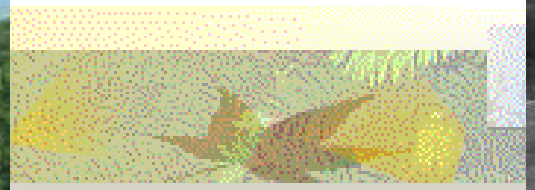
Design Speed and Design Traffic Concepts



Objectives

- Get familiar with design speeds for functional classes
- Describe traffic demand and determine for roadway design
- Define ADT, AADT, DHV, D, DDHV, K-Factor, and T

- Posted speed = speed limit
- Operating speed = free flow (spot speed)
- Running speed = length of highway section ÷ running time
- Design speed = selected speed used to determine geometric design features

Design Speed

- Design speed is defined by the AASHTO Green Book as: ***…the maximum safe speed that can be maintained over a specified section of highway when conditions are so favorable that the design features of the highway govern.***
- Design Speed should: 1) "…be consistent with the speed the driver is likely to **expect**." and 2) ". . .fit the travel desires and habits of nearly all drivers."
- Not posted speed and not operating speed (but ALWAYS higher than both)
- See first part of: http://www.fhwa.dot.gov/environment/flex/ch04.htm (Chapter 4 from FHWA's Flexibility in Highway Design)

Design Speed Considerations

- Functional classification of the highway
- Character of the terrain
- Density and character of adjacent land uses
- Traffic volumes expected to use the highway
- Economic and environmental considerations

Design Speed in Green Book

(suggested minimum design speed)

Rural Local Roads

Type of terrain	Metric: Design speed (km/h) for specified design volume (veh/day)						US Customary: Design speed (mph) for specified design volume (veh/day)					
	under 50	50 to 250	250 to 400	400 to 1500	1500 to 2000	2000 and over	under 50	50 to 250	250 to 400	400 to 1500	1500 to 2000	2000 and over
Level	50	50	60	80	80	80	30	30	40	50	50	50
Rolling	30	50	50	60	60	60	20	30	30	40	40	40
Mountainous	30	30	30	50	50	50	20	20	20	30	30	30

Exhibit 5-1. Minimum Design Speeds for Local Rural Roads

Source: *A Policy on Geometric Design of Highways and Streets* (The Green Book). Washington, DC. American Association of State Highway and Transportation Officials, 2001 4th Ed.

Design Speed in Green Book
(suggested minimum design speed)

Rural Collectors

Type of terrain	Metric			US Customary		
	Design speed (km/h) for specified design volume (veh/day)			Design speed (mph) for specified design volume (veh/day)		
	0 to 400	400 to 2000	over 2000	0 to 400	400 to 2000	over 2000
Level	60	80	100	40	50	60
Rolling	50	60	80	30	40	50
Mountainous	30	50	60	20	30	40
Note: Where practical, design speeds higher than those shown should be considered.						

Exhibit 6-1. Minimum Design Speeds for Rural Collectors

Source: *A Policy on Geometric Design of Highways and Streets* (The Green Book). Washington, DC. American Association of State Highway and Transportation Officials, 2001 4th Ed.

Design Speed in Green Book
(suggested minimum design speed)

Rural Arterials

- 60 – 120 kph (40-75 mph)
- Depends on …
  - Terrain
  - Driver expectancy
  - Alignment (reconstruction)

Design Speed in Green Book
(suggested minimum design speed)

