Rural Road Safety Course

SAFETY IN INTERSECTION DESIGN

Introduction

- Road Intersections critical element of roads
- Major Bottleneck
- Major Accident Spots

Type of Intersections

1. Uncontrolled At-Grade Intersections
2. Priority Control Intersections
3. Time Separated or Signalized Intersections
4. Space Separated or Grade Separated Intersections

Uncontrolled At-Grade Intersections

- Intersection between any two roads with relatively low traffic volume
- Neither road has precedence over the other

Priority Control Intersections

- Usually between Major & Minor Roads
- No Delay to Major Road
- Minor road controlled by STOP sign or GIVE WAY sign

Time Separated or Signalized Intersections

- Warrants for Signalized intersection in IRC 93 – 1985
- Heuristic for Signal Control (IRC SP41):
  - Major road traffic > 650 – 800 vehicles per hour (both directions) &
  - Minor road traffic > 200 – 250 vehicles per hour (one direction)


vodafone
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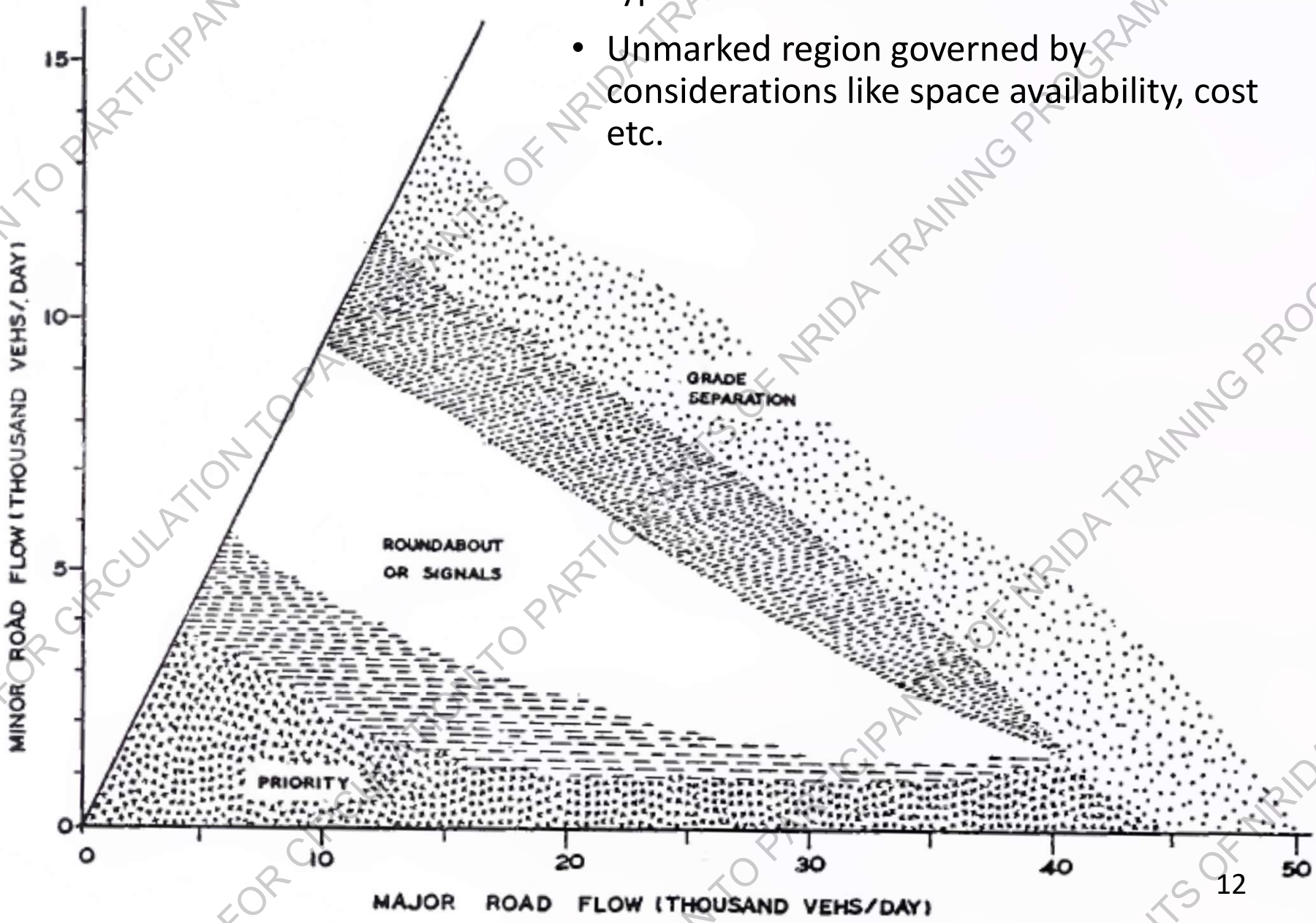
KATA POLICE
BOROVEA
TATA

Space Separated or Grade Separated Intersections

- Warrants for grade separation in IRC 92 – 1985
- Heuristic for Grade Separation (IRC SP41):
  - Total incoming traffic from all arms > 10,000 PCU per hour

- Graphical relationship (UK) for selecting type of intersection in urban areas
- Unmarked region governed by considerations like space availability, cost etc.



Factors Influencing Design of Intersections

- Human Factors
- Traffic Factors
- Road & Environment Factors
- Economic Factors

Human Factors

- Driving habits
- Decision making ability
- Driver expectancy
- Decision time & Reaction time
- Natural path of movement
- Pedestrian use & habits

Traffic Factors

- Design & actual capacity
- Turning movement
- Size & operating characteristics of vehicles
- Type of movements (merging, diverging, weaving, crossing)
- Speed
- Accident experience
- Traffic mix

Road & Environment Factors

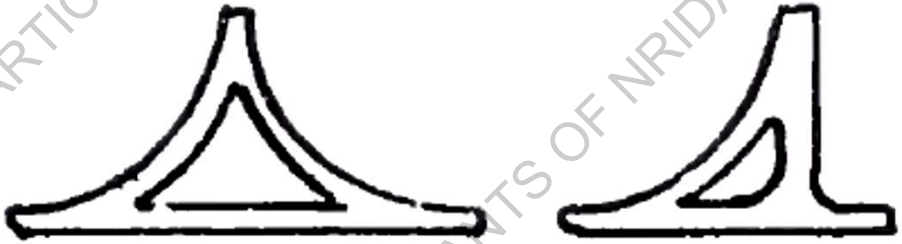
- Abutting land use
- Vertical & horizontal alignment
- Sight distance
- Angle of intersection
- Conflict area
- Speed change lanes
- Geometric features
- Traffic control devices
- Lighting
- Safety features

Economic Factors

- Cost of improvements
- Cost of controlling or limiting right of way on abutting properties

