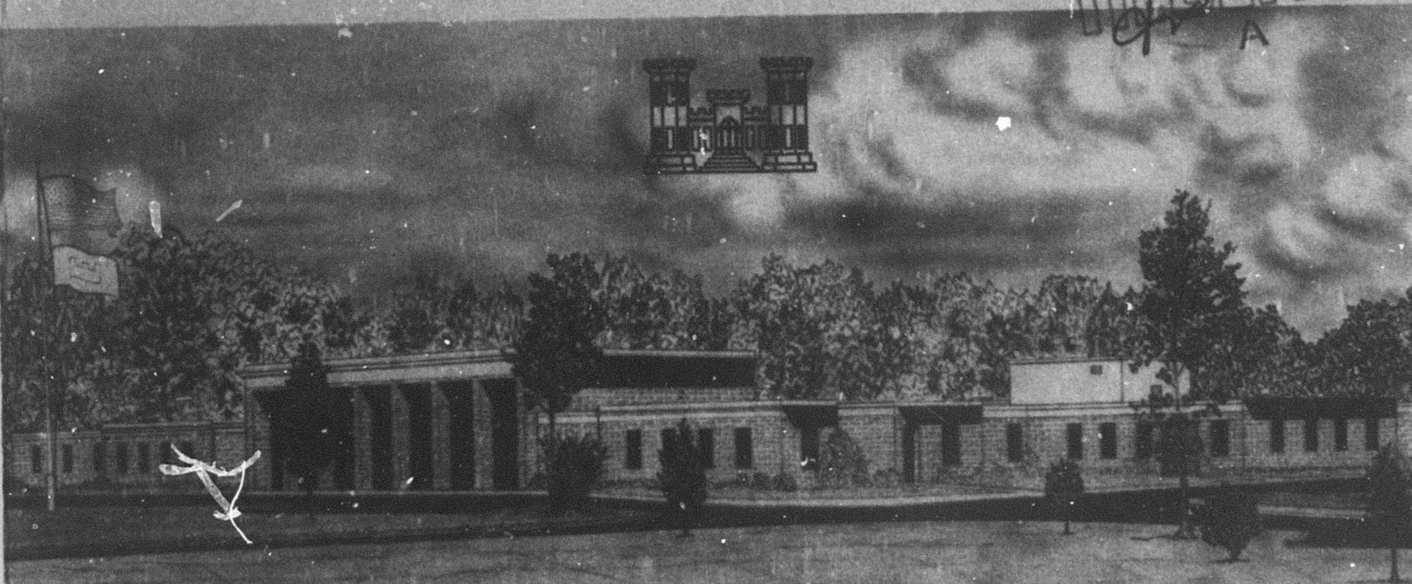
INSTRUCTION REPORT S-72-1

GEOMETRIC DESIGN OF MILITARY ROADS IN THE THEATER OF OPERATIONS (INTERIM PROCEDURE)

by

V. C. Barber, D. N. Brown



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13. ABSTRACT

This instruction report presents a procedure for rapid and definitive geometric design and evaluation of military roads in the Theater of Operations. Step-by-step procedures are presented for the design or evaluation of a facility based on the number of vehicles in the using unit or units or on the number of tons handled daily by the using activity, thus eliminating field counts or estimates.

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FOREWORD

The work reported herein was accomplished during the period March 1970-July 1971 by personnel of the U. S. Army Engineer Waterways Experiment Station (WES) under Military Engineering Design and Expedient Construction Criteria (MEDECC) Project 4A062112A859, Task 01, "Expedient Road and Storage Area Design Criteria," Work Unit 002, "Theater of Operations Highway and Storage Area Design, FY 70 and 71."

Engineers of the Soils Division, WES, who were actively engaged in the planning and criteria development phases of this study were Messrs. J. P. Sale, Division Chief, R. G. Ahlvin, R. L. Hutchinson, D. N. Brown, C. D. Burns, and V. C. Barber. This report was prepared by Messrs. Barber and Brown.

Directors of the WES during the conduct of the work and the preparation of this report were COL Levi A. Brown, CE, and COL Ernest D. Peixotto, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

CONVERSION FACTORS, BRITISH TO METRIC UNITS OF MEASUREMENT

British units of measurement used in this report can be converted to metric units as follows:

Multiply	By	To Obtain
inches	2.54	centimeters
feet	0.3048	meters
miles (U. S. statute)	1.609344	kilometers
tons (2,000 lb)	907.185	kilograms
miles per hour	1.609344	kilometers per hour

SUMMARY

This instruction report presents a procedure for rapid and definitive geometric design and evaluation of military roads in the Theater of Operations. Step-by-step procedures are presented for the design or evaluation of a facility based on the number of vehicles in the using unit or units or on the number of tons handled daily by the using activity, thus eliminating field counts or estimates.

