The Project for Urban Mobility Improvement in Kigali

The 6th Working Group 2 (6. Lecture 3: Signal Phase Planning)

22nd Feb 2022

Aims of Lecture

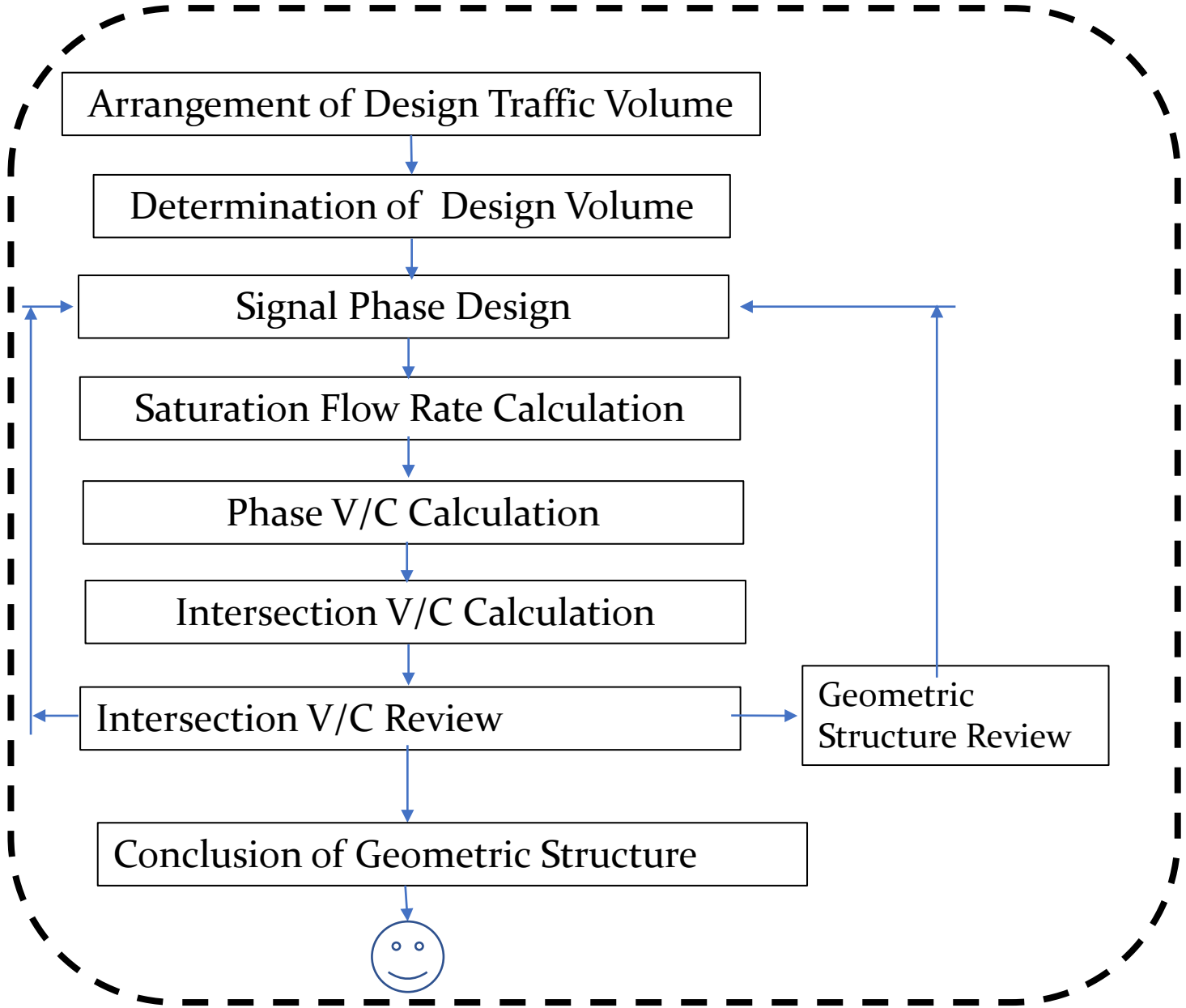
The lecture aims the followings.

