EXPERIMENT NO: 07

DETERMINATION OF ROADWAY CAPACITY

(Highway Capacity Manual (HCM)-1994, FHA, USA)



7.1 INTRODUCTION

The capacity of a roadway is its ability to accommodate traffic. It is usually expressed as the number of vehicles that can pass a given point in a certain time at a given speed.

Of course roadways are not ideal and prevailing roadway and traffic conditions those reduce ability of a road to accommodate traffic must be taken into consideration in highway capacity estimation. In determining highway capacities for uninterrupted flow conditions the general procedure, described below, is to apply appropriate empirically based adjustments for prevailing roadway and traffic conditions. The capacity of a given section of roadway stated either as unidirectional or both directions for a two lane or three lane roadway, may be defined as maximum number of vehicle that has a reasonable expectation of passing over a given section of roadway during a given time period under prevailing roadway and traffic condition.

While the maximum number of vehicle that can be accommodated remains fixed under similar roadway and traffic conditions, there is a range of lesser volumes which can be handled under differing operating conditions. Operation at capacity provides the maximum volume, but as both volume and congestion decrease there is an improvement in the level of service.

Level of service denotes any of an infinite number of differing combinations of operating conditions that can occur on a given lane or roadway when it is accommodating various traffic volumes.

Six levels of service (LOS), Level A through F, define full range of driving conditions from the best to worst in that order.

Level of service “A” represent free flow at low densities with no restriction due to traffic conditions. Level “B”, the lower limit of which is often used for the design of rural highways, is the zone of stable flow with some slight restriction of driver freedom. Level “C” denotes some of stable flow with more marked restriction in driver’s selection of speed and with reduced ability to pass. The conditions of level “D” reflect little freedom for driver maneuverability and condition approaches unstable flow. Level “E” area of unstable flow, is the zone of low operating speed and volume. Level “F” is the level of service provided by the familiar traffic jam, with frequent interruptions and breakdown of flow as well as volumes below capacity, coupled with low operating speed.

7.2 CAPACITY UNDER UNINTERRUPTED CONDITION

The capacity of roadway under uninterrupted flow condition can be obtained by modifying the capacity of the roadway under ideal conditions. Table 7.1 shows capacity of highway under ideal conditions according to Highway Capacity Manual (HCM)-1994 (USA).

These *ideal conditions comprise: 1. uninterrupted flow, with no interference by side traffic or obstructions, 2. a vehicle stream composed solely of passenger vehicles, 3. 12 ft wide traffic lane, and 4. should be capable of providing operation at 70 mph, with 5. no restriction of passing sight distance.*

Table 7.1: Capacity of roadway as per HCM-1994

Roadway Type	Capacity (passenger Vehicle/hr)
Multi-lane Free Flow	2000 per lane
Two lane, two way	2000 total both direction
Three lane , two way	4000 total both direction

calculation korar jonno kontar capacity nibo?

The adjustment factors used in modifying the capacity under ideal conditions to give capacity and service volumes under prevailing conditions may be grouped under

1. Roadway factors
2. Traffic factors

roadway factors are:
i. level of service (operating speed)
ii. lane width (for 12', modifying factor = 1)
iii. edge clearance (shoulder width)

Table 7.2 gives the scale of operating characteristics established for various levels of service on 2 lane highways and summarizes general level of service criteria during uninterrupted flow conditions. Included, in addition to operating speeds and basic volume/capacity ratios for ideal alignment, are approximate measures of the influences of passing sight distance, expressed as a percentage of the total section that is adequate if greater than 1500 ft and of average highway speeds on volume/capacity ratios.

