Al-Mansour University College

قسم الهندسة المدنية

Civil Eng. Dept.

المرحلة الثالثة

3rd. Stage

Traffic

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Lec.1&2

المرور

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Chapter One

Characteristics of the driver, the pedestrian, the vehicle, and the road

Traffic Engineering: Is the part of engineering which deals with traffic planning and design of roads, parking facilities and with the control of traffic to provide safe and economical movement of vehicles and pedestrians.

The four main components of the highway mode of transportation are:

1. The driver.
2. The pedestrian.
3. The vehicle.
4. The road.

1. Driver Characteristic:

The Human Response Process:

Actions taken by drivers on a road result from their evaluation and reaction to

A. Visual Reception: The principal characteristics of the eye are visual acuity, peripheral vision, color vision, glare vision and recovery, and depth perception.

1. **Visual Acuity:** is the ability to see fine details of an object, it can be represented by the visual angle. Most people have clear vision within a conical angle of 3 to 5 degrees and fairly clear vision within a conical angle of 10 to 12 degrees. Vision

   in traffic and highway emergencies:

   1. Static visual acuity: both the objects and driver are stationary.

   2. Dynamic visual acuity: the driver ability to detect relatively moving objects.

<u>The factors that affect static acuity include:</u>

1- Background. 2- Brightness. 3- Contrast. 4- Time.

2. **Peripheral Vision:** Peripheral vision is the ability of people to see objects beyond the cone of clearest vision. Details and color are not clear. The cone for

   affected by the speed of the vehicle, Age also influences peripheral vision.

3. **Color Vision:** Color vision is the ability to differentiate one color from another,

   Combinations of black and white and black and yellow have been shown to be those to which the eye is most sensitive.

4. Glare Vision and Recovery: The time required by a person to recover from

time is about 3 seconds when moving from dark to light and can be 6 seconds or more when moving from light to dark. Glare vision is of great importance during night driving.

particularly important on two-lane highways during passing maneuvers

B. Hearing Perception: The ear receives sound stimuli, which is important to drivers only when warning sounds, usually given out by emergency vehicles, are to be detected.

<u>C.Perception-Reaction process:</u>

The process through which a driver, cyclist, or pedestrian evaluates and reacts to a stimulus can be divided into four sub processes:

1.

2. <u>Identification:</u> the driver identifies the object or control device and thus understands the stimulus

3. Emotion: the driver decides what action to take in response to the stimulus; for example, to step on the brake pedal, to pass, to swerve, or to change lanes

4. Reaction or volition: the driver actually executes the action on during the emotion sub-process.

PIER Perception-Reaction Time: is an important factor in the determination of braking distances and the length of the yellow phase at signalized intersections, the by the American Association of State Highway and Transportation Officials (AASHTO) stipulates 2.5 seconds for stopping-sight distances.

Example: vehicle travelling at 65 km/h if P.R time is 2.5 sec, calculate the stopping distance.

Solution:

Velocity (V) $= \frac{Distance\ (D)}{Time\ (t)}$

$65000 = \frac{Distance\ (D)}{0.0007} \rightarrow$ D= 45.14 m

2. Pedestrian Characteristic: Same Characteristics of driver, with addition of others which influence the design and location of pedestrian control devices, such as:

- Special pedestrian signals.
- Safety zones and islands at intersections.
- Elevated walkways.
- Crosswalks.

Significant differences have also been observed between male and female walking speeds. At intersections, the mean male walking speed has been determined to be 4.93 normally used for design purposes.

1.5 m/Sec

1.41 m/Sec

1.2 m/Sec

3. The vehicle characteristics:

Criteria for the geometric design of highways are partly based on the:

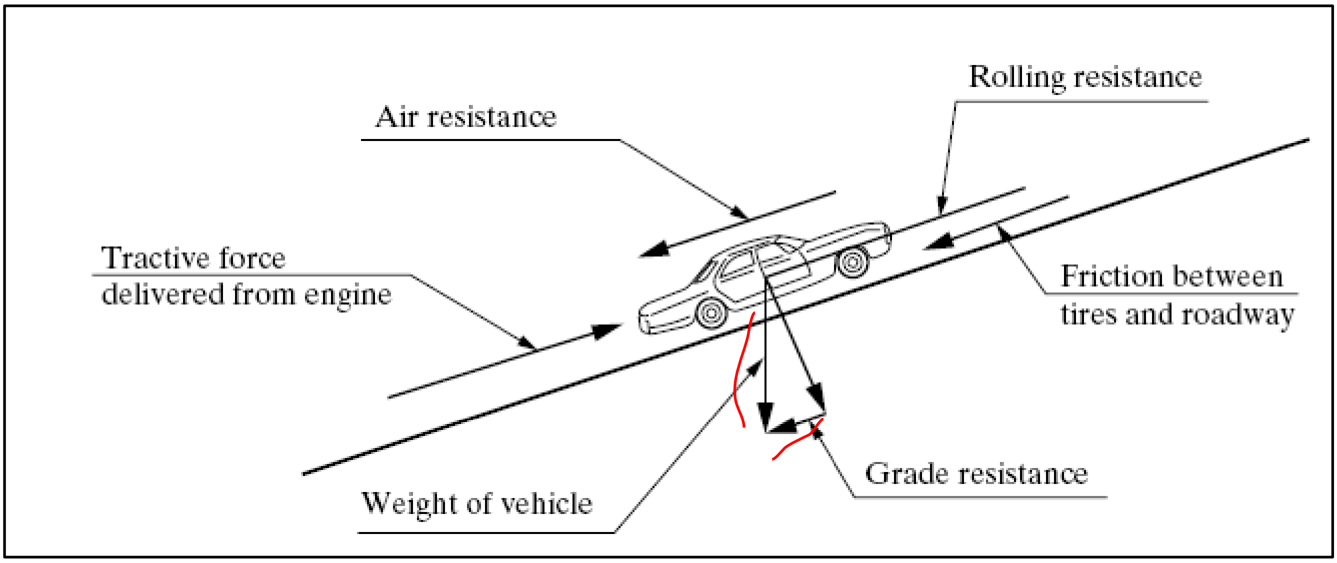
1. **Static characteristics:** Static characteristics include the weight and size of the vehicle. The size of the design vehicle for a highway is an important factor in the determination of design standards for several physical components of the highway. These include lane width, shoulder width, length and width of parking bays, and lengths of vertical curves.

vehicle without considering the forces that cause the motion.

3. **Dynamic characteristics:** Dynamic characteristics involve the forces that cause the motion of the vehicle.

    1- Air resistance. 2-Grade resistance. 3-Rolling resistance.

    4-Curve resistance. 5-Friction resistance.



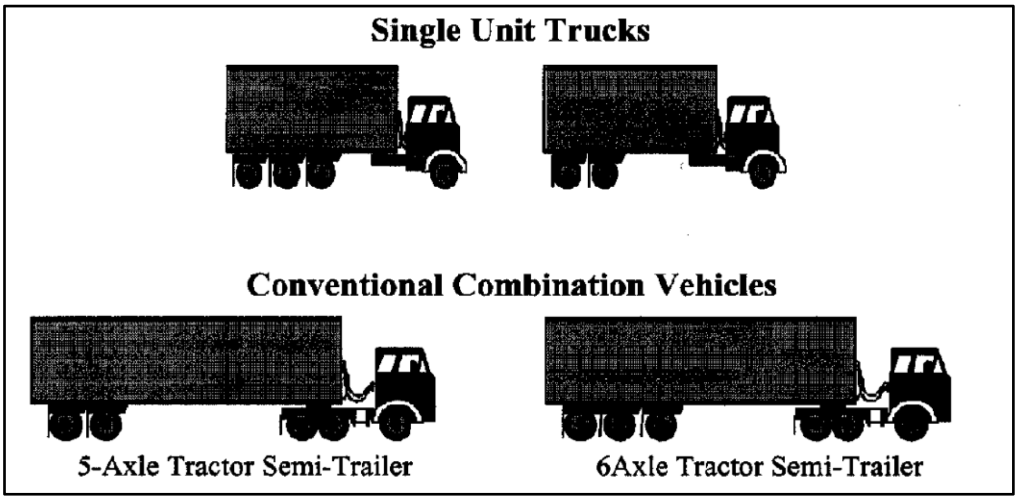
Forces Acting on a Moving Vehicle

Types of vehicles:

1. **Passenger cars (P-car):** Vehicle that has four tires touching the pavement like (bus, minibus and pick up).