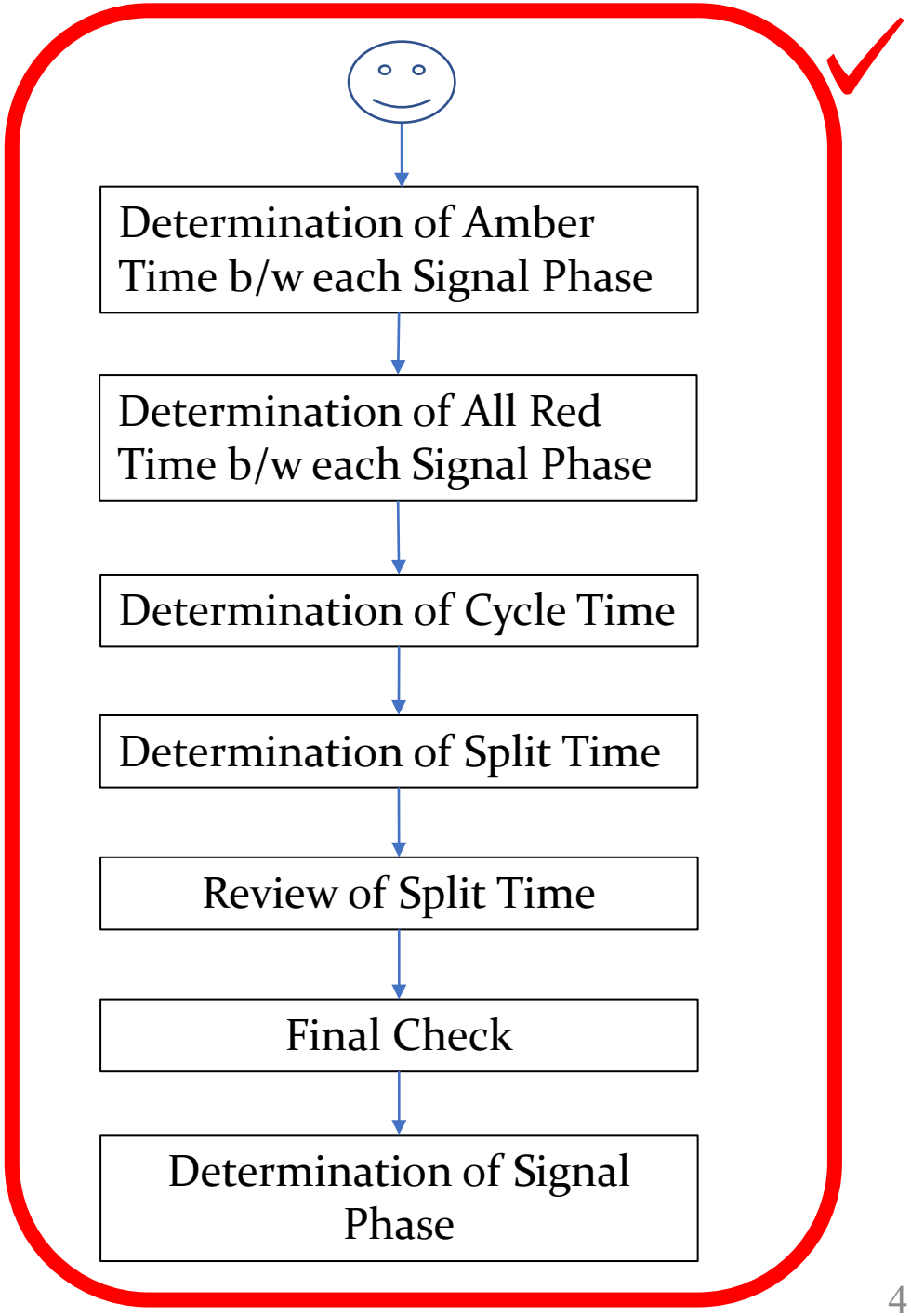
1. ***Enhance understanding of role and function of Traffic Signal***
2. ***Acquire the basic knowledge about Signal Phase Design***

Overall Lecture Contents

- **Role of Traffic Signal**
- **Basic of Signal Parameter**
- **Clearance Interval and Total Loss Time**
- **Saturation Flow Rate and Flow Ratio**
- **Calculation of Cycle Length**
- **Calculation of Split**
- **Calculation of Signal Phase of S03-12 Intersections**

Design Process of Signal Phase





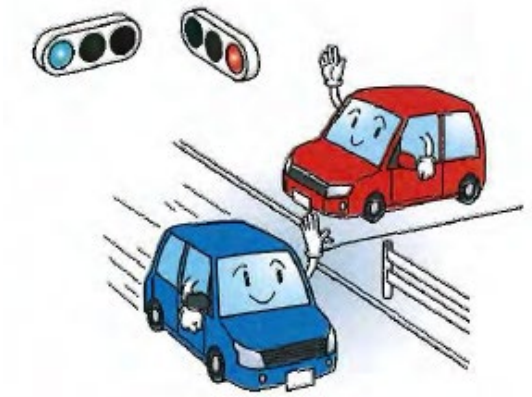
1. Roles of Traffic Signal

1: Preventing Traffic Accidents

Traffic signals ensure a temporal separation of traffic flows moving in different directions. They control traffic flows to prevent vehicles from colliding with or obstructing other vehicles and pedestrians, thereby protecting them from traffic accidents.

2: Ensuring smooth traffic flow

Traffic signals are operated at an optimal timing based on the traffic volume to ensure a smooth flow of traffic.