Type of At-Grade Intersections

1. T - Intersection



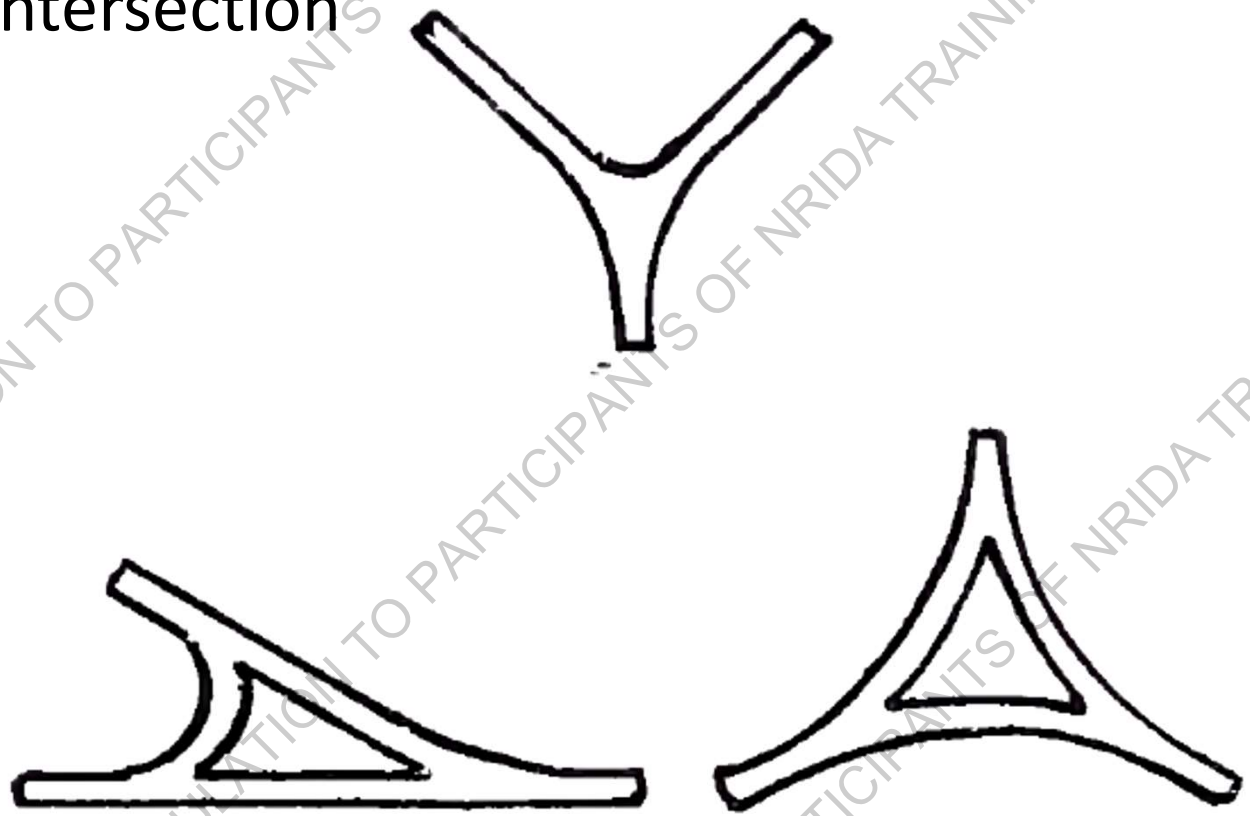
T WITH TURNING ROADWAYS

UNCHANNELIZED T

FLARED T

Type of At-Grade Intersections

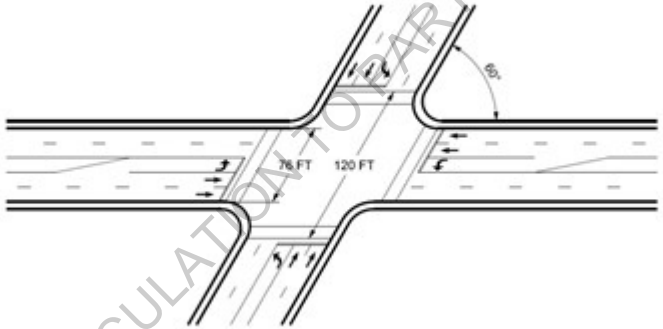
2. Y - Intersection



Y WITH TURNING ROADWAYS

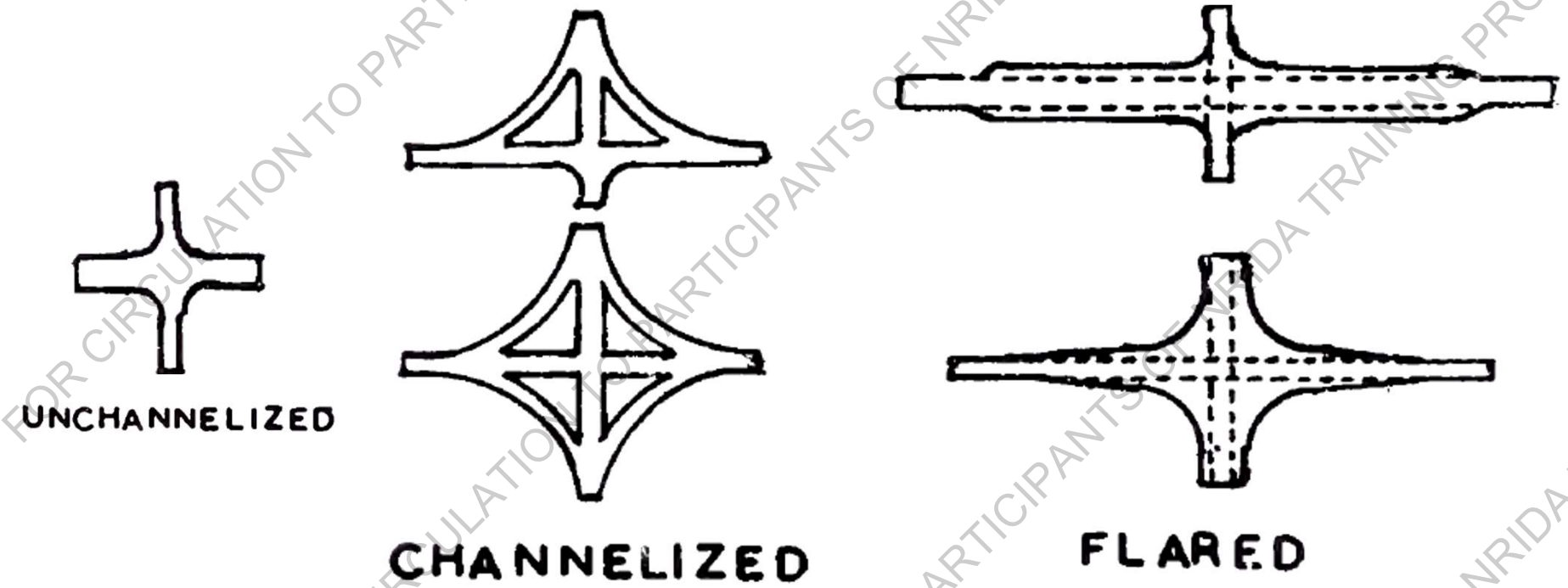
Type of At-Grade Intersections

3. Scissor Intersection (Skewed)



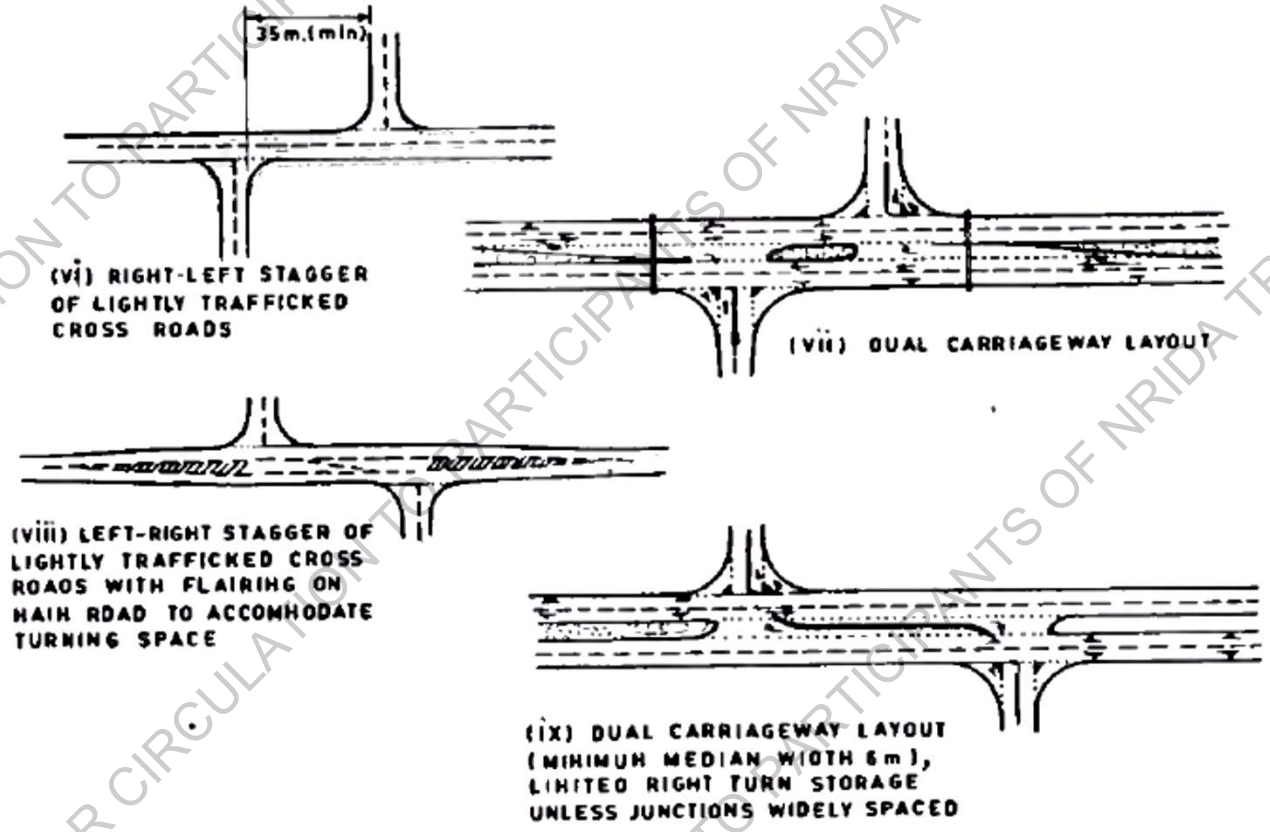
Type of At-Grade Intersections

4. Cross Intersection (90^{o} Four Legged)



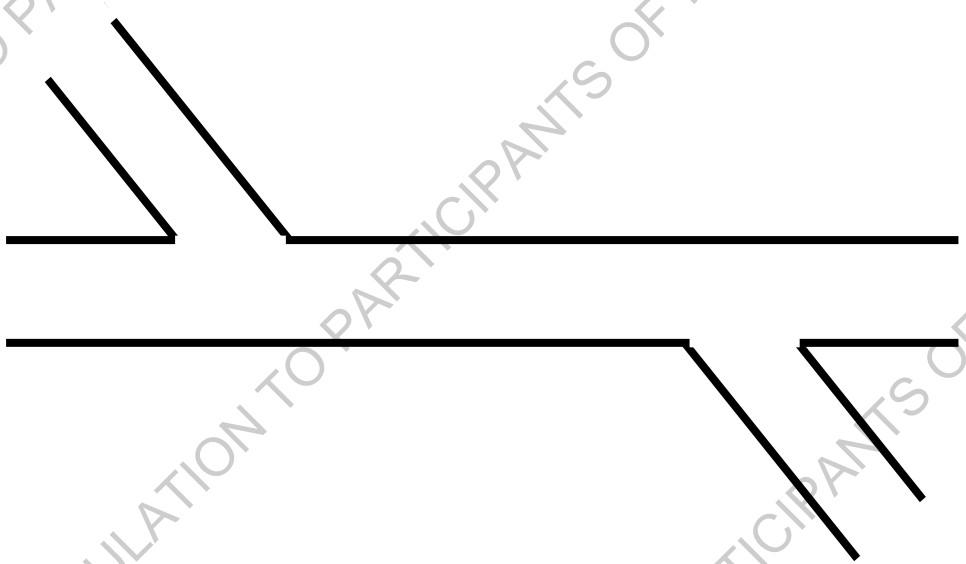
Type of At-Grade Intersections

5. Staggered Intersection



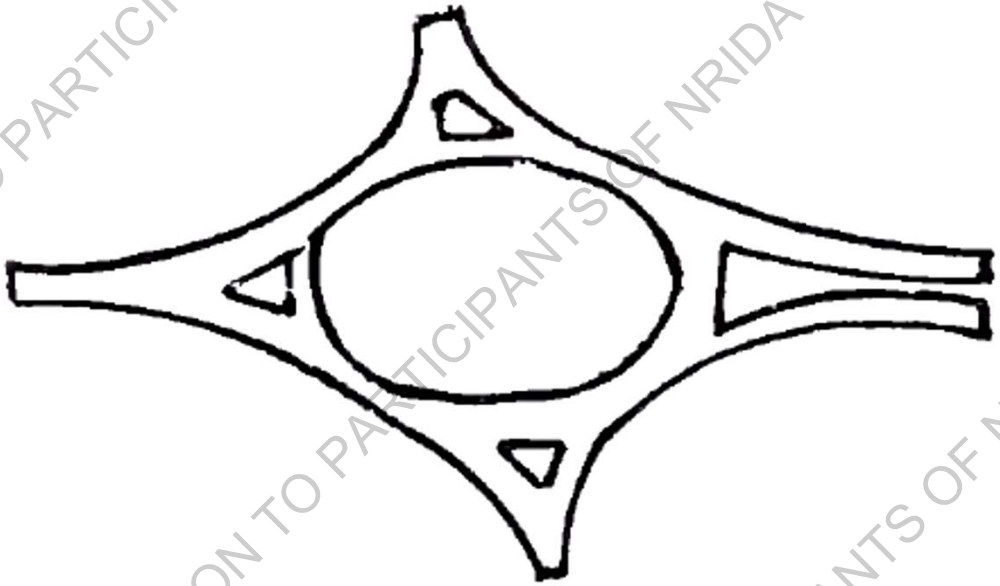
Type of At-Grade Intersections

6. Skewed & Staggered Intersection



Type of At-Grade Intersections

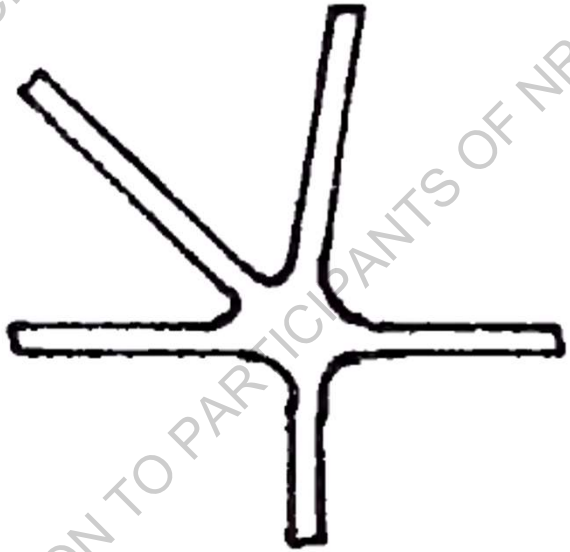
7. Rotary or Roundabout



ROTARY INTERSECTION

Type of At-Grade Intersections

8. Multi-legged Intersection



MULTILEG INTERSECTION

Basic Design Principles

Goals:

SAFETY

SMOOTH & EFFICIENT TRAFFIC FLOW

Basic Design Principles

Design Principles:

- Uniformity & Simplicity
- Minimize Conflict Points
- Safety
- Alignment & Profile

Uniformity & Simplicity

While designing keep in mind:

- Capabilities & limitations of drivers, pedestrians & vehicles
- Should be based on what driver will do rather than what he/she should do
- Traffic information, road signs, markings should be considered during design stage
- Movements should be obvious for unfamiliar drivers
- Complicated decision making scenarios should be avoided

Basic Design Principles

Design Principles:

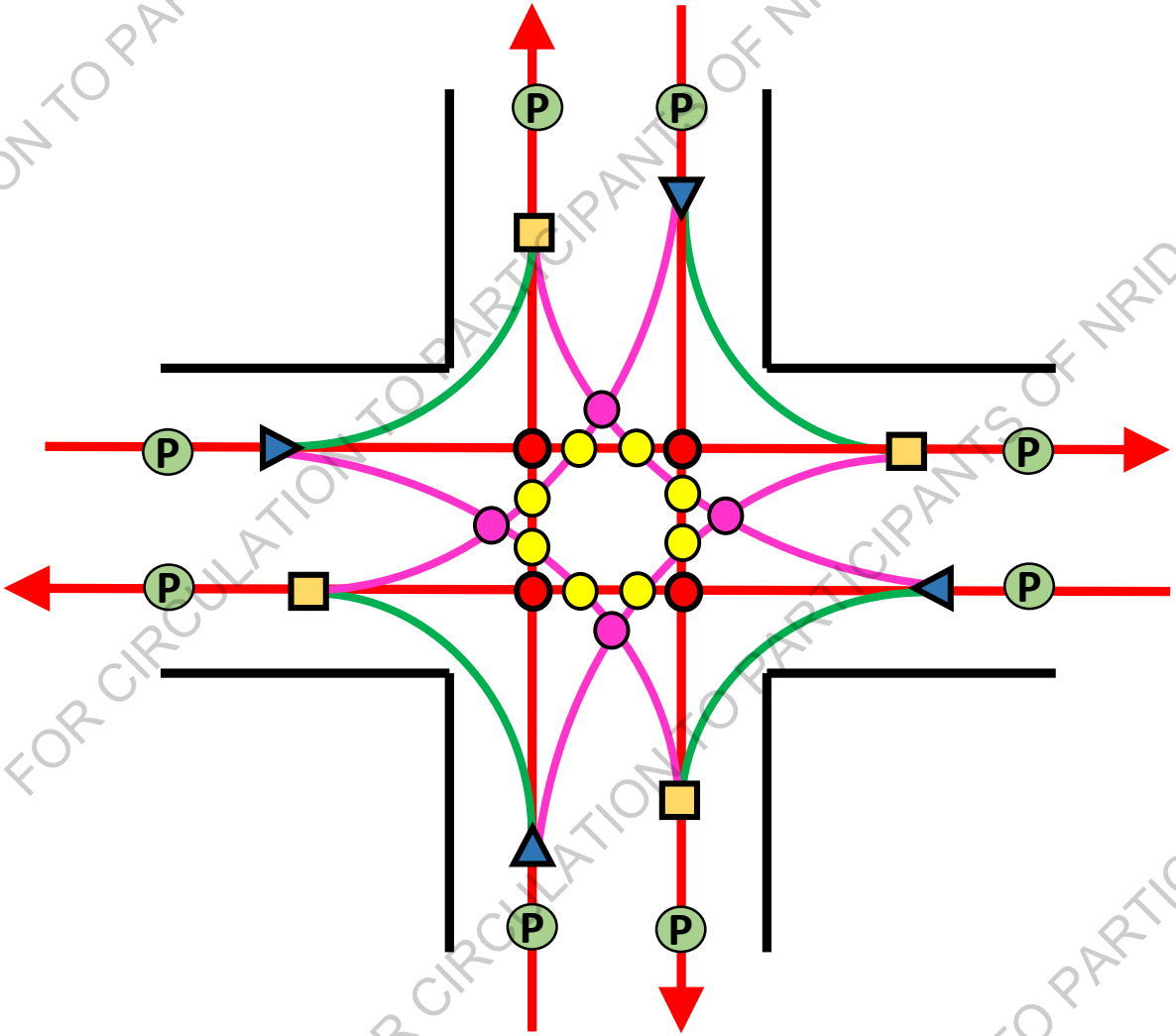
- Uniformity & Simplicity
- Minimize Conflict Points
- Safety
- Alignment & Profile

Minimize Conflict Points

Objective:

Minimize NUMBER & SEVERITY of potential conflicts

Conflict Points



- 4 x Diverging Conflict
- 4 x Merging Conflict
- 4 x Straight-Straight Conflict
- 8 x Right-Straight Conflict
- 4 x Right-Right Conflict
- 8 x Pedestrian Conflict

TOTAL 32 CONFLICT POINTS

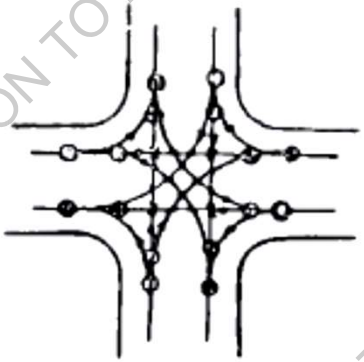
Minimize Conflict Points

Ways to minimize conflict points

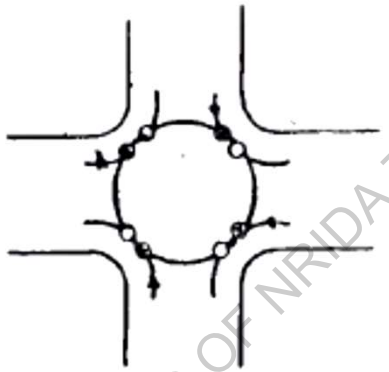
- Space Separation – Access control, islands, channelizing & Grade separation
- Time Separation – Waiting Lanes & Traffic Signals

Minimize Conflict Points

- Convert to roundabout (12 conflict points)



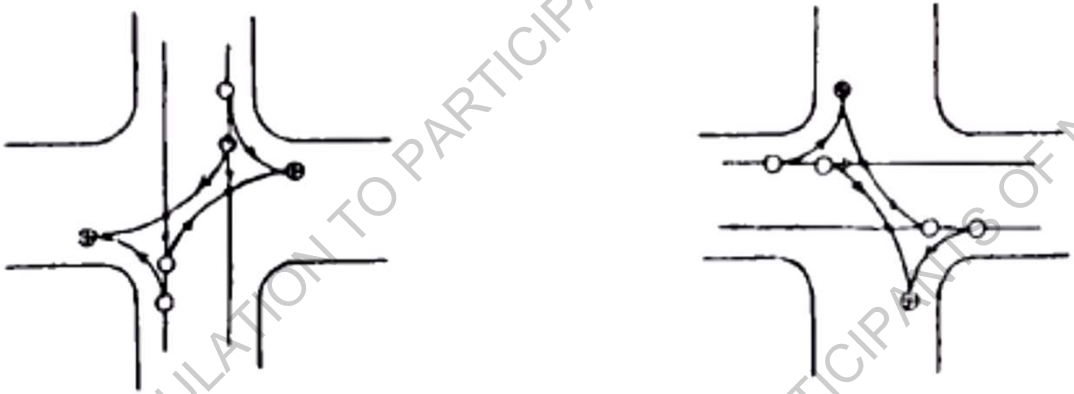
Four arm non signalised intersection



Round-about

Minimize Conflict Points

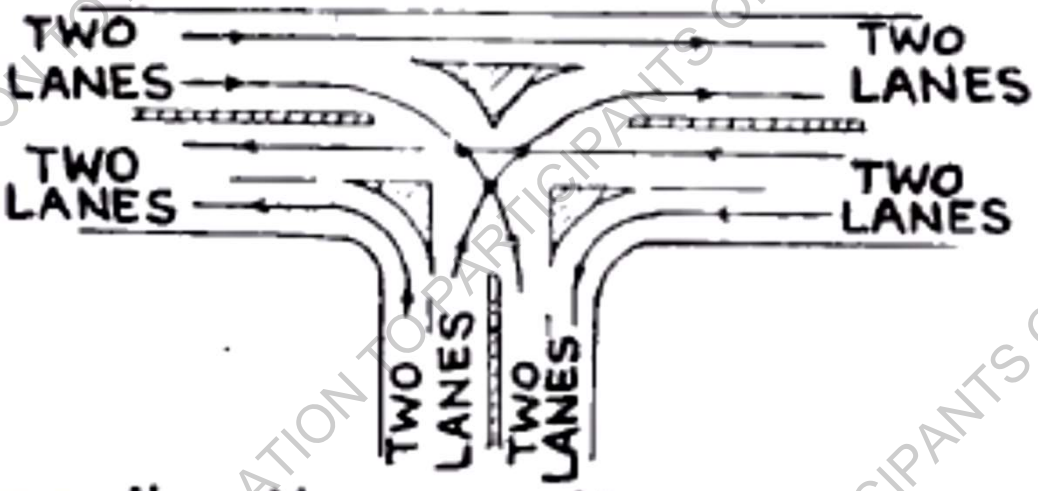
- Convert to two phase signal (16 conflict points)
- Increasing phases can eliminate all conflicts
- **Be careful - Signals increase accidents on low volume roads & reduce them on high volume/complex roads**