2.

1. Tractor –trailers. 2. Semitrailer. 3. Single unit truck.



Examples of Different Types of Trucks

Vehicle Dimensions:

Vehicle Type	Dimensions (m)			15 km (min. turn radius
	Width	Length	Height	
Passenger car	2.1	5.8	1.3	>3
Single unit truck	2.6	12	4.1	12.8
Tractor-trailer	2.6	20	4.1	13.7

4. The Road characteristics:

A-Urban Road: Urban roads are functionally classified into arterials, collectors, and local roads.

1. **Principal Arterial:** Is the road that crosses the city from one direction to another and has several lanes and two-way.

   - **Properties:**

≈ B. 4. Full control of access.

2. **Minor Arterial:**

   - Properties:

LOS

1. Moderate speed design 100 km/hr. 2. Design level of service ≈B-C

3. **Collectors:** The main purposes of streets within this system are to collect traffic from local streets in residential areas or in central business districts (CBDs) and convey it to the arterial system. Thus, collector streets usually go through residential areas and facilitate traffic circulation within residential, commercial, and industrial areas.

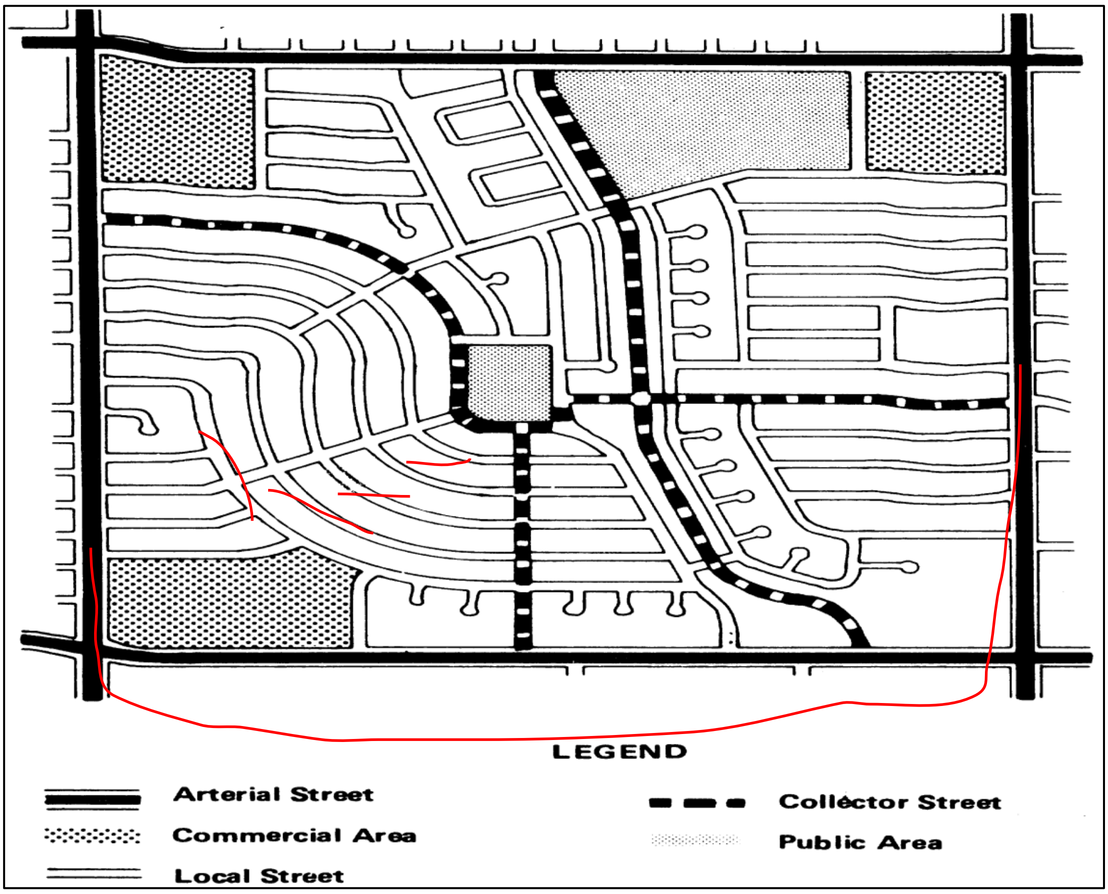
   - Properties:

LOS

1. Moderate speed design **≈80** km/hr. 2. Design level of service ≈C-D

4. **Local roads and Local Street:** This system consists of all other streets within the urban area that are not included in the three systems described earlier. The primary purposes of these streets are to provide access to abutting land and to the collector street.

- Properties: Moderate speed design **≈40** km/hr.

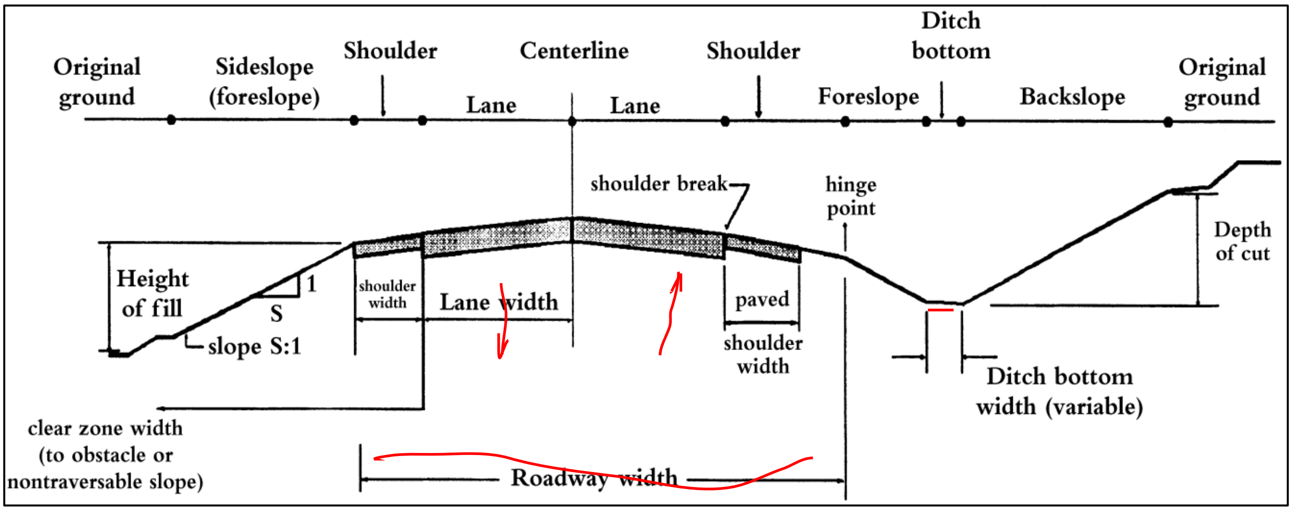


Schematic Illustration of the Functional Classes for a Suburban Road Network

Local Street: Urban area (Area with population >5000 Capita).

Local Street: Rural area (Area with population <5000 Capita).

B-Rural Road: Highway facilities outside urban areas comprise the rural road system. These highways are categorized as principal arterials, minor arterials, major collectors, minor collectors, and locals. And the figure below shows the cross section elements for rural two-lane highway.



Cross Section Elements for Rural Two-Lane Highway

Right of Way:

The right of way is the total land area acquired for the construction of a highway. The width should be sufficient to accommodate all the elements of the highway cross section, any planned widening of the highway, and public-utility facilities that will be installed along the highway. The right of way for two lane urban

(12-18)m

collector streets should be between 40 ~~and~~ 60 ft, whereas the desirable minimum for

25.6 m

two-lane arterials is 84 ft.

Intersections

Intersection is an area, shared by two or more roads, whose main function is to provide for the change of route directions.