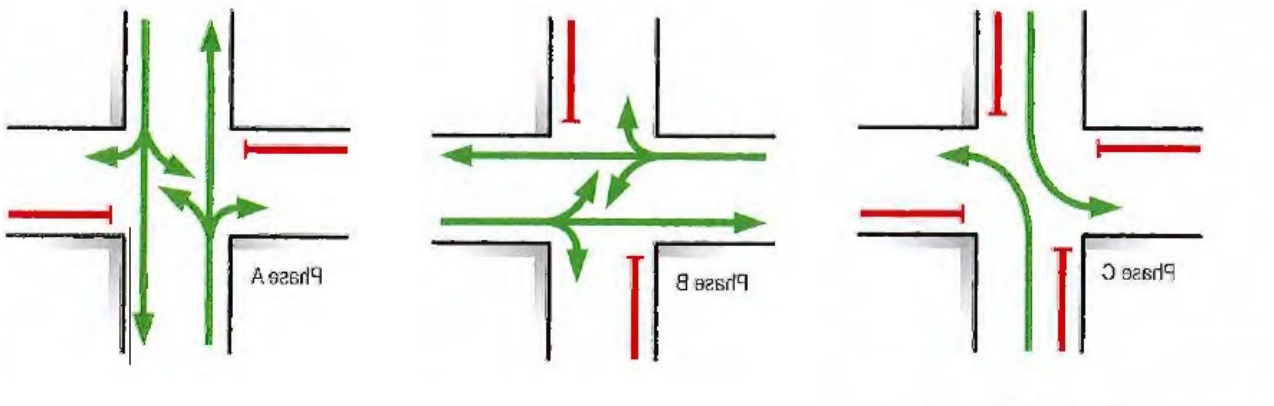
3: Improving the Traffic Environment

Smooth traffic reduces the number of vehicle stops and ensures as table traffic flow, thereby reducing traffic related problems, such as exhaust emissions and noise. It al so contributes to a reduction in carbon emissions.

2. Basics of Signal Parameter

(1)Signal phase

Traffic signal phase refers to a period of time during which a specific set of traffic movements are allowed to proceed through an intersection.



(2)Cycle length

The time it takes for as set of traffic lights to change from green to yellow to red and back to green again is called the cycle length, which is expressed in seconds.

(3)Split

The amount of time within a single cycle length that is
allocated to each signal indication is called the split,
which is represented as a percentage of the cycle
length.

2.Basics of Signal Parameter

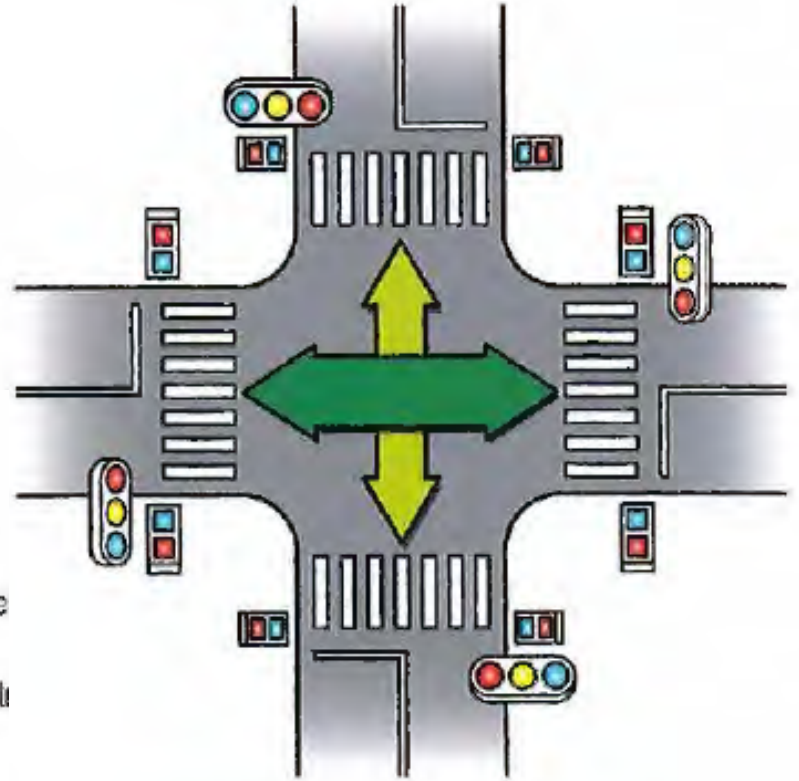
Step

Step	1	2	3	4	5	6	7	8	9	10
Main road vehicle signal (A)										
Subsidiary road vehicle signal (B)										
Duration in seconds	45	5	5	3	2	25	5	5	3	2
Signal phase	①					②				
Traffic flow										

Green signal for vehicles and pede
Yellow signal for vehicles
Red signal for vehicles and pedestr
Flashing signal for pedestrians

Pedestrian flow
Vehicle flow

Signal phase table (example)