Four-arm signalised intersection

Minimize Conflict Points

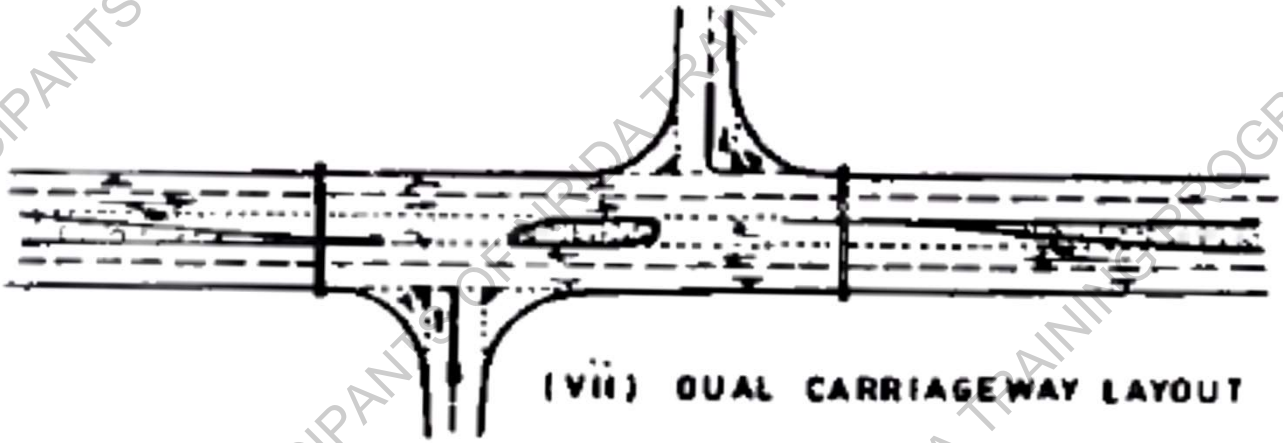
- Channelize traffic using islands & medians



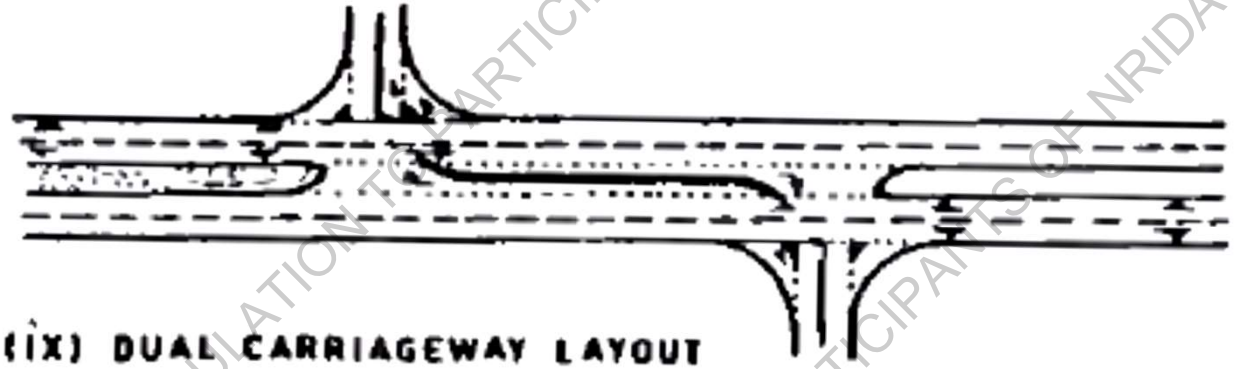
Channelisation on three-arm intersection

Minimize Conflict Points

- Stagger a 4-arm junction to Two T-junctions. But ensure that minimum distance between them is 45m & prefer Right Staggered Junction



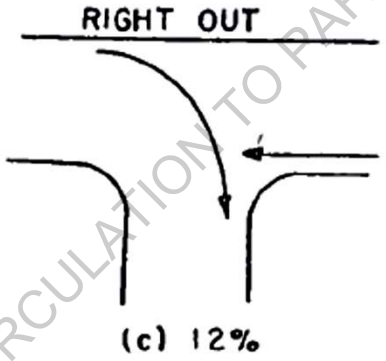
(viii) DUAL CARRIAGEWAY LAYOUT

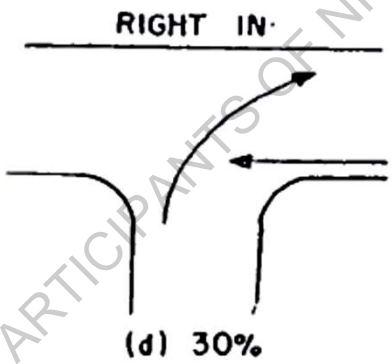


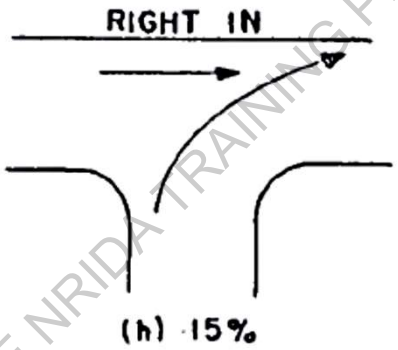
(ix) DUAL CARRIAGEWAY LAYOUT
(MIHIMUH MEDIAN WIOTH 6 m),
LIHITED RIGHT TURN STORAGE
UNLESS JUNCTIONS WIDELY SPACED

Minimize Conflict Points

- Study accident records and classify accidents by type of conflicts

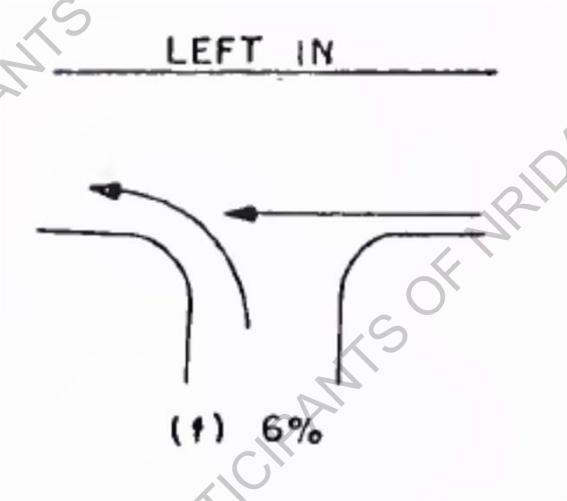






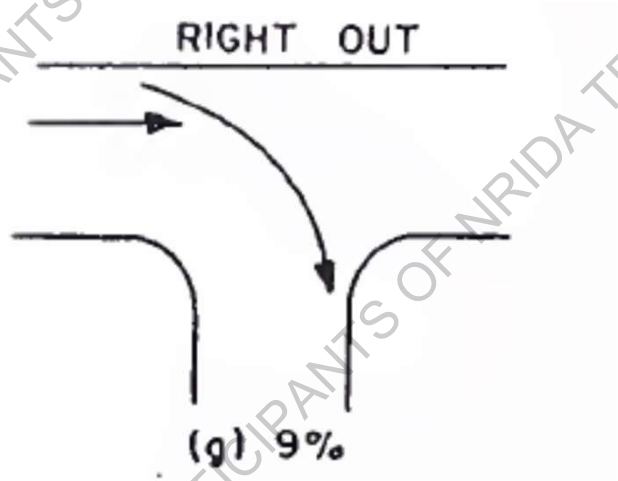
- Turning conflicts can be removed by controlling traffic movement manually or by traffic signal

Minimize Conflict Points



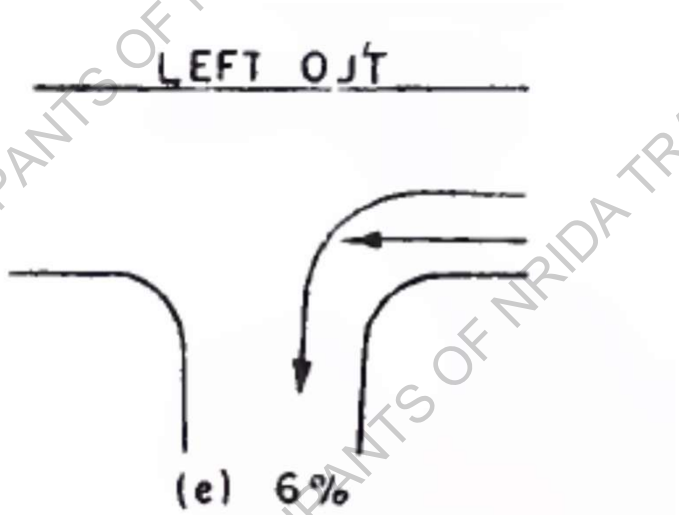
- Provide left channelizing island & acceleration lane

Minimize Conflict Points



- Provide channelized through lane & dedicated right turning lane

Minimize Conflict Points



- Provide channelized left turning island and maybe a deceleration lane too

Basic Design Principles

Design Principles

- Uniformity & Simplicity
- Minimize Conflict Points
- Safety
- Alignment & Profile

Safety

- Safety can be assessed by studying the frequency of type of accidents and their correlation with volume and type of traffic
- Systematic accident records should be maintained in Accident Record Forms as per IRC 53
- Prioritization can be done based on Severity Factor

$$C = \frac{A}{\sqrt{Q \times q}}$$

C is Severity factor

A is No. of accidents

Q & q are traffic volume on major & minor roads

Basic Design Principles

Design Principles

- Uniformity & Simplicity
- Minimize Conflict Points
- Safety
- Alignment & Profile

Alignment & Profile

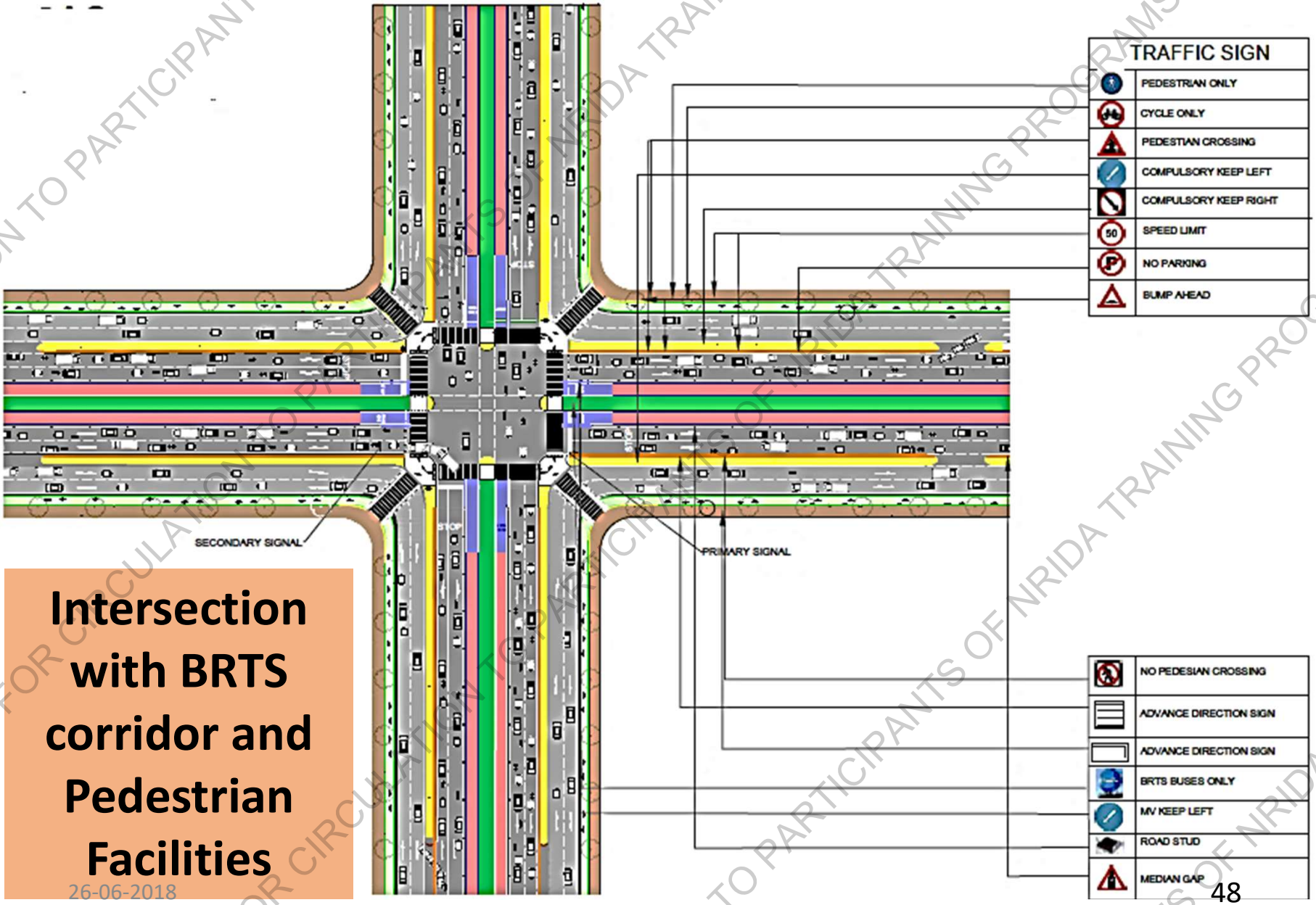
- Intersecting roads should meet at nearly right angles
- However, angles above 60^0 do not warrant realignment
- Intersection should be avoided on sharp curves. Super-elevation & widening complicate design
- Substantial grade changes at intersections should be avoided. Keep it Flat.
- Grades > 3% to be avoided
- Grades > 6% should not be allowed

IRC Codes for Intersection Design

- IRC 92-1985 Design of Interchanges in Urban Areas
- IRC 65-1976 Design of Rotary
- IRC 93-1985 Design and Installation of traffic signals
- IRC SP41-1994 At Grade Intersections
- IRC SP 90-2010 Grade Separators
- IRC 35-2015 Road Markings
- IRC 67-2012 Road Signages