GEOMETRIC DESIGN OF MILITARY ROADS IN THE THEATER OF OPERATIONS (INTERIM PROCEDURE)

PART I: INTRODUCTION

Background

1. The design of military roads to meet specific needs has often presented problems to field commanders due to the difficulty in obtaining data pertaining to amount and composition of anticipated traffic. Existing Theater of Operations (TO) design criteria dictate predetermination of traffic volume and composition, which is the basis for road design. Data of this type can rarely be determined in combat situations and thus must be estimated, which in turn may result in improper selection of design criteria. In addition, existing criteria for use in the design of roads do not provide for geometric design of roads to meet specific needs of various military units or activities. At the same time, the lack of a family of road designs to use as standards with which existing roads or road nets can be compared results in extensive evaluation efforts on the part of tactical or logistical planners.

Purpose

2. The purpose of this report is to present a procedure for rapid and definitive geometric design and evaluation of military roads, through knowledge of military unit or activity requirements and a broad selection of road types. Step-by-step procedures are presented for use by the designer in selecting a facility to meet his needs based on the number of vehicles in the using unit or units (defined on the following page) or on the number of tons handled daily by the using activity (defined on the following page), thereby eliminating field counts or estimates. It is intended that the data provide the military designer

with criteria and methodology that will enable him to provide rapid and adequate design and evaluation in the presence of foreseeable contingencies in military situations in the TO.

3. The value of the techniques described in this procedure lies in the fact that they can be applied in a matter of minutes once the planner has become familiar with the procedure. Literature is available for designers needing detailed information regarding any aspect of road design.[1-6] This literature also describes conventional methods of design and current criteria for roads other than the expedient types in the TO.

Definitions of Pertinent Terms

4. For clarity, certain terms used in this report are defined as follows:

a. Military road. A horizontal structure consisting mainly of a traveled way, shoulders, and drainage facilities and intended as a route of travel by ground vehicles.

b. Military streets. Horizontal structures similar to military roads but distinguished by two features:

(1) Military streets are located in areas where buildings, activities, or units are located along the streets at intervals of less than 1/4 mile.*

(2) Military streets usually accommodate traffic traveling at lower speeds than that on military roads and may incorporate parking lanes between the traveled way and the shoulder or curb.

c. Road classification system. An organized listing of five road types based upon the number of vehicles that each type is designed to accommodate in a 24-hr period. Each road type possesses the required geometric characteristics to accommodate its design number of vehicles in terms of average daily traffic.

d. Average daily traffic (ADT). The anticipated average number of vehicles per day that will use a completed facility. The ADT is the parameter that determines the number of vehicles (capacity) for which a road is designed.

* A table of factors for converting British units of measurement to metric units is presented on page vii.

e. Design hourly volume (DHV). The number of vehicles that a road may typically be expected to accommodate in an hour. In this report, the DHV is 15 percent of the ADT.

f. Design speed. The speed for which a facility was designed. Pertinent geometric features, such as horizontal curves, grades, etc., are based upon the design speed.

g. Average running speed. Speed expected to be maintained by most vehicles as an average. Average running speed is equal to total distance traveled divided by total time consumed.

h. Geometric design (geometry or geometric features). All visible features of the road, such as lane width, shoulder width, alignment, etc.

i. Sight distance restriction. Percentage of total length of road on which sight distance is restricted to less than 1500 ft.

j. Traffic composition. The parameter used to describe the types of vehicles, by percent, that make up the total traffic volume or ADT. Based on pertinent research of representative tables of organization and equipment, the composition considered representative in this report is as follows:

(1) Forty-five percent traffic by 2-1/2-ton or larger vehicles.

(2) Fifty-five percent traffic by vehicles smaller than 2-1/2 tons, including indigenous traffic.

k. Traffic unit. One hundred vehicles having the same composition as the total ADT.

l. Average daily tonnage. Total tonnage that can be moved on a given road in 24 hr. Average daily tonnage is based on the hauling capability of the ADT or of the traffic unit. Based on composition studies mentioned in subparagraph j, tonnage capacity has been determined to be 286 tons per traffic unit.

m. Military unit (for purposes of this report). A fixed organization that requires a road or street to serve its needs. When units or groups of units, such as companies, brigades, etc., are located at a single point, their demands upon a road or street should be combined for design purposes.

n. Military activity. An operation such as that which occurs at a depot, motor pool, etc., that is definable by daily activity rather than by a unit name. Selection of a road to serve its needs should be made according to tons handled per day (total movement of tonnage received or dispersed) or vehicles per day, as necessary.

Concepts

5. The procedure presented herein is based on the following concepts:

- a. The classes of roads described possess certain geometric characteristics that are required for accommodating given amounts of traffic. ADT is the basis of design, and each road or street, regardless of location, must possess certain geometric characteristics in order to perform its intended function.
- b. Each military unit or activity exerts a known demand upon the roads or streets it uses or is expected to use, and a designer can select a road or street or combinations thereof to meet this demand.
- c. A military unit's demand upon a road is a function of the number of vehicles in that unit.
- d. A military activity's demand upon a road is a function of the tonnage handled per day by that activity.
- e. ADT is directly relatable to tonnage per day.

PART II: CLASSIFICATION SYSTEM

Development

6. The road classification system presented herein has been developed on the basis of a study of traffic generated by various military units and/or activities. The traffic volumes selected as a basis for design were obtained from an extensive study of the traffic generated by the ground vehicles organic to many representative military units and activities.