Urban

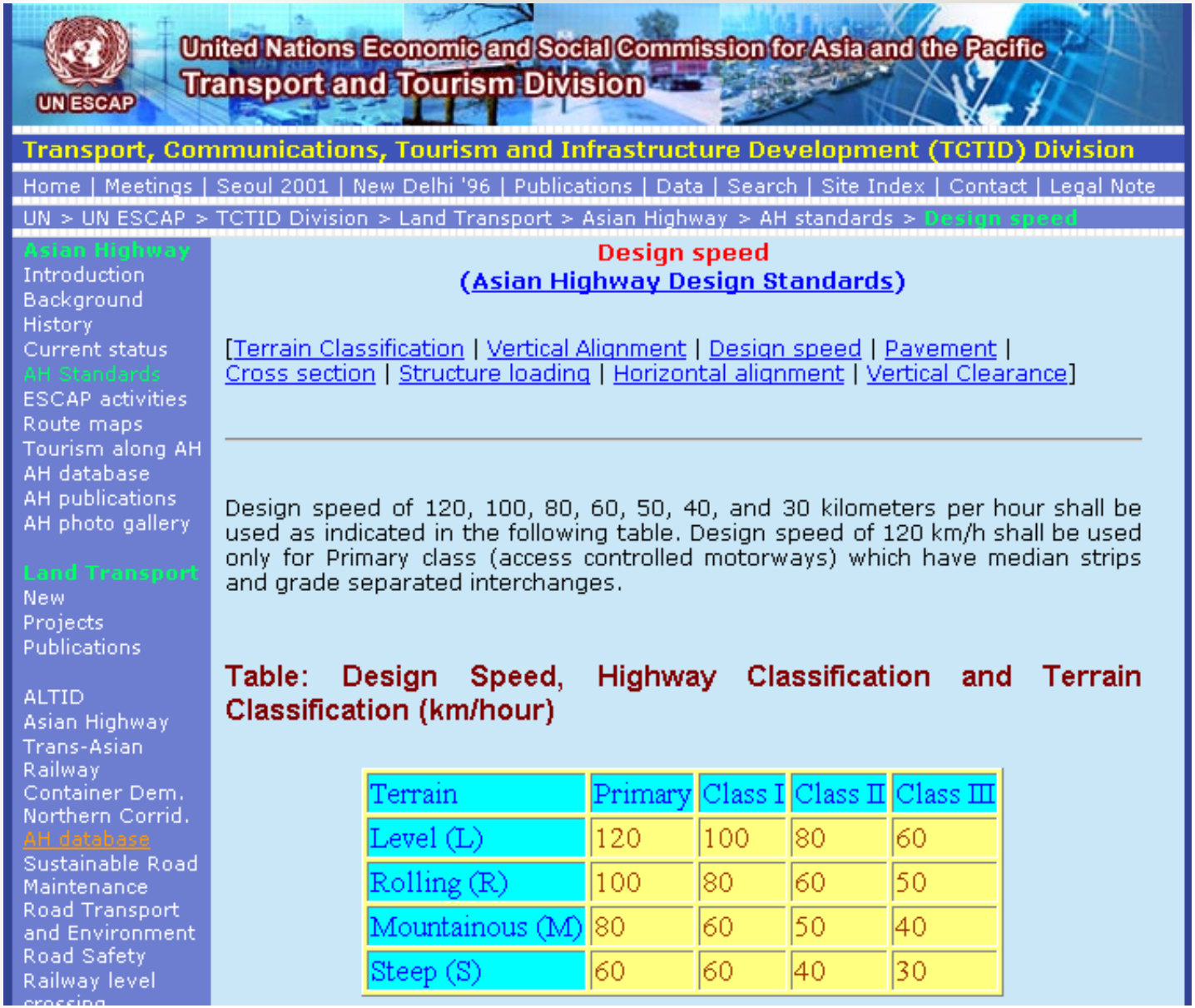
- Locals 20-30 mph
- Collectors 30 mph+
- Arterials 30-60 mph

Freeways	Design Speeds	
Terrain	**Rural**	**Urban**
Flat	70-80	70
Rolling	60-70	60-70
Mountainous	50-60	50-60
Arterial Highways		
Terrain	**Rural**	**Urban**
Flat	60-70	30-60
Rolling	40-60	30-50
Mountainous	30-50	30-50
Collector and Local Roads		
Terrain	**Rural**	**Urban**
Flat	30-50	30-40
Rolling	20-40	20-40
Mountainous	20-30	20-30

Values represent the minimum acceptable design speeds for the various conditions of terrain and traffic volumes associated with new or reconstructed highway facilities