Table 7.2: Operating characteristics for various levels of service on 2 lane highways and general level of service criteria during uninterrupted flow conditions as per HCM-1994

Level of Service	Traffic Flow Condition		Passing Sight Distance (%)	Basic Limiting Value for AHS* of 70 mph	Maximum service value under ideal condition
	Description	Operating Speed (mph)	>1500 ft		
A	Free Flow	≥ 60	100	0.20	400
			80	0.18	
			60	0.15	
			40	0.12	
			20	0.08	
			0	0.04	
B	Stable	≥ 50	100	0.45	900
			80	0.42	
			60	0.38	
			40	0.34	
			20	0.30	
			0	0.24	
C	Approaching unstable flow	≥40	100	0.70	1400
			80	0.68	
			60	0.65	

			40 20 0	0.62 0.59 0.54	
D	Approaching unstable flow	≥ 35	100 80 60 40 20 0	0.85 0.84 0.83 0.82 0.81 0.80	1700
E	Unstable Flow	30	Not Applicable	<=<1	2000
F	Forced Flow	<30	Not Applicable	Not Meaningful	Widely Variable (0 to capacity)

*AHS = Average highway speed

7.2.1 Roadway factors

The roadway factors make allowances for the effects of design elements such as lane width, lateral clearances at the edge of lanes, alignment and grades. Table 7.3 shows the effect of reduced lane widths on capacity and Table 7.4 shows the effect of edge clearance. Under both conditions the driver has a feeling of restricted movement with limited clearance resulting reduced capacity and lower level of service.

Capacity of a roadway is also highly influence by width of shoulder. For safe operation and to develop full traffic capacity well maintained shoulder is required. Outside shoulder should be at least 10 ft preferably 12 ft and free of all obstructions for heavily traveled, high speed roadways. Fully implemented, firm and smooth shoulders increase traffic lane-width by 2 ft.

Table 7.3: Effect of lane width on capacity for uninterrupted flow conditions as per HCM-1994

Lane Width (ft)	Capacity %	
	Two-lane Roadways	Multi Lane Roadways
12	100	100
11	88	97
10	81	91
09	76	81

Table 7.4: Effective roadway width due to restricted lateral clearance under uninterrupted flow as per HCM-1994

Clearance from Pavement to Observation, Both Sides (ft)	Effective Width of Two 12-ft lane (ft)	Capacity of Two 12-ft Lanes (%)
6	24	100
4	22	92
2	20	83
0	17	72

7.2.2 Traffic factors

In addition to roadway factors, traffic factors (such as many trucks and buses in the traffic stream and variation of flow) affect the capacity and service columns of a road way. Trucks and busses, because of their restricted maneuverability, reduce the number of vehicles that a facility can handle. This reduction in vehicle is represented by the term passenger can equivalent (PCE), which indicates the equivalent number of passenger cars that have been displaced by the presence of each truck or bus, Table 7.5 shows passenger car equivalents for different types of vehicles as mentioned by the Roads and Highways Department.

Table 7.5: PCU values for different types of vehicles

Vehicle Type	Passenger Car Unit (PCU) Value
Truck	3
Bus	3
Mini-bus	2
Passenger car	1
Utility	1
C.N.G, Baby taxi	0.75
Motorcycle	0.5
Bicycle	0.5
Cycle Rickshaw	2

Bullock Cart	4

(Source: Geometric Design Standards for Roads & Highways Department, Draft version-4, October 2004, Page-4)

The method of estimation of highway capacity described in this article is applicable to rural highway situation only. In urban conditions, the roadway capacity mainly depends on the discharge capacity of the intersections. The commonly used intersections are: signalized, priority-controlled un-signalized and roundabout/traffic circles. However, considering the difficulties in arranging a field data collection trip to a representative rural highway section, required data will be collected from city roads. Therefore, it is suggested that an intersection free long stretch of road should be taken as the field site in order to get closer to the rural highway situation.

EXAMPLE

Find the capacity of a roadway section for the following data:

1. Roadway pattern : Two lane two way
2. Lane width : 11 ft
3. Shoulder condition: 4 ft on both side of roadway smooth and well maintained
4. Operating speed : 40 mph
5. % of passing sight distances: 80
6. Level of service C

Solution:

From Table 7.1 and Table 7.2
Capacity of two lane two way = 2000× 0.68 = 1360 veh/hr.