Capacity

Traffic composition

7. A study was made of the characteristics (length, width, etc.) of the various vehicles assigned to the various military units considered. The objective of this study was to determine an average overall traffic composition, which required an operational area in which traffic was representative of that generated by the military units considered. Results of this study indicated that the most representative overall traffic composition should consist of traffic composed of 45 percent by 2-1/2-ton or larger vehicles (trucks) and 55 percent by vehicles smaller than 2-1/2 tons (cars).

Traffic volume

8. Analysis of the traffic generated by the military units and/or activities considered plus recognition of the ever-present possibility of emergency requirements for rapid movement have shown that the ADT generated by a specific unit or activity is approximately equal to twice the number of vehicles organic to a specific unit or to twice the number of vehicles engaged in a specific activity. Thus, the traffic volume, which should be considered in design of the road, in terms of ADT is equal to twice the number of vehicles generating the traffic. Analysis of actual traffic volume data has shown that the hourly traffic volume varies considerably over a 24-hr period according to time of day,

location, and traffic composition. As a result, it has been determined that the average hourly volume (ADT/24) is not representative of the traffic volume that will actually occur on a road during part of a 24-hr period. Further studies have shown that the traffic volume for the 30th highest hour each year best represents the traffic volume per hour. Generally, this 30th highest hour traffic volume is equal to 15 percent of the ADT. Thus, the DHV is equal to 15 percent of the ADT. The DHV has been selected as a standard unit of traffic to be a basis for geometric design in order to take advantage of the technology developed and published by the American Association of State Highway Officials[1] and the Highway Research Board.[2]

Traffic unit

9. In order to provide design criteria for roads in the TO in terms of tons per day as an alternate basis of design, a study of the relationship between traffic in terms of ADT and tons forward per day (TFD) was made. It was determined that ADT could be converted to TFD if the nature of the traffic composition were known. Further analysis showed that the basic composition of 45 percent trucks and 55 percent cars could be further divided into exact numbers of specific vehicles, and it was reasonable to assume that any group of 100 vehicles composed of 45 percent trucks and 55 percent cars would contain at least one vehicle of all types considered. This representative group of 100 vehicles has been designated a traffic unit.

Traffic in terms of tonnage

10. Analysis of the vehicles comprising the traffic unit shows that the rated cargo capacity of the unit is equal to 286 tons, or 2.86 tons per vehicle. If it is assumed that in normal logistics operations vehicles moving cargo between two locations will make the return trip empty, then one-half of the rated traffic unit capacity, 143 tons, will equal the TFD per 100 vehicles. With this logic in mind, road capacity in terms of ADT can be converted to capacity in terms of TFD as follows:

$$\mathrm{TFD} = \frac{\mathrm{ADT}}{100} \times 143 = 1.43\ \mathrm{ADT} \qquad (1)$$

Design capacity

11. Both geometric and structural design of roads in the TO will be based on the amount and type of traffic expected from military units or activities. Based on the results of studies discussed briefly in paragraphs 6-10, the following ranges of traffic volumes have been selected as being representative of basic design capacity requirements for five classes of roads in the TO:

Road Classification	Geometric Design DHV	Structural Design ADT
A	510-1000	3400-6700
B	300-510	2000-3400
C	140-300	935-2000
D	30-140	200-935
E	<30	<200

Selection of Proper Road Class

Unit requirements

12. If a road is to be constructed for the use of a specific military unit or group of units, the first step is to determine the total number of vehicles in the unit or units. This value is generally known by the key personnel of a unit or can be determined from tables of organization and equipment or by actual count. If the road to be constructed is to be a main artery with military units randomly located alongside, the combined total number of vehicles in all units should be used as the total. Once the number of vehicles has been established, the planner should then consult table 1. In columns 1 and 2 are listed several military units and the numbers of vehicles in the units, respectively. If a unit is not listed in column 1, the planner should find a value in column 2 approximately equal to the number of vehicles in the unlisted unit. Reading further to the right, the planner will find the ADT requirement for the unit and the road class (see tabulation in paragraph 11 and table 2) required for its needs, as well as an alternate set of road classes. The alternate set may be used when more than one

Given: ADT = 500 (from column 3, table 1)

Then: DHV = (0.15)(500) = 75

And: Strict interpretation of the geometric design policies for roads (shown in table 2) indicates that a class C road is required because the lower end of the range of DHV for a class D road (80-40) is less than the required DHV value of 75. However, strict interpretation of the road requirements may not be justified in all cases. Therefore, it is suggested that the completed plans for the road be checked for sight distance restrictions; that is, it should be determined what percentage of the road has sight distances less than 1500 ft. The variation, within the range shown in table 2, of DHV with sight distance restriction may be interpolated on a straight-line basis as shown in fig. 1. For instance, if the plans for the road in question show that the alignment (both horizontal and vertical) of the road is such that the sight distance restriction is 62 percent, then by interpolation the DHV would be 80 (read DHV for 62 percent sight reduction from class D interpolation line in fig. 1), and a class D road would be sufficient. However, if the interpolated DHV based on the sight distance restriction had been less than 75, then a class C road would have been required.

b. <u>Design based on TFD:</u>

Problem: Determine class of road required for moving 4000 tons of material daily.