Source: Traffic *Engineering Handbook (Fourth Edition)*, Institute of Transportation Engineers, Washington, DC, 1992, p. 156. Note: 1 mile/hr = 1.613 km/hr

International



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Asian Highway
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Land Transport
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ALTID
Asian Highway
Trans-Asian Railway
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Northern Corrid.
AH database
Sustainable Road Maintenance
Road Transport and Environment
Road Safety
Railway level crossing

Design speed
(Asian Highway Design Standards)

[Terrain Classification | Vertical Alignment | Design speed | Pavement | Cross section | Structure loading | Horizontal alignment | Vertical Clearance]

Design speed of 120, 100, 80, 60, 50, 40, and 30 kilometers per hour shall be used as indicated in the following table. Design speed of 120 km/h shall be used only for Primary class (access controlled motorways) which have median strips and grade separated interchanges.

Table: Design Speed, Highway Classification and Terrain Classification (km/hour)

Terrain	Primary	Class I	Class II	Class III
Level (L)	120	100	80	60
Rolling (R)	100	80	60	50
Mountainous (M)	80	60	50	40
Steep (S)	60	60	40	30

Design Traffic

Traffic Definitions

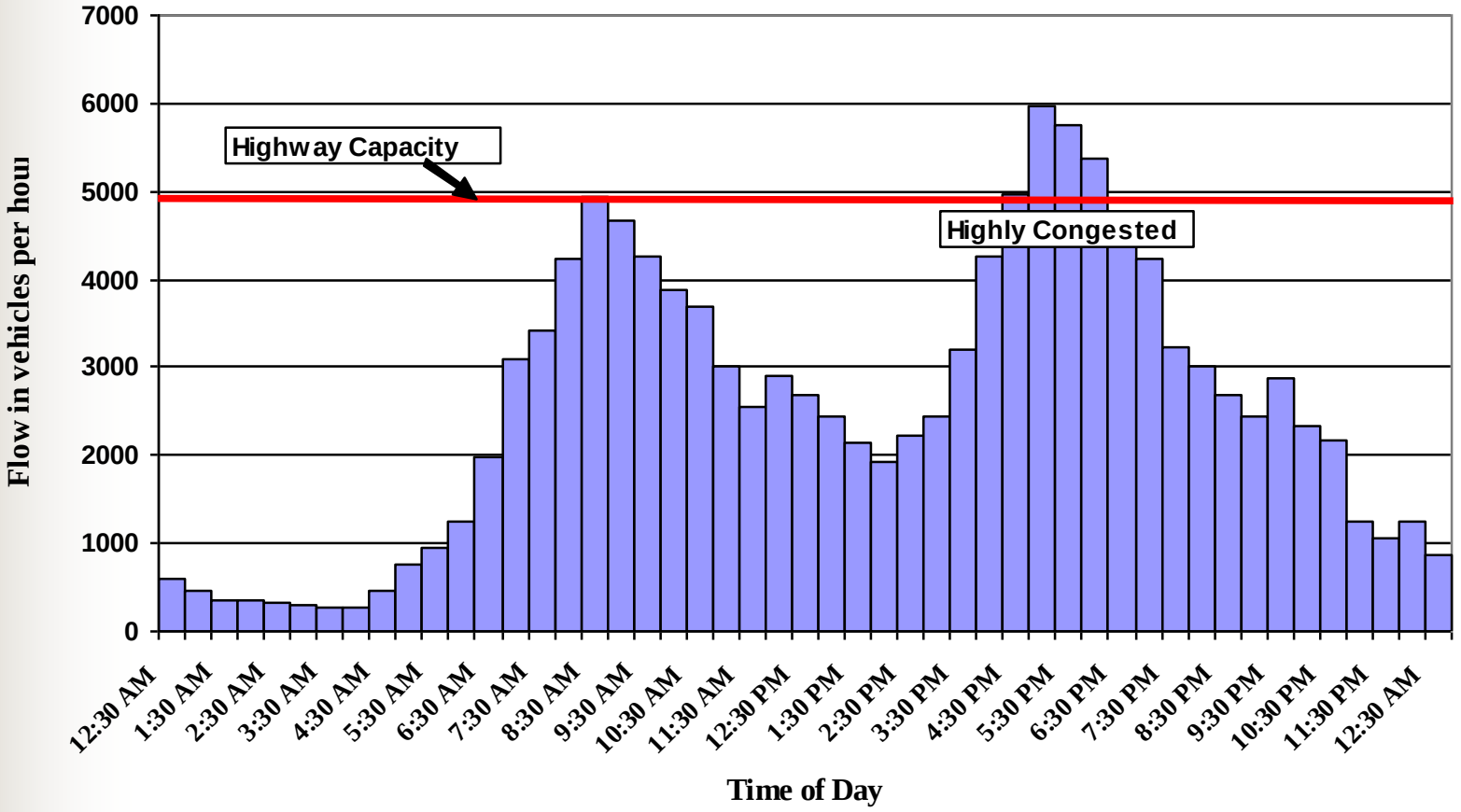
- **Volume:**
  - number of vehicles, pedestrians, etc. passing a point during a specific period of time
  - for vehicles, usually expressed as veh/hour (vph) or veh/hour/lane (vphpl)

