Capacities of Narrow Streets with Manual Control And Signal Control

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● THIS paper reports on the capacities of narrow streets at Fort Belvoir, Virginia, as determined by field survey of capacities at intersections.

Capacities of approach lanes of intersections are presented as percentage overloads above practical capacity under local conditions, the latter being calculated according to Highway Research Board formulas published in the Highway Capacity Manual.

The general significance of the paper lies in the fact that it presents data bearing upon possible extension of the curves in Figure 24 of the Highway Capacity Manual entitled, "Average Reported Intersection Capacities for Two-Way Streets."

BACKGROUND

In recent years the Department of Defense has been stimulating the preparation of master plans for future development of Army, Navy and Air Force permanent installations. The master plan work has included surveys and the preparation of maps recording existing conditions. Information on existing conditions is taken as a starting point for preparation of a master plan.

Until recently the survey and recording of existing conditions had not extended into the field of comprehensive traffic surveys. One of the early ventures in this direction was the letting of a special contract for a comprehensive traffic survey[1] at Fort Belvoir, Virginia. The results of the traffic survey were to be used, along with other portions of the master plan work, in developing a master plan of streets and roads for the fort. The contract referred to was let by the Corps of Engineers, U.S. Army, Office of the District Engineer, Washington District, Washington, D.C., to the firm of Groll-Beach and Associates, Architects and Planning Engineers, Washington, D.C. Field work was carried on in July and August of 1953, and the report published under the title, "Vehicular Traffic Survey and Master Plan of Streets and Roads, Fort Belvoir, Virginia, September 1953."

EXTRAPOLATION OF FIGURE 24, HCM

In order to apply Highway Research Board formulas to the narrow streets of Fort Belvoir, it was necessary first to extrapolate the appropriate curves on the graph of average reported intersection capacities published as Figure 24 of the Highway Capacity Manual. In this figure as published the curves do not extend to streets of narrower width than thirty feet, while most of the streets in Fort Belvoir are between eighteen and twenty four feet wide.

The curves selected for extrapolation were the "intermediate with parking prohibited" and the "outlying or rural." Belvoir streets are generally too narrow to permit on-street parking; there is not enough pedestrian traffic nor enough closely developed building frontage to justify a downtown classification; and in many cases the absence of curb and gutter and the open character of adjoining land make the outlying or rural classification quite accurate.

Advice was sought from several experts as to the character of an appropriate extrapolation (See Fig. 1). Using a 20 ft. wide street as a check point, Mr. O.K. Normann, co-author of the Highway Capacity Manual, suggested a figure of 400 vehicles per hour of green, Mr. Prisk of the Bureau of Public Roads 450, and Mr. Henry Evans, editor of the Traffic Engineering Handbook, 540. An intermediate figure of 500 was adopted and the two curves were extended in a straight line to that point.

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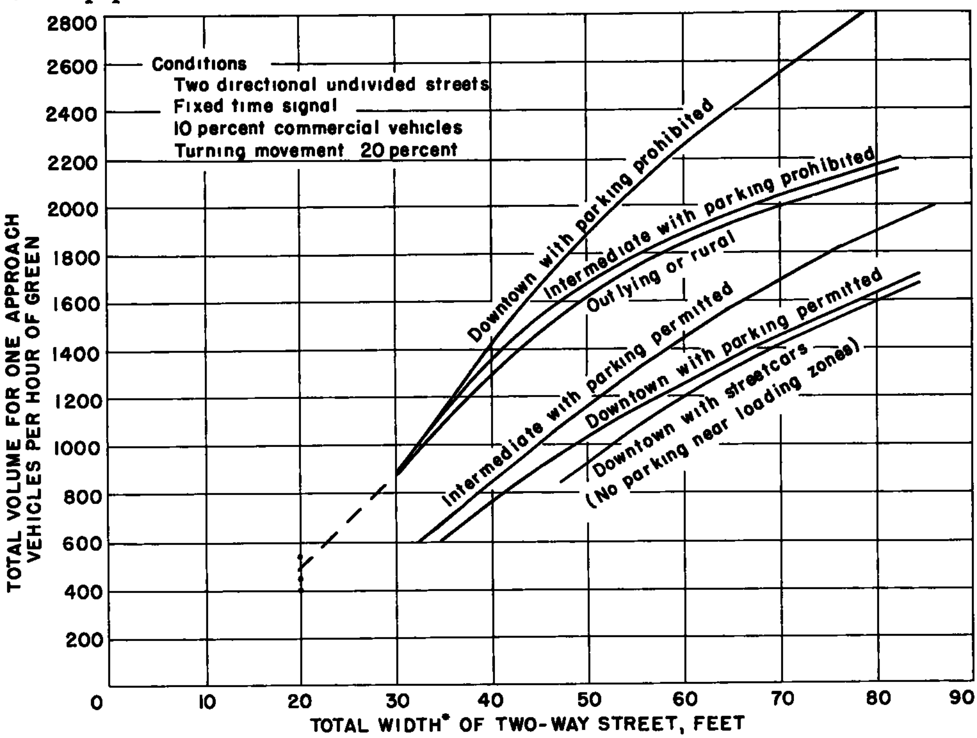
[1]Street and intersection traffic volumes and capacities, speed-and-delay, origin-and-destination, accident, parking, signs and markings, signal operation.

CALCULATION OF PRACTICAL CAPACITY FOR LOCAL CONDITIONS

Practical capacities under local conditions were calculated according to the formulas of the Highway Capacity Manual, using the extrapolated curve reduced ten percent to practical capacity, and using field data on widths of approach lanes, percents of commercial vehicles, right turns and left turns, presence of parking and bus stops, and minutes of green time. Details of these calculations are presented in Table 7 at the end of the paper.



*Includes street space occupied by parked vehicles, car tracks, and loading platforms if any

Figure 1. Average reported intersection capacities for two-way streets by type of area and parking regulation. (See text for description of annotations).

OVERLOADS

When measured flows were compared with calculated practical capacities, and the excess designated overload, the following percentage overloads were found to exist during the peak hour:

TABLE 1

PEAK HOUR OVERLOADS ON APPROACHES TO INTERSECTIONS, IN ORDER OF SIZE

No. of approaches	Overload (percent)
1	100
3	80
1	70
1	60
3	50
3	30
2	20
1	10

These data are presented graphically in Figure 2, a bar chart in which each horizontal bar represents one overloaded approach to an intersection. The outlined portion of the bar, on the left side of the figure, represents capacity in use, in each case this being 100 percent of practical capacity for local conditions, except for one factor. Only five of these approaches were controlled by fixed time signals. Practical capacities for the other ten were calculated as though they were controlled by fixed time signals. The solid portion of each bar, on the right side of the figure, represents

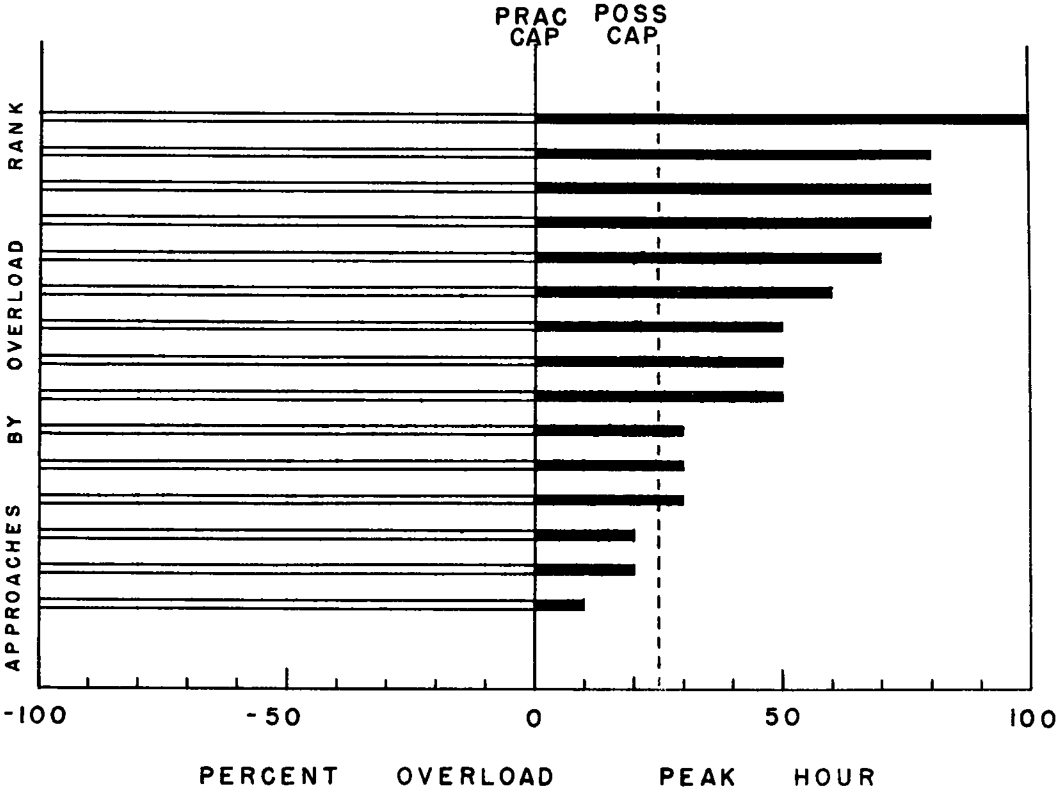


Figure 2. Peak hour overloads on approaches to intersections, in order of size.

actual traffic flow in excess of calculated practical capacity.