Given: TFD = 1.43 ADT (equation 1)

$$4000 = 1.43 \text{ ADT}$$

$$\text{ADT} = \frac{4000}{1.43} = 2800$$

Then: DHV = (0.15)(2800) = 420

And: As in the example above, strict interpretation of the road requirements shown in table 2 indicates that a class A road is required because the lower end of the range of DHV for a class B road (300-510) is less than the required DHV value of 420. Again as in example a, the proposed alignment should be checked for sight distance restriction. If, for instance, the sight distance restriction is 40 percent, then the interpolated DHV is 370 (see fig. 1) for a class B road. Because this value is less than the required DHV of 420, the class A road originally selected is required.

PART III: GEOMETRIC DESIGN

Features

15. Certain features of a road must be considered in geometric design in order to provide sufficient operating area for the volume of traffic for which the road is designed. These features along with relative maximum or minimum values are given in table 2 for a range of traffic volumes.

Road Requirements

16. Requirements for typical military units in terms of road classifications are shown in table 1. Column 1 shows typical military units; column 2 shows the number of vehicles assigned to each unit; column 3 shows ADT, which is approximately twice the number of vehicles assigned to each unit (see paragraph 8); column 4 shows number of traffic units; column 5 shows road class (from table 2); and column 6 shows alternate combinations of various road classifications with total capacity equal to the capacity of the road class shown in column 5.

Geometric Design Examples

17. It is absolutely essential that the values shown in table 2 for each geometric feature be attained to ensure that the road will have a capacity equal to or greater than the minimum DHV shown in the table. Where feasible, values less than the maximum but greater than the minimum value (except for the cross slope value) shown should be used. By judicious selection of values for each feature, the capacity of the road may approach the maximum traffic volume shown. For purposes of demonstrating the use of the information presented in tables 1 and 2 in geometric design of roads, the following examples are given:

a. Design based on ADT:
Problem: A road is to be designed to serve a transportation light truck company.

18. Guidance relative to design and placement of curbs, medians, guardrails, guideposts, and earth slopes is shown in figs. 2 and 3.

19. The procedure for the design of streets is the same as that for the design of roads. However, the normal flow of traffic on streets may be reduced considerably by interruption of cross traffic at intersections and in zoned areas. If it is anticipated that the average running speed on a substantial length of street will be appreciably less than that shown for classified roads in table 2, the capacity (DHV) should be reduced in accordance with the following tabulation:

Average Running Speed, mph	Capacity (DHV) in Percentage of Values Shown in Table 2
30	100
25	95
20	87
15	72

PART IV: THICKNESS REQUIREMENTS

20. For the convenience of the planner, calculations have been made to determine the thickness requirements for roads surfaced with flexible pavement and for unsurfaced roads for each of the classified roads described in table 2. These thicknesses are shown in table 3. Those thicknesses shown for flexible pavement are based on the volume of traffic (ADT) shown for each road class in table 1 and are for a design life of 10 years. Those thicknesses shown for unsurfaced roads are based on the same traffic volume (ADT) and are for a design life of 2 years. Test procedures for determining the CBR design values given in table 3 are presented in detail in reference 7.

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1. American Association of State Highway Officials, "A Policy on Geometric Design of Rural Highways," 1965, Washington, D. C.

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4. Departments of the Army and Air Force, "Planning and Design of Roads, Airbases, and Heliports in the Theater of Operations," Technical Manual 5-330, Sep 1968, Washington, D. C.

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6. Brown, D. N. and Ahlvin, R. G., "Revised Method of Thickness Design for Flexible Highway Pavements at Military Installations," Technical Report No. 3-582, Aug 1961, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

7. U. S. Department of Defense, "Test Method for Pavement Subgrade, Subbase, and Base-Course Materials," Military Standard MIL-STD-621A, Dec 1964, Washington, D. C.

Table 1

Recommended Road Requirements for Military Units or Activities

Unit or Activity				Road Requirements	
		Capacity**			
Unit Type*	No. of Vehicles Per Military Unit	ADT	Traffic Units	Recommended Road Class	Alternate Combinations
Armored Division	5454	10,900	109	A & A	(B,B,B)(C,C,C,C,B) (B,C,C,C,D,D)
Infantry Division	4200	8,400	84	A & B	(B,B,C)(C,C,C,C,D)
Infantry Division minus two Brigades	3208	6,400	64	A	(B,B)(B,C,C) (C,C,C,C)
ABN Division	1756	3,500	35	A	(C,C)(B,D)(B,E)
Two Infantry Brigades	992	2,000	20	B	(D,D)(D,C)
Infantry Brigade	496	1,000	10	C	(D,E)(E,E,E,E,E)
Corps Signal Battalion	341	700	7	D	(E,E,E,E)
Transportation Light Truck Company	269	500	5	D	(E,E,E)
Engineer Battalion (C)	199	400	4	D	(E,E)
Supply and Transportation Battalion	144	300	3	D	(E,E)
Field Artillery Battalion	105	200	2	D	(E)
Infantry Battalion Armored Division	100	200	2	D	(E)
Transportation Heavy Truck Company	39	100	1	E	†
Hq and Hq Company Brigade	24	50	1	E	†

* If a unit is not listed, consult column 2 for a vehicle amount approximately equal to that for the unit in question.