- **Demand:**
  - number of vehicles, pedestrians, etc. that desire to travel between locations during a specific period
  - Frequently higher than volume during certain peak times
  - Trips are diverted or not made when there are constraints in the system
  - difficult to measure actual demand because capacity constrains the demand
- **Capacity:**
  - maximum number of vehicles that can pass a point during a specific period
  - A characteristic of the roadway or facility

Characteristics of Traffic Flow

- Highly variable
  - Time of day
  - Day of week
  - Season
  - Road characteristics
  - Direction

Traffic Typically Peaks twice per day



Source: www.ecn.purdue.edu/~darcy

Volume Studies

- AADT: Annual average daily traffic (counted for 365 days)
- ADT: average daily traffic (counted for > 1 day and < 365)
- PHV: peak hour volume
- Classification counts: fleet mix

Estimating AADT

- Annual Average Daily Traffic
- Use count station information
- Extrapolate to non-count locations
- Used to adjust ADT for
  - Seasons
  - Daily variation

AADT Data Helps to:

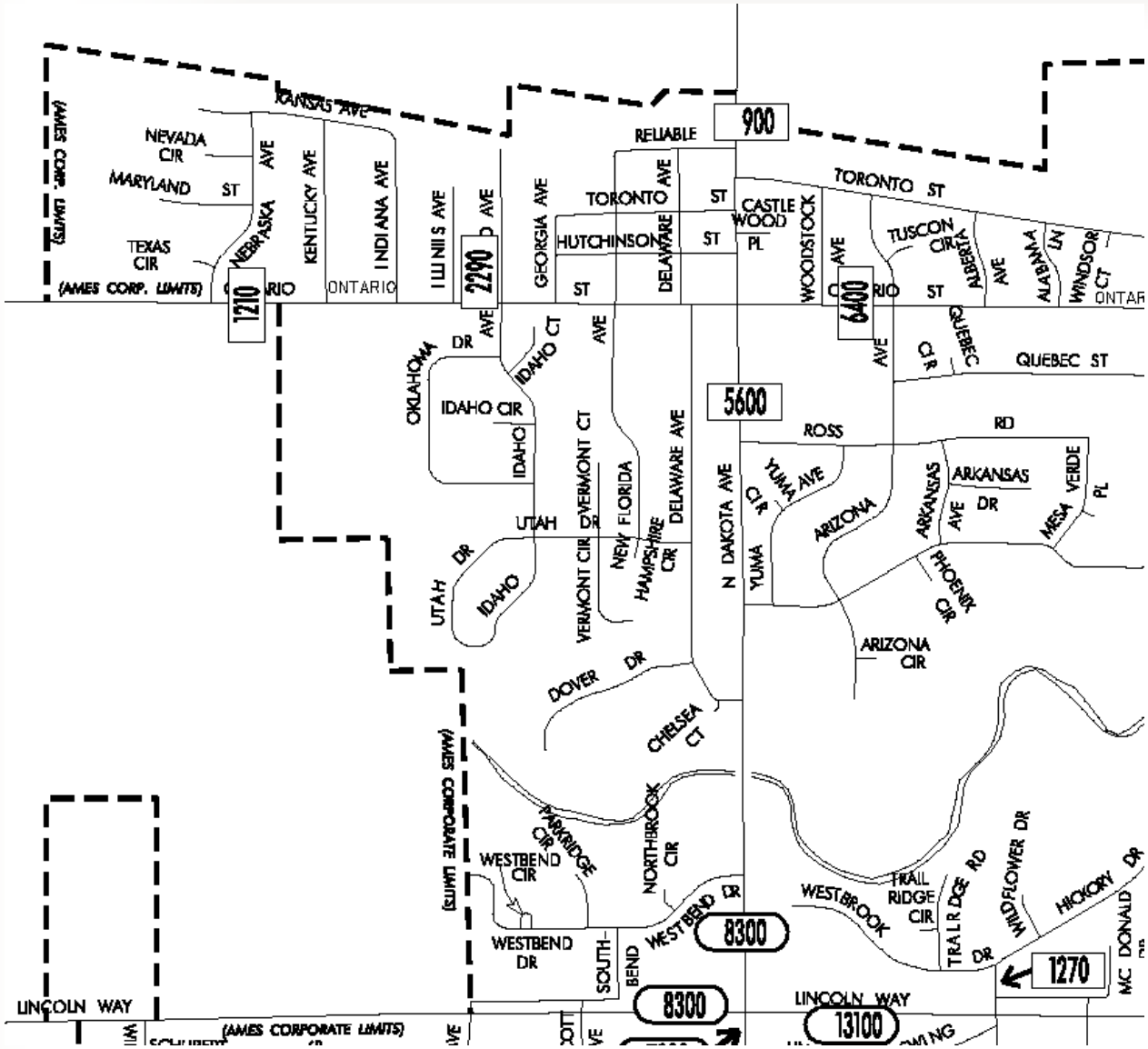
- Estimate highway revenues
- Establish overall volume trends
- Establish annual accident rates
- Analyze benefits of road improvements