The vertical dashed line represents the limit of possible capacity under the formula that practical capacity is about eighty percent of possible capacity. The reciprocal of this relationship is that possible capacity is about 125 percent of practical capacity.

The bar chart indicates a fairly even distribution of overloads through the range from ten to 100 percent. As a check on this general impression, however, another bar chart showing frequency distribution of overloads by ten percent classes is given in Figure 3. This chart indicates that there is no pronounced concentration of overloads at any point in the general range of overloads.

When the peak hour overloads are segregated according to the type of control exercised at intersections, the following breakdown is obtained:

TABLE 2

PEAK HOUR OVERLOADS ON APPROACHES TO INTERSECTIONS, BY TYPE OF CONTROL

Type of control	No of approaches	Overload (percent)
Military police[1]	1	100
	1	80
	1	70
	3	30
Traffic actuated signal	1	80
	1	60
	1	50
Fixed time signal	1	80
	2	50
	1	20
	1	10
None	1	20

[1] Either by direct manual control or by pushbutton operation of signals

The same results are presented graphically in Figure 4.

It will be noted from these data that intersection approach capacity under conditions of overloading appears to vary directly with the degree to which traffic control devices can respond to excessive traffic demands.

Figure 5, which is Plate 16 from the final report, shows the manner in which peak hour overloads were presented in map form. In this figure north lies to the left, the Potomac River is to the right, the Belvoir peninsula is bounded by Dogue Creek at the top and Accotink Bay at the bottom. The

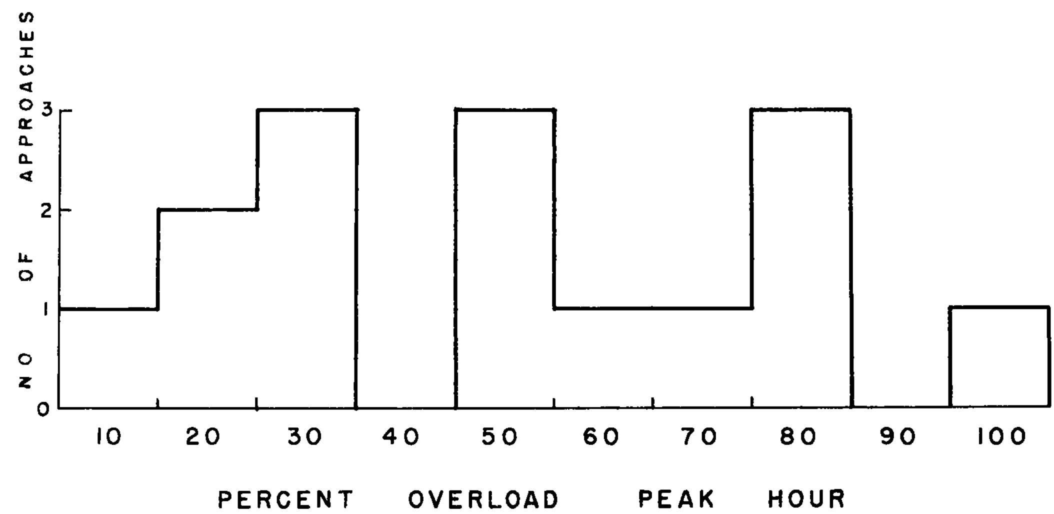


Figure 3. Frequency distribution of peak hour overloads on approaches to intersections, by size of overload.

Washington-Richmond highway, US 1, runs vertically through the figure at the left third point. The Main, or South Post lies to the right of US 1, the smaller North Post to the

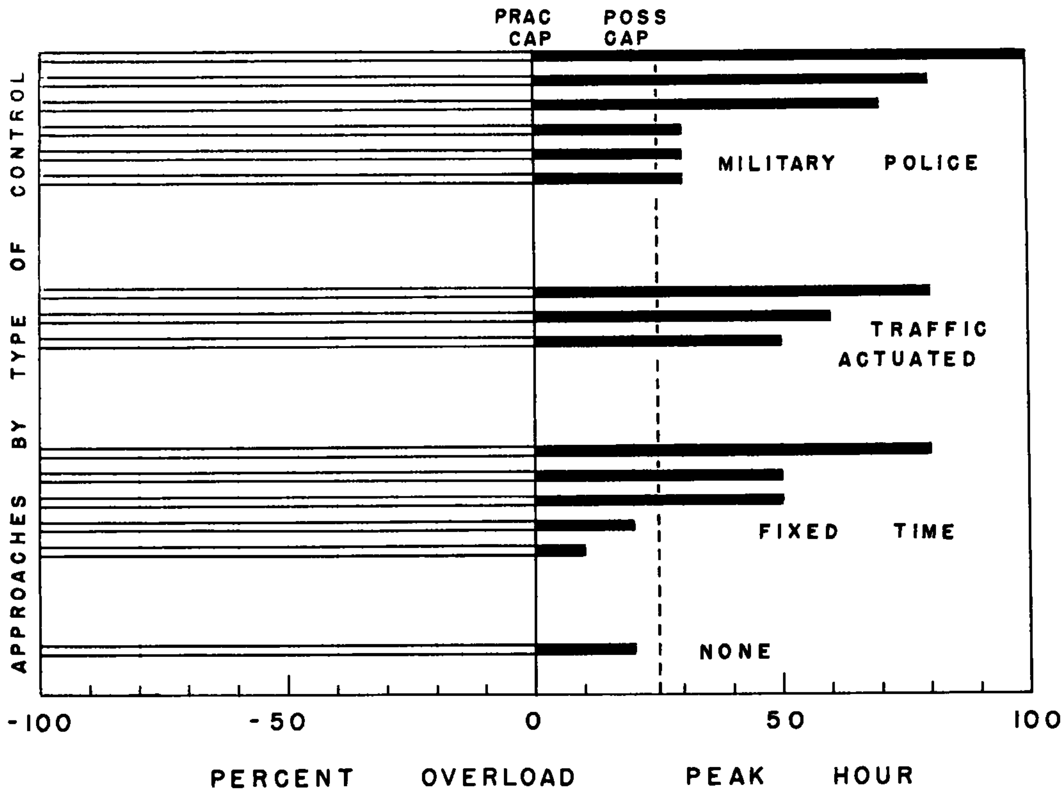


Figure 4. Peak hour overloads on approaches to intersections, by type of control.

left. The upper horizontal road is Belvoir Road, the main entrance to the fort. The lower horizontal road is Gunston Road which overpasses US 1 to connect North and South Posts.

Of the color annotations, white indicates the intersections which were studied; dark tone, capacity in use; light tone, capacity available but not used; and black, recorded flow above capacity, or overload. Colored bands for one approach to an intersection are carried back along the approach road to the approximate midpoint between the intersections studied. On some of the less important intersections, unused capacity is not shown.

The relative widths of the dark tone and black bands show the degree of overloading, while the actual width of the black band shows the volume of traffic passing through the intersection as overload.

The data presented thus far symbolize aggregate overloads during the peak hour without revealing variations in the degree of overloading during the hour. It is by no means certain that all these approaches were loaded on each cycle or go period during the peak hour. Specific field records were not kept on this point. Based upon general knowledge of traffic conditions at the fort, it is believed, however, that at least one approach was definitely not loaded on all cycles, and that five others were probably not loaded on all cycles. The peak hour analysis has been made primarily to permit correlation of these data with other peak hour figures such as those given in the Highway Capacity Manual.