** ADT capacity requirement per military unit is equal to twice the number of vehicles in the unit rounded off to the nearest 100 vehicles. (A traffic unit is equal to ADT divided by 100).

† When ADT is to be less than class E capacity, road may be built to standards less than class E standards by use of pioneer methods.

Table 2

Geometric Design Policies for Military Roads

Design Controls and Elements	Class A (4 Lane)	Class B (2 Lane)	Class C (2 Lane)	Class D (2 Lane)	Class E (1 Lane)
Design Controls					
Traffic composition					
ADT (45% trucks)	3400-6700	2000-3400	935-2000	200-935	Under 200
DHV (1)	510-1000	300-510	140-300	30-140	Under 30
Sight distance restriction, % (2)	40-0	60-0	80-20	80-40	100
Design speed, mph	60	60	50	40	30
Average running speed, mph	45	45	40	35	25
Cross-Section Elements					
Pavements (3)					
Min width of traffic lane, ft					
With barrier curb	12	12	11	10	10
Without barrier curb	12	12	11	10	10
Min dist between curb faces, ft	53	29	27	25	15
Lateral clearance from edge of traffic lane to obstructions, ft	6	6	6	6	4
Normal cross slope, in./ft	1/8-1/4	1/8-1/4	3/16-3/8	1/4-1/2	1/4-1/2
Curbs (4)					
Types	← See fig. 2 →				
Offset for barrier curbs, ft	2.5	2.5	2.5	2.0	2.0
Medians (5)	See fig. 2	None	None	None	None
Shoulders	There should be a color or texture contrast between traffic lane and shoulder surfaces				
Min width without barrier curbs, ft	10	10	6	6	4
Normal cross slope, in./ft	1/2-3/4	1/2-3/4	1/2-3/4	1/2-3/4	1/2-3/4
Type (permanent road)	Dustless	Stable (see fig. 2)	Select material	Compacted soil	Compacted soil
Guardrails, guideposts, and earth slopes	← See fig. 3 →				
Bridge clearance (permanent)	Width of traveled way should be equal to width of lanes plus 5 ft (2.5 ft each side); 14.75-ft vertical clearance				
Alignment Elements					
Sight distance					
Min stop sight dist, ft	475	475	350	275	200
Min pass sight dist, ft	NA	2100	1800	1500	NA
Horizontal alignment					
Max horizontal curvature, deg (6)	5.5	5.5	8.9	14.5	26.7
Pavement widening, ft (7)	None	None	2-3	2-4	2-5.5
Vertical alignment					
Grade					
Max grade, %	6	6	8	10	15
Critical length, ft (8)	700	700	550	450	250
Min grade, %	0.3	0.3	0.3	0.3	0.3
Vertical curve lengths (9)					
Crest vertical curve, k	160	160	85	55	28
Sag vertical curve, k	105	105	75	55	35
Absolute min length, ft	180	180	150	120	80

Remarks

(1) The DHV shown for all roads is in total vehicles per hour for all lanes in both directions. The DHV is approximately 15 percent of the ADT

(2) The values shown for this term indicate the combined effects of horizontal (curves) and vertical (grade) alignment on capacity. A value of zero percent indicates an absolutely straight, flat alignment with no restriction on sight distance. A value of 100 percent indicates a road with numerous sharp curves and grade changes on which the sight distance is less than 1500 ft at any point on the road

(3) If the anticipated traffic includes a significant number of vehicles wider than 8.5 ft, the traffic lanes should be widened the amount by which the vehicle width exceeds 8.5 ft

(4) Curbs will generally not be provided in open areas

(5) Opposite-lane traffic on multilane roads should be separated by medians when feasible

(6) Values shown were calculated on basis of maximum superelevation of 0.1 ft/ft

(7) Pavement widening for a class C road varies from 2 to 3 ft as the curvature varies from 5 to 8.9 deg. Pavement widening for a class D or class E road varies 2 to 5.5 ft as the curvature varies from 2 to 26.7 deg. Values obtained may be rounded off to the nearest 0.5 ft

(8) The term critical length is used to indicate the maximum length of a designated upgrade upon which a loaded truck can operate without an unreasonable reduction in speed. Critical lengths may be increased at an approximate rate of 50 ft per percent decrease in grade from the values shown

(9) The minimum lengths of vertical curves are determined by multiplying k by the algebraic differences in grades (in percent)

General notes:

When roads are to be located in built-up areas (i.e., when roads can be classified as streets), the speed limits may be reduced as desired. Parking lanes along streets should be 9 ft wide and should be distinguishable from the traffic lanes