Arrangement of traffic signals

Cycle (100s)
Split (60%:40%)

Phase

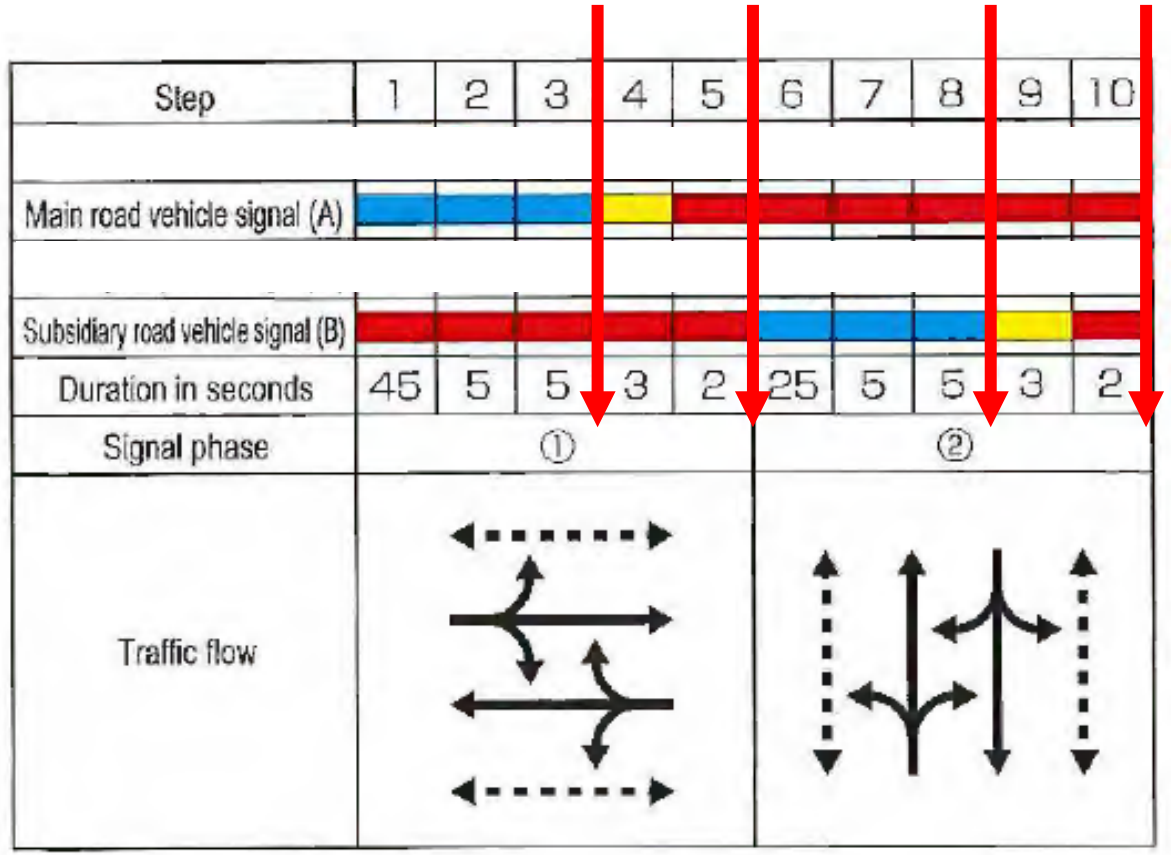
3. Clearance Interval and Total Loss Time

(1) Clearance Interval

When signal phase switch from phase A to phase B, vehicles in phase A must either stop before the stop line or cross the intersection before phase B begins to avoid the collision. Clearance interval is the period of time is set aside b/w phases A and B to ensure that the intersection is clear of vehicles.

The clearance interval is basically designed according to the average of vehicle speed and size of the intersection.

In Japan, it's generally set like Amber(4s), All Red(3~4s) for large size intersection and Amber(3s), All Red(2~3s) for middle size intersection



Signal phase table (example)