TABLE 3

PEAK 15 MINUTE OVERLOADS ON APPROACHES TO INTERSECTIONS, IN ORDER OF SIZE

No. of approaches	Overload (percent)
1	260
1	210
1	200
1	190
1	170
1	160
1	140
1	130
1	110
3	100
1	90
1	80
1	70
3	60
1	50
1	40
3	30
6	20
2	10

For the purpose of calculating and designing the required enlargement of intersections at Fort Belvoir, a comparable analysis of peak 15 minute data was made.

Thirty-one approaches to intersections were found to be loaded above calculated practical capacity under local conditions. Overloads ranged from ten to 260 percent. Table 3 and Figure 6 show these overloads arranged according to rank, while Figure 7 shows the frequency distribution of overloads in ten percent bands. Generally speaking, the heaviest grouping of overloads comes in the zero to 100 percent band; there is a marked reduction in the 100 to 200 percent band; and only two items fall in the 200 to 300 percent band. When the peak 15 minute overloads are arranged according to type of traffic control at intersections, the same sequence is observed as with peak hour data, that the highest overloads are obtained under military police control, the next highest with traffic-actuated signals, and the lowest, aside from uncontrolled approaches, with fixed-time signals. Table 4 and Figure 9 show the details of arrangement by type of control. The greater relative size of the group of approaches under military police control is due to the fact that the post has only one traffic-actuated and two fixed-time signals. As more intersections become overloaded during thirty or forty-five minute rush periods, more military police teams are assigned to rush hour traffic control.

Figure 8 shows the peak 15 minute overloads in map form. It is readily apparent that percentage overloads are higher than during the peak hour and that more approaches are overloaded.

SIGNIFICANCE OF THE FINDINGS

Since the primary purpose of this paper is to present the findings rather than to an-

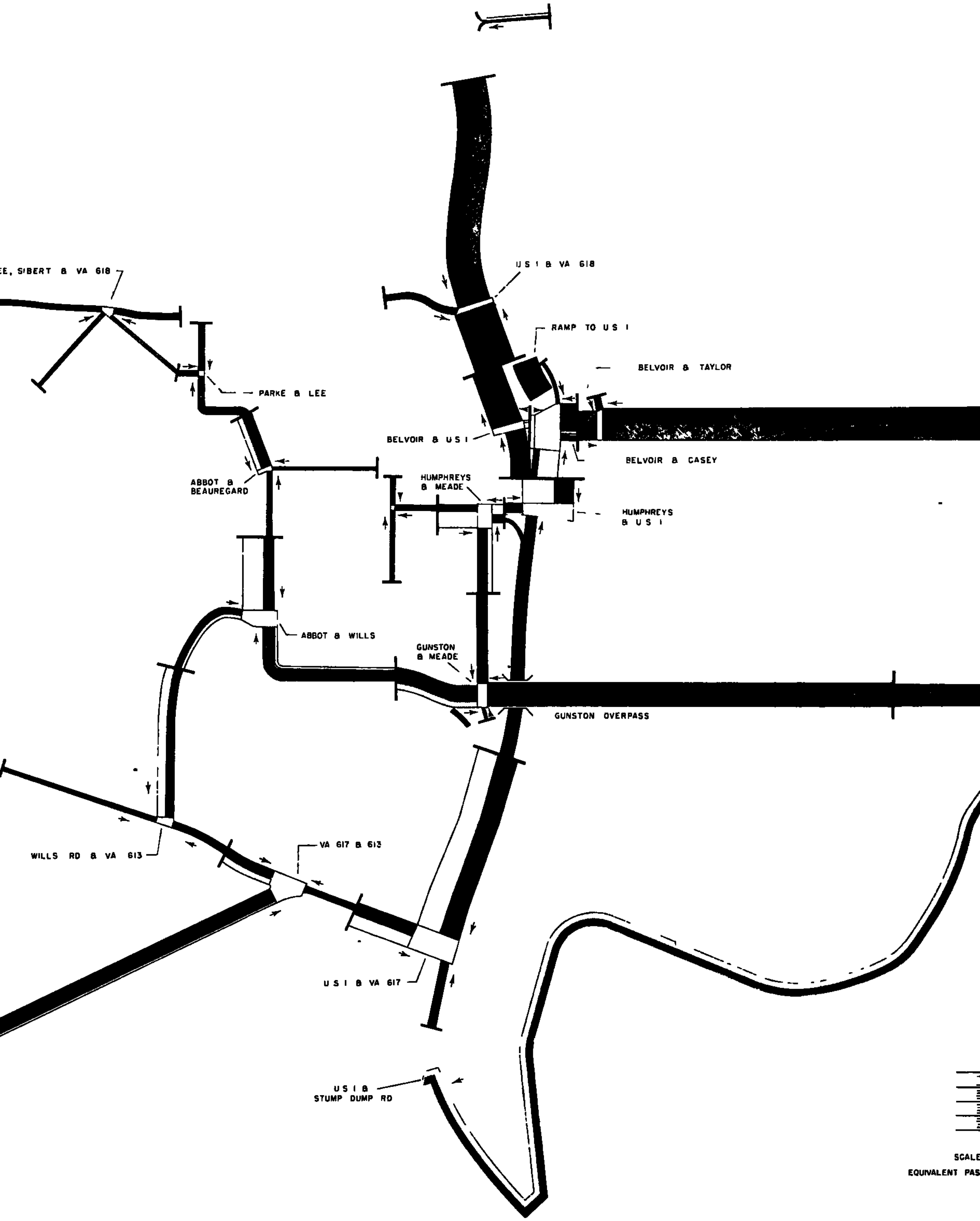
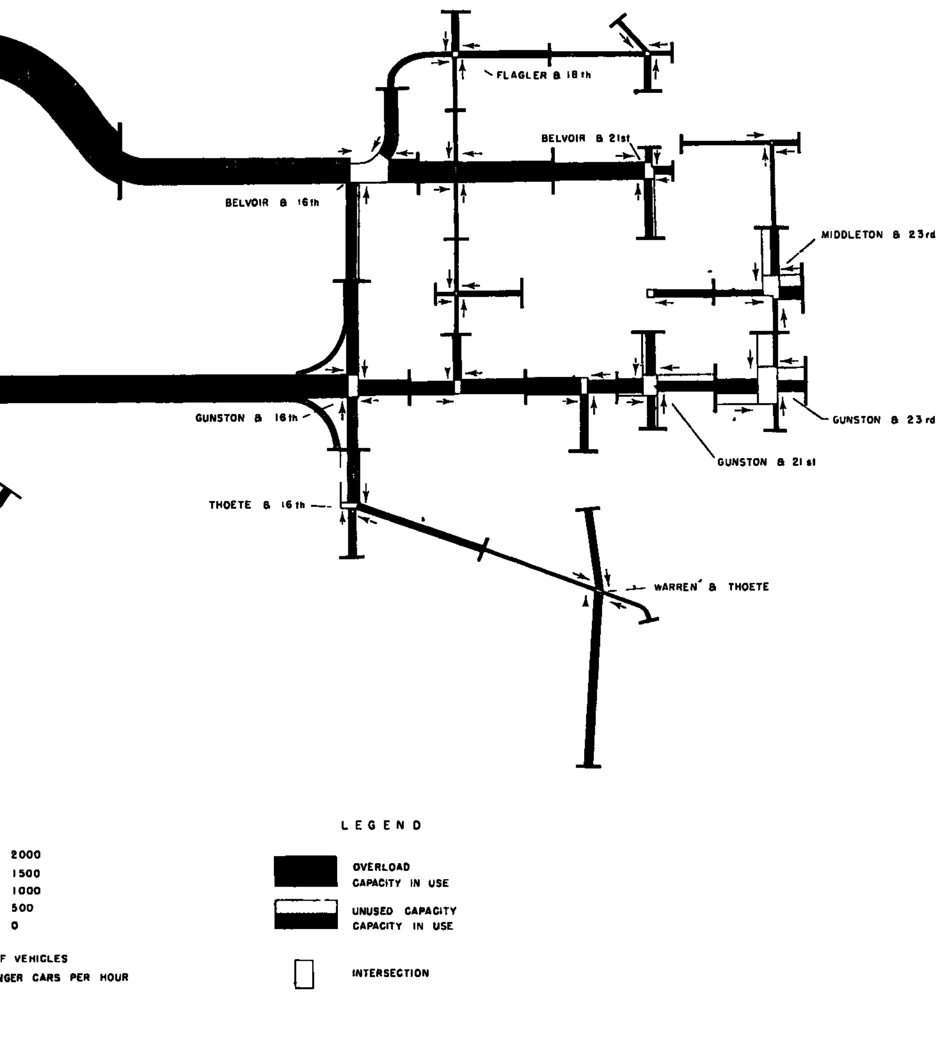


Figure 5. Peak-hour flows, capacities, overloads, and unused capacities on approach



lanes of intersections, Fort Belvoir, Virginia. Courtesy of Groll-Beach & Associates.