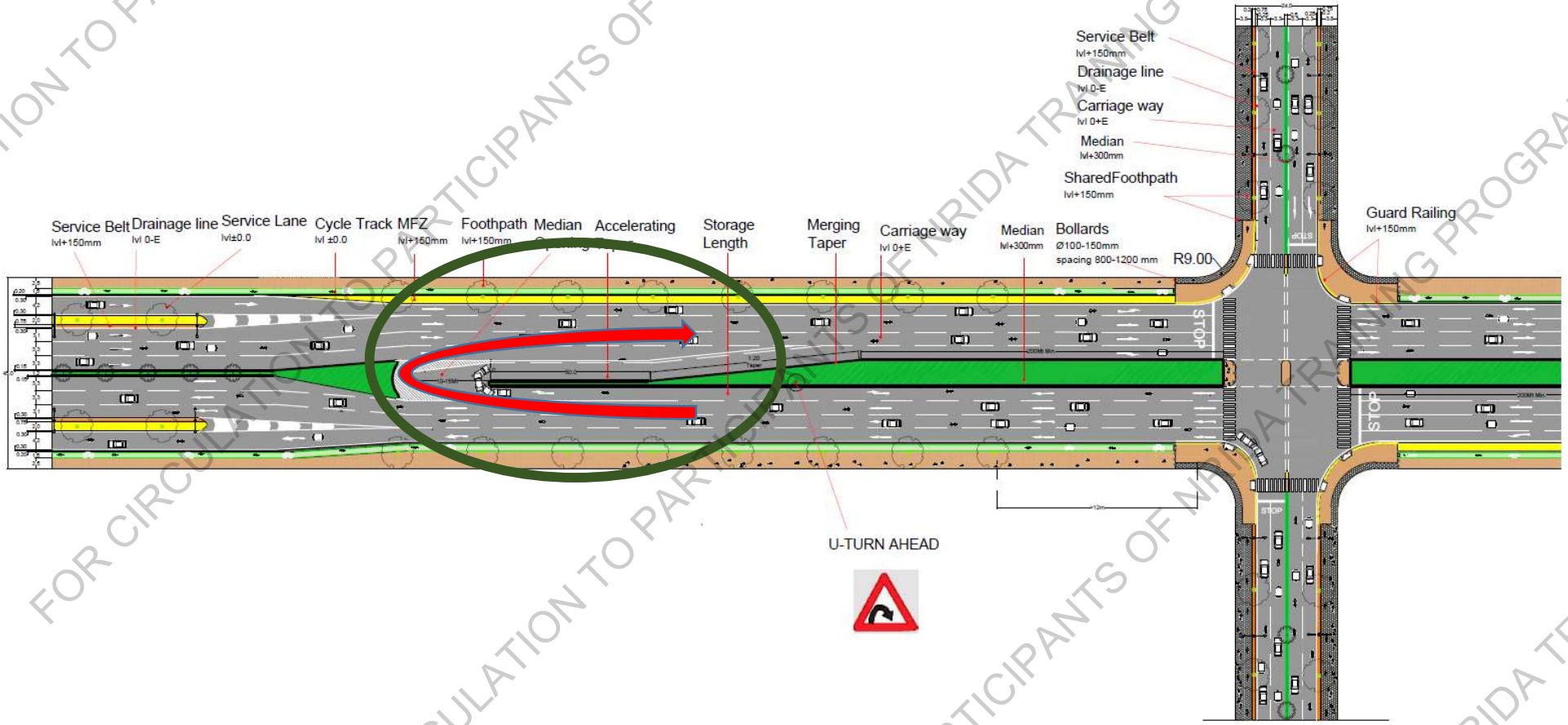
Ideal Designs

Ideal Intersection design

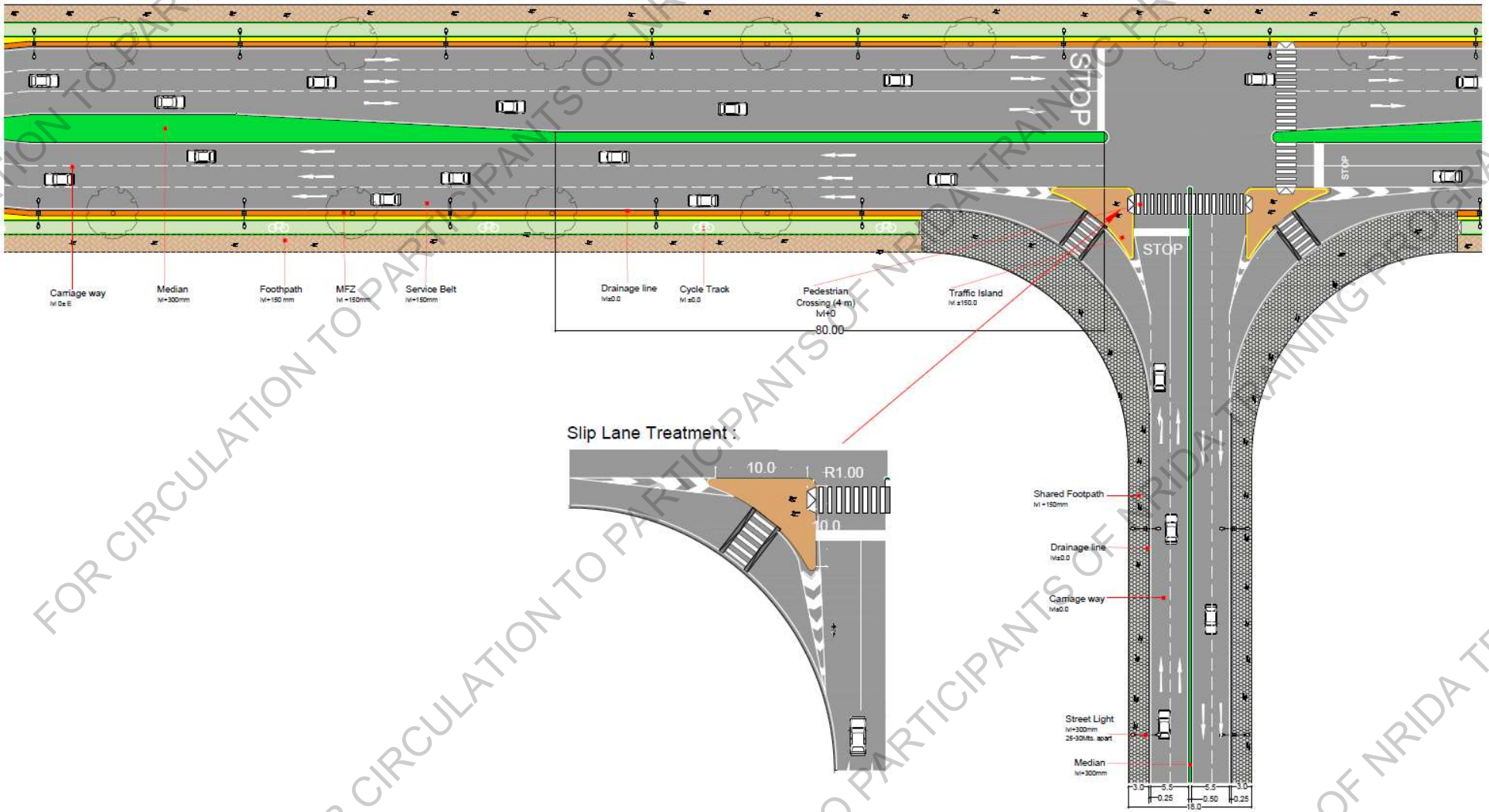


Intersection with BRTS corridor and Pedestrian Facilities

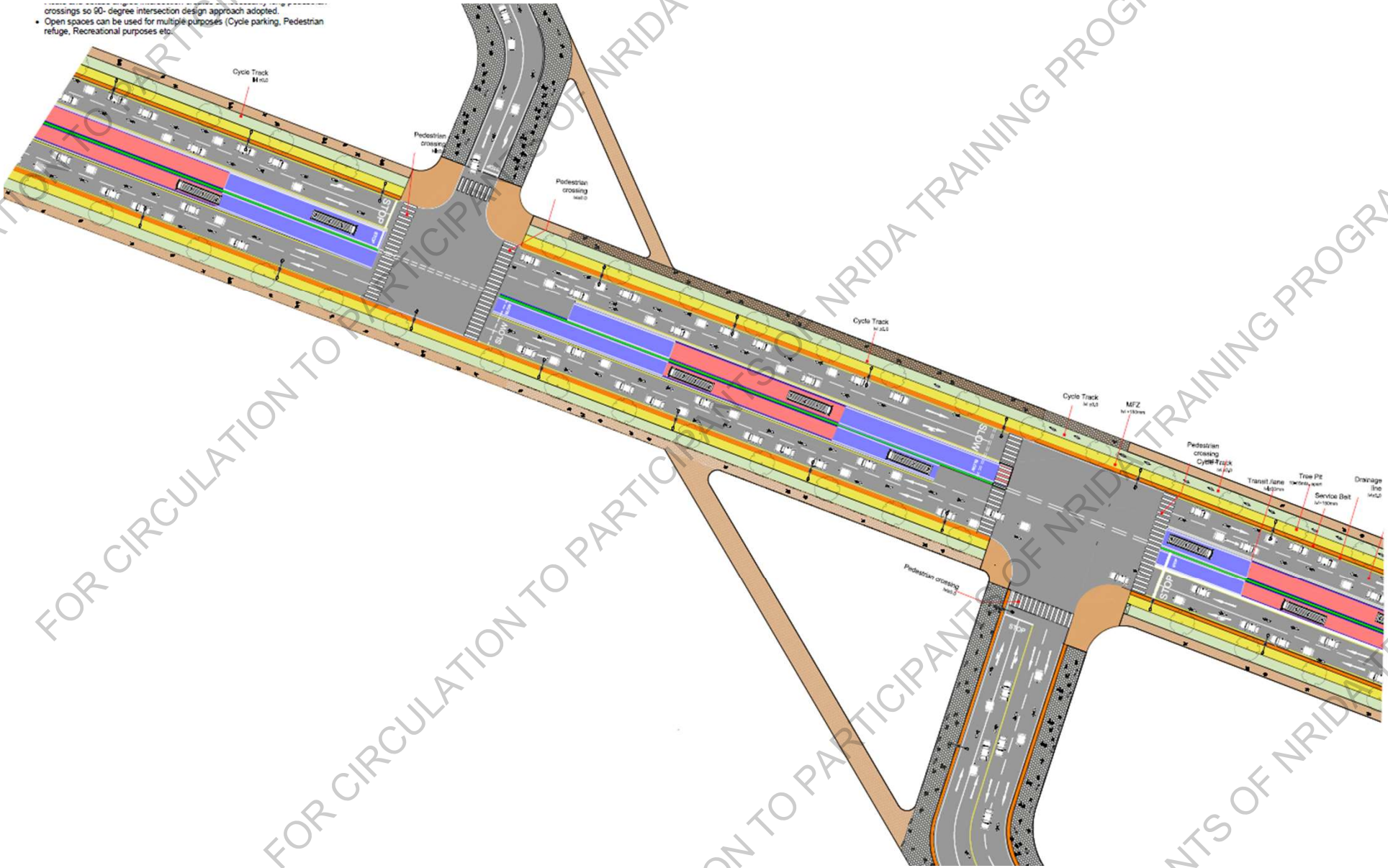
RoW: 45 m x 24 m (With directional Median gap)



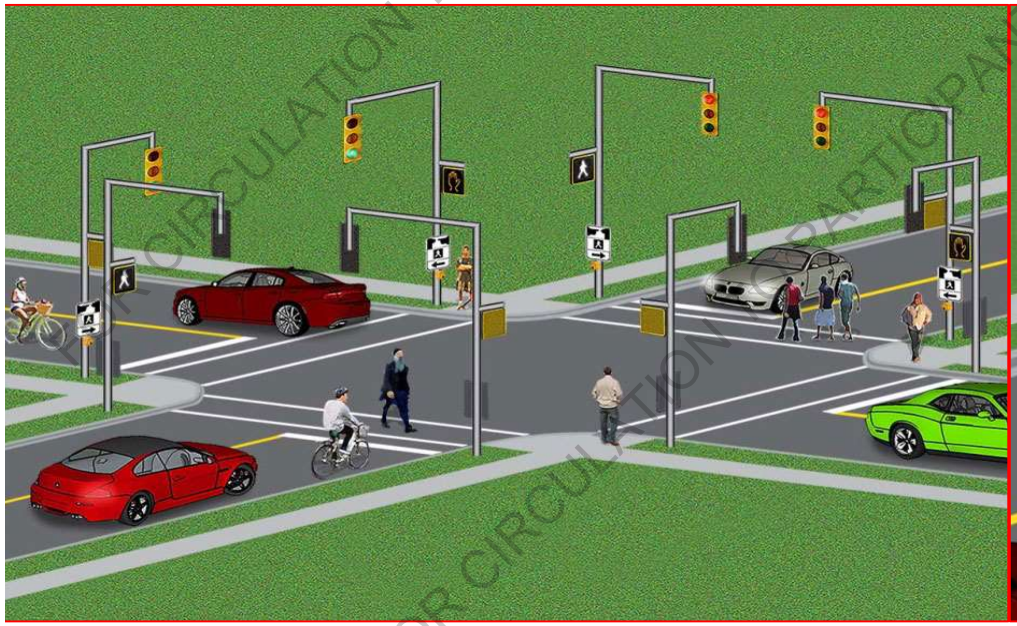
T- Intersection RoW: 36 m x 18 m

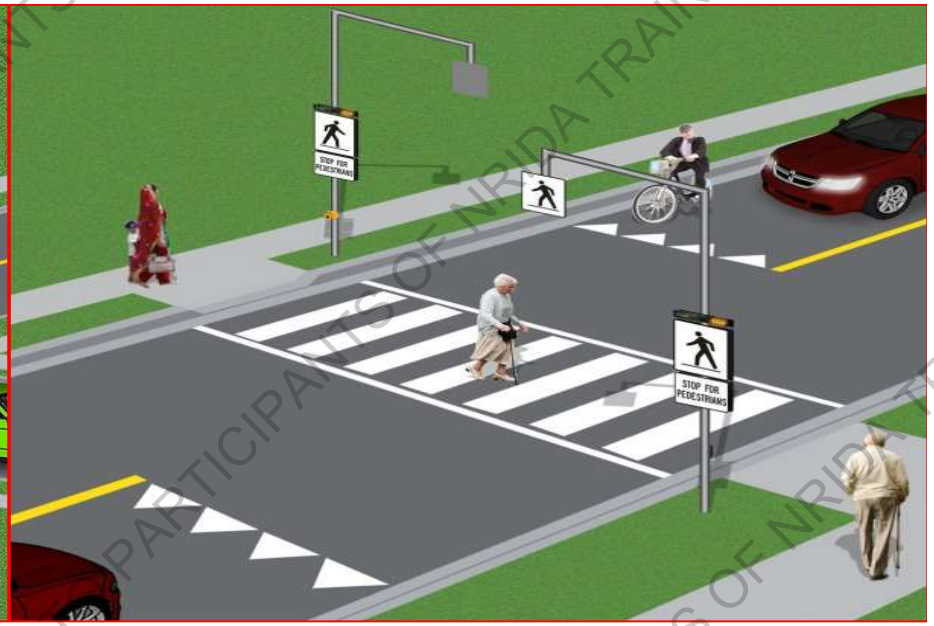


Staggered Intersection (36 x 24 x 18)



PEDESTRIAN FACILITIES





Practical Examples

Major problems observed in traffic intersections at urban areas

- Inappropriate traffic control at intersection
- Inadequate sight distance at intersection
- Inadequate guidance for motorists
- Vehicle conflicts with non-motorists
- Poor operational performance of signalised intersection
- Misjudgement of gaps in traffic
- Over-Speeding and Dilemma
- Non-compliance with intersection traffic control devices.
- Signs and Marking are absent
- Lack of proper visibility
- Facilities for users like pedestrian and non-motorized vehicles are rarely provided

EXCESSIVE CONFLICTS WITHIN OR NEAR THE INTERSECTION

The intersection is susceptible to frequent near-misses or conflicts and resulting collisions between vehicles due to a combination of traffic volumes, operating speeds, and turning movements at or near the intersection.

SHORT TERM IMPROVEMENTS

1. Warning reflective marking and sign for the presence of channelizing island
2. Ingress and Egress from parking area be restricted to certain length instead of whole segment
3. Traffic should be regulated, strict enforcement of traffic rules be overseen
4. Pedestrian crosswalk facilities with refugee area should be provided

1. Lane markings are absent and should be provided as an aid to road users
2. Pick-up and Drop-of point for the para transit users should be provided at regulated spots, were the disturbance from them to the traffic is minimum

1. Provide Warning reflective marking and sign for the presence of bridge pillar or isolation from the carriageway.
2. Crosswalk marking or pedestrian facilities should be provided to support the given pedestrian crossing sign
3. Reflector markings be made on the electric pole obstructing the side of carriageway
4. Pedestrian crosswalk facilities with refugee area should be provided

1. Pick-up and Drop-of point for the para transit users should be provided at regulated spots
2. No crosswalk marking or pedestrian facilities should be provided
3. Warning reflective marking and sign for the presence of bridge pillar, removal of construction material
4. Inadequate sight distance, due to blockage of view from construction. Cautionary sign should be placed

Vehicles parked on decelerating auxiliary lane

Non- Regulation of traffic, area occupied by two conflicting streams and pedestrian at the same time. Crosswalk facilities and traffic stream channelizing along with priority rules should be set

Restriction of on-street parking of paratransit units.

Refuge area for the pedestrian to aid crossing manoeuvre should be provided

Regulation to discourage pedestrian from walking on the carriageway

Overlaying road markings and performing timely scheduled maintenance

Crosswalk marking is discontinued in between, but it should be provided till the end, kerb-kerb or shoulder-shoulder

Carriageway should be stripped of the dirt and cleaned with proper laying of road markings and road boundaries

Cautionary signs or railing should be provided to avoid sudden egress of vehicles on the road and prevent accidents

Channelizing of conflicting streams using lane marking and placement of water/sand Drums

DESIGN THE CITY FOR PEOPLE NOT FOR VEHICLES

Footpath Width:

Expectation

Should be wide enough to accommodate pedestrian flow at any given point of time.

Reality

Traffic regulation and enforcement from local governing authority can help overcome the situation

Walk Environment

The footpath should be clean and free of stink.