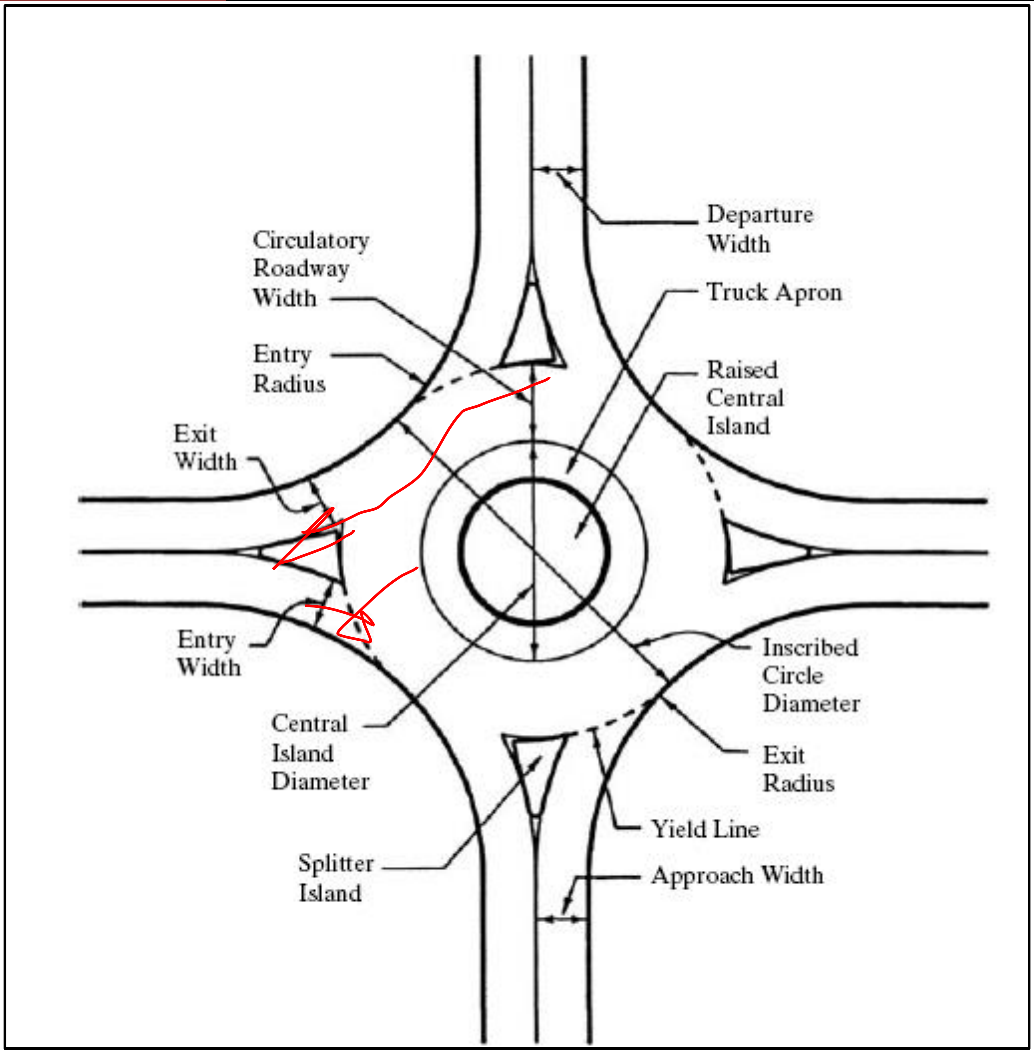
Types of intersections:

1. Roundabout (Rotary):
2. Channelized intersections:
3. Traffic light intersections.

1. **Roundabout (Rotary)**: is a type of circular intersection or junction in which road traffic is slowed and flows almost continuously in one direction around a central island to several exits onto the various intersecting roads.

Characteristics of the Design of the Rotary Intersection:

1. If the number of intersecting streets four or more streets the rotation solve the problem.
2. Maximum traffic volume per hour 3000 vehicles.
3. Speed will be slow in rotary intersection.
4. The pedestrian crossing intersections will be difficult.
5. There are wide spaces not used inside the rotary.
6. Roads related to rotary may be one-way or two-way.
7. Number of conflicts points is great.



Geometric Elements of a Single-Lane Modern Roundabout

2. **Channelized intersections:**

   A. At Grade intersections:

   B. Grade Separated intersections:

Factors affecting the design of interchange:

1. Topography of the site.
2. Traffic characteristics.
3. Land availability.
4. Impacts of the surrounding areas.

5. Overall environment.

6. Economic viability.

7. Financial constraints.

Functions of Interchanges:

1. Provide grade separation between two or more traffic arteries.
2. To make the possible the easy transfer from one artery to the other or between local street and freeway.

A. At Grade intersections:

Characteristics:

1. Takes the traffic volume in the rush hour.
2. Working to provide rotated for vehicles.
3. Take traffic characteristics and the design speed at design.

Types of at Grade intersections:

1. **T-Intersection.**
2. **Cross- Intersection (four legs).**
3. **Y- Intersection.**
4. **Five or more legs.**

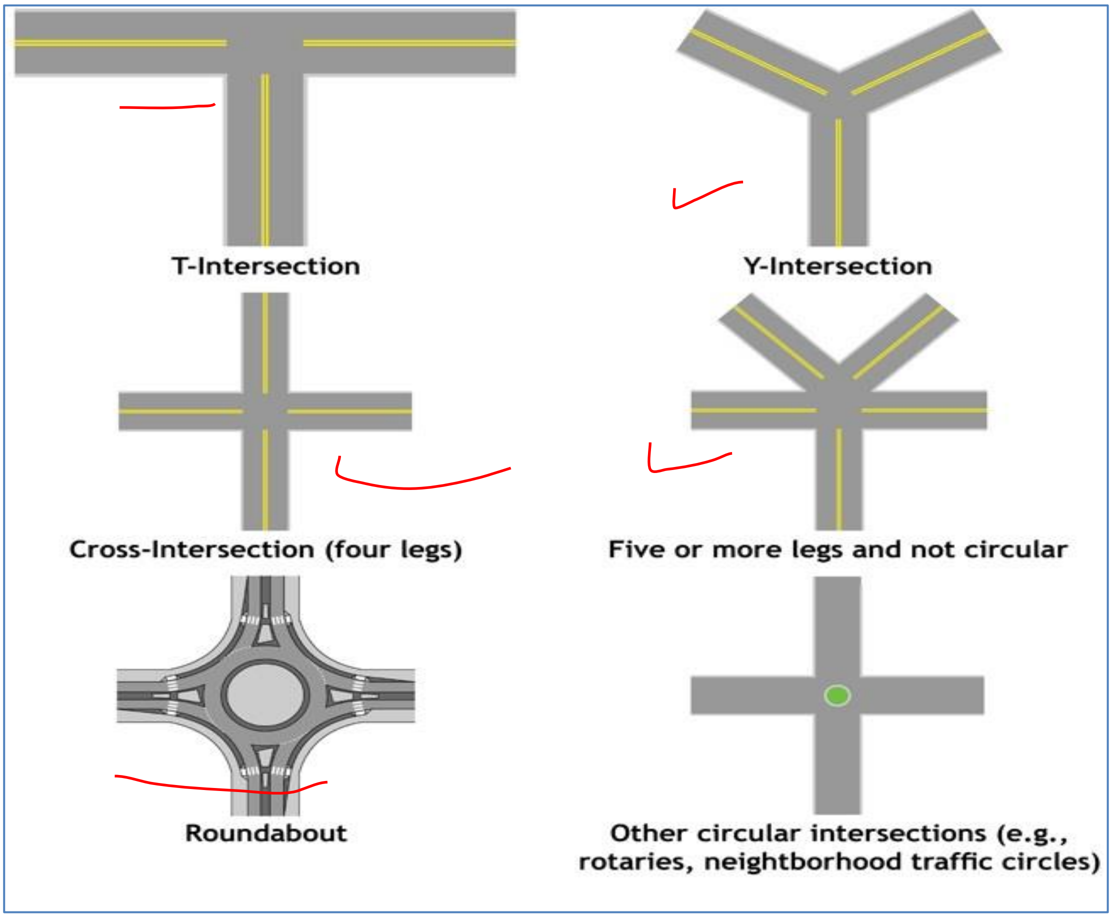


Illustration of Types of at Grade Intersection Geometry.