TABLE 4

PEAK 15 MINUTE OVERLOADS ON APPROACHES TO INTERSECTIONS, BY TYPE OF CONTROL

Type of control	No. of approaches	Overload (percent)
Military police	1	260
	1	210
	1	190
	1	140
	1	130
	1	110
	1	100
	1	90
	2	60
	1	50
	2	30
	3	20
	2	10
Traffic actuated signal	1	200
	1	160
	1	80
Fixed time signal	1	170
	2	100
	1	70
	1	60
	1	20
None	1	40
	1	30
	2	20

TABLE 5

SAMPLE SPEEDS ON APPROACHES TO INTERSECTIONS

Length of approach (ft.)	Elapsed time (min. and sec.)	Average speed (mph.)
1900	8:30	2.5
3700	13:02	3.2
3000	10:02	3.4
10000	19:27	5.8

TABLE 6

SAMPLE SEQUENCE OF STOP PERIODS FOR MINOR FLOW AT INTERSECTION (min. and sec.)

1:11
2:15
1:48
:58
2:40
:35
2:27
:20
1:40
2:25
:25
:25
1:18
1:56

alyze their significance, only a few comments will be made under this heading.

In addition to the overloads which were pushed through Fort Belvoir intersections during peak periods, there were frequently tremendous backlogs of vehicles unable to transit the intersections. Speed and delay runs on four intersection approaches yielded the results shown in Table 5. A speed and delay run through the main entrance of the post to a popular destination covered 2.9 miles in 23 minutes and 15 seconds for an average speed of 7.4 miles per hour.

At intersections under military police control, the overloads were generally accomplished by stretching the go period for the major flow to such extreme lengths that cross traffic was severely penalized. During a thirty minute period one minor traffic stream, though itself a rush hour home-to-work movement, was held by military police for the stop periods shown in Table 6.

Of course, such excessive single-cycle delays to cross traffic could not occur at intersections controlled by fixed-time signals, although lengthy back-ups did occur. The observed high rates of flow at such intersections must have been stimulated in part by close driver familiarity with road and traffic conditions, and in part by uniform driver motivation, e.g., a desire to get to work on time or to get home as quickly as possible.

After allowances have been made for continuously loaded approaches, highly unusual operating conditions, and rush hour driver characteristics, the question is raised, but by no means answered in this study, whether the curves in Figure 24 of the Highway Capacity Manual, if carried down to narrower street widths, should not tend to flatten out toward the horizontal as they reach the range of two-way streets 18 to 24 ft. wide.

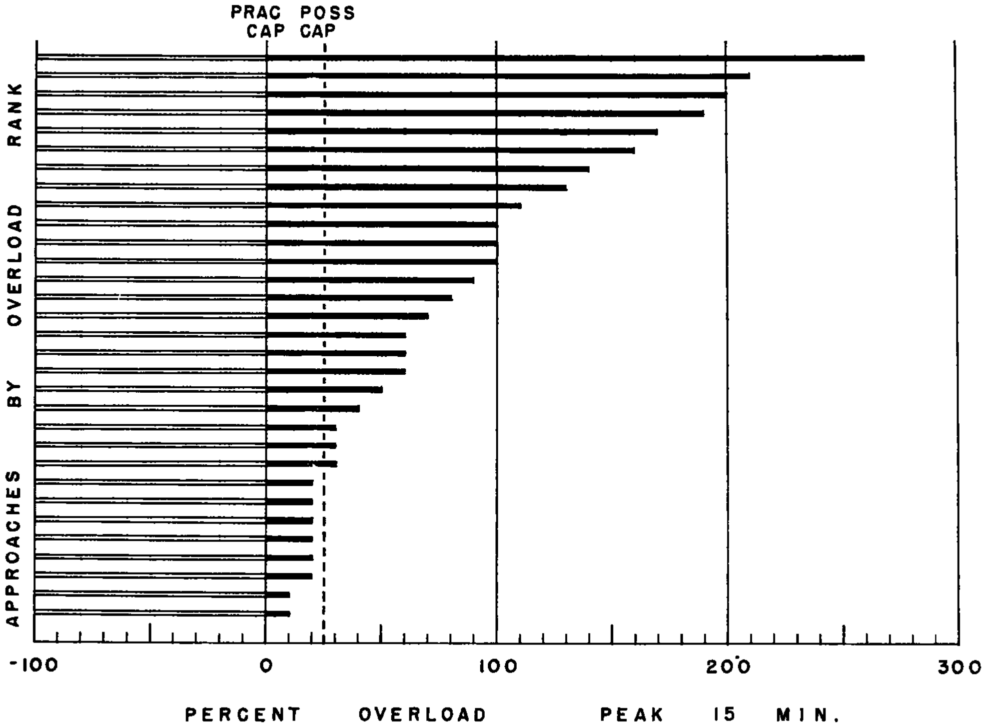


Figure 6. Peak 15 minute overloads on approaches to intersections, in order of size.

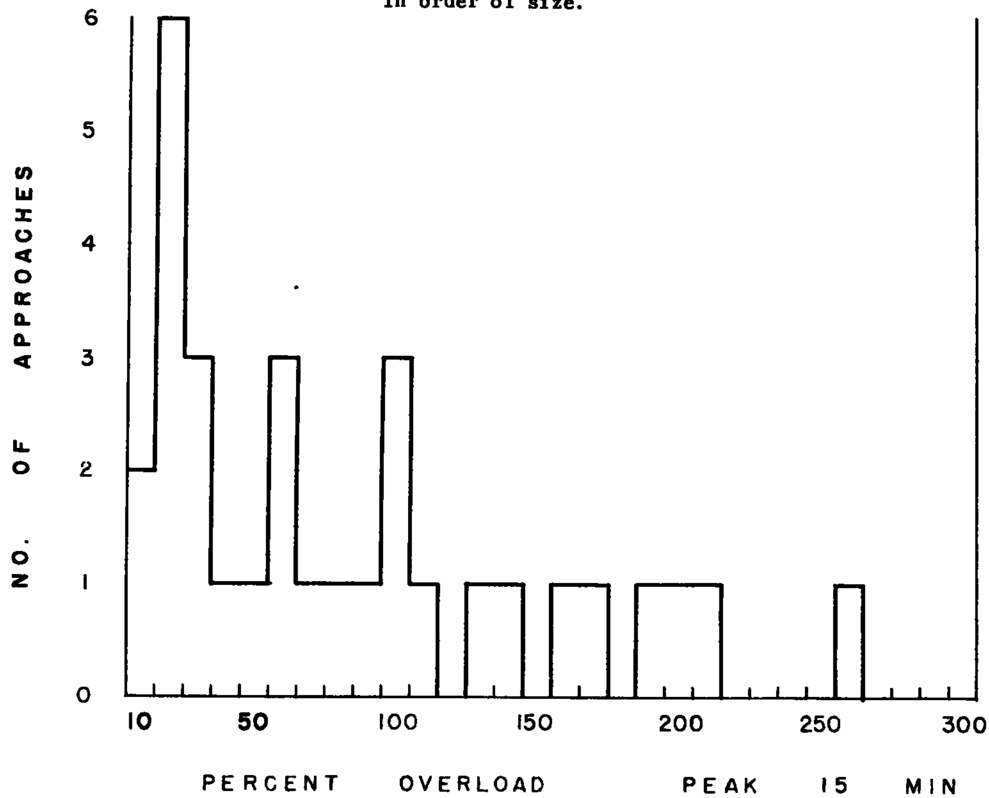


Figure 7. Frequency distribution of peak 15 minute overloads on approaches to intersections, by size of overload.