Median pedestrian refuge on two-way road

Median pedestrian refuge at light-controlled junction

Extending the footpath at a crossing

Kerb ramps and crossings at roundabouts

MEDIUM TERM SOLUTIONS

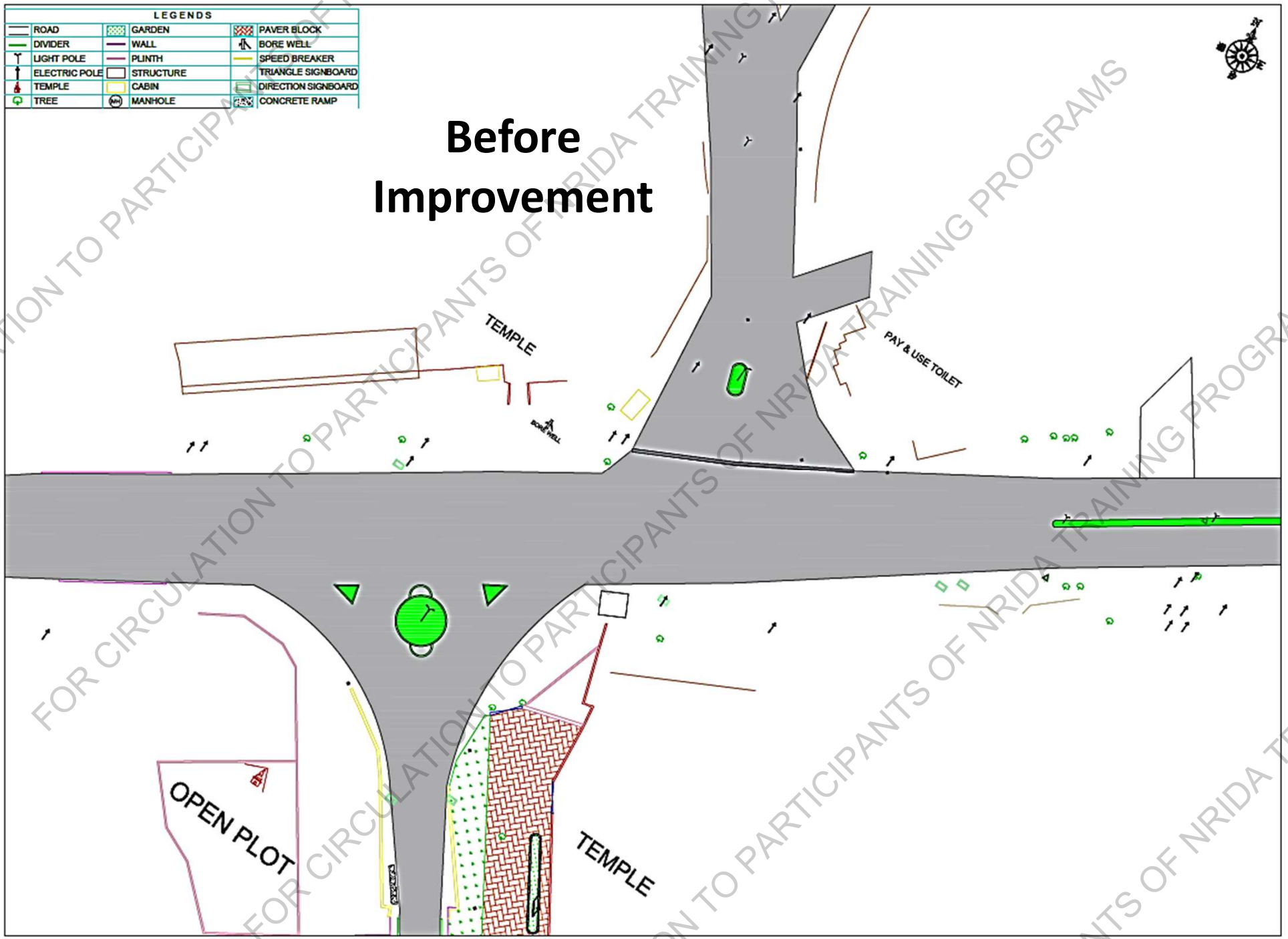
Coming to medium term solutions

- Solutions that require **several weeks** to achieve and provide **better efficiency** in terms of volume flow, level of service, delay to the passengers for a considerable time can be grouped into this category.
- Generally implemented methods are

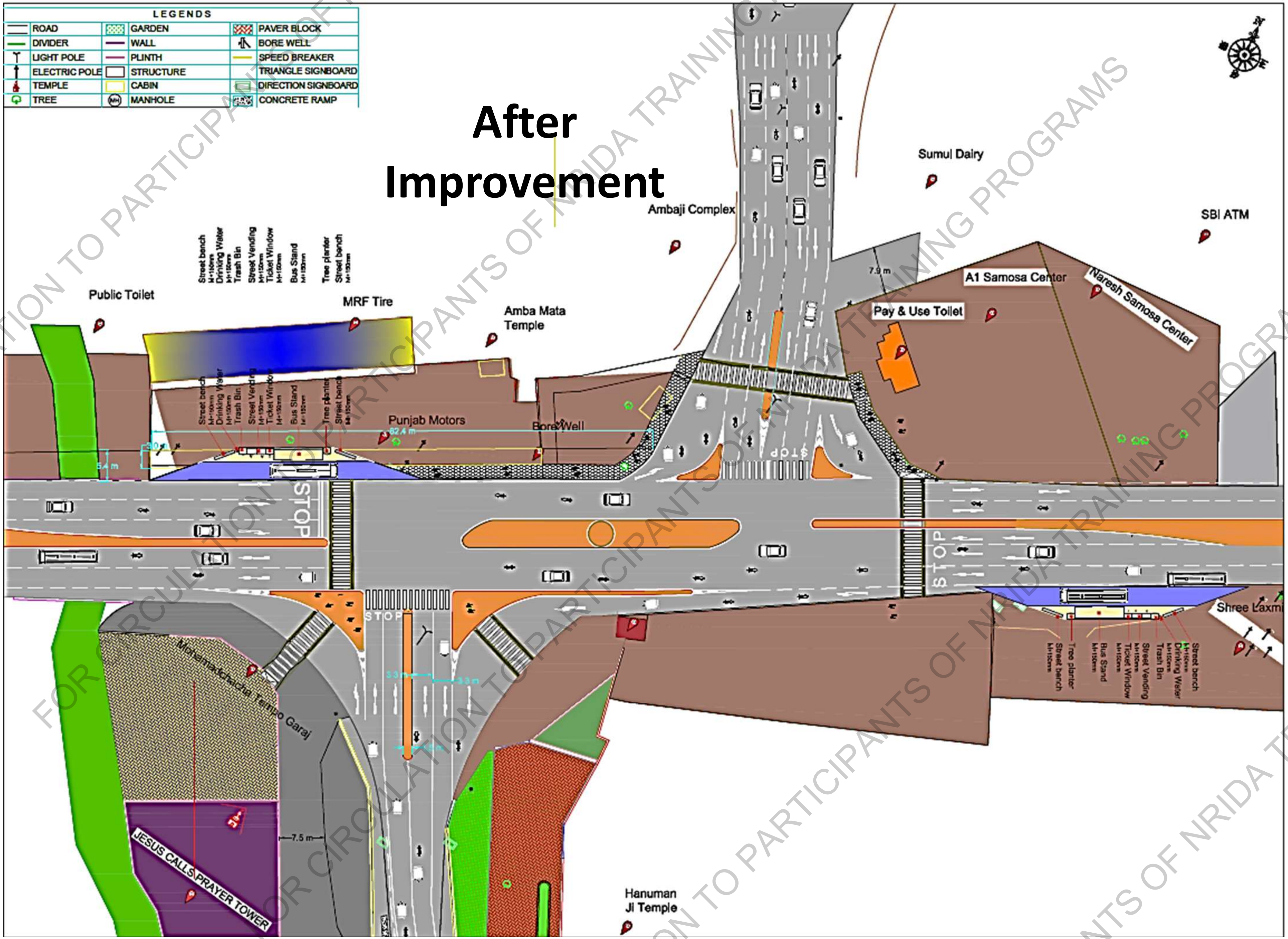
1. Diversion of Traffic
2. Geometric Correction
3. Signalization (also a long term solution) (Depends upon the site conditions, traffic demand, etc.)