(2) Total Loss Time

Total Loss Time = Clearance Interval and Designated Pedestrian Crossing Time

4. Saturation Flow Rate and Flow Ratio

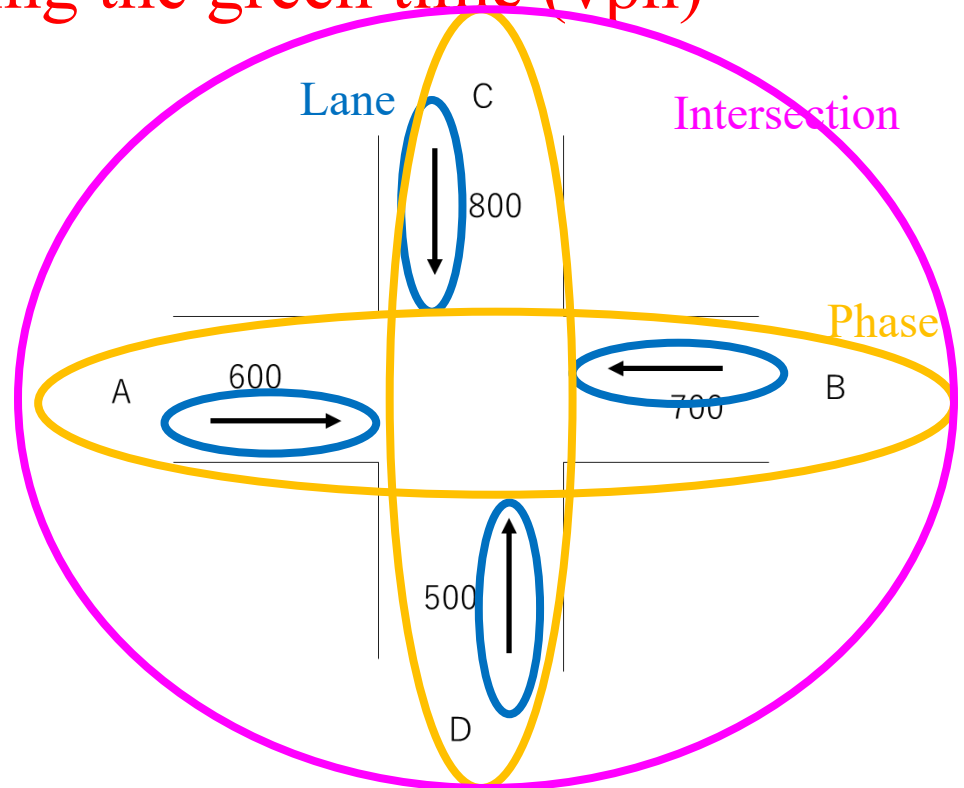
(1)Saturation Flow Rate (Capacity)

Saturation traffic flow rate is the maximum flow rate of vehicles that can be accommodated on a roadway section without a significant decrease in the speed of the traffic stream.

The number of vehicle passing intersection during the green time (vph)

Straight lane = 1800 vph

Left turn lane = 1700 vph



(2)Volume/Capacity Ratio (V/C Ratio)

-Lane V/C
-Phase V/C
-Intersection V/C

5.Calculation of Cycle Length

Minimum Cycle Length: $C = \frac{L}{1-\lambda}$

C : Minimum cycle length
L : Total loss time
λ : Intersection V/C

Step1: Calculation of Lane V/C

Lane A 600(volume)/1800(capacity)=0.333
Lane B 700(volume)/1800(capacity)=0.389
Lane C 800(volume)/1800(capacity)=0.444
Lane D 500(volume)/1800(capacity)=0.277