TABL

TRAFFIC STREAM

COMPUTAT

Intersection (1)	Traffic Bound (2)	Entering Intersection On (3)	Width of Approach Lane, Feet (4)	Length of Peak Flow Period, Minutes (5)	Time of Peak Flow, Hour of Day (6)	Practical Capacity of Approach Lane Under Average Conditions Veh/hr (7)	ADJUSTMENT: Commercial Vehicles (1) No (8)	Commercial Vehicles Adj % (9)	Right Turn No (10)	Right Turn % (10)/(23) (11)	Right Turn Adj (2) % (12)	No. (13)
Belvoir Rd & 21st St	South	Belvoir Rd	12' - 9"	60	0715-0815	648	25	+10	103	23 0	-6 5	96
				15	0730-0745	162	11	+10	38	25 5	-7 7	25
Belvoir Rd & 21st St	East	21st St	11' - 0"	60	1630-1730	522	2	+10	2	1 0	+5 0	152
				15	1630-1645	130	1	+10	1	1.0	+5.0	58
Belvoir Rd & 16th St	South	Belvoir Rd	12' - 4"	60	0700-0800	618	23	+10	99	13 2	-1 6	27
				15	0745-0800	154	9	+10	35	14 4	-2 2	10
Belvoir Rd & 16th St	North	Belvoir Rd	12' - 0"	60	1630-1730	594	19	+10	0	0 0	+5 0	32
				15	1645-1700	149	3	+10	0	0 0	+5 0	13
Belvoir Rd & 16th St	East	16th St	15' - 4"	60	0730-0830	834	67	+10	102	43 7	-10 0	124
				15	0745-0800	218	20	+10	44	T	+5 0	40
Belvoir Rd & Harris Rd	West	Harris Rd	10' - 6"	60	1630-1730	486	7	+10	317	T	+5 0	NP
				15	1700-1715	121	0	+10	131	T	+5.0	NP
Belvoir Rd & Taylor Rd	North Thru lane only	Belvoir Rd	12' - 0"	60	1630-1730	594	28	+10	0	0	+5 0	
				15	1645-1700	149	5	+10	0	0	+5 0	
Belvoir Rd & Taylor Rd	South	Belvoir Rd	11' - 6"	60	0700-0800	558	27	+10	NR	NR	+5 0	49
				15	0730-0745	139	2	+10	NR	NR	+5 0	16
Belvoir Rd & Casey Rd	North R lane only	Belvoir Rd	12' - 9"	60	1630-1730	648	40	+10	81	8 4	+1 0	0
				15	1645-1700	162	6	-10	24	8 3	+1 0	0
Belvoir Rd & Casey Rd	East	Ramp (S)	21' - 0"	60	0700-0800	1310	17	+10	192	93 0	-10 0	0
				15	0730-0745	338	4	+10	71	100 0	-10 0	0
Belvoir Rd. & Casey Rd.	South	Belvoir Rd	20' - 6"	60	0700-0800	1295	23	+10	NP	NP	+5 0	5
				15	0730-0745	324	6	+10	NP	NP	+5.0	0
Belvoir Rd & U S No 1	North Lt only	Belvoir Rd	10' - 0"	60	1630-1730	1000 (4)	18	0	(4)	(4)	(4)	172
				15	1645-1700	250 (4)	5	0	(4)	(4)	(4)	50
Belvoir Rd & U S No 1	West Lt turn lane only	U S No 1 -	10' - 0"	60	0700-0800	1000 (4)	42	0	(4)	(4)	(4)	(4)
				15	0730-0745	250 (4)	12	0	(4)	(4)	(4)	(4)
Middleton Rd & 23rd St	North	Putman	9' - 10"	60	1600-1700	621 (6)	3	+10	192	55 5	-10 0	0
			19' - 8"	15	1630-1645	292	0	+10	162	55 6	-10 0	0
Middleton Rd. & 23rd St	West	23rd St	12' - 1"	60	0700-0800	600	4	+10	5	2 2	+ 4 0	191
				15	1730-1745	150	3	+10	0		+ 5.0	87
Gunston Rd & 23rd St	South	Gunston	12' - 6"	60	0700-0800	630	18	+10	15	3 8	+ 3 0	62
				15	0730-0745	158	7	+10	6	3 1	+ 3 5	31
Gunston Rd & 23rd St	North	Gunston	11' - 3"	60	1600-1700	540	9	+10	15	5 5	+ 2 0	
				15	1630-1645	135	4	+10	9	4 5	+ 3 0	
Gunston Rd & 23rd St	West	23rd St (S)	12' - 0"	60	1200-1300	594	4	+10	13	20 0	- 5 0	16
				15	1215-1230	148	2	+10	5	22 7	- 6 0	6
Gunston Rd & 21st St	South	Gunston	12' - 3"	60	0715-0815	612	29	+10	23	5.9	+ 2.0	88
				15	0730-0745	153	9	+10	5	2 7	+ 4 0	22
Gunston Rd & 21st St	North	Gunston	12' - 3"	60	1615-1715	612	11	+10	45	15 4	- 2 7	44
				15	1630-1645	153	7	+10	33	14 6	- 2 0	33
Gunston Rd & 21st St	West	21st St (S)	11' - 0"	60	1630-1730	522	5	+10	96	47 7	-10 0	8
				15	1700-1715	130	1	+10	63	61 7	-10 0	2
Gunston Rd & 21st St	East	21st St (S)	11' - 0"	60	0715-0815	522	9	+10	68	44 1	-10 0	23
				15	0730-0745	130	0	-10	48	69 5	-10 0	2
Gunston Rd & 16th St	South	Gunston	11' - 9"	60	0715-0815	576	86	-10	0	0 0	+ 5 0	30
				15	0745-0800	144	25	-10	0	0 0	+ 5 0	9
Gunston Rd & 16th St	North	Gunston	11 - 11"	60	1630-1730	588	45	+10	54	13 0	+ 1 5	25
				15	1645-1700	147	14	+10	21	7 9	+ 1 0	12
Gunston Rd & 16th St	West	16th St	12' - 3"	60	0715-0815	612	88	-10	0	0 0	+ 5 0	57
				15	0745-0800	153	25	-10	0	0 8	+ 5 0	23
Gunston Rd & 16th St	East	16th St	11' - 9"	60	1615-1715	576	40	-10	19	- 1	+ 1 0	113
				15	1630-1645	144	12	+10	7	7.7	+ 1.0	36
Gunston Rd & Meade Rd	North	Gunston	15' - 0"	60	1630-1730	810	67	-10	327	39 9	-10 0	3
				15	1700-1715	202	11	+10	93	39 2	-10 0	0
Gunston Rd & Meade Rd	South	Gunston	12' - 1"	60	0715-0815	600	74	+10	0	0 0	+ 5 0	8
				15	0730-0745	150	10	+10	0	0 0	+ 5 0	2
Gunston Rd & Meade Rd	West	Meade Rd (S)	11' - 7"	60	0700-0800	564	21	+10	12	3 0	+ 4 0	321
				15	0730-0745	141	7	+10	1	0.0	+ 5.0	155
Thoete Rd & 16th St	West	16th St	10' - 6"	60	0730-0830	486	37	+10	1	0 0	+ 5 0	51
				15	0745-0800	122	12	-10	1	0 0	+ 5 0	60
Humphreys Rd & Meade Rd	North	Humphreys Rd	12 - 0"	60	0700-0800	594	17	+10	NR	NR	+ 5 0	271
				15	0730-0745	149	7	-10	NR	NR	+ 5 0	88
Humphreys Rd & Meade Rd	East	Meade Rd (S)	10' - 0"	60	1630-1730	450	13	+10	337	T	+ 5 0	9
				15	1700-1715	113	2	+10	105	T	+ 5 0	4
Humphreys Rd & Meade Rd	South	Humphreys Rd	12' - 0"	60	1700-1800	594	20	+10	6	2 8	+ 4 0	NR
				15	1700-1715	149	5	+10	3	3.4	+ 3.0	NR
Abbot Rd & Wills Rd	East	Abbot Rd	10' - 4"	60	1630-1730	474	36	+10	NR	NR	+ 5 0	184
				15	1645-1700	119	15	+10	NR	NR	+ 5 0	58
Abbot Rd & Wills Rd	West	Abbot Rd	19' - 3"	60	0730-0830	1161	40	+10	33	10 5		NR
				15	0730-0745	290	6	+10	3	3 0	+ 4 0	NR
Abbot Rd & Wills Rd	South	Wills Rd (S)	10' - 3"	60	0700-0800	468	19	+10	165	T	+ 5 0	40
				15	0730-0745	117	4	+10	64	T	+ 5.0	6
Abbot Rd & Beauregard Rd	West	Abbot Rd	10' - 4"	60	0715-0815	474	45	+10	NR	NR	+ 5 0	37
				15	0730-0745	119	16	+10	NR	NR	+ 5.0	17
U S No 1 & Va No 235	North	Va No 235 (S)	20' - 5"	60	1600-1700	1245	10	+10	41	37 2	-10 0	68
				15	1615-1630	311	5	+10	16	45.7	-10.0	19
U S No 1 & Va No 618	East	U S No 1	19' - 0"	60	1630-1730	1134	56	+10	NR	NR	+ 5 0	132
				15	1645-1700	284	12	+10	NR	NR	+ 5 0	27
U S No 1 & Va No 618	West	U S No 1	20' - 0"	60	0700-0800	1215	54	+10	112	9 4	0 0	NR
				15	0730-0745	304	16	+10	40	8 4	+ 1 0	NR
U S No 1 & Va No 618	South	Va No 618	11' - 2"	60	0715-0815	534	14	+10	177	T	+ 5 0	47
				15	0745-0800	134	4	+10	58	T	+ 5.0	8
Humphreys Rd & U S No 1	West Thru	U S No 1	23' - 6"	60	1645-1745	1454	40	+10	NR	NR	+ 5 0	NR
				15	1700-1715	363	12	+10	NR	NR	+ 5 0	NR
Humphreys Rd & U S No 1	South Left	Humphreys Rd (S)	12' - 0" (8)	60	1630-1730	594	29	+10	NR	NR	+ 5 0	363
				15	1700-1715	148	7	+10	NR	NR	+ 5.0	122
U S No 1 & Va No 617	West	U S No 1	20' - 0"	60	1630-1730	1215	40	+10	163	24 4	- 7 0	NR
				15	1700-1715	304	4	+10	49	28 3	- 9 0	NR
U S No 1 & Va No 617	South	Va. No. 617 (S)	15' - 10"	60	0700-0800	834	13	+10	109	33 1	-10 0	221
				15	0730-0745	208	3	+10	57	41.0	-10.0	82
U S No 1 & Bache Rd	North	Bache Rd. (S)	10' - 0"	60	1615-1715	450		+10	98	42 6	-10 0	132
				15	1630-1645	113		+10	40	47.6	-10.0	44
Va No 617 & Va No 613	East	Va No 617	11' - 0"	60	0700-0800	522	21	+10	262	T	+ 5 0	175
				15	0730-0745	130	5	+10	93	T	+ 5 0	36
Va No 617 & Va No 613	South Right	Va. No. 613 (S)	10' - 6"	60	1645-1745	486	8	+10	248	83 0	-10 0	NR
				15	1645-1700	122	4	+10	91	88.0	-10.0	NR
Wills Rd & Va No 613	West	Wills Rd. (S)	11' - 6"	60	1630-1730	558	11	+10	84	26 3	- 8 0	23
				15	1645-1700	139	3	+10	23	22.1	- 6.8	81
Shirley Hwy & Va No 617	North	West Ramp (S)	13' - 9"	60	0700-0800	720	16	+10	422	T	+ 5 0	2
				15	0715-0730	180	4	+10	148	T	+ 5 0	0
Shirley Hwy & Va No 617	West	Va. No. 617	13' - 9"	60	1645-1745	720	11	+10	357	86 0	-10 0	NR
				15	1715-1730	180	3	+10	107	82.0	-10.0	NR
Humphreys Rd & U S No 1	West Rt to Gate	U S No 1	10' - 0" (9)	60	0700-0800	1000 (4)	13	0	(4)	(4)	(4)	(4)
				15	0730-0745	250 (4)	3	0	(4)	(4)	(4)	(4)