B. Grade Separated intersections:

Characteristics:

1. Volume of traffic that crosses the intersection approaching or equal to the traffic capacity of the two intersecting roads.
2. Keeps the design speed of the road.
3. No conflict points.

Types of Grade Separated Intersections:

1. **Over pass**: is a bridge, road, railway or similar structure that crosses over another road or railway.

2. Diamond Interchange: The diamond Interchange is the simplest form of grade separated intersection between two roadways.

Advantages of Diamond Interchanges:

1. Reducing delay and theoretically improves pedestrian safety.
2. Reduced horizontal curvature reduces risk of off-road crashes.
3. Increases the capacity of turning movements to and from the ramps.
4. Reduces the number of conflict points, thus theoretically improving safety.

Disadvantages of Diamond Interchanges:

1. Pedestrians would be required to cross free-flowing traffic on freeway ramps. This could be mitigated by signalizing all movements, without impacting the two-phase nature of the interchange's signals.
2. Free-flowing traffic in both directions on the non-freeway road is impossible, as the signals cannot be green at both intersections for both directions simultaneously.

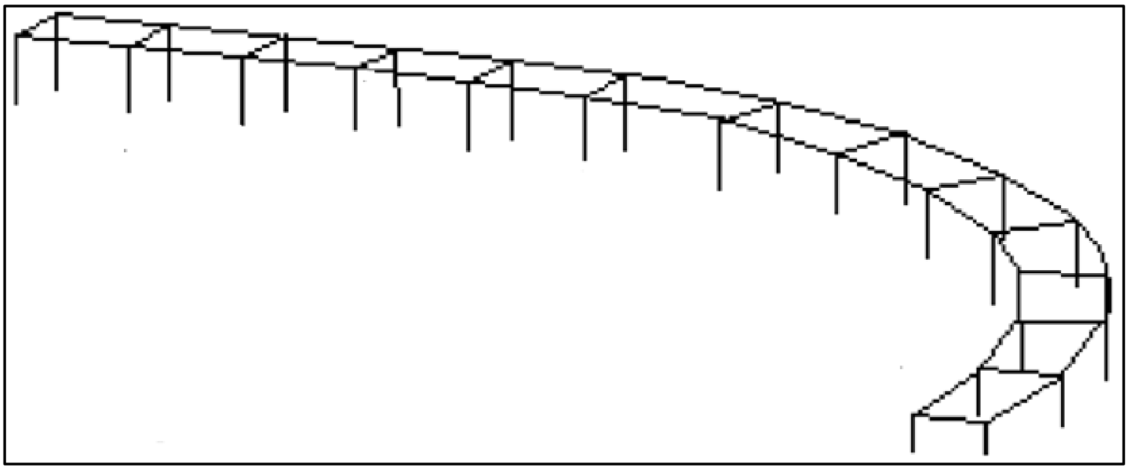
3. **Cloverleaf Interchange:** are four-leg interchanges that employ loop ramps to accommodate left-turning movements. Interchanges with loops in all four quadrants are referred to as "full cloverleaf"

Advantages of Cloverleaf Interchanges

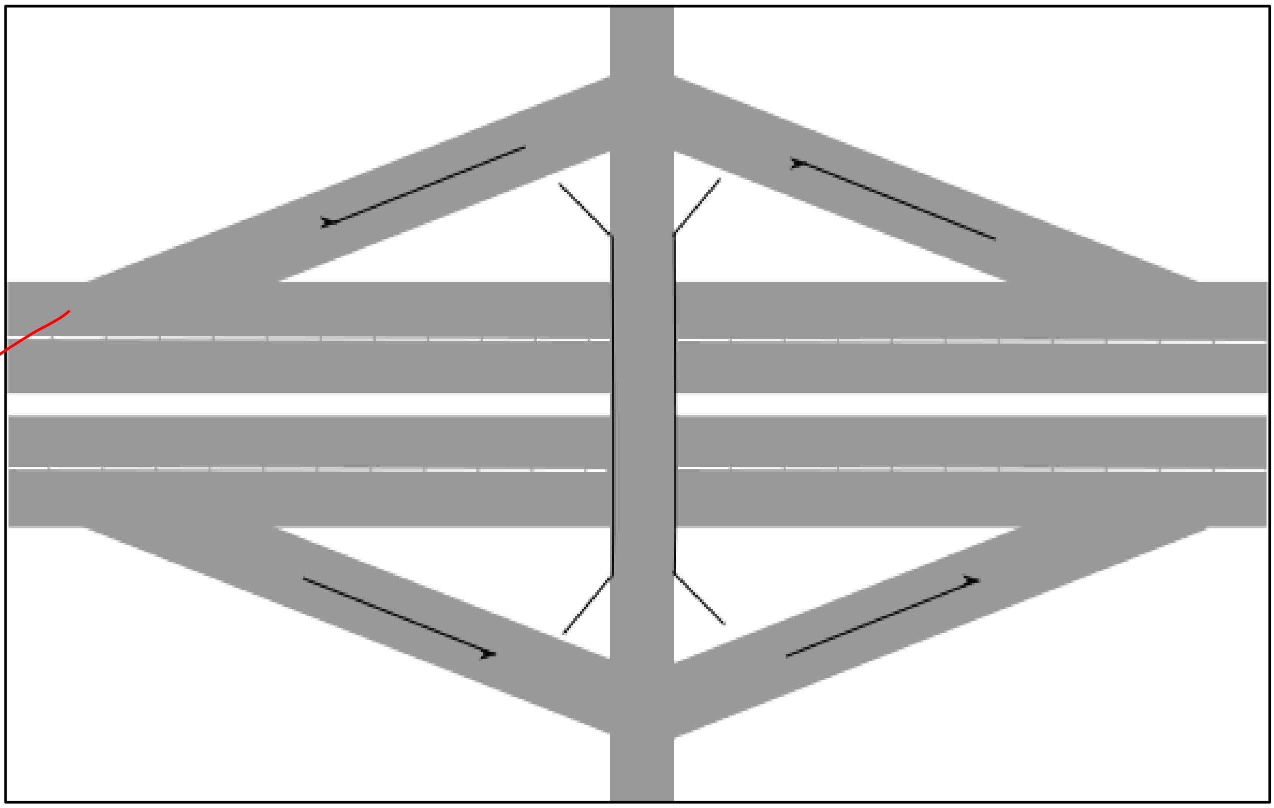
1. A configuration with loop ramps to safely accommodate left-turning movements that is well suited for the intersection of two freeways.

Disadvantages of Cloverleaf Interchanges:

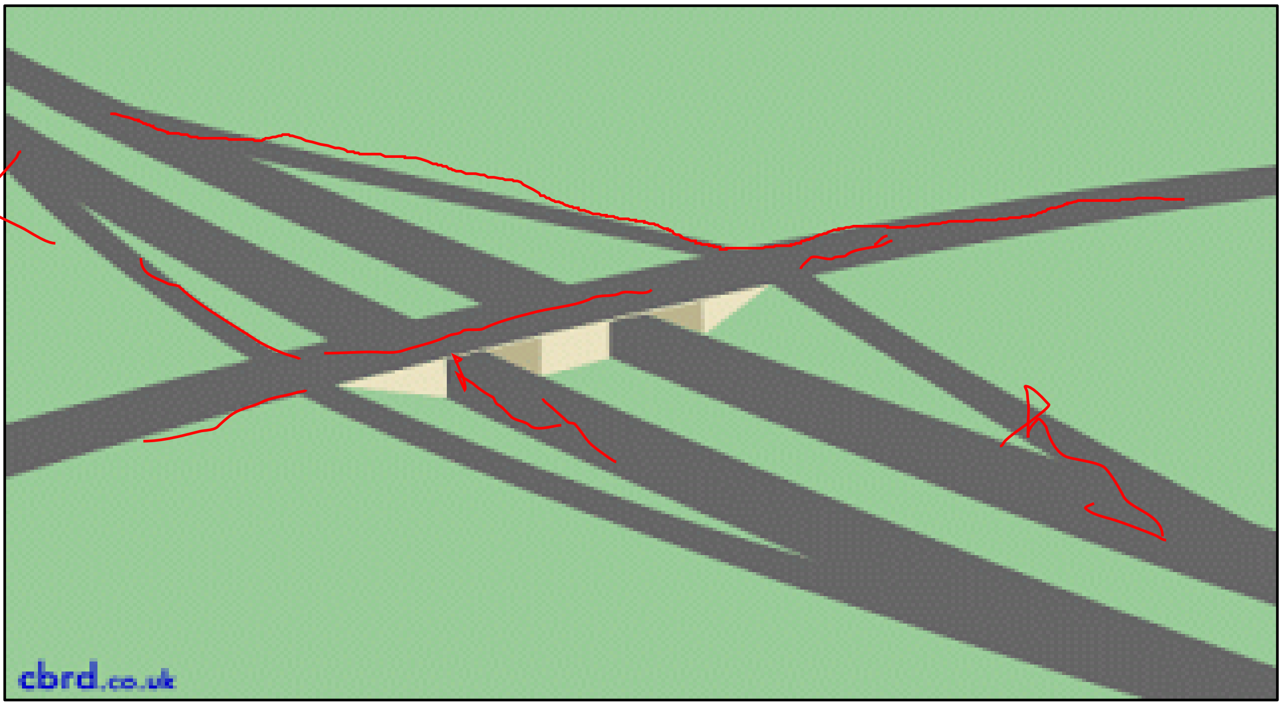
1. The interchanges require more right of way area than that for a diamond interchange.
2. It requires more travel distance for the left-turning traffic than the corresponding movement in a diamond interchange.