Step2: Calculation of Phase V/C

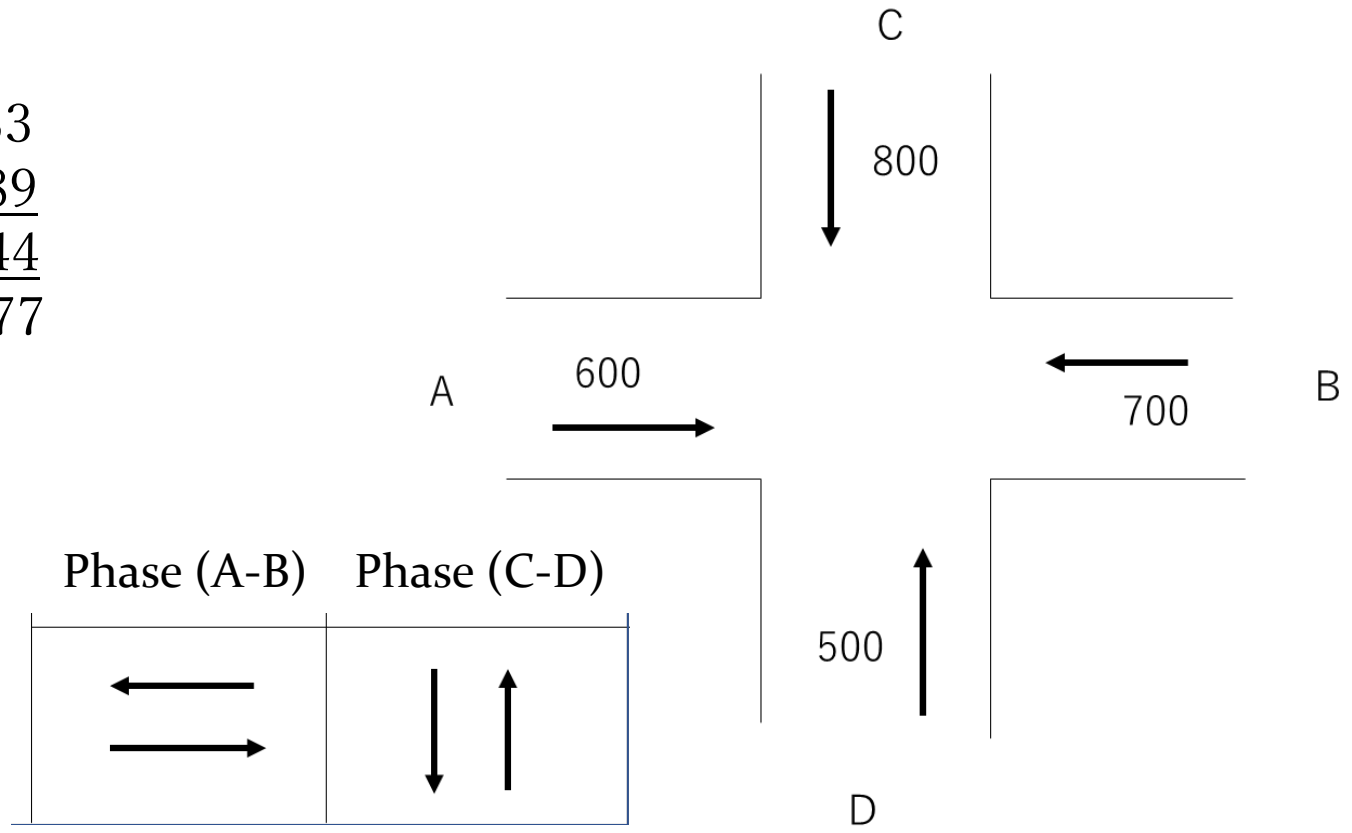
Phase (A-B): 0.389
Phase (C-D): 0.444

Step3: Calculation of Intersection V/C

Intersection: 0.389+0.444=0.833

Step4: Calculation of Minimum Cycle Length

C=L/(1- λ)=12/(1-0.833)=72(s)



L = {Amber time (4s) + RR time (2s)}*2phases=12s

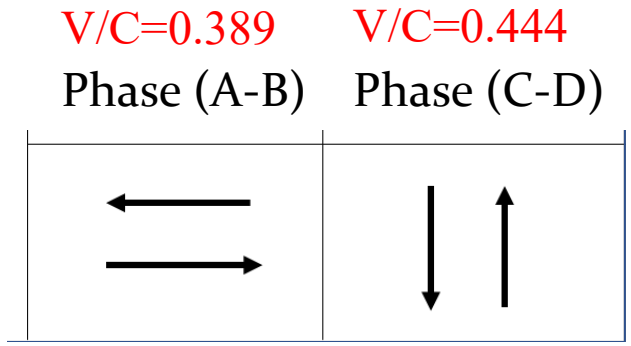
6.Calculation of Split

$$Gi = C \times \rho i$$

Gi : Split of Phase I
C: Minimum cycle length
ρ i : Phase i V/C / Intersection V/C