NP Not permitted
NR No road
S Stop sign
T T-Intersection
(1) Already converted to E P C in Col 23 shown for information only
(2) Maximum reduction for right turn is 10%
(3) Maximum reduction for left turn is 20%
Maximum combined reduction is 20%
E P C = equivalent passenger cars
(4) Added turning lane on separate signal 1000 vehicles/10 ft /hr (Ref p 91 para c, Highway Capacity Manual)

(5) Traffic backed up almost to Va No 235
(6) 3/4 hr 438/hr 1/4 hr 292 per 1/4 hr = 621
(7) Arbitrarily reduced because of gutter across right turn
(8) Only one lane of approach road is normally used because of (1) custom (2) lack of signing, (3) only one lane available on U S No 1 for eastbound traffic (other lane is used by traffic Ramp to South Gate)
(9) Width of approach governed by lane width of U S No 1 20' ramp width

RESULTS

ON-AVERAGE CONDITIONS: Turn Adj (2) %	No Parking or Bus Stop Adj %	Total Adj % (9)-(12)-(15)-(16)	Adjusted Prac Capacity per Hr of Green (7) x (17)	Go Time as Fraction of Period Minutes	Practical Capacity Under Local Conditions Pass cars/Peak Pd (18) x (19)	PEAK PERIOD ACTIVITY: Length of Time Minutes (5)	Maximum Desirable Flow Passenger Cars (20)	Actual Flow E P C. (3)	Unused Capacity % (22)-(23)/(22)	Excess of Actual Flow over Desirable: Computed % (23)-(22)/(22)	Excess of Actual Flow over Desirable: Rounded %
(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)
-12 3	+5	-3 8	623	23/60	239	60	239	430		80	80
- 7 0	+5	8 0	162	7/15	75	15	75	149		99	100
-20 0	+5	0 0	522	31/60	269	60	269	237	12		
-20.0	+5	0.0	130	8/15	69	15	69	82		19	20
+ 6 4	+5	+17 0	723	46/60	554	60	554	749		35	30
+ 6 0	+5	+19 0	173	9/15	104	15	104	243		134	130
+ 5 0	+5	+25 0	743	30/60	372	60	372	634		70	70
+ 4 4	+5	+24 0	184	6/15	74	15	74	229		209	210
+10 0	+5	+15 0	959	15/60 Est	240	60	240	233	3		
-20 0	+5	0 0	218	2/15	29	15	29	85		193	190
+10 0	+5	+30 0	549	27/60	247	60	247	329		33	30
+10 0	+5	+30.0	157	8/15	84	15	84	132		57	60
+10 0	+5	+30 0	772	48/60	618	60	618	1125		82	80
+10 0	+5	+30 0	194	11/15	142	15	142	336		137	140
+ 5 0	+5	+25 0	698	42/60	489	60	489	987		102	100
+ 5 4	+5	+25 0	174	14/15	162	15	162	346		114	110
+10 0	+5	+26 0	816	58/60	788	60	788	956		21	20
+10 0	+5	+26 0	204	15/15	204	15	204	286		40	40
+10 0	+5	+15 0	1507	37/60	928	60	928	196	79		
+10 0	+5	+15 0	389	5/15	129	15	129	71	45		
+ 9 4	+5	+29 0	1671	42/60	1169	60	1169	725	38		
+10.0	+5	+30.0	421	8/15	224	15	224	268		20	20
(4)	(4)	0 0	1000	16/60	226	60	226	172	35		
(4)	(4)	0 0	250	3/15	50	15	50	50		0	0
(4)	(4)	0 0	1000	42/60	700	60	700	725		4	0
(4)	(4)	0 0	250	8/15	133	15	133	268		102	100 (5)
+10 0	+5	+15 0	714	58/60	690	60	690	344	50		
+10 0	+5	+15 0	336	13/15	291	15	291	291		0	0
-24 0	+5	- 5 0	540	54/60	486	60	486	218	55		
-20.0	+5	0.0	142	12/15	114	15	114	88	23		
- 6 0	+5	+12 0	706	58/60	682	60	682	391	43		
- 6 0	+5	+13 0	179	14/15	167	15	167	192		15	10
+10 0	+5	+27 0	686	56/60	640	,0	640	269	58		
+10 0	+5	+28 0	173	11/15	127	15	127	198		56	60
-14 6	+5	- 5.0	564	57/60 Est	536	60	536	65	88		
-14 0	+5	- 5.0	141	14/15 Est	132	15	132	22	83		
-13.0	+5	+ 4.0	636	41/60	434	60	434	386	11		
- 2 0	+5	+17 0	179	8/15	95	15	95	181		91	90
- 5 0	+5	+ 7.0	655	41/60	447	60	447	292	35		
- 5 0	+5	+ 8 0	165	14/15	154	15	154	226		47	50
+ 6 0	-5	+11.0	579	44/60	425	60	425	201	53		
+ 8 0	-5	+13 0	147	8/15	79	15	79	102		29	30
- 5 0	+5	0 0	522	31/60	270	60	270	154	43		
+ 7.0	+5	+12.0	146	6/15	58	15	58	69		20	20
+ 6 0	+5	+21 0	670	39/70	373	60	373	579		55	50
+ 6 0	+5	+21 0	174	39/70	97	15	97	186		73	70
+ 4 0	+5	+18 0	693	39/70	386	60	386	415		7	10
+ 5 5	+5	+22 0	179	39/70	99	15	99	263		166	170
- 8 0	+5	+12 0	685	23/70	225	60	225	262		16	20
-10 0	+5	+10 0	168	23/70	55	15	55	89		62	60
-20 0	+5	- 4 0	553	23/70	181	60	181	264		46	50
-20.0	+5	- 4.0	138	23/70	45	15	45	90		100	100
+10 0	+5	+15 0	932	50/60	780	60	780	819		5	0
+10 0	-5	+15 0	232	12/15	189	15	189	237		25	20
+ 8 5	-5	+29 0	774	48/60	712	60	712	506	29		
+ 9 0	+5	+29 0	194	10/15	129	15	129	158		22	20
-20 0	-5	- 1 0	558	30/60	279	60	279	362		30	30
-20.0	+5	0.0	141	5/15	47	15	47	169		260	260
- 6 0	+5	14 0	554	58/60 Est	535	60	535	321	39		
-20 0	+5	0 0	122	15/15 Est.	122	15	122	133		9	10
-20 0	+5	0 0	594	57/60	564	60	564	396	30		
-20 0	-5	0 0	149	14/15	139	15	139	118	15		
+ 8 0	+5	+28 0	576	56/60	537	60	537	346	36		
+ 6 0	+5	+26 0	142	13/15	123	15	123	109	11		
+10 0	+5	+29 0	766	55/60	704	60	704	213	70		
+10.0	+5	+28.0	191	10/15	128	15	128	86	33		
-20 0	+5	0 0	474	54/60	427	60	427	411	4		
-20 0	+5	0 0	119	14/15	111	15	111	131		18	20
+10 0	+5	+25 0	1451/1200 (7)	52/60	1039	60	1039	313	70		
+10 0	+5	+29 0	374/300	14/15	280	15	280	97	65		
-10 0	+5	+10 0	515	39/60	335	60	335	205	39		
- 1.0	+5	+21.0	142	9/15	85	15	85	70	18		
+ 1 0	+5	+19 0	564	57/60 Est	536	60	536	347	35		
0.0	+5	+20.0	143	14/15 Est.	133	15	133	167		26	30
+10 0	+5	+15 0	1431	7/60 Est	166	60	166	110	31		
+10.0	+5	+15.0	358	2/15 Est.	48	15	48	35	27		
+ 1 0	+5	+21 0	1372	40/60	915	60	915	1436		57	60
+ 3 0	+5	+23 0	349	10/15	233	15	233	413		77	80
+10 0	+5	+25 0	1518	31/60	783	60	783	1189		52	50
+10 0	+5	+26 0	383	7/15	179	15	179	474		165	160
-10 0	+5	+15 0	614	12/60	123	60	123	224		82	80
- 2.0	+5	+23.0	165	2/15	22	15	22	66		200	200
+10 0	+5	+30 0	1890	57/60	1796	60	1796	624	65		
+10 0	-5	+30 0	472	14/15	440	15	440	246	44		
+10 0	-5	+30 0	772	38/60	489	60	489	447	9		
+10.0	+5	+30 0	192	9/15	115	15	115	146		27	30
+10 0	-5	+18 0	1434	60/60	1434	60	1434	665	54		
+10 0	-5	+16 0	353	15/15	353	15	353	173	51		
+10 0	0	+10.0	917	53/60	810	60	810	330	59		
+10.0	0	+10.0	228	13/15	197	15	197	139	29		
+10 0	+5	+15 0	518	50/60	431	60	431	230	47		
+10.0	+5	+15.0	130	10/15	83	15	83	84		1	0
-20 0	-5	0 0	522	55/60 Est	478	60	478	437	9		
-18 0	+5	+ 2 0	133	14/15 Est	124	15	124	129		4	0
+10 0	+5	+15 0	559	56/60	522	60	522	299	43		
+10.0	+5	+15.0	140	14/15	131	15	131	103	31		
+10 0	+5	+17 0	653	55/60 Est	598	60	598	319	47		
+10.0	+5	+19.0	165	12/15 Est.	132	15	132	104	21		
+10 0	+5	+30 0	936	57/60 Est	889	60	889	424	52		
+10 0	+5	+30 0	234	13/15 Est	156	15	156	148	5		
+10 0	+5	+15 0	828	60/60 Est	828	60	828	413	50		
+10.0	+5.	+15.0	207	15/15 Est.	207	15	207	131	37		
(4)	(4)	(4)	1000	60/60	1000	60	1000	424	58		
(4)	(4)	(4)	250	15/15	250	15	250	154	38		