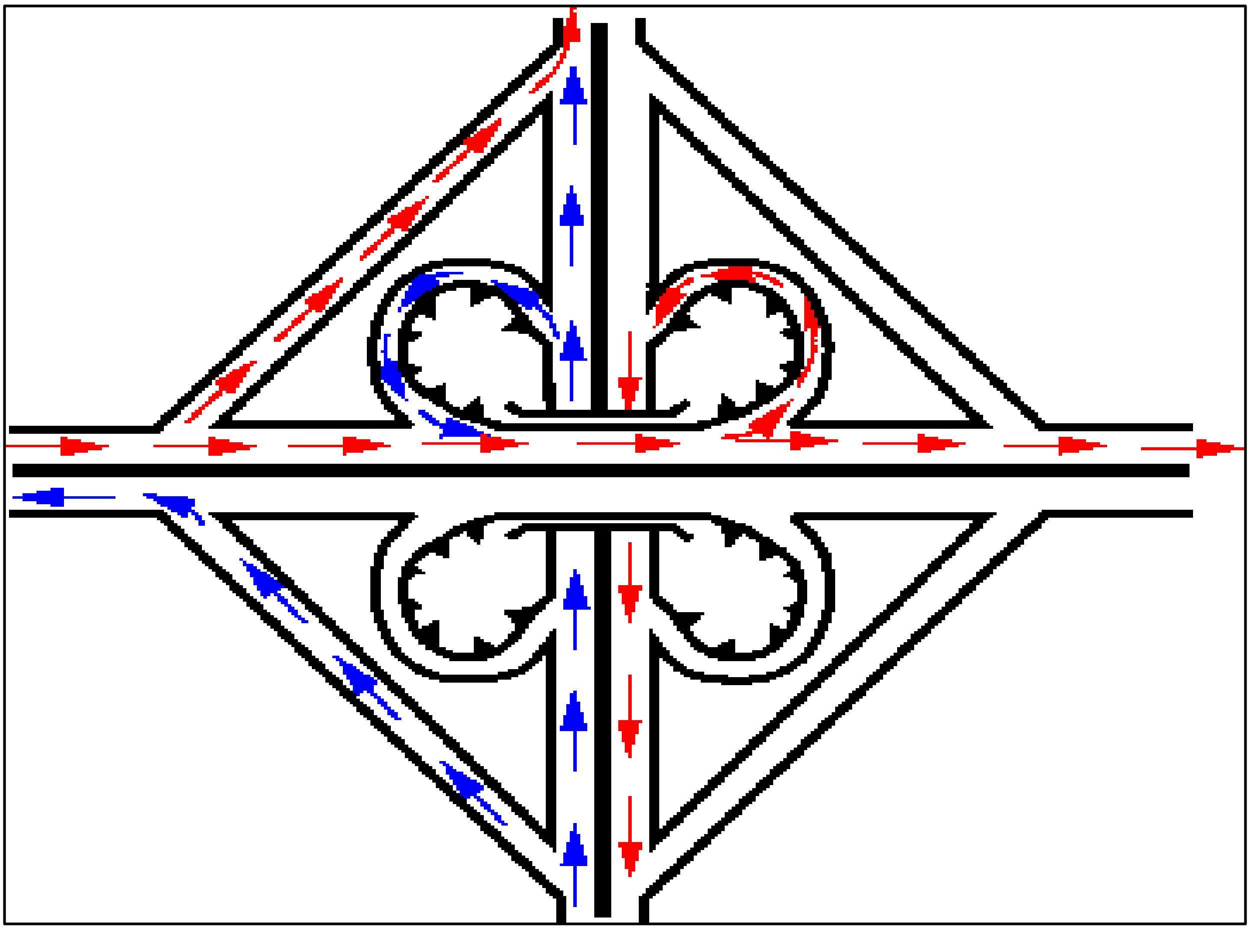


Overpass

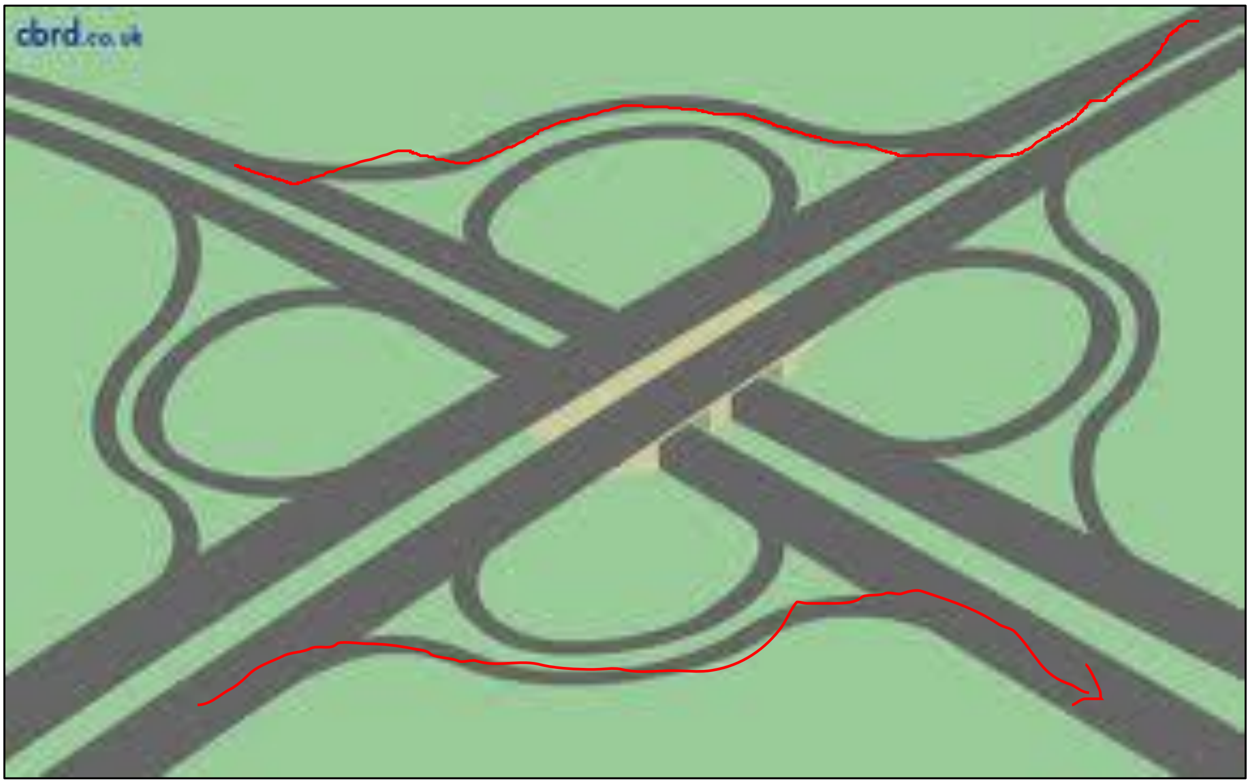


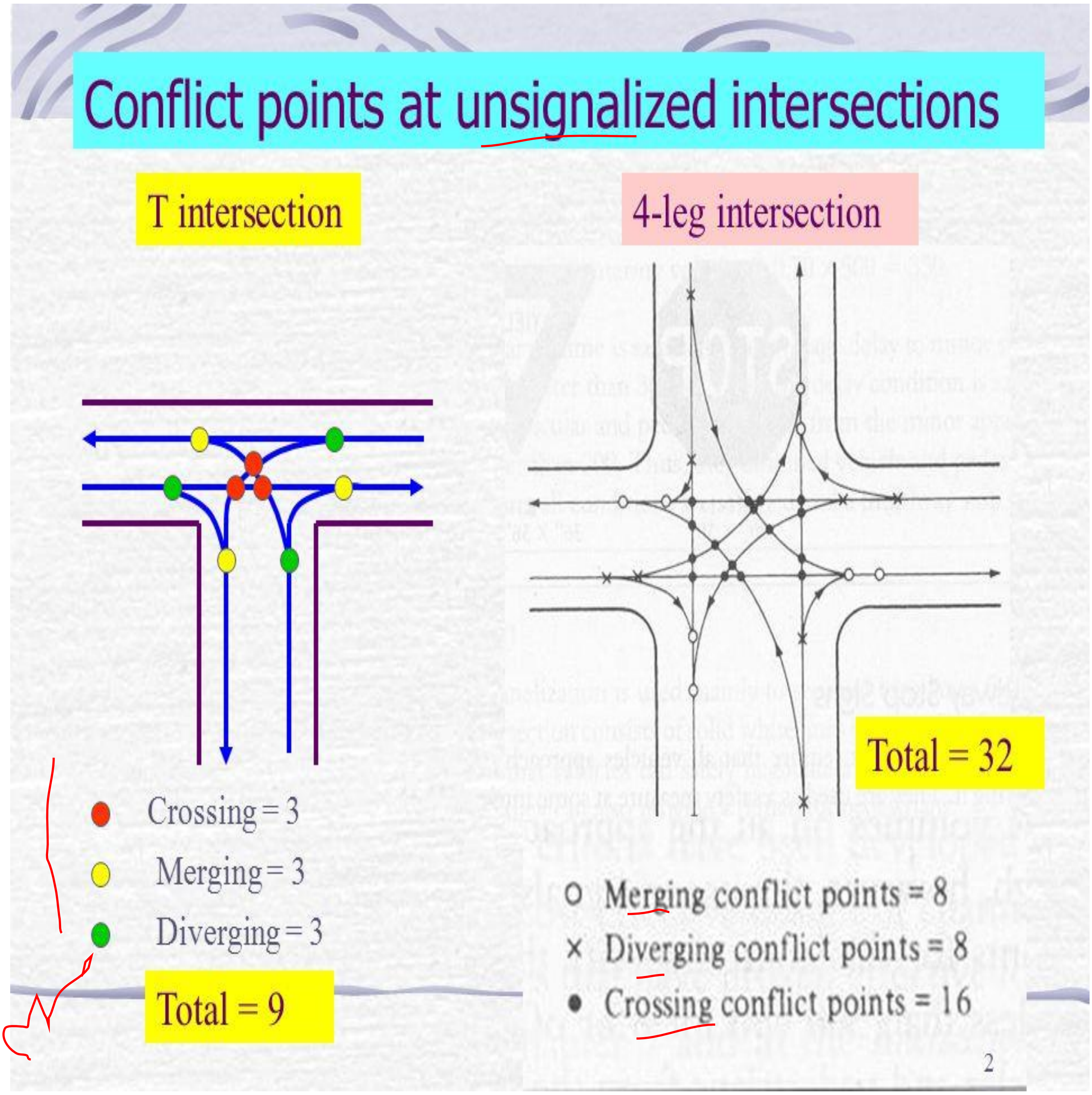
Typical Diamond Interchange





Typical Cloverleaf Interchange




Conflict points at unsignalized intersections
T intersection
4-leg intersection
Crossing = 3
Merging = 3
Diverging = 3
Total = 9
Total = 32
Merging conflict points = 8
Diverging conflict points = 8
Crossing conflict points = 16
2

Chapter Two

Traffic Volume Studies

❖ Definitions:

- **Volume:** The numbers of vehicles passing a given point during a specified period time, or the number of vehicles pass over a given section of lane. Traffic volume can be expressed in terms of annual traffic or daily and hourly traffic. The unit of volume is (Veh/hr).

- **Average Annual Daily Traffic (AADT):** It is total yearly volume divided by the number of days in a year.

$$AADT = \underline{Total\ \ of\ the\ Year}\ 365$$

- **Average Daily Traffic (ADT):** The traffic 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.

$$ADT =$$

- **Design Hour Volume (DHV):** is defined as the 30th highest hourly volume within a year. It is an important traffic parameter for transportation studies, planning, and pavement design. The DHV is normally expressed as a percentage of ADT (about 15% of ADT).

$$D.H.V = ADT \times k$$

$$D.D.H.V = ADT \times k \times D$$

$$K = \frac{DHV}{ADT} \times 100$$

k:0.12-0.18 (Rural) , k:0.08-0.12 (Urban)

- **Peak Hourly Volume:** the highest number of vehicles per one hour passing a given point during a specified period of time. PHF (1-0.25)

$$\text{PHF} = \frac{\text{Hourly Volume}}{\text{Peak Flow Rate}(4 \times \text{max. vol. in 15 min.})}$$

(7-9) Am (2-4) Pm (7-8) Pm

Peak Hourly Volume Used For:

a. Functional classification of highways.

b. Design of the geometric characteristics of a highway, for example, number of lanes, intersection signalization, or channelization.

c. Capacity analysis.

d. Development of programs related to traffic operations.

e. Development of parking regulations.

Density: The number of vehicles that occupying a unit length of a moving lane of a roadway at a given instant. (Veh/km)

$$Volume\ (\frac{veh}{hr}) = Speed\ \left(\frac{km}{hr}\right) \times Density(\frac{veh}{km})$$

Methods of Conducting Volume Counts:

There are two methods of measuring the flow of vehicle along a road:

1. **Manual Counting:**
2. **Mechanical Counting:**

Manual Counting: Manual counting involves one or more persons recording observed vehicles using a counter. With this type of counter, both the turning movements at the intersection and the types of vehicles can be recorded.

Advantages:

1. Simple and quick.
2. Flexibility.
3. Permits traffic classification by the vehicle type.
4. Cheap for short sample counts.

Disadvantages:

The main disadvantages of the manual count method are that:

1. It is labor intensive and therefore can be expensive.
2. It is subject to the limitations of human factors,
3. It cannot be used for long periods of counting.

- **Mechanical Counting:** In this method, the total number of vehicles crossing at a road intersection in the desired period is automatically recorded by a mechanical recorder. These recorders are either fixed type or portable type. Mechanical counters can be classified into two general categories:

A. **Portable Mechanical:**

1. **Pneumatic Road Tube:** A rubber tube that is placed across the lanes that uses pressure changes to record the number of axle movements in a counter placed on the side of the road.

2. **Inductive Loop:** A wire embedded in the road in a square formation that creates a magnetic field that relays the information to a

counting device at the side of the road. This has a generally short life expectancy because it can be damaged by heavy vehicles.

Advantages of Portable Devices:

1. Low cost compared to the duration in which they operate devices.
2. Provide full coverage of the time throughout the day of the week, months and years.

Disadvantages of Portable Devices:

1. Do not distinguish between types of vehicles.
2. Can not counting the passengers inside vehicles.

B. Fixed Mechanical:

1. **Video Image Detection:** use of overhead video cameras to record vehicle numbers. Different software is available to analyze the video images. Weather may limit accuracy.