Split of Phase (A-B) = 72 * 0.389/(0.389+0.444)
= 33.623 s

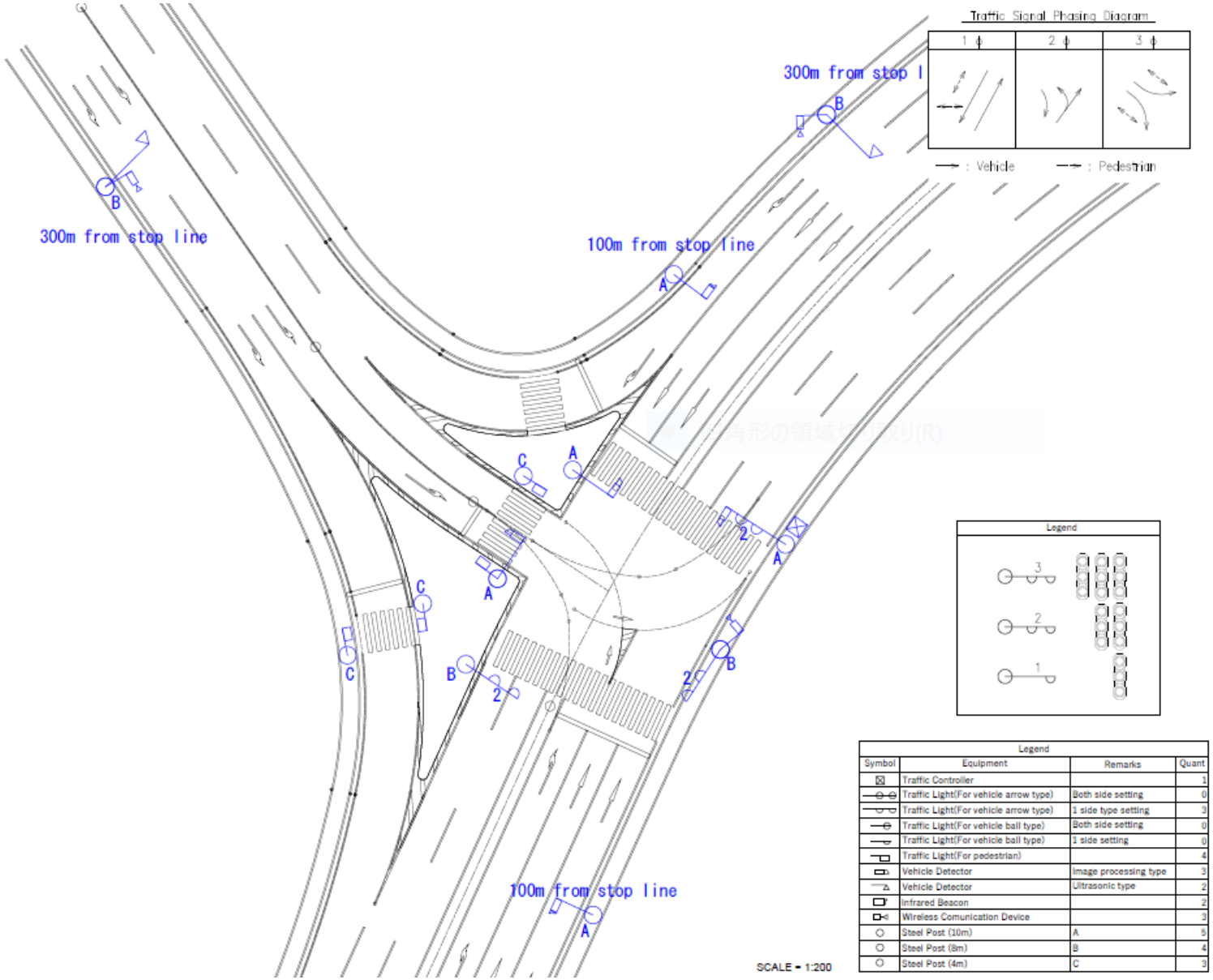
Split of Phase (C-D) = 72 * 0.444/(0.389+0.444)
= 38.376 s



※Review of Split

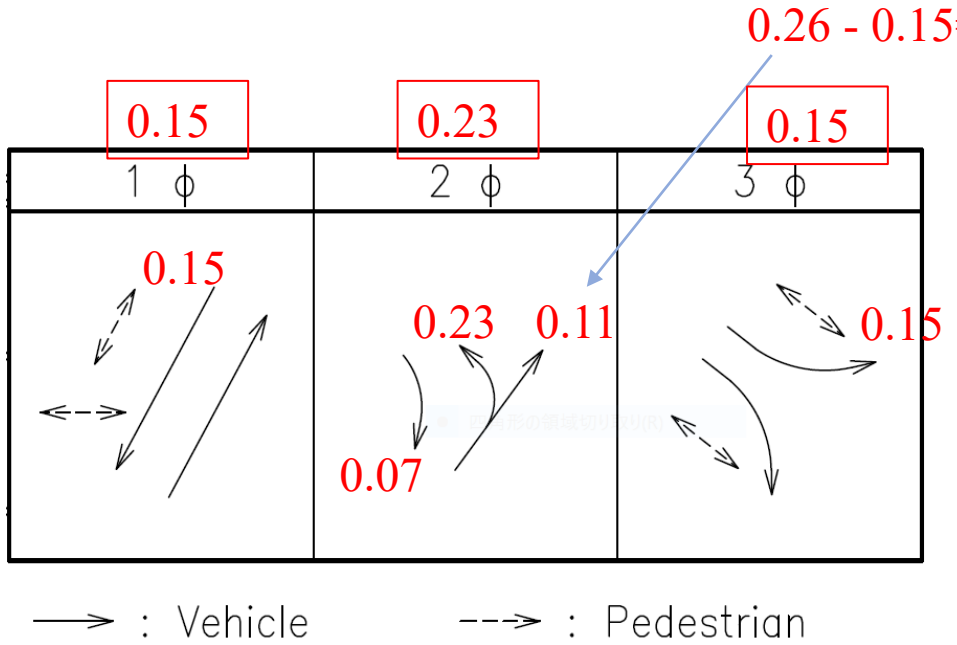
If the calculated split is not enough for pedestrians to cross, the minimum cycle length should be extended for setting longer split.