As can be seen, capacities are shown as a range of values. If maximum (or minimum) design values shown are rigidly adhered to, then the resultant capacity of the road will be on the lower side of the capacity range. Therefore, discretion should be used in selecting design values by avoiding maximums or minimums whenever possible

Turnouts should be provided at 1/4-mile intervals on Class E roads

NA - not applicable

Table 3

Thickness Requirements for Flexible Pavement and Unsurfaced Roads

Road Class and Type	Thickness Required, in., at Indicated CBR Design Value*														
	2	3	4	5	6	7	8	10	12	15	20	25	30	40	50
A Flexible pavement	48	37	31	27	24	22	19	16	14	12	9	8	7	5	4
Unsurfaced soil	34	26	22	19	17	15	14	11	10	8	6	5	5	0	0
B Flexible pavement	48	37	31	27	24	22	19	16	14	12	9	8	7	5	4
Unsurfaced soil	34	26	22	19	17	15	14	11	10	8	6	5	5	0	0
C Flexible pavement	47	36	30	26	23	21	18	15	13	11	8	7	6	4	3
Unsurfaced soil	33	25	21	18	16	14	13	11	10	8	6	5	5	0	0
D Flexible pavement	44	35	28	25	22	20	18	15	13	11	8	7	6	4	3
Unsurfaced soil	31	25	21	18	15	14	13	11	9	7	6	5	0	0	0
E Flexible pavement	43	32	26	23	20	18	17	13	12	10	8	7	6	4	3
Unsurfaced soil	30	23	19	17	15	13	12	10	8	7	6	5	0	0	0

* Test procedures for determining the CBR design values are presented in detail in reference 7.