2. **Radar:** mounted overhead the devices record moving vehicles and speed. With the exception of radar, devices they have difficulty in detecting closely spaced vehicles and do not detect stationary vehicles. They are not affected by weather.

3. **Passive Magnetic:** magnetic sensors that count vehicle numbers, speed, and type are placed under or on top of the roadbed. In operating conditions the sensors have difficulty differentiating between closely spaced vehicles.

Traffic Volume Data Presentation:

The data collected from traffic volume counts may be presented in one of several ways:

1. **Traffic Flow Map:** These maps show traffic volumes on individual routes.
2. **Intersection Summary Sheets:** These sheets are graphic representations of the volume and directions of all traffic movements through the intersection. Figure (1) show a typical intersection summary Sheet.
3. **Time-Based Distribution Charts:** These charts show the hourly, daily, monthly, or annual variations in traffic volume in an area or on a particular highway, Figure (2) shows typical charts for monthly, daily, and hourly variations.

4. Summary Tables: These tables give a summary of traffic volume data such as PHV, Vehicle Classification (VC), and ADT in tabular form. Table 1 is a typical summary table.

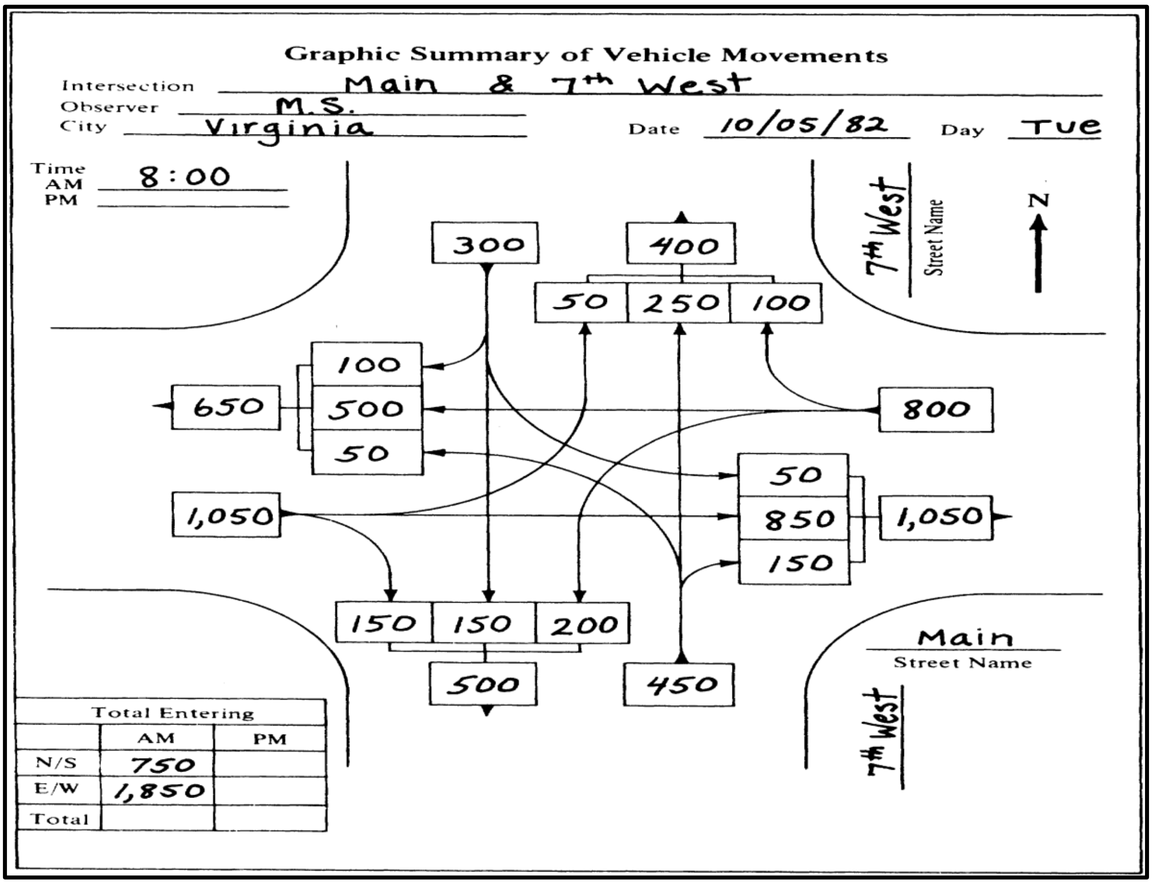


Figure (1) show a typical intersection summary

PHV	430
ADT	5375
Vehicle Classification (VC)	
Passenger cars	70%
Two-axle trucks	20%
Three-axle trucks	8%
Other trucks	2%

Table (1) show Summary of Traffic Volume Data for a Highway

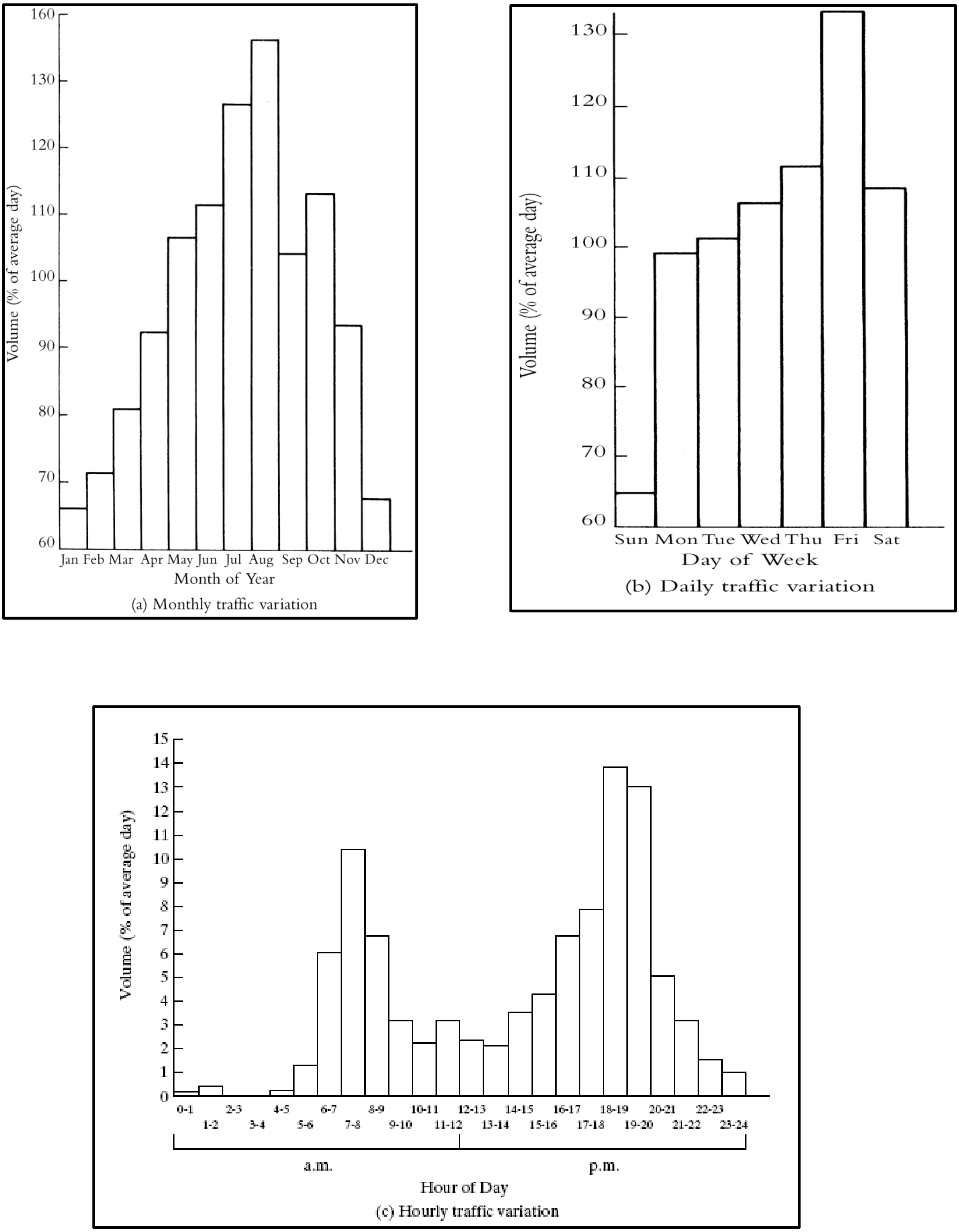


Figure (2) shows typical charts for monthly, daily, and hourly variations Sheet

Expansion Factors from Continuous Count Stations:

Daily Factor $(D.F) = \dfrac{7\ days\ average\ of\ 24-hours}{24\ hour\ count\ for\ a\ day}$

Seasonal Factor $(S.F) = \dfrac{Average\ 24\ hours\ count\ for\ 12\ months}{24\ hours\ count\ for\ a\ month}$

Average Daily Traffic $(A.D.T) = Coverage\ count \times S.F$

% of total 24 hours daily volume $= \dfrac{\text{average vol.for particular hour}}{\text{average vol.for 24 hour}}$

Variation Factor $= \dfrac{100}{\text{\% of total 24-hour vol.}}$

24-hour volume=8-hour vol. $\times\ variation\ factor$

Estimated Average Daily volume $= 24\ hour\ volume\ \times daily\ factor$

Hourly expansion factors (HEF) $= \dfrac{\text{total volume for 24-hr period}}{\text{volume for particular hour}}$

Weekly Factor $= \dfrac{(Total\ volume\ of\ a\ week/7)}{volume\ for\ a\ day}$

Monthly Factor $= \dfrac{Total\ yearly\ volume\ /12}{total\ vol.for\ a\ particulsar\ month}$

Directional Distribution Factor $= \dfrac{\text{One direction volume}}{\text{Two directional volume}}$

Traffic Projection Factor $= (1 + r)^{n+x}$

Where:

r: rate of annual increase in traffic. **n:** design life. **x:** years for construction.

Determination the Number of Lanes in Highway:

(1)Future A.D.T=current A.D.T×T.P.F	**Directional Design-Hour Volume** **D.D.H.V / Direction= D.H.V*** D.D.F
(2)D.H.V = future A.D.T× k **(for both direction)**	**No of Lanes=** $\frac{\textbf{D.D.H.V per Direction}}{\textbf{\textit{Design Capacity per lane}}}$

Passenger Car Equivalent Factor or Truck Equivalency Factor:

$$\mathbf{E_t = 1 + \frac{\left(\frac{Q_c}{Q_v} - 1\right)}{P_t}}$$

Where:

Q_c**:** Passenger car volume. Q_v**:** Mixed volume. P_t**:** Truck percentage.

Example (1): If the mix traffic volume is 3000 veh/hr and the passenger car volume is 3500 veh/hr. calculate the truck equivalent factor if the truck percentage is 10%.

Solution: $E_t = 1 + \frac{\frac{3500}{3000} - 1}{\frac{10}{100}} = 2.66$

Total volume equivalent passenger car=3000×2.66=8000

Example (2): If the 8- hours count from (7-11) am to (2-6) pm is made on Tuesday in the month of May. Estimate the ADT for this station if the 8-hours count is 6900 vehicles. If the % of total weekly volume is 40% for Sunday and is equal in value for other days.

Hourly Variation Table:

Hour	volume	% vol. of total 24 hour	Hour	Volume	% vol. of total 24 hour vol.
6-7 am	90	0.83	6-7 pm	300	2.77
7-8 am	300	2.77	7-8 pm	200	1.84
8-9 am	900	8.31	8-9 pm	80	0.73
9-10 am	1300	12	9-10 pm	20	0.18
10-11 am	1200	11.08	10-11 pm	5	0.04
11-12 am	900	8.31	11-12 pm	3	0.02
12-1 pm	1000	9.23	12-1 am	2	0.01
1-2 pm	1270	11.73	1-2 am	1	0.009
2-3 pm	1400	12.93	2-3 am	1	0.009
3-4 pm	800	7.39	3-4 am	3	0.02
4-5 pm	400	3.69	4-5 am	10	0.09
5-6 pm	600	5.54	5-6 am	40	0.36

$\boxed{\sum = 10825\ vehicle}$

Solution:

Variation factor=$\frac{100}{2.77+8.31+12+11.08+12.93+7.39+3.69+5.54}$ = 1.569 for 8-hours

24-hour volume= 6900×1.569=10826.1 veh.

Day	% of total vol. weekly	Volume
Sunday	40	43304.4
Monday	10	10826.1
Tuesday	10	10826.1
Wednesday	10	10826.1
Thursday	10	10826.1
Friday	10	10826.1
Saturday	10	10826.1

<u>Volume %</u>

10826.1 10

X 100

x=$\frac{100*10826.1}{10}$ = 108261 veh. On a week

Weekly factor=$\frac{108261/7}{10826.1}$=1.428

Estimated Average daily vol.= weekly factor × 24- hour vol.

=1.428×10826.1=15459.6 veh.

If the % of total monthly volume is 60 % for (May, June, July and August) and is equal for other month.

<u>Monthly Variation Table</u>

Month	% volume	Volume	No. of days	Month	% volume	volume	No. of days
January	5	479247.6	31	July	15	479247.6	31
February	5	432868.8	28	August	15	479247.6	31
March	5	479247.6	31	September	5	463788	30
April	5	463788	30	October	5	479247.6	31
May	15	479247.6	31	November	5	463788	30
June	15	463788	30	December	5	479247.6	31

Monthly Factor=$\frac{(7*479247.6+4*463788+43286.8)/12}{479247.6} = \mathbf{0.981}$

A.D.T=15459.6 × 0.981=15168.6 veh/day

Example (3): If the current A.D.T 5000 veh/day and T.P.F 4, lane capacity 800 veh/hr/lane. Find the number of lanes in rural highway if D.D.F 50%

Solution:

Future A.D.T= current A.D.T× T.P.F=5000 ×4=20000 Vpd

D. H.V. = k× future A.D.T=0.15×20000=3000 Vpd for both direction

D.D.H.V=3000×$\frac{50}{100} = 1500$ Vph/direction

No. of lanes= $\frac{1500}{800} = 1.875$ 2lane /direction

Total no. of lanes= 2×2=4 lanes in both direction

Example (4): For the table below find the peak hourly factor:

Time	Road A	Road B
8.00-8.15	100 veh.	0
8.15-8.30	100 veh.	0
8.30-8.45	100 veh.	0
8.45-9.00	100 veh.	400 veh.
Sum	400 veh.	400 veh.

Solution:

$$\text{PHF} = \frac{\text{Hourly Volume}}{\text{Peak Flow Rate}(4 \times \text{max. vol. in 15 min.})}$$

PHF (Road A) =$\frac{400}{4\times100} = 1$

PHF (Road B) =$\frac{400}{4\times400} = 0.25$

Example (5)

For the following information, find the $30^{th} hourly\ volume\ factor$.

DDHV=580 Veh/day , AADT=5800 Veh/day , directional distribution factor=(60-40)%.

Solution

$DDHV = AADT \times k \times D$

$580 = 5800 \times 0.6 \times k$

$K = 0.1667$

Example (6):

The AADT for a highway was 550 pcu/day at a year 2010. If D=65%, K=12%, passenger car percent=80, truck percent=12, and bus percent=8,What was the AADT traffic (one direction) at year 1997, when truck=2.5 pcu, bus=2 pcu, growth factor=3%.

Solution:

Future volume $= present\ volume\ (1+i)^n$

550 =present $(1+0.03)^{13}$

present volume (1997) =374.5 pcu =375 pcu

DDHV=AADT × K × D

$$375 = AADT \times 0.12 \times 0.65 \quad , \qquad AADT = 4807.69 \sim 4808\,\frac{pcu}{day}$$

Total No. equivalent passenger car$= AADT \times 0.8 + AADT \times 0.12 \times 2.5 + AADT \times 0.08 \times 2$

AADT=3816 Veh/day in (1997)