KRASAWA
Decent
KRASAWA
DAWAKAZ

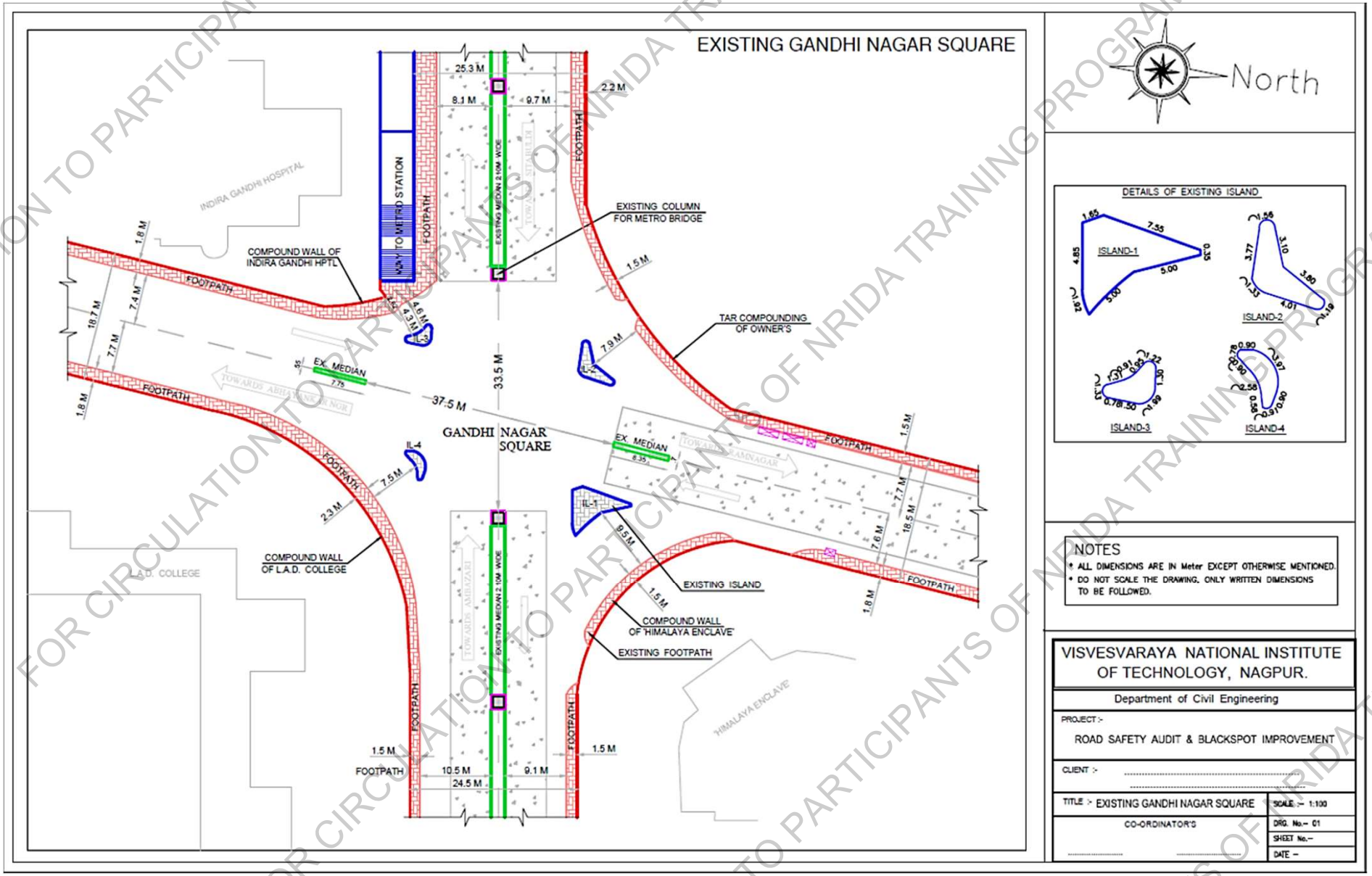
Junction Improvement : Vyara Town



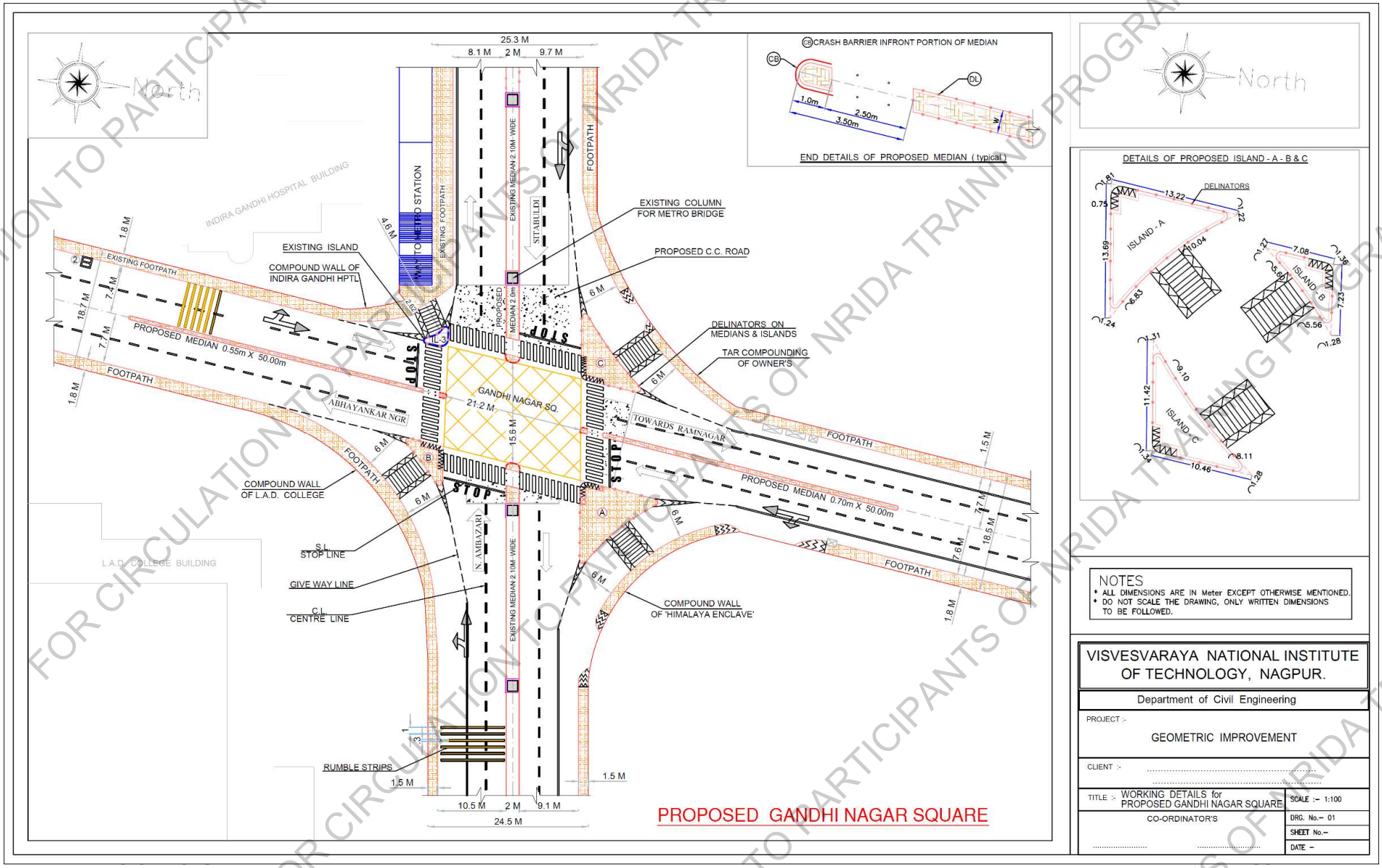
After Improvement



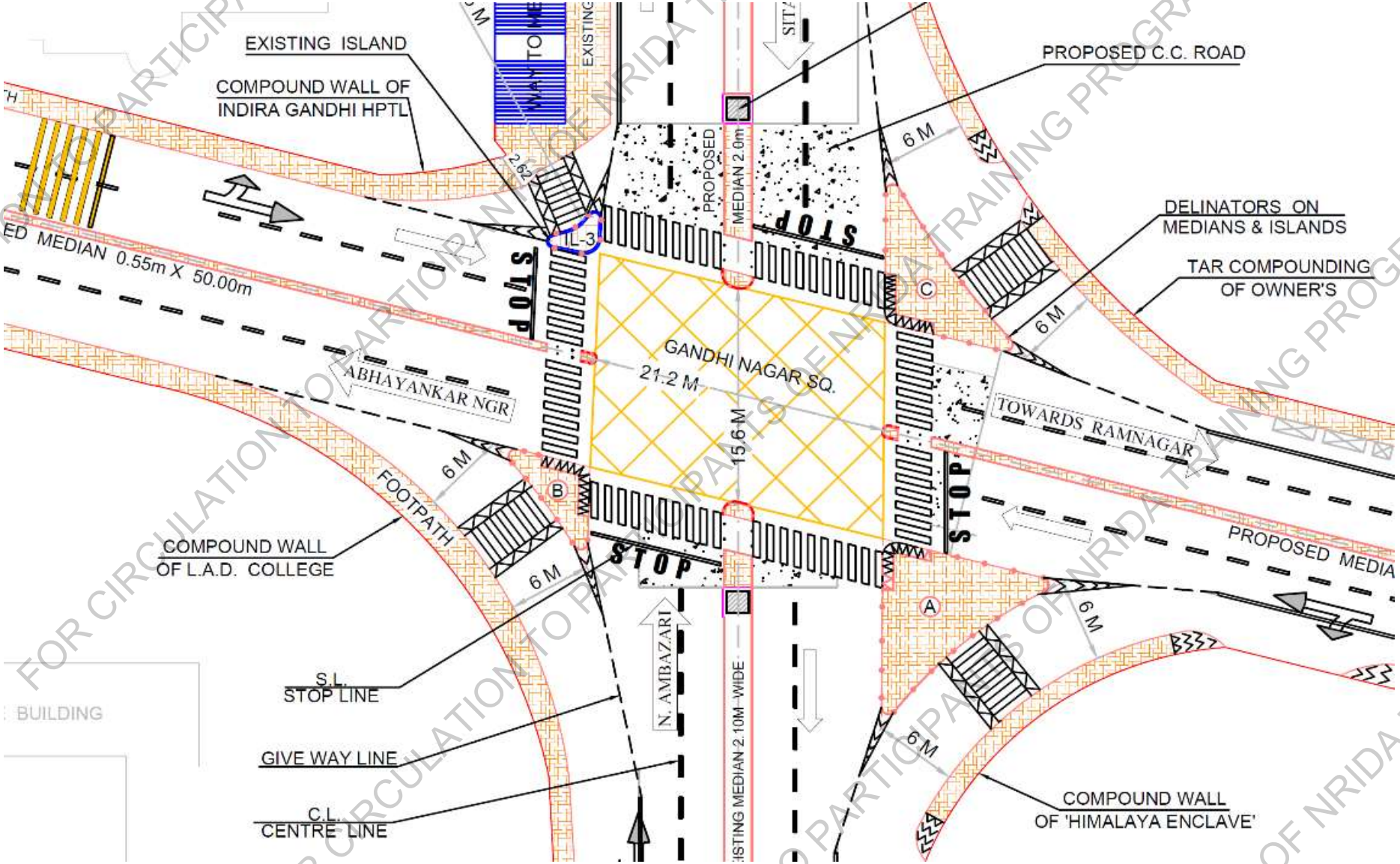
Gandhi Nagar (LAD Square) - Existing



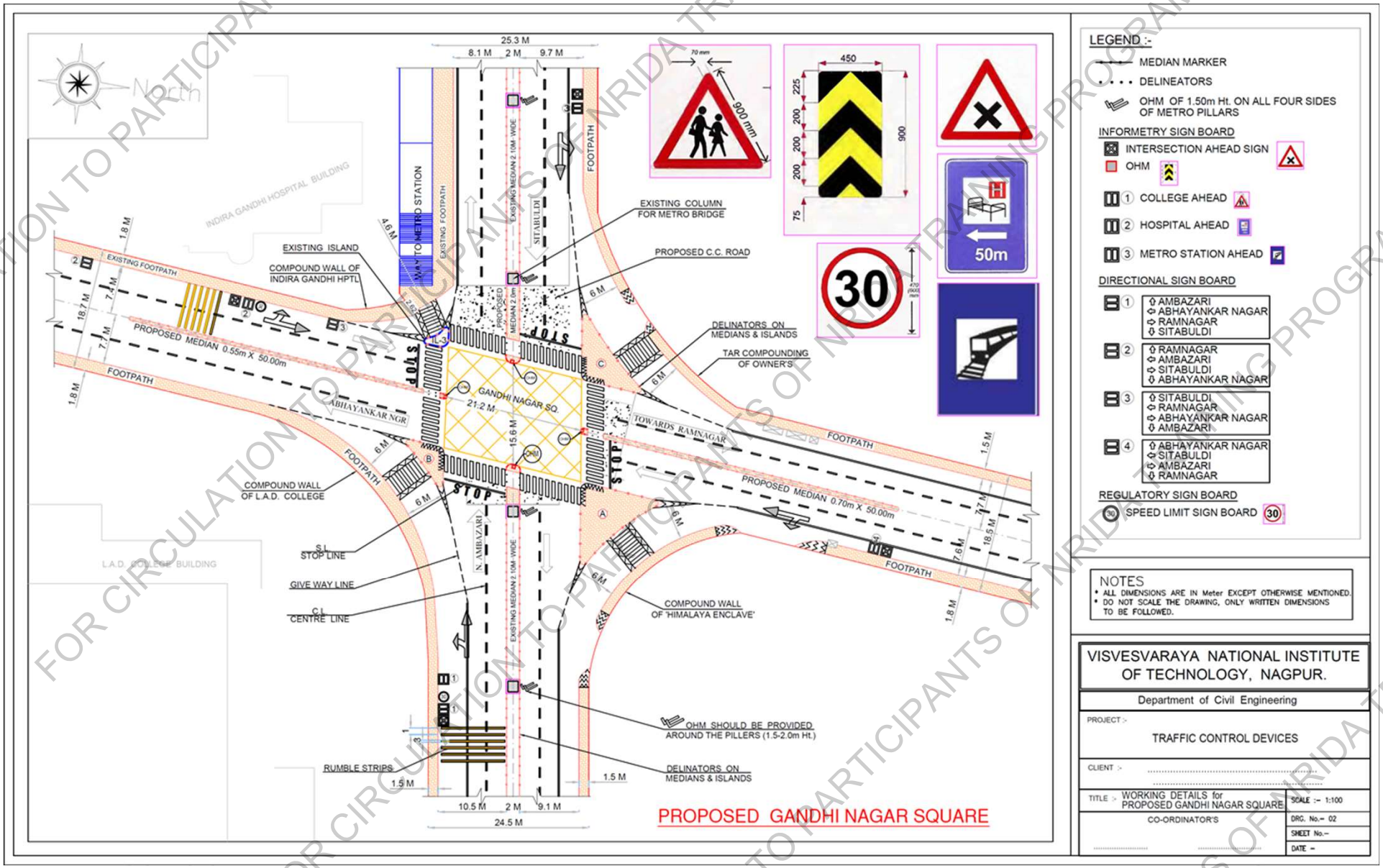
Proposed Geometric Improvements



Proposed Geometric Improvements + TCDs



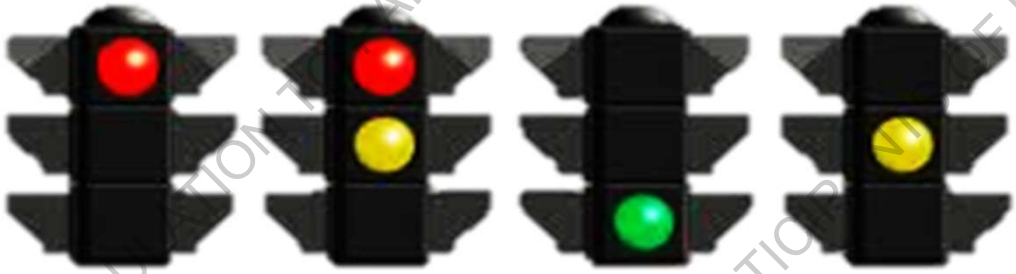
Proposed Geometric Improvements + TCDs



Signalization

Traffic signal

- Co-ordinated signal
- Fixed time Signal
  - Manually Operated Signal
  - Traffic Actuated Signal
- Pedestrian Signal

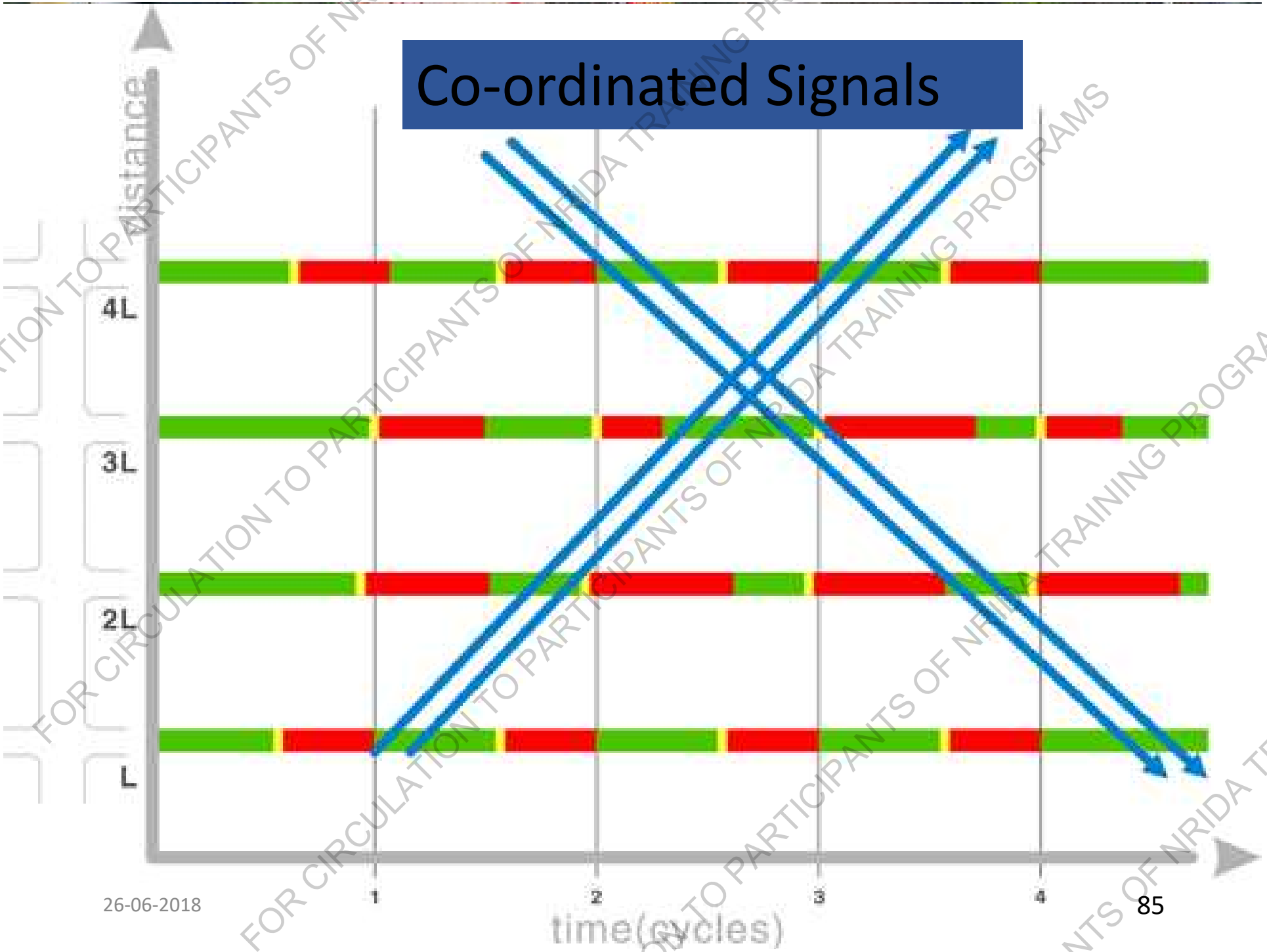


STOP | STOP | GO | GO

Prepare to go

If safe to do so

Co-ordinated Signals



Area Traffic Control (ATC) System

- ATC involves the coordination of traffic signals over a complete network of signals covering an area that may be considered homogeneous from the traffic operation point of view.
- The system required to be supported by computer as the problem is extremely complex because of crossing of several routes at common intersection.
- An Area Traffic Control System is basically a collection of electronic circuits, computers and software, microprocessors.
- These are skillfully put together and form a sophisticated tool for the traffic engineer to use and help to solve traffic problems in the city

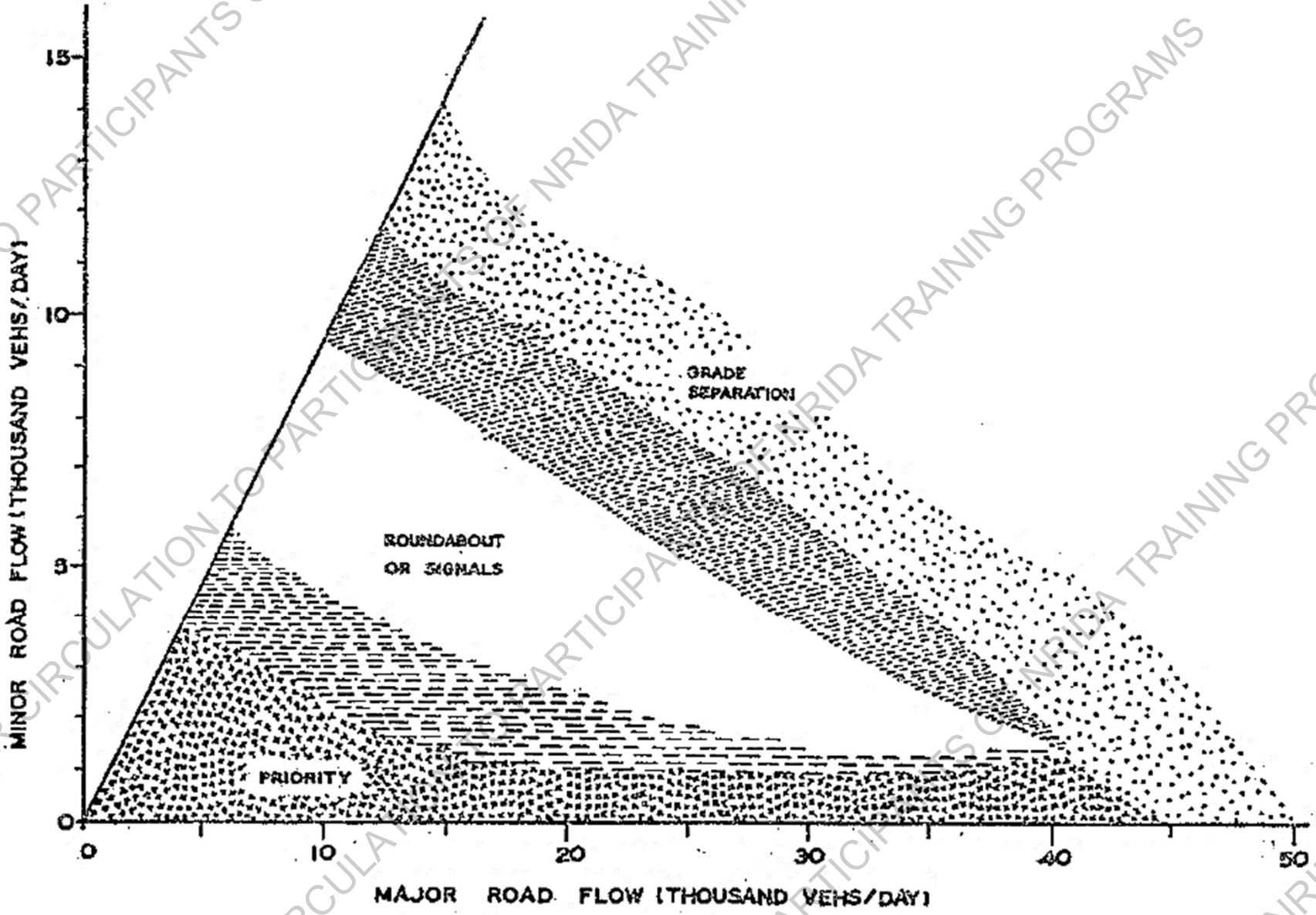
OBJECTIVES OF ATC

- Control and coordination of traffic signals on a wide basis to ensure traffic movements in safe and smooth manner.
- Reduction in journey times and vehicle stops to attain minimum delay.
- Continuous monitoring of traffic signal equipments of the system to ensure speedy rectification.
- Reduction in traffic congestion caused by road works and accidents.
- Reduction in journey time for emergency vehicles by providing priority facility.
- Maximum utilization of road space.
- Reduction in fuel consumption and consequently vehicle operation cost. (VOC)
- Reduction in air pollution from vehicle exhaust fumes.