Counting Program

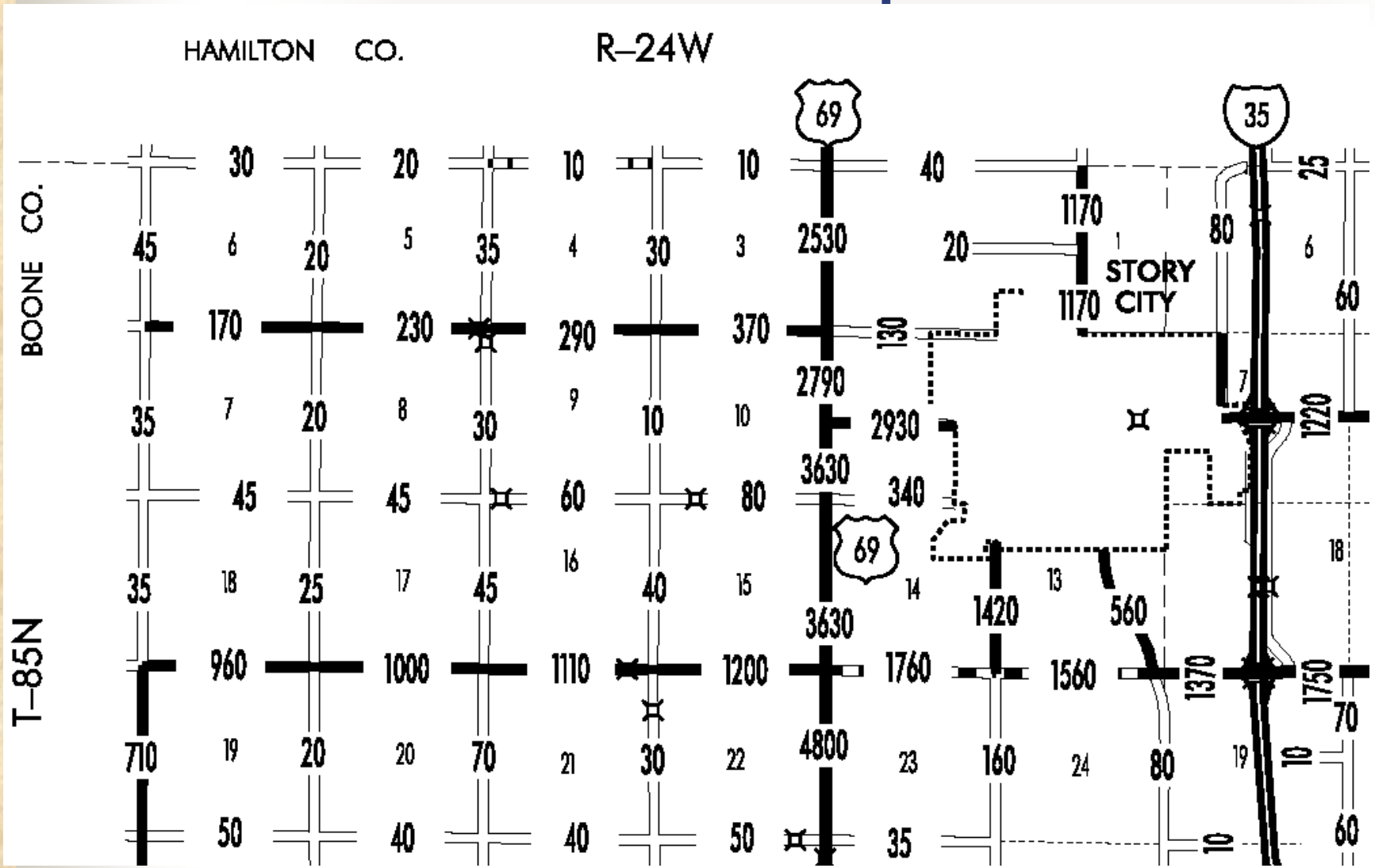
- To satisfy the traffic volume data needs for all roads under a particular jurisdiction, we establish a **Counting Program**

  A systematic pattern of counting at different times and locations

Traffic Counts Maps



Traffic Counts Maps



Design Volume

- Usually hourly volume
- Which hour?
  - Average hourly volume – inadequate design
  - Maximum peak hour – not economical
  - Hourly volume used for design should not be exceeded very often or by very much
  - Usually use 30th highest hourly volume of the year
  - On rural roads 30 HHV is ~ 15% of ADT
  - Tends to be constant year to year