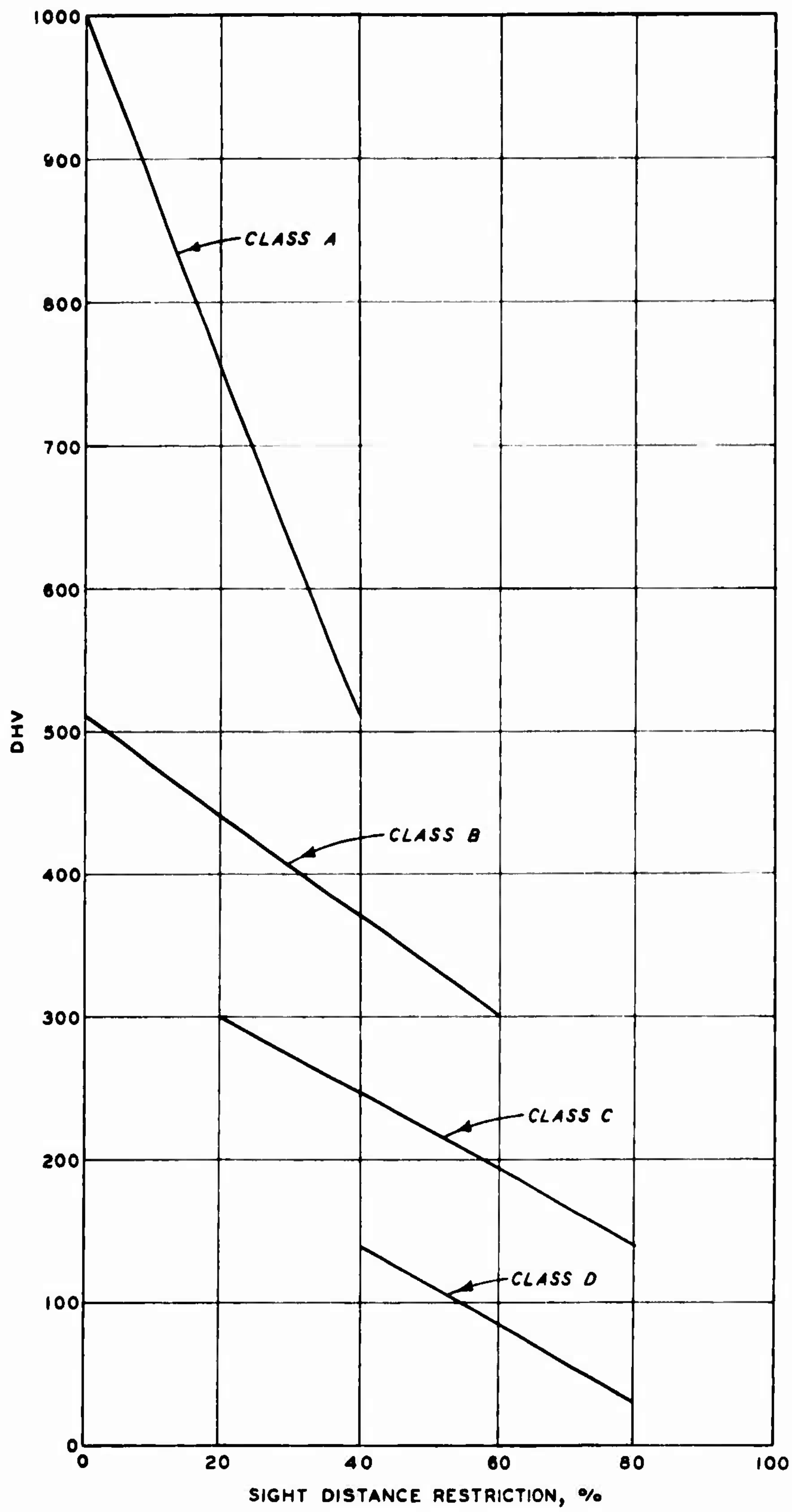
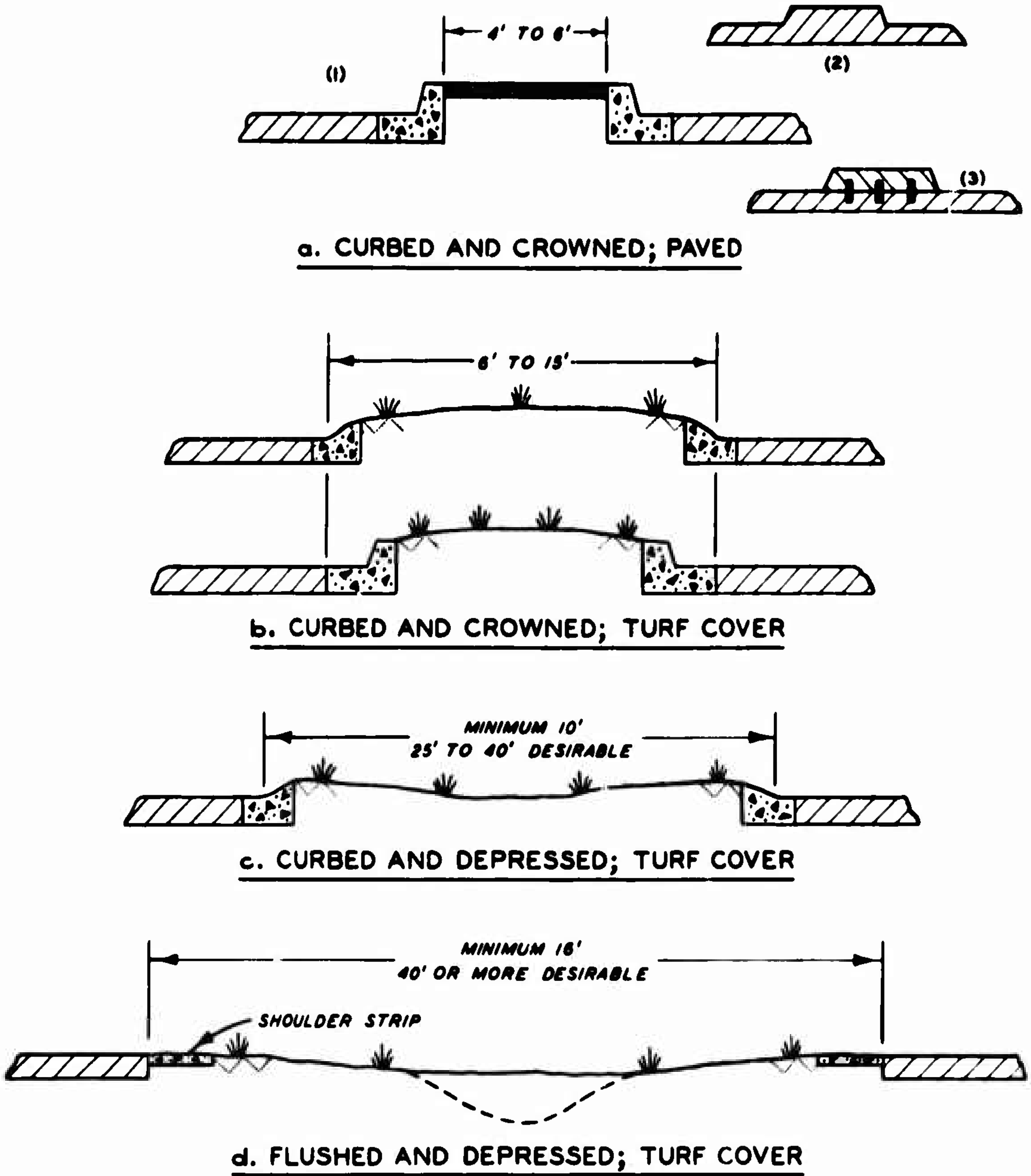