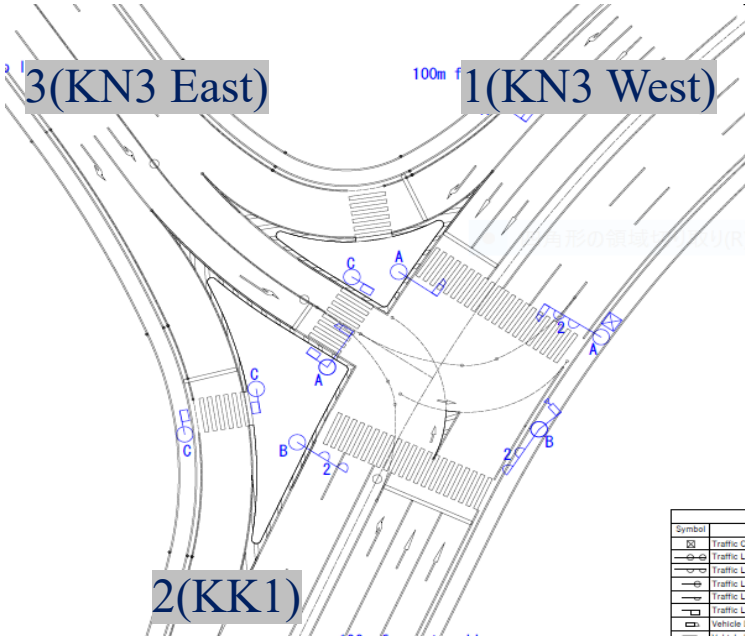
7.Calculation of Signal Phase (S03-12)



Legend			
Symbol	Equipment	Remarks	Quant
☒	Traffic Controller		1
	Traffic Light(For vehicle arrow type)	Both side setting	0
	Traffic Light(For vehicle arrow type)	1 side type setting	3
	Traffic Light(For vehicle ball type)	Both side setting	0
	Traffic Light(For vehicle ball type)	1 side setting	0
	Traffic Light(For pedestrian)		4
	Vehicle Detector	Image processing type	3
	Vehicle Detector	Ultrasonic type	2
	Infrared Beacon		2
	Wireless Comunication Device		3
○	Steel Post (10m)	A	5
○	Steel Post (8m)	B	4
○	Steel Post (4m)	C	3

Approach Road		1(KN3 West)			2(KK1)			3(NK3 East)				
		Right	Straight	Left	Right	Straight	Left	Right	Straight	Left		
Number of Lane			2			2	1	1		1		
Pedestrian Green Time (s)			10						17			
Saturation Flow Rate/Lane			1800			1800	1700	1700		1700		
Saturation Flow Rate			3600			3600	1700	1700		1700		
Design Volume(q)			556			943	390	115		262		
Lane V/C			0.15			0.26	0.23	0.07		0.15	Phase V/C	
	1 ϕ		0.15								1 ϕ	0.15
	2 ϕ					0.11	0.23				2 ϕ	0.23
	3 ϕ							0.07		0.15	3 ϕ	0.15





Approach Road		1(KN3 West)			2(KK1)			3(NK3 East)						
		Right	Straight	Left	Right	Straight	Left	Right	Straight	Left				
Number of Lane			2			2	1	1		1				
Pedestrian Green Time (s)			10						17					
Saturation Flow Rate/Lane			1800			1800	1700	1700		1700				
Saturation Flow Rate			3600			3600	1700	1700		1700				
Design Volume(q)			556			943	390	115		262				
Lane V/C			0.15			0.26	0.23	0.07		0.15	Phase V/C		Intersection V/C	
	1φ		0.15								1φ	0.15	0.54	
	2φ					0.11	0.23				2φ	0.23		
	3φ							0.07		0.15	3φ	0.15		
Total Loss Time		2φ Y=3、2φ AR=2 、3φ Y=3、3φ Y=2 Total 10s										C=L/1- λ	=	22

【Cycle Calculation】

C=L/1-λ

=10s/(1-0.54)

=22

【Split Calculation】

Split (1Φ)=22s * 0.15/0.54=6s ＞＝10 NG

Split (2Φ)=22s * 0.23/0.54=9s

Split (3Φ)=22s * 0.15/0.54=6s ＞＝17 NG

Approach Road		1(KN3 West)			2(KK1)			3(NK3 East)						
		Right	Straight	Left	Right	Straight	Left	Right	Straight	Left				
Number of Lane			2			2	1	1		1				
Pedestrian Green Time (s)			10						17					
Saturation Flow Rate/Lane			1800			1800	1700	1700		1700				
Saturation Flow Rate			3600			3600	1700	1700		1700				
Design Volume(q)			556			943	390	115		262				
Lane V/C			0.15			0.26	0.23	0.07		0.15	Phase V/C		Intersection V/C	
	1φ		0.15								1φ	0.15	0.54	
	2φ					0.11	0.23				2φ	0.23		
	3φ							0.07		0.15	3φ	0.15		
Total Loss Time		2φ Y=3、2φ AR=2 、3φ Y=3、3φ Y=2 Total 10s									C=L/1- λ	=	22	

Cycle =60s

【Split Calculation】

Split (1Φ)=60s * 0.15/0.54=17s ＞＝10

Ok!

Split (2Φ)=60s * 0.23/0.54=26s

Split (3Φ)=60s * 0.15/0.54=17s ＞＝17

Ok!

END