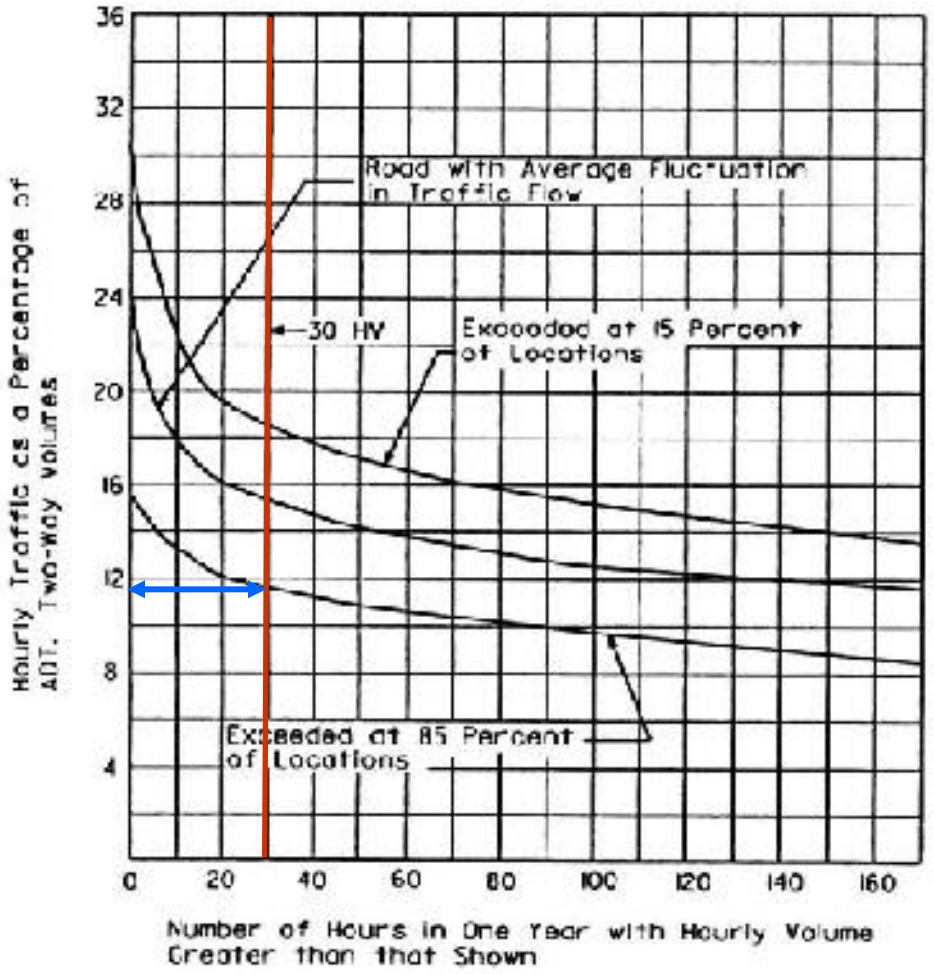
Traffic Demand

- Design Hourly Volume (DHV) – future hourly volume (both directions) used for design - typically 30th HHV (highest hourly volume) in the design year
- Why 30th HHV?
  - Breakpoint of 2-28
  - Compromise: too high is wasteful, too low poor operation
  - Approximately median weekly peak hour volume (top highest week peak hours)

(30th HHV exceed 29 times in year)

Traffic Demand (cont.)

3. Exhibit 2-28 relationship between HHV and percent of ADT in peak hour (referred to as K-factor)



Source: *A Policy on Geometric Design of Highways and Streets* (The Green Book). Washington, DC. American Association of State Highway and Transportation Officials, 2001 4th Ed.

Design Hourly Volume

DHV is a representation of peak hour traffic, usually for the future, or horizon year

K-factor represents proportion of AADT that occurs in the 30th HHV

$$\text{K-factor} = \frac{\text{DHV}}{\text{AADT}} \times 100$$

K = 8 to 12% urban, 12 to 18% rural

Design Hourly Volume (Example)

If AADT is 3500 vpd and the 30th highest hourly volume for the year is 420 vph what is the K-factor for that facility?

$$\text{K-factor} = \frac{\text{DHV}}{\text{AADT}} \times 100$$

$$\text{K-factor} = \frac{420}{3500} \times 100 = \underline{12}$$

Question: What's the impact of choosing different K factor for design?

If AADT is 3500 vpd, how will the design volume differ for K-factor = 8% vs. 12%?

$$DHV = \frac{\text{K-factor} \times AADT}{100}$$

$$DHV_{k=8\%} = \frac{8 \times 3500}{100} = 280 \text{ vph}$$

$$DHV_{k=12\%} = \frac{12 \times 3500}{100} = 420 \text{ vph}$$

(diff of 140 veh)

Traffic Demand (cont.)

- D = directional distribution = one way volume in peak direction (expressed as a percentage of two-way traffic) Rural 55 to 80%
- Can also adjust for how traffic is distributed between lanes (e.g., 3 lanes, highest/outside lane may be 40% of total directional flow)

Directional Distribution (example)

If traffic is directionally split 60/40, what is directional distribution of traffic for previous example (Design hourly volume = 420 veh/hr)?

Directional Design Hourly Volume (DDHV) =

0.6 x 420 = 252 veh/hr

Notice we use 0.6 not 0.4!!

Traffic Demand (cont.)