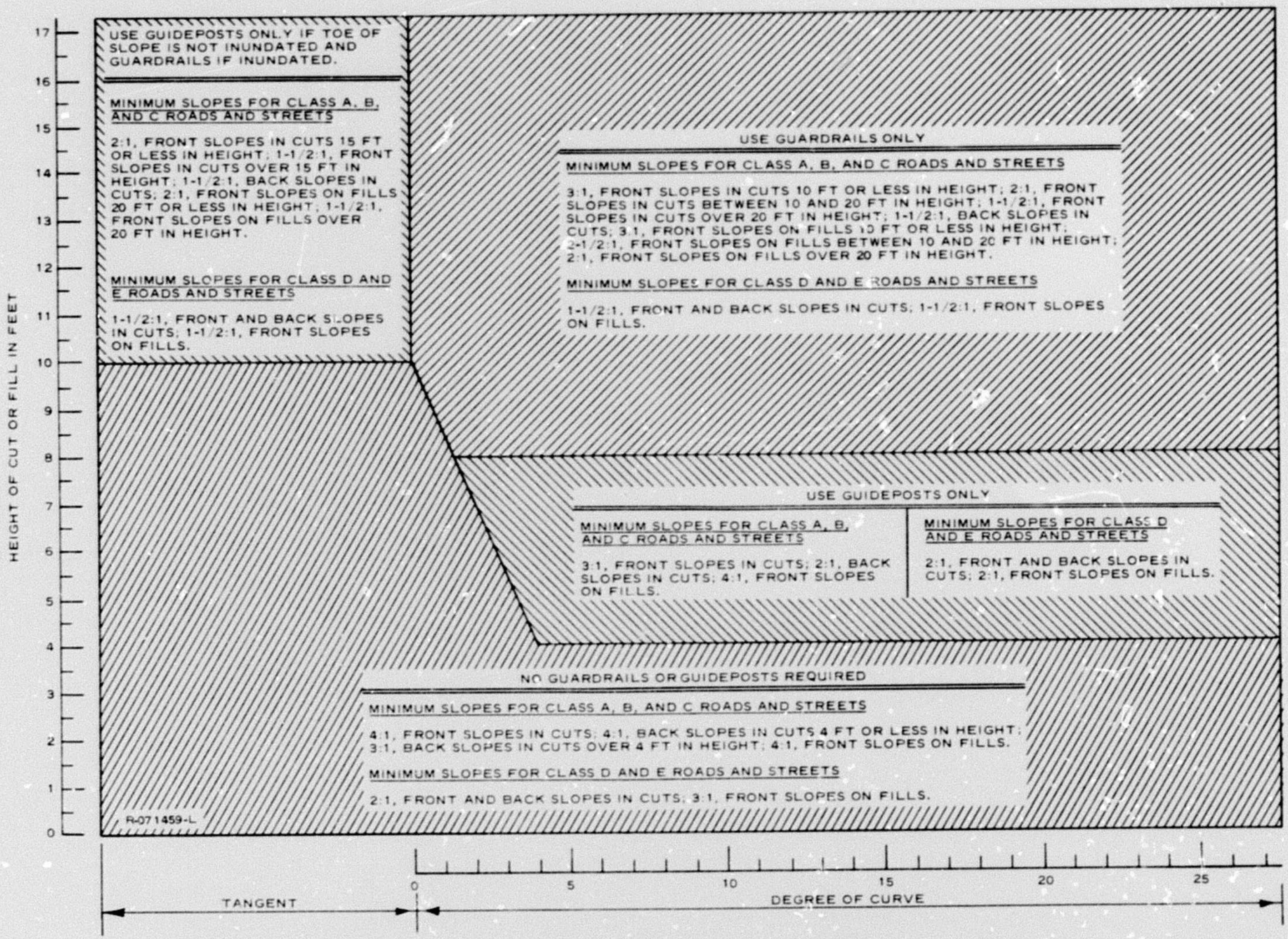
Fig. 1. Interpolation of DHV for selection of road class



NOTES: a. CURBS AND PAVED MEDIAN MAY BE MONOLITHIC AS IN a(2), OR MAY BE SURFACE-MOUNTED ON MONOLITHIC PAVEMENT AS IN a(3). IF SURFACE-MOUNTED, THE CURB-AND-MEDIAN SLAB MUST BE ANCHORED OR BONDED TO THE PAVEMENT (FIGURE a(3)).

a THROUGH d. ALL MEDIANS LESS THAN 10 FEET WIDE SHOULD BE DESIGNED WITH BARRIER CURBS. IF VEGETATION IS TO BE MAINTAINED ON MEDIAN, OR IF SNOW REMOVAL WILL BE REQUIRED, THE MINIMUM WIDTH OF MEDIAN SHOULD BE 10 FEET. SEPARATING GUARDRAILS WILL BE INSTALLED IN MEDIANS IF JUSTIFIED BY TRAFFIC CONDITIONS.

Fig. 2. Median cross sections



NOTE: 1. GENERALLY THE DEPTH OF CUT ADJACENT TO ROADS AND STREETS SHALL NOT BE GREATER THAN 6 FT BELOW THE GRADE LINE OF THE OUTSIDE EDGE OF THE SHOULDER. GREATER DEPTHS MAY BE USED WHEN SPECIFICALLY APPROVED BY THE OFFICE, CHIEF OF ENGINEERS.

2. CUTS IN SOLID ROCK OR LOESS SHOULD HAVE VERTICAL SIDE WALLS; THEREFORE, NO BACK SLOPE WILL BE REQUIRED IN THESE MATERIALS.

Fig. 3. Design policy for guardrails, guideposts, and earth slopes