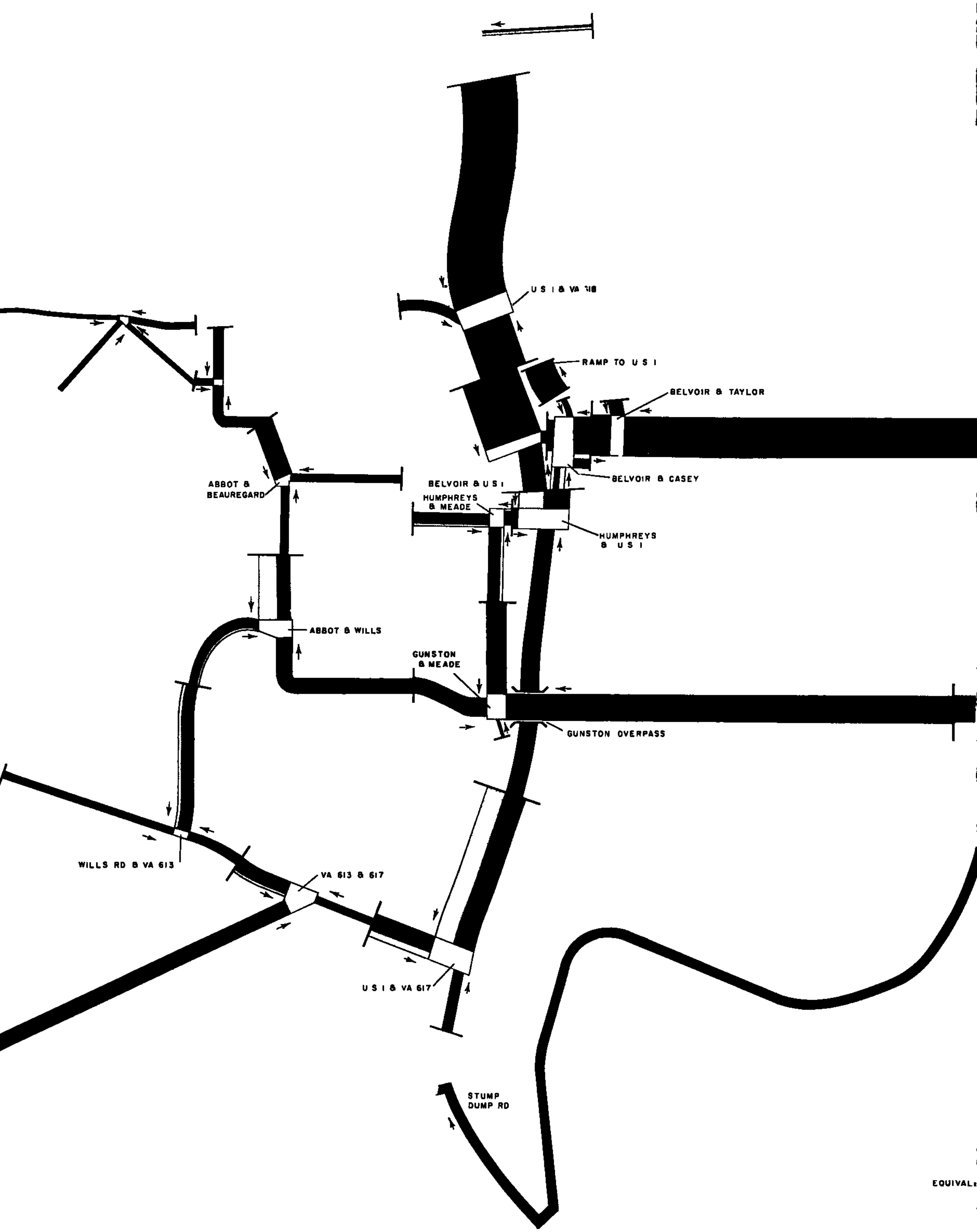
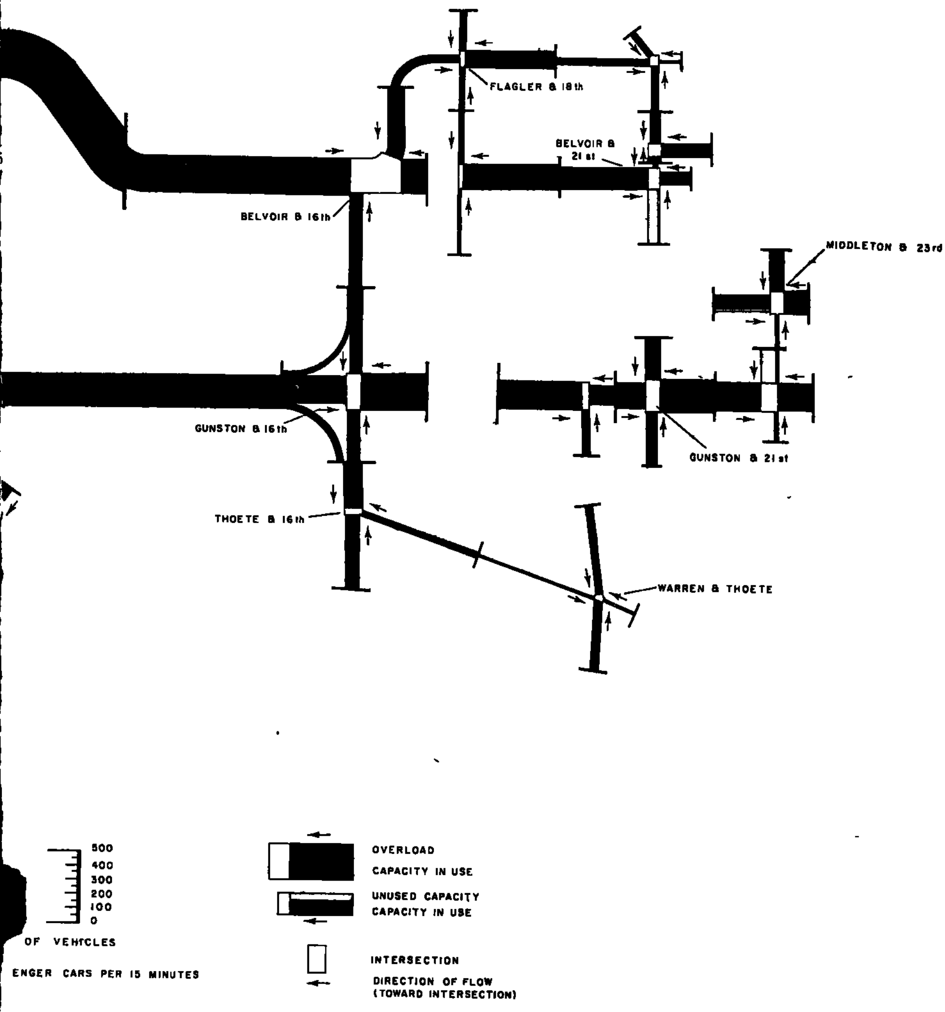