LONG TERM SOLUTIONS

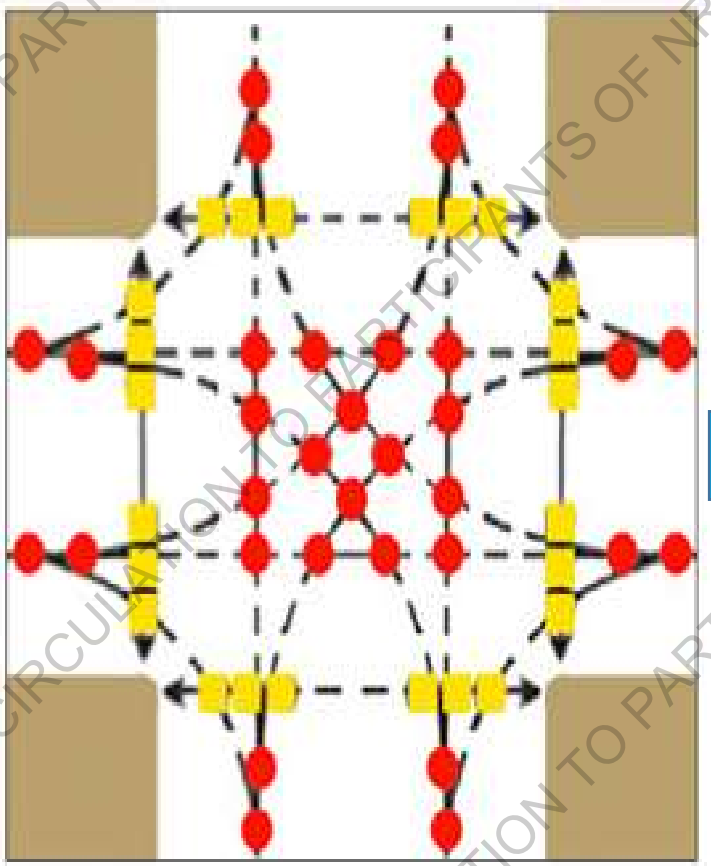
Long Term Solution-Roundabout & Interchange

- Long Term Measures may require considerable restructuring of the Infrastructure.
- The higher levels of results achieved using the methods could provide better performance and results for several years
- Most common results being
  1. Provision of Roundabout
  2. Grade separated Interchange



Reduction of Conflict Points

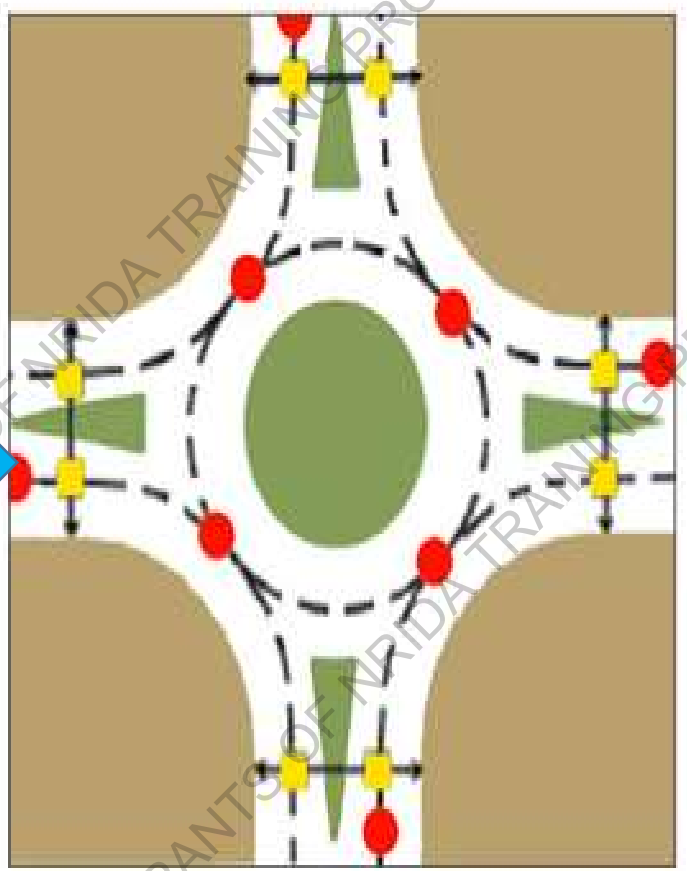
Intersection



32 Vehicle conflicts

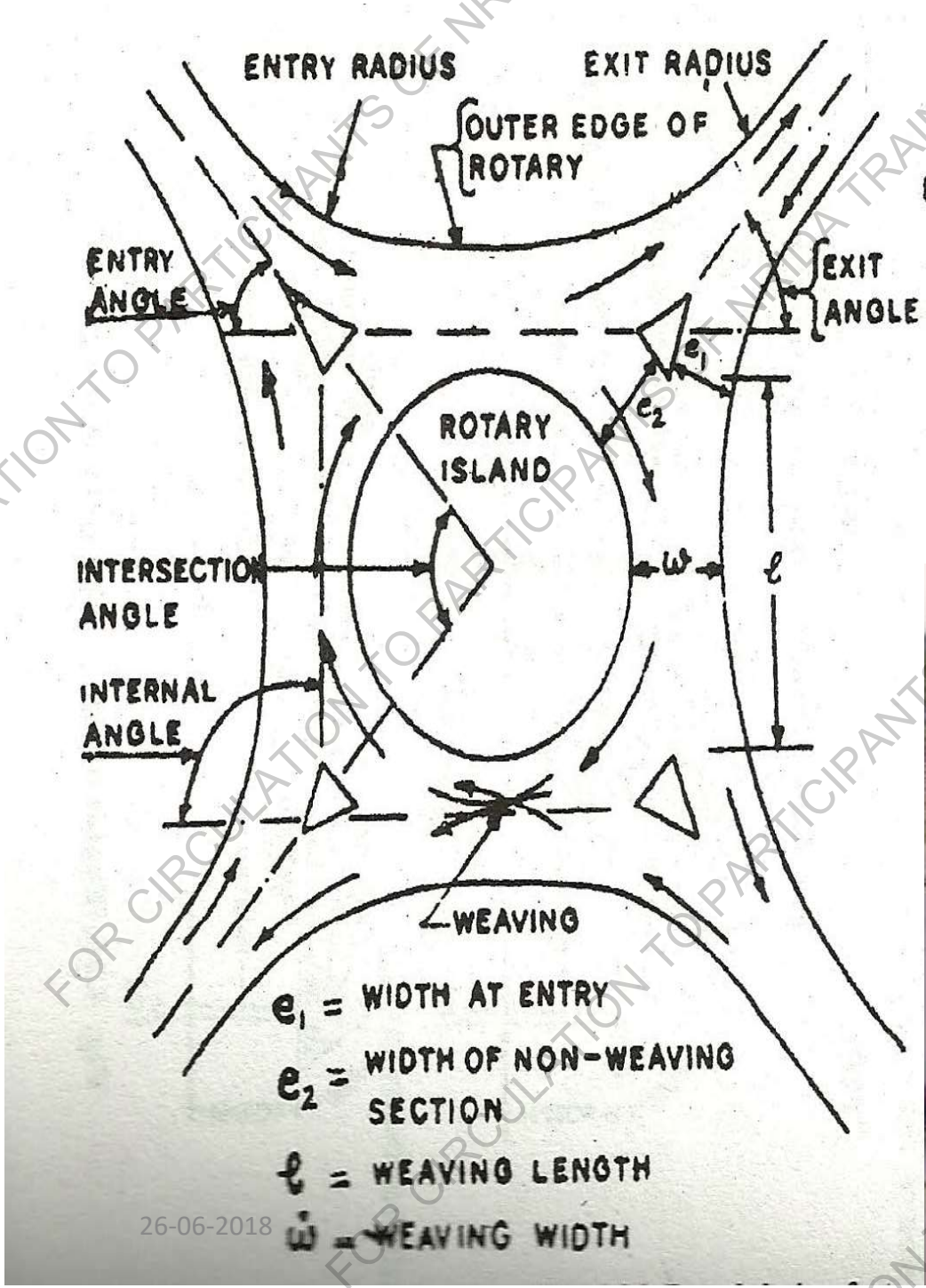
24 Pedestrian conflicts

Roundabout



8 Vehicle conflicts

8 Pedestrian conflicts

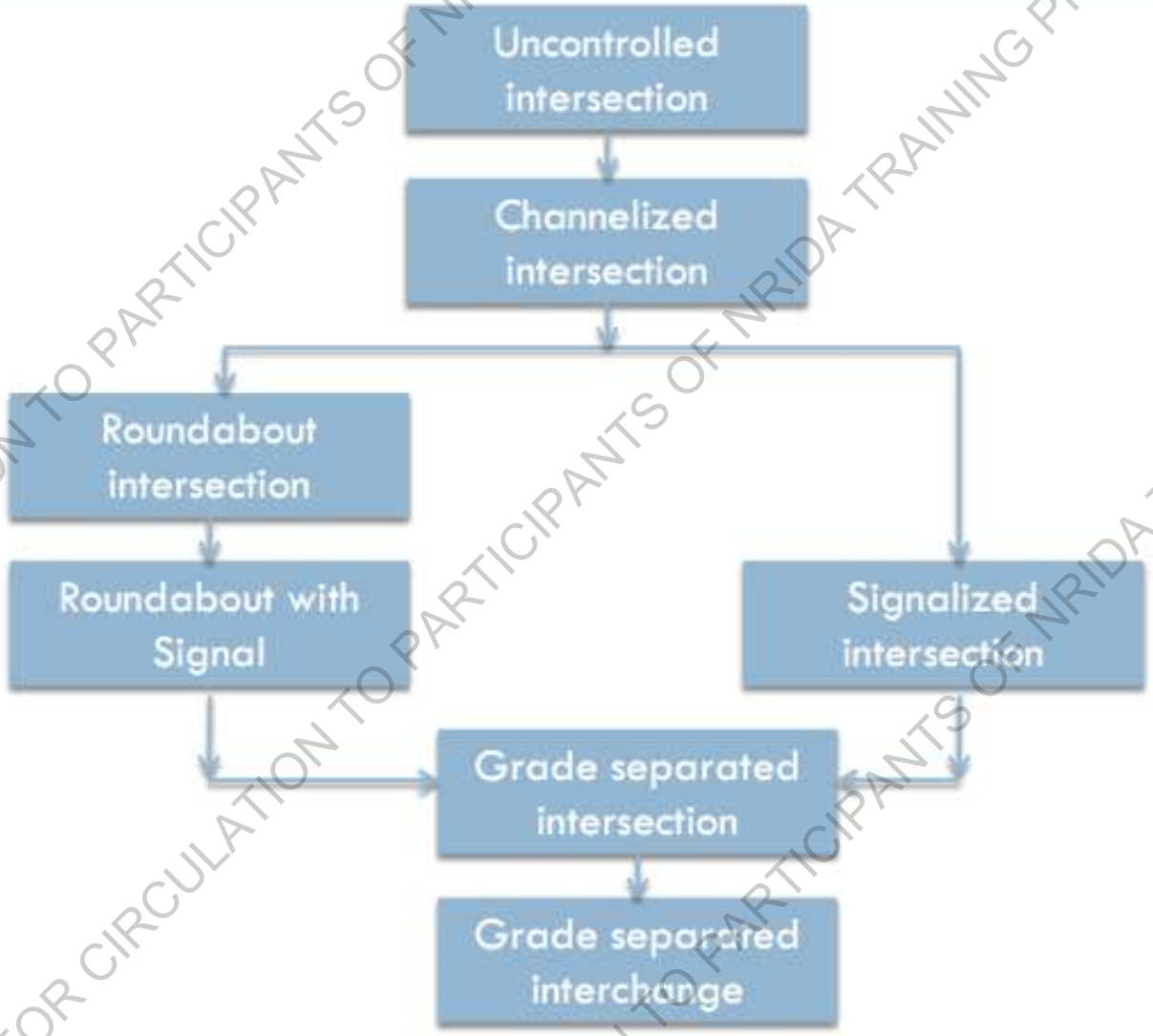


A compound Roundabout when there is a high demand for Vehicular and Pedestrian Traffic

Definition: Interchange

- System of interconnecting roadways in conjunction with one or more grade separations, providing for the movement of traffic between two or more roadways on different levels.

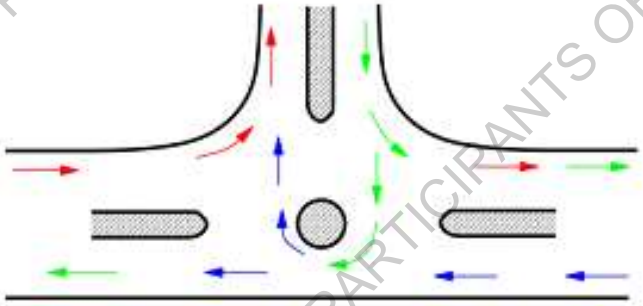
Life Cycle of Intersections



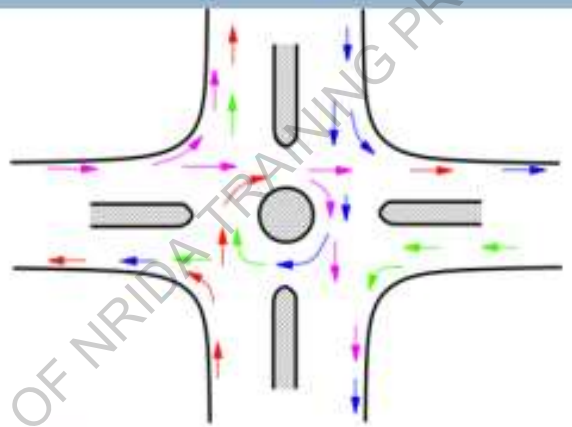
Major Interchanges type

- Underpass
- Overpass
- Trumpet Interchange
- Diamond Interchange
- Cloverleaf Interchange
- Partial cloverleaf Interchange
- Directional Interchange
- Bridged Rotary