From Table 7.3,
Capacity reduction factor for 11 ft lane width =0.88

From Table 7.4 :
Capacity reduction factor for 4 ft shoulder = 0.92
Therefore actual roadway capacity = 1360×0.88×0.92 = 1101 passenger veh/hr. (total in both direction)

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Find the capacity of a roadway section for the following data:

1. Roadway pattern :

2. Lane width :

3. Shoulder condition :

4. Operating speed :

5. % of passing sight distances :

6. Level of service :

Calculation:

Signature of the Course Teacher

Department of Civil Engineering, BUET

Experiment No. 14

Determination of Roadway Capacity

Traffic Count Survey Data Sheet

Date: May 5th,2018

Approach Name: Through

Counting Hours: 12:30 pm to 1:00 pm

Weather: Sunny

Station Name: Palashi - Nilkhet

Vehicle Type	*Interval, minutes*						*Total no. of Vehicles*	*PCE*	*PCU*	*Total no. of Vehicles in Opposite Direction*	*PCU in Opposite Direction*
	0 to 5	6 to 10	11 to 15	16 to 20	21 to 25	26 to 30					
Rickshaw	126	88	112	113	98	124	661	0.5	331	548	274
Private Car	46	29	21	65	25	33	219	1	219	96	96
CNG	17	20	12	14	9	13	85	1	85	54	54
Leguna	3	8	10	4	4	8	37	1	37	2	2
Motor Bike	35	27	23	34	21	28	168	0.5	84	100	50
Bicycle	1	2	4	5	0	2	14	0.5	7	5	3
							Total:		763		479
							Total PCU/30 min in both direction =		1242		
							Total PCU/hr. in both direction =		2484		

Operating Speed Calculation

Vehicle Type	No. of Vehicles	Distance, ft	Time, sec	Velocity, fps	Average Velocity, fps	Operating Speed, mph
Rickshaw	6	88	9.2	9.57	9.54	14.5
		88	7.7	11.43		
		88	11.3	7.79		
		88	10.4	8.47		
		88	9.4	9.37		
		88	8.3	10.61		
Private Car	5	88	5	17.6	23.326	
		88	3.1	28.39		
		88	3.7	23.79		
		88	3.4	25.89		
		88	4.2	20.96		
CNG	5	88	4.5	19.56	18.918	
		88	4.1	21.47		
		88	3.9	22.57		
		88	7.7	11.43		
		88	4.5	19.56		
Leguna	5	88	5.4	16.3	18.314	
		88	4.7	18.73		
		88	5.2	16.93		
		88	4.6	19.14		
		88	4.3	20.47		
Motor Bike	5	88	3.8	23.16	20.76	
		88	3.2	27.5		
		88	5.8	15.18		
		88	4.9	17.96		
		88	4.4	20		
Bicycle	3	88	5	17.6	15.5667	
		88	6	14.67		
		88	6.1	14.43		

Sample Calculation:

Operating Speed Calculation:

$$Operating\ Speed = \frac{\sum(number\ of\ individual\ motorized\ vehicle \times average\ speed)}{total\ number\ of\ motorized\ vehicle}$$
$$= \frac{219 \times 23.326 + 83 \times 18.918 + 37 \times 18.314 + 168 \times 20.76}{509} = 14.6\ mph$$

Roadway Capacity Calculation:

Roadway pattern: 4 lanes two way

Lane width: 11 ft

Shoulder condition: 4 ft on both side of roadway

Passing sight distance: 600 ft

% of passing sight distances: $\frac{600}{1500} \times 100\% = 40\%$

Level of service: C

Capacity of 4 lane two way $= 2000 \times 2\frac{veh}{hr}\ total\ in\ both\ direction$

For 40% passing sight distance, reduction factor = 0.62

Capacity reduction factor for 11 ft multilane roadway = 0.97

Capacity reduction for 4 ft shoulders in both side = 0.92

$$\therefore actual\ roadway\ capacity = 0.62 \times 0.97 \times 0.92 \times 2000 \times 2\frac{veh}{hr}\ total\ in\ both\ direction$$
$$= 2213\ \frac{veh}{hr}\ total\ in\ both\ direction = 1106\ \frac{veh}{hr}\ total\ in\ one\ direction$$

From data sheet,

observed volume $= 2484\frac{veh}{hr}\ total\ in\ both\ direction > 2213\frac{veh}{hr}\ total\ in\ both\ direction$

$\therefore Demand > Capacity$

Result:

Actual roadway capacity = 2213 veh./hr. total in both direction

Observed volume of traffic = 2484 veh./hr. total in both direction