Figure 8. Peak-15-minute flows, capacities, overloads, and unused capacities on approach



anes of intersections, Fort Belvoir. Redrafted by Groll-Beach from original color plates.

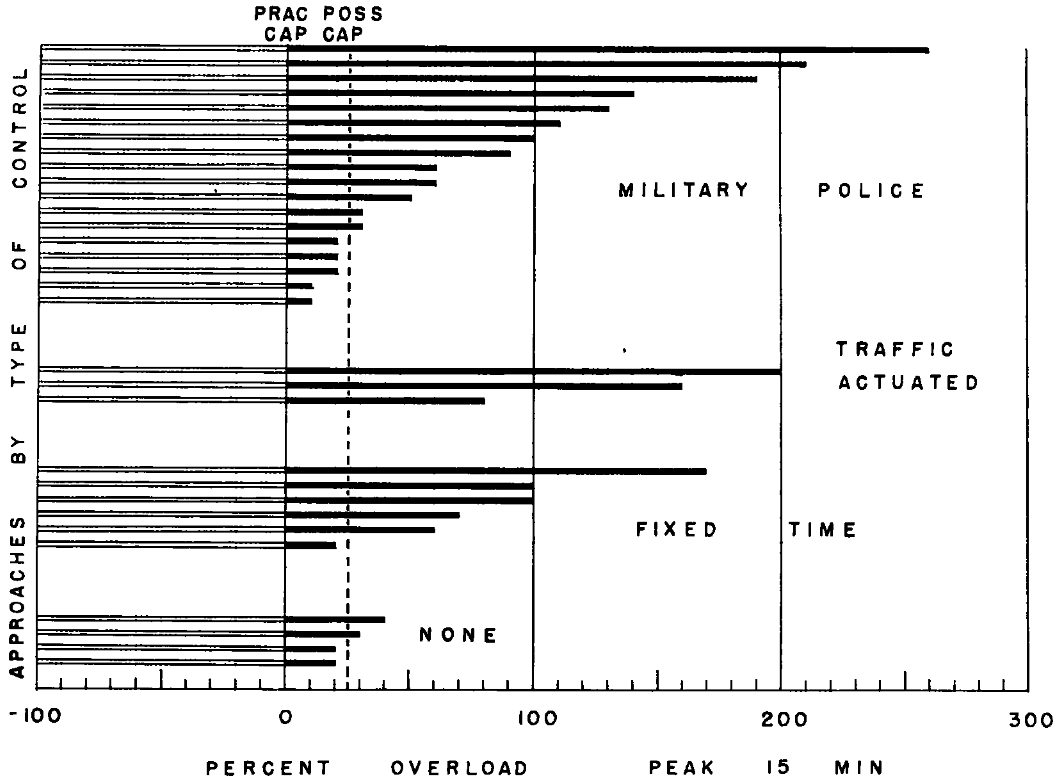


Figure 9. Peak 15 minute overloads on approaches to intersections, by type of control.

CONCLUSION

The principal conclusion which the author would draw from the Fort Belvoir Traffic Study lies in another field, however. While 31 intersection approaches were found to be overloaded in the peak 15 minute period, only two sections of roadway were found to be in urgent need of widening. Capacity restrictions in the post road net were due almost entirely to intersection deficiencies. Particularly on a military post, where all land is in single ownership and building setbacks are usually very generous, it is much simpler to increase road network capacity by enlarging intersections than by widening existing roads or building new roads. In general, it was surprising that budget and other authorities had allowed the traffic situation at Fort Belvoir to develop to the point it had reached, and that relatively simple remedial measures had not been taken.

But the lack of understanding of intersectional capacity limitations on military property is only a minor reflection of our more serious failure on a national scale to design and build the current additions to our urban road networks in such a way that intersection capacities will equal street capacities on primary and secondary uncontrolled access thoroughfares.

Do not the traffic engineers have a professional obligation to hammer away at state, county and city highway departments (who acquire land by purchase) and county and city planning commissions (who oversee the acquisition of land by dedication during the process of subdivision), insisting that right-of-way acquisition for intersections of major surface thoroughfares should be generous enough to provide additional lanes on the intersection approaches to replace the street capacity lost at the intersection through minutes of red, right and left turns, the slow starting of commercial vehicles, parking, and bus stops?

Discussion

HERBERT S. LEVINSON, Wilbur Smith and Associates, New Haven, Connecticut—Sutermeister has developed a most interesting analysis. His finding peak-hour volumes considerably in excess of published capacity values leads one to believe that the established capacity criteria cannot be universally or indiscriminately applied.

(1) Relating vehicular headways, effective lanes, and available green time, how would computed capacities compare with observed saturation loadings?

(2) If the roads at Ft. Belvoir were considered as "expressways," how would the saturation loadings compare with calculated capacity values using the Capacity Manual?

(3) Can it be inferred that, the capacity of any street - in vehicles per hour of green - lies somewhat between the expressway and typical street curves set forth in the Capacity Manual?

(4) Would the exact values to be used depend on the type and nature of marginal interferences resulting from abutting land use?

OSCAR SUTERMEISTER, Closure—In response to Mr. Levinson's questions:

(1) Headways were not timed in the field. Average headways could be computed from data presented on effective lanes, available green time, and actual flow. Capacity computed on the basis of such calculated average headway would of course equal observed saturation loading. If some normal or standard headway were used to compute capacity, the result would probably be somewhat lower than observed saturation loading.

(2) The suggested calculations and comparisons could be made from data presented, but have not been worked out by the author.

(3) In my opinion, no. Special conditions outlined in the paper differentiate Belvoir roads from usual city streets enough to preclude the inference that all streets have a capacity equal to or higher than that indicated in the Manual.

(4) Not necessarily, I feel. Departures from Manual capacity in the Belvoir case were not due to "type and nature of marginal interferences resulting from abutting land use." They were due to special local characteristics of traffic operations and of the traffic stream, as identified in the paper.