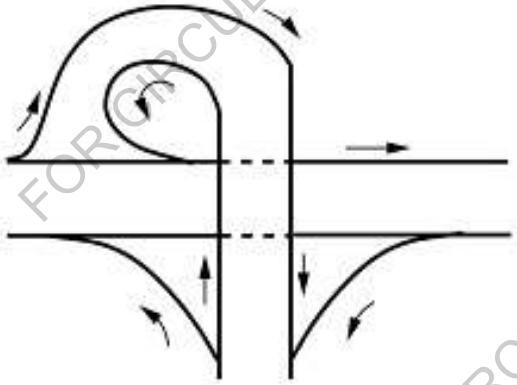
Intersections / Interchanges



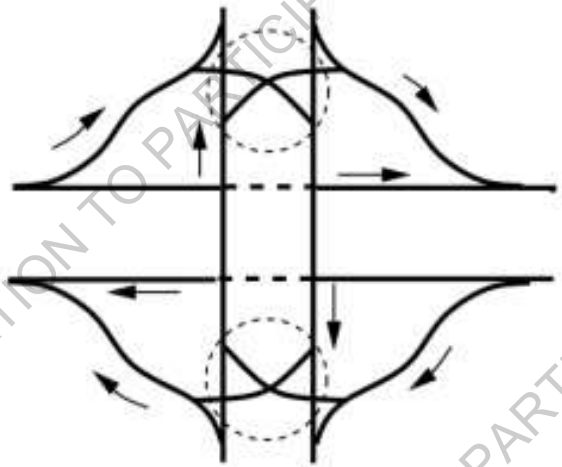
Channelization of traffic through a three legged intersection



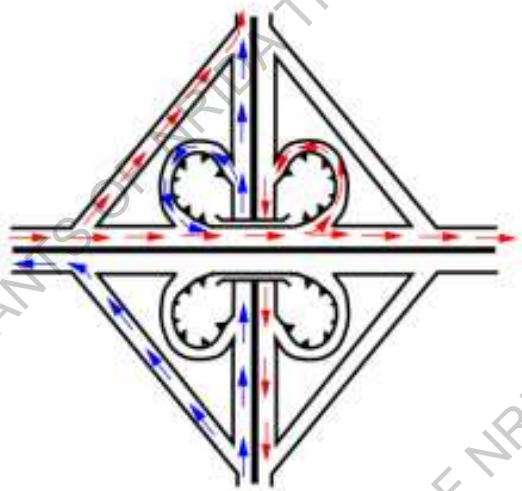
Channelization of traffic through a four legged intersection



Trumpet interchange



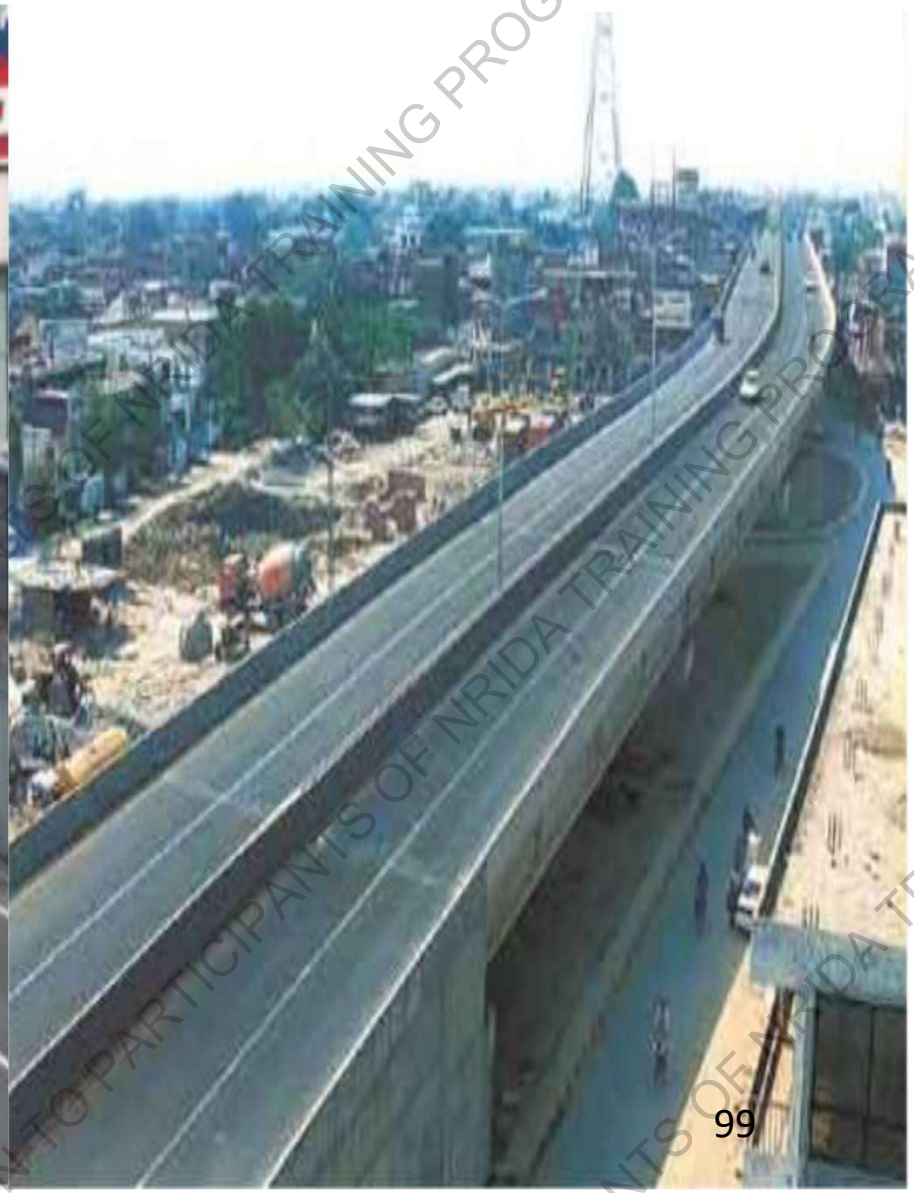
Diamond interchange



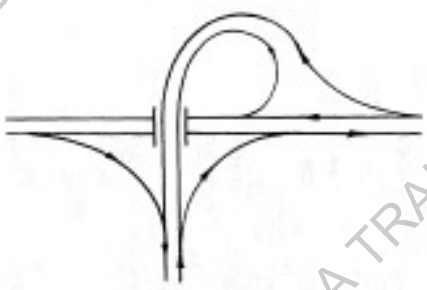
Cloverleaf Interchange

Underpass

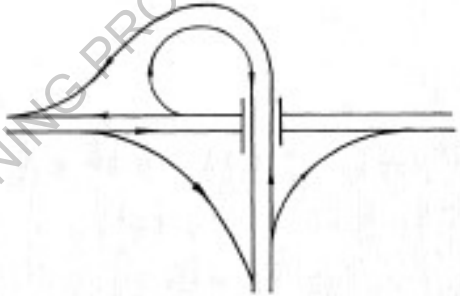
Overpass



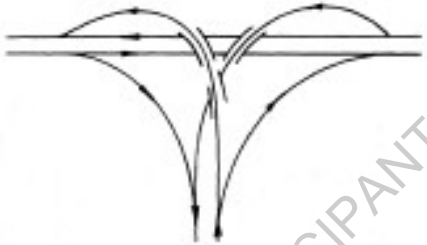
Three-legs



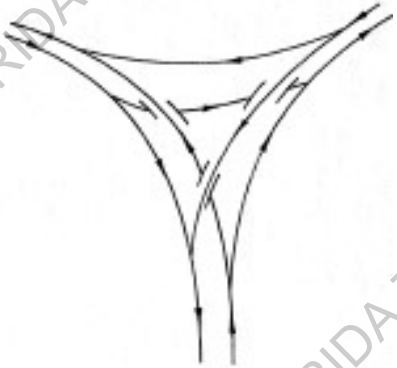
TRUMPET - A



TRUMPET - B

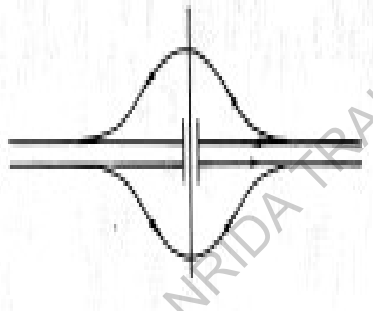


DIRECTIONAL -T

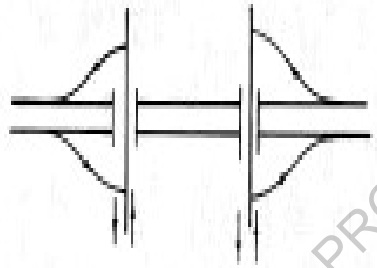


DIRECTIONAL -Y

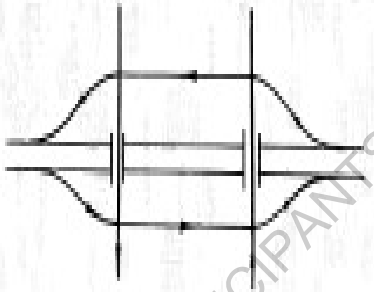
Four-Leg Intersections
(Diamond Interchange)



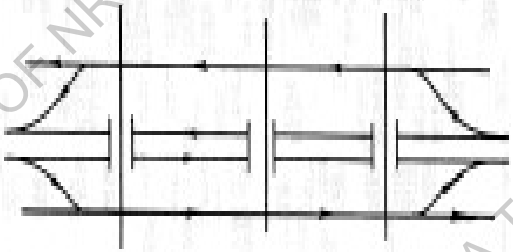
CONVENTIONAL DIAMOND



SPLIT DIAMOND

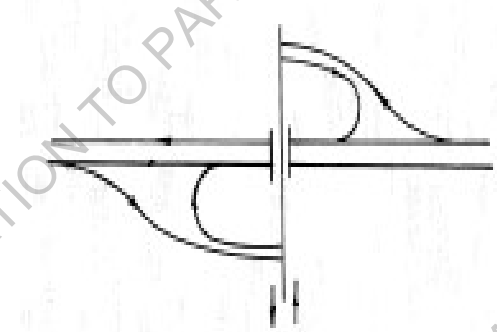


SPLIT DIAMOND WITH ONE-WAY CROSSROADS

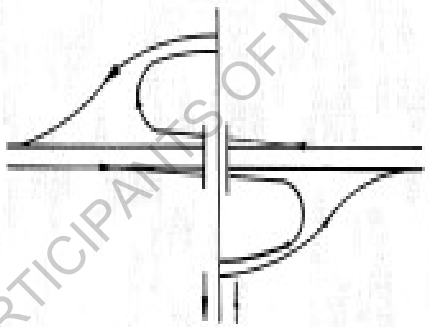


DIAMOND INTO ONE-WAY FRONTAGE ROADS

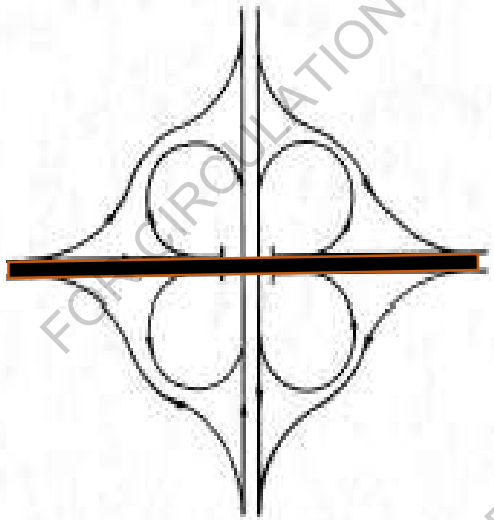
Four-Leg Intersections



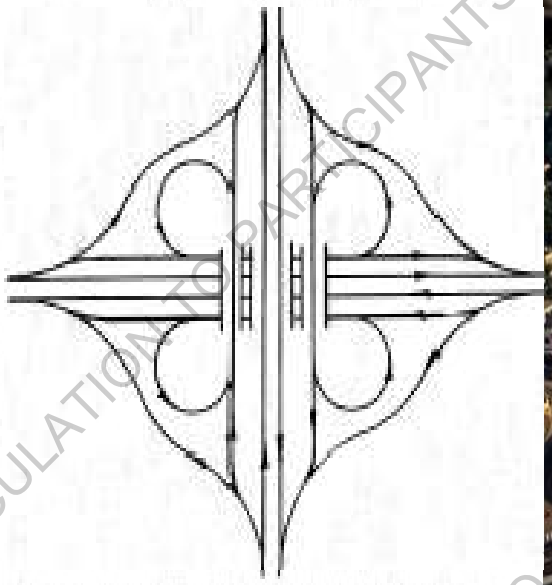
PARTIAL CLOVERLEAF



PARTIAL CLOVERLEAF

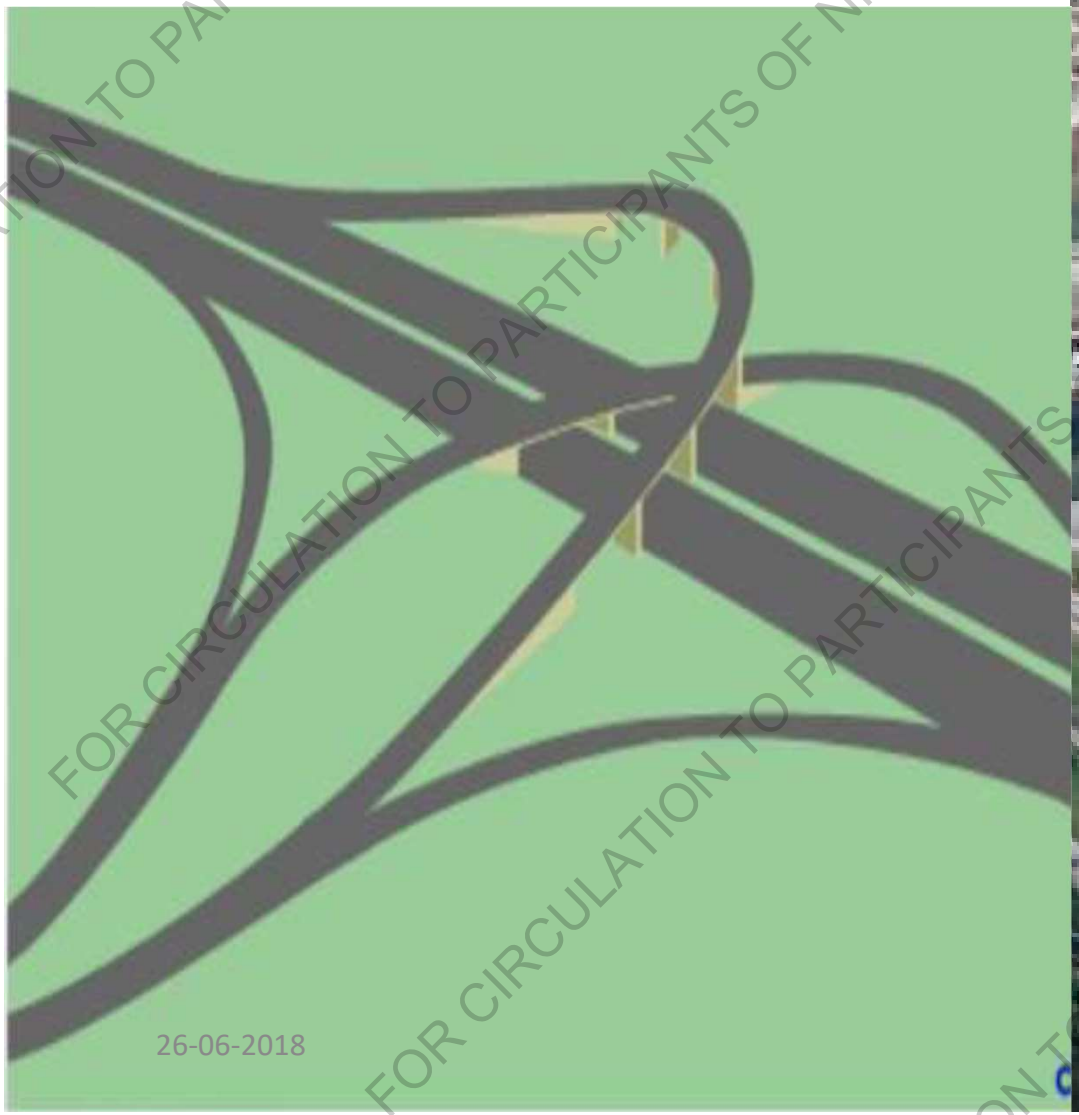


CLOVERLEAF



CLOVERLEAF WITH C-D ROADS

Directional Interchange



AIIMS Interchange (Delhi)

Dhaula Kuan (Delhi)

Thank You