- T = percentage of heavy vehicles during design hour (Iowa interstate 35% plus)
- Affects capacity, ability to pass on two-lane rural roads, etc.
- Larger, occupy more space
- Should determine % during design hour (truck patterns may not be same as passenger vehicles)

Peak Hour Factor (PHF)

$$PHF = \frac{\text{peak-hour volume}}{4(\text{peak 15-min volume})}$$

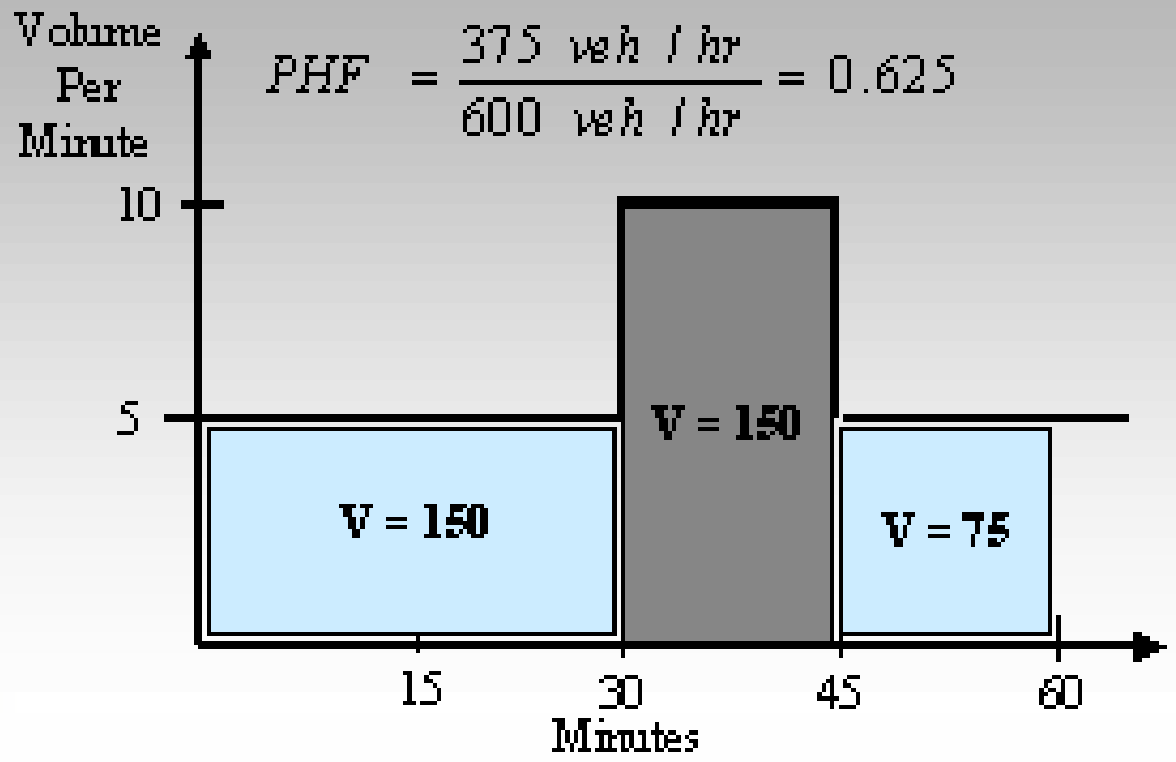
Flow is not uniform throughout an hour

HCM considers operating conditions during most congested 15-minute period of the hour to determine service level for the hour as a whole

Peak Hour Factor

$$PHF = \frac{hourly\ \ volume}{peak\ 15\ min\ \ flow\ \ rate}$$

$$PHF = \frac{375\ veh\ /\ hr}{600\ veh\ /\ hr} = 0.625$$



$$DHV = \frac{\text{Peak-Hour Volume}}{PHF}$$

Example

Peak hour volume from previous = 375 vph

PHF = 0.625

$$DHV = \frac{375}{0.625} = \mathbf{600\ vph}$$

Note: the traffic you design for is the busiest 15 minutes during the peak hour … another way to think of it is 150 vehicles per 15 minutes = 600 vehicles per 60 minutes