Transportation Engineering- II
Lecture 4

Traffic characteristics-Volume

- The design of a highway and its features should explicitly consider traffic volumes and traffic characteristics
- However, traffic volumes can indicate the need for the improvement and directly influence the selection of geometric design features, such as number of lanes, widths, alignments, and grades

Traffic characteristics-Volume

- **Traffic Volume.** Number of vehicles passing a point on a highway during a specified time interval. Units: Simply vehicles or vehicles per unit time (veh/day; veh/hr)
- **Average annual daily traffic (AADT).** The average 24-hour volume at a given location over a full 365-day year (366 days in leap year).
- **Average daily traffic (ADT).** The average 24-hour volume at a given location over a defined time period less than one year; a common application is to measure an ADT for each month of the year

OR

- The ADT is defined as the total volume during a given time period (in whole days), greater than one day and less than one year, divided by the number of days in that time period

Traffic characteristics-Volume

- **Peak-Hour Traffic**
- The reasonableness of 30 HV as a design control is indicated by the changes that result from choosing a somewhat higher or lower volume
- The curve steepens quickly to the left of the point showing the 30th highest hour volume and indicates only a few more hours with higher volumes
- The curve flattens to the right of the 30th highest hour and indicates many hours in which the volume is not much less than the 30 HV

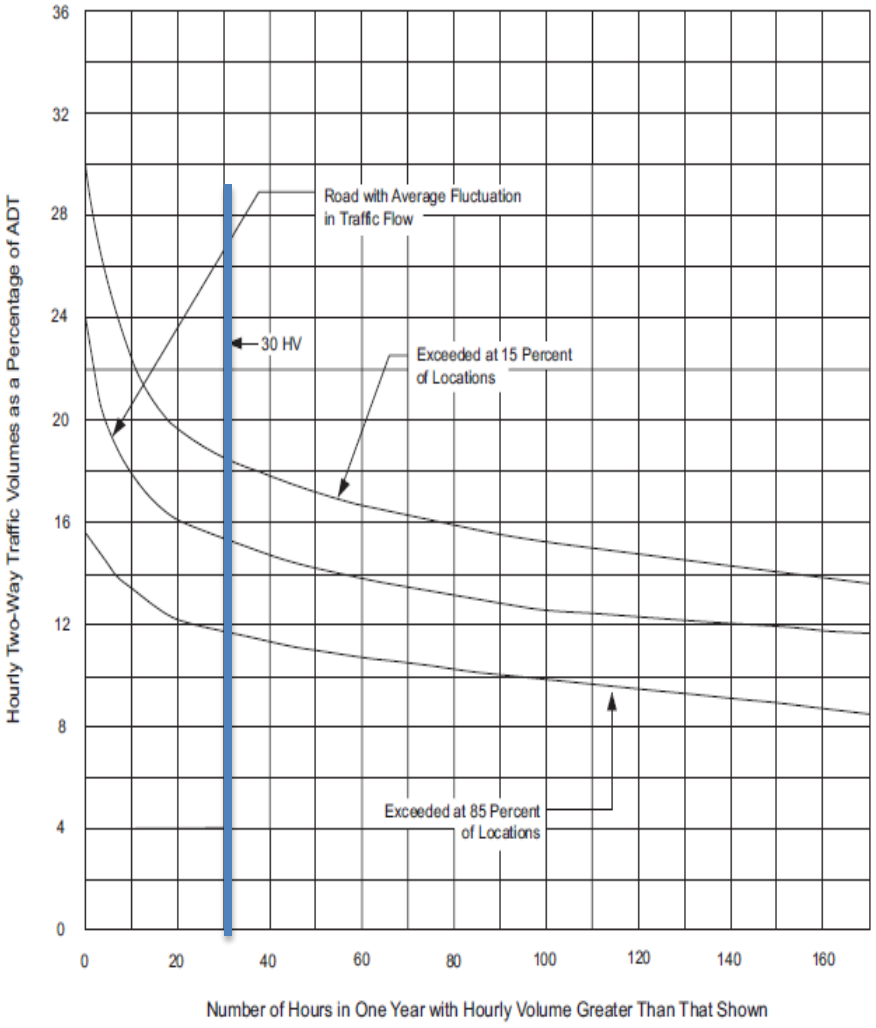

Figure 2-28. Relation between Peak-Hour and Average Daily Traffic Volumes on Rural Arterials

Traffic characteristics-Volume

Peak-Hour Traffic

- On rural roads with average fluctuation in traffic flow, the 30 HV is typically about 15 percent of the ADT
- The maximum hourly volume, which is approximately 25 percent of the ADT on the graph, exceeds 30 HV by about 67 percent.
- Typically, 30HV
  - 15% of AADT in rural areas, and
  - 8-12% in urban areas.

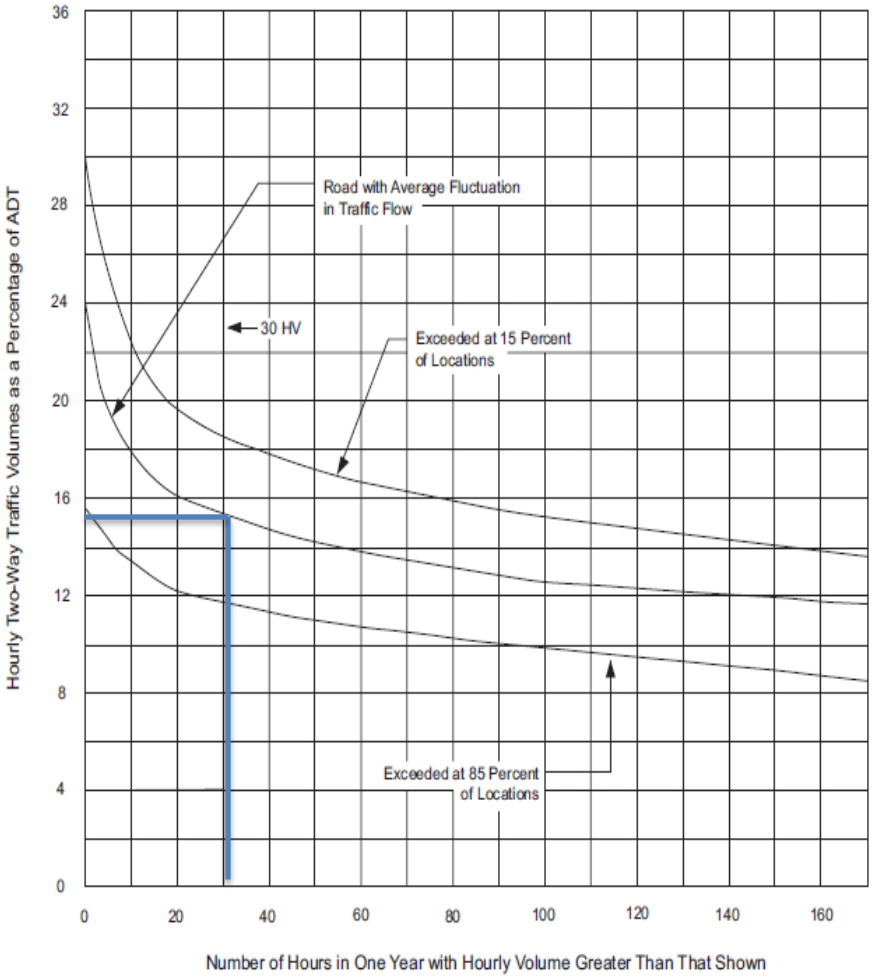

Figure 2-28. Relation between Peak-Hour and Average Daily Traffic Volumes on Rural Arterials

Traffic characteristics - Volume

- **Directional Distribution**
- Highways must be designed to adequately serve the peak-hour traffic volume in the peak direction of flow.
- Total hourly traffic in both directions is used to design **two-lane roads**
- In the design of highways **with more than two lanes** and on two-lane roads where important intersections are encountered or where additional lanes are to be provided later, knowledge of the hourly traffic volume for each direction of travel is essential- **Directional traffic is used for multilane roads and streets**
- Typically, one direction contributes by 55-70% in total traffic, although occasionally 80% is observed.

Traffic characteristics - Volume

- **Directional Distribution - Example**
- For example, consider a rural road with a design volume of 4,000 vehicles per hour (vph) for both directions of travel combined
- If during the design hour, the directional distribution is equally split, or 2,000 vph is one direction, two lanes in each direction may be adequate
- If 80 percent of the DHV is in one direction, at least three lanes in each direction would be needed for the 3,200 vph

Traffic characteristics - Volume

- Directional Distribution -Directional Design Hourly Volumes DDHV- ADTs are converted to a peak-hour volume in the peak direction of flow

$$DDHV = AADT * K(Peakhr) * D(Peakdir - flow)$$

- K = proportion of daily traffic occurring during peak hour
- D = proportion of peak hour traffic travelling in peak direction of flow
- For design, the K factor often represents the proportion of ADT occurring during the 30^{th} peak hour of the year

Traffic characteristics - Volume

Example Consider the case of a rural highway that has a 20-year forecast of AADT of 30,000 veh/day, for given highway, the K factor ranges from 0.15 to 0.25, and the D factor ranges from 0.65-0.80.

$$DDHV = ADT * K(Peakhr) * D(Peakdir - flow)$$

$$DDHV(low) = 30{,}000 * .15 * .65 = 2{,}925 veh/h$$

$$DDHV(high) = 30{,}000 * .25 * .80 = 6{,}000 veh/h$$

Table 5.2: General Ranges for K and D Factors

Facility Type	Normal Range of Values	
	K-Factor	*D*-Factor
Rural	0.15–0.25	0.65–0.80
Suburban	0.12–0.15	*0.55–0.65*
Urban:		
Radial Route	0.07–0.12	0.55–0.60
Circumferential Route	0.07–0.12	0.50–0.55

Class Example

❖ **Consider the case of a Urban highway (Radial) that has a 30-year forecast of AADT of 50,000 veh/day**

- Calculate the 30th Design hourly Volume (DHV)
- Calculate the DDHV.

Table 5.2: General Ranges for *K* and *D* Factors

Facility Type	Normal Range of Values	
	K-Factor	*D*-Factor
Rural	0.15–0.25	0.65–0.80
Suburban	0.12–0.15	*0.55–0.65*
Urban:		
Radial Route	0.07–0.12	0.55–0.60
Circumferential Route	0.07–0.12	0.50–0.55

Traffic characteristics - Volume

- **Composition of Traffic**
- Vehicles of different sizes and weights have different operating characteristics that should be considered in highway design
- **Trucks have a greater individual effect on highway traffic operation than do passenger vehicles**
- The effect on traffic operation of one truck is often equivalent to several passenger cars depending upon the gradient.
- **Thus, the larger the proportion of trucks in a traffic stream, the greater the equivalent traffic demand and the greater the highway capacity needed**
- Traffic composition should be determined by traffic study

Traffic characteristics - Volume

- **Projection of Future Traffic Demands**
- Geometric design of new highways or improvements to existing highways should not usually be based on current traffic volumes alone, but should consider future traffic volumes expected to use the facility
- **A highway should be designed to accommodate the traffic volume that is likely to occur within the design life of the facility**
- Many highway engineers believe the maximum design period is in the range of 15 to 24 years. **Therefore a period of 20 years is widely used as a basis for design**

Traffic characteristics - Speed

- **Design speed is a selected speed used to determine the various geometric design features of the roadway**
- In selection of design speed, every effort should be made to attain a desired combination of safety, mobility, and efficiency within the constraints of environmental quality, economics, aesthetics, and social or political impacts
- Once the design speed is selected, all of the pertinent highway features should be related to it to obtain a balanced design
- **Some design features, such as curvature, super elevation, and sight distance, are directly related to, and vary appreciably with, design speed**

Traffic characteristics - Speed

❖ **Design Speed Summary**

- Should be consistent with drivers' expectations
- Should fit the traffic habits of nearly all drivers
- Should not change over a substantial length of highway
- Depends on the functional class
- Ranges from 30 km/h to 110 km/h with 10 km/h increment

Highway Capacity

- The capacity of a facility is: “the **maximum hourly rate** at which **persons or vehicles** can be reasonably **expected to traverse a point or uniform segment** of a lane or roadway **during a given time period under prevailing roadway, traffic, and control conditions**.”

The LOS Concept

- Level of Service is a quality measure describing **operational conditions within a traffic stream**, generally in terms of such service measures as speed and travel time, freedom to maneuver, traffic interruptions, and comfort and convenience.
- The levels of service range from level of service A (least congested) to level of service F (most congested)

The LOS Concept

Table 2-4. General Definitions of Levels of Service

Level of Service	General Operating Conditions
A	Free flow
B	Reasonably free flow
C	Stable flow
D	Approaching unstable flow
E	Unstable flow
F	Forced or breakdown flow

Note: Specific definitions of levels of service A through F vary by facility type and are presented in the HCM (*37*).

The LOS Concept

Table 2-5. Guidelines for Selection of Design Levels of Service

Functional Class	Appropriate Level of Service for Specified Combinations of Area and Terrain Type			
	Rural Level	Rural Rolling	Rural Mountainous	Urban and Suburban
Freeway	B	B	C	C or D
Arterial	B	B	C	C or D
Collector	C	C	D	D
Local	D	D	D	D

The LOS Concept

Table 14.2: Level of Service Criteria for Basic Freeway Segments and Multilane Highways

Level of Service	Density Range for Basic Freeway Sections (pc/mi/ln)	Density Range for Multilane Highways (pc/mi/ln)
A	$\geq 0 \leq 11$	$\geq 0 \leq 11$
B	$> 11 \leq 18$	$> 11 \leq 18$
C	$> 18 \leq 26$	$> 18 \leq 26$
D	$> 26 \leq 35$	$> 26 \leq 35$
E	$> 35 \leq 45$	$> 35 \leq$ (40–45) depending on FFS
F	Demand Exceeds Capacity > 45	Demand Exceeds Capacity $>$ (40–45) depending on FFS

Highway Design analysis

Design analysis (Find number of lanes needed to serve desired MSF)

- In design analysis, an existing or forecast demand volume is used to determine the number of lanes needed to provide for a specified level of service. The number of lanes may be computed as:

$$N_i = \frac{DDHV}{PHF * MSF_i * f_{HV} * f_p}$$

where: N_i = number of lanes (in one direction) required to provide level of service "i"

$DDHV$ = directional design hour volume, veh/h

PHF = peak-hour factor

MSF = Maximum Service Flow Rate

f_{HV} = adjustment factor for presence of heavy vehicles

f_p = adjustment factor for presence of occasional or non-familiar users of a facility

Maximum Service Flow Rate (Freeways)

Table 12.3: Level-of-Service Criteria for Basic Freeway Sections

Criteria	Level of Service				
	A	B	C	D	E
Free-Flow Speed = 75 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	75.0	74.8	70.6	62.2	53.3
Maximum v/c	0.34	0.56	0.76	0.90	1.00
Maximum service flow rate (pc/h/ln)	820	1,350	1,830	2,170	2,400
Free-Flow Speed = 70 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	70.0	70.0	68.2	61.5	53.3
Maximum v/c	0.32	0.53	0.74	0.90	1.00
Maximum service flow rate (pc/h/ln)	770	1,260	1,770	2,150	2,400
Free-Flow Speed = 65 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	65.0	65.0	64.6	59.7	52.2
Maximum v/c	0.30	0.50	0.71	0.89	1.00
Maximum service flow rate (pc/h/ln)	710	1,170	1,680	2,090	2,350
Free-Flow Speed = 60 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	60.0	60.0	60.0	57.6	51.1
Maximum v/c	0.29	0.47	0.68	0.88	1.00
Maximum service flow rate (pc/h/ln)	660	1,080	1,560	2,020	2,300
Free-Flow Speed = 55 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	55.0	55.0	55.0	54.7	50.0
Maximum v/c	0.27	0.44	0.64	0.85	1.00
Maximum service flow rate (pc/h/ln)	600	990	1,430	1,910	2,250

Maximum Service Flow Rate (Highways)

Table 12.4: Level of Service Criteria for Multilane Highways

Criteria	Level of Service				
	A	**B**	**C**	**D**	**E**
Free-Flow Speed = 60 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	40
Minimum speed (mi/h)	60.0	60.0	59.4	56.7	55.0
Maximum v/c	0.30	0.49	0.70	0.90	1.00
Maximum service flow rate (pc/h/ln)	660	1,080	1,550	1,980	2,200
Free-Flow Speed = 55 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	41
Minimum speed (mi/h)	55.0	55.0	54.9	52.9	51.2
Maximum v/c	0.29	0.47	0.68	0.88	1.00
Maximum service flow rate (pc/h/ln)	600	990	1,430	1,850	2,100
Free-Flow Speed = 50 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	43
Minimum speed (mi/h)	50.0	50.0	50.0	48.9	47.5
Maximum v/c	0.28	0.65	0.65	0.86	1.00
Maximum service flow rate (pc/h/ln)	550	900	1,300	1,710	2,000
Free-Flow Speed = 45 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	45.0	45.0	45.0	44.4	42.2
Maximum v/c	0.26	0.43	0.62	0.82	1.00
Maximum service flow rate (pc/h/ln)	490	810	1,170	1,550	1,900

Highway Design analysis

Heavy Vehicle Adjustment Factor

$$f_{HV} = \frac{1}{1 + P_T (E_T - 1) + P_R (E_R - 1)}$$

where: P_T = proportion of trucks and buses in the traffic stream

P_R = proportion of RVs in the traffic stream

E_T = passenger car equivalent for trucks and buses

E_R = passenger car equivalent for RVs

Highway Design analysis

Table 12.13: Passenger-Car Equivalents for Trucks, Buses, and RVs on Extended General Terrain Sections of Freeways or Multilane Highways

Factor	Type of Terrain		
	Level	**Rolling**	**Mountainous**
E_T	1.5	2.5	4.5
E_R	1.2	2.0	4.0

(Used with permission of Transportation Research Board, National Research Council, *Highway Capacity Manual*, Dec 2000, Exhibit 23-8, pg. 23-9.)

Highway Design analysis

- **Driver Population Factor**
- The values for f_p range from 1.0 to 0.85.
- In general, the analyst should select 1.0, which reflects commuter traffic (i.e., familiar users), unless there is sufficient evidence or it is the analyst's judgment that a lesser value reflecting more recreational traffic characteristics should be applied

Example

- A new freeway is being designed through a rural area. The directional design hour volume (DDHV) has been forecast to be 2,700 veh/h during the peak hour, with a PHF of 0.85 and 15% trucks in the traffic stream. The facility will have level terrain characteristics. If the objective is to provide level of service C, how many lanes must be provided. Take Free flow speed of 75mile/hr.?

Access Control and Access Management

- **Regulating access is called “access control.”**
- The principal advantages of controlling access are the preservation or improvement of service and the reduction of crash frequency and severity
- **Access management involves providing (or managing) access to land development while simultaneously preserving the flow of traffic on the surrounding road system in terms of capacity, speed, and low crash frequency and severity**


Q